Neuroplasticity, Motor control, Cutting-Edge Technology & Rehabilitation

Proceedings of the XIXth Congress of the International Society of Electrophysiology & Kinesiology

BRISBANE, AUSTRALIA
19-21st JULY, 2012

Editors
Kylie Tucker
Bianca Butler
Paul Hodges

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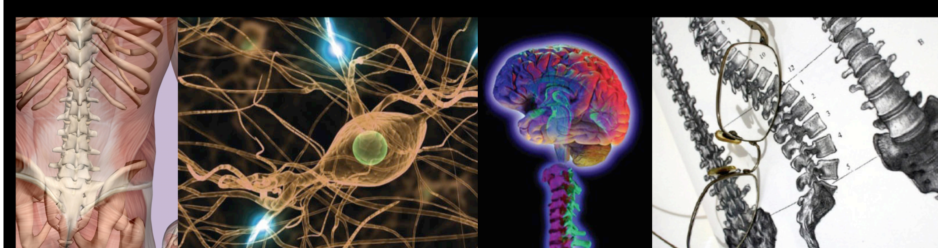

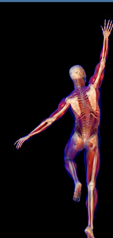

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Kylie Tucker, Scientific Committee Chair

Bianca Butler, Proceedings Editor & Congress Secretary

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KEYN_1 CONTROL OF THE HAND: FROM EVOLUTION TO MOTONEURONES

Prof Simon Gandevia, Neuroscience Research Australia, Barker St, Randwick, NSW, Australia

It has long been tempting to regard the hand as a pinnacle of evolutionary progress. However recent findings suggest that the hand of the great African apes appears more specialised such that it differs more from the hand of our last common ancestor than does the human hand. The talk will consider some of the neural and mechanical limits to hand performance both using single muscles and multiple muscles in a simple grasp. In addition, some unexpected properties of the descending corticofugal connection with intrinsic hand motoneurones will be covered.

KEYN_2 PAIN. NOT A SENSORY INPUT

Prof Lorimer Moseley, Sansom Institute for Health Research, University of South Australia, Adelaide, & Neuroscience Research Australia, Sydney.

Pain is often considered something that occurs in a particular body part and is detected by pain receptors. Fifty years of animal and human experiments have proved this idea wrong, yet pain and nociception are seldom differentiated in physiological investigations in humans. Pain is a conscious experience that serves to protect our body tissues and, although nociceptive input is very important, it is neither sufficient nor necessary to cause pain. In this talk, I will outline a conceptual framework with which to understand pain that both integrates the important function of nociception, but also the critical role of non-nociceptive sensory inputs and non-sensory factors. This framework has implications for our management of patients in pain, but also for the design and interpretation of research.

KEYN_3 NEW FRONTIERS IN ELECTRICAL MUSCLE STIMULATION: IS IT AN EFFECTIVE TREATMENT FOR THE MAJOR LIFESTYLE RELATED DISEASES OF MODERN SOCIETY?

Professor Toshio Moritani, Laboratory of Applied Physiology, The Graduate School of Human & Environmental Studies, Kyoto University, Kyoto, Japan

The prevalence of lifestyle related diseases such as type 2 diabetes, obesity and heart disease are rapidly increasing in the modern world and have the potential to cripple economies and compromise quality of life for millions. Exercise is one of the recommended treatments, but it is proving difficult to engage individuals to initiate exercise programs. Electrical muscle stimulation (EMS) may provide an alternative and more efficient solution. Although EMS has undergone a decline in use, mainly because of stimulation discomfort, new technologies allow painless application of strong contractions. Such activation can be applied in higher exercise dosages and more efficiently than people are likely to achieve with exercise. Unlike orderly recruitment of motor units (MUs) during low intensity voluntary exercise EMS activates large fast-twitch MUs with glycolytic fibers first and this could have benefit for prevention and treatment of diabetes and chronic diseases associated with muscle atrophy that ultimately lead to bed-ridden conditions. Recent evidence highlights the potential for EMS to make a major impact on these and other lifestyle related diseases and its role as a useful modality for orthopedic and cardiac rehabilitation. This talk will discuss the potential for EMS to break new ground in effective interventions in these frontiers of medical science.

KEYN_4 REANIMATION OF MOVEMENT USING PROBABILISTIC CONTROL OF MUSCLE STIMULATION

Prof Andrew J. Fuglevand, Departments of Physiology and Neuroscience, College of Medicine, University of Arizona, Tucson USA

Functional electrical stimulation (FES) involves artificial activation of muscles with surface or implanted electrodes to restore motor function in paralyzed individuals. The range of motor behaviors that can be generated by FES, however, is limited to a small set of preprogrammed movements such as hand grasp and release. A broader range of movements has not been implemented because of the substantial difficulty associated with identifying the patterns of muscle stimulation needed to elicit specified movements. In order to overcome this limitation in controlling FES systems, we have used different forms of probability-based models (e.g., Bayesian density estimation, dynamic neural networks) to estimate patterns of muscle activity in human and non-human primates during a wide range of free movements of the upper limb. In addition, we have developed a generalized transfer function to convert predicted levels of muscle activity into appropriate patterns of electrical stimulation. Complex movements generated by probabilistic-controlled FES showed good correspondence to desired trajectories. Therefore, this approach should provide a flexible means to control FES and thereby expand the repertoire of motor functions available to paralyzed individuals.

KEYN_5 NEURAL PLASTICITY: FOUNDATION FOR NEUROREHABILITATION

Associate Professor Jeffrey Kleim, School of Biological and Health Systems Engineering, Arizona State University, Tempe, AZ, USA

Neurorehabilitation is undergoing a paradigm shift that is centered around the recognition that the CNS is a target of treatment. Basic science has enhanced our understanding of the key behavioral and neural signals driving neural plasticity. This work is now being translated into several novel therapies to promote plasticity and enhance functional recovery. The basic principles of neural plasticity will be discussed in the context of augmenting the efficacy of rehabilitation therapies. Examples of how knowledge of the molecular, physiological and behavioural mechanisms of plasticity can advance the development of novel more effective therapies for treating a range of neurological disorders will be described.

KEYN_6 MUSCLE RECRUITMENT STRATEGIES DURING DYNAMIC LANDINGS: CAN WE PREVENT ACL INJURIES?

Prof Julie Steele, Biomechanics Research Laboratory, School of Health Sciences, University of Wollongong, Wollongong NSW AUSTRALIA; Past President, International Society of Biomechanics

Anterior cruciate ligament (ACL) rupture, a potentially devastating injury, frequently occurs in tasks involving abrupt deceleration such as single-limb landings from a forward leap. Integrity of the ACL during such dynamic tasks relies upon proper coordination of the lower limb muscles, especially coordination of the quadriceps and hamstring muscles. This is because the hamstring muscles play a vital role in protecting the ACL during functional landing movements by restraining anterior motion of the tibia relative to the femur, to counteract the anterior drawer force imparted to the tibia by the quadriceps as they eccentrically contract to control knee flexion at foot-ground contact. Correct muscle lower limb recruitment strategies are therefore important in reducing ACL injury susceptibility. The aim of this talk is to provide an overview of research pertaining to muscle recruitment patterns displayed during dynamic landings, and how these strategies are moderated by gender and age, with implication for ACL injury prevention strategies.

KEYN_7 EMG-ASSISTED NEUROMUSCULAR SKELETAL MODELLING: GOING BEYOND EMG TO ASSESS THE ACTION OF MUSCLES IN MOVEMENT

Prof David Lloyd, Centre for Musculoskeletal Research, Griffith Health Institute & School of Physiotherapy and Exercise Science, Griffith University, Gold Coast Campus, Australia

Electromyography (EMG) only provides a reflection of how muscles act to produce movement. Conversely, computational neuromuscular skeletal models can directly estimate the forces generated and action of muscles. However, the neural activation of muscles in these models has relied on optimisation of what seems to be arbitrary mathematical criteria. Further, the validity of these models has always been questioned. Newly developed EMG-driven and now EMG-assisted neuromuscular skeletal models are now reaching a high level of sophistication. New EMG-assisted models can now account for EMGs that cannot be measured due muscles being too deep. These models are been well validated by their prediction of joint moments and motion, and now using muscle tendon kinematics via ultrasound and articular loading in the knee. This gives one the confidence in their results, and the findings and understanding that are forthcoming.

KEYNOTE PRESENTATIONS

ORAL PRESENTATIONS

BIOMECHANICS

BIOM_O1.1 BIOMECHANICAL AND NEUROMOTOR EFFECTS OF THORACIC SPINE MANIPULATION IN SUBJECTS WITH SIGNS OF SHOULDER IMPINGEMENT

Dr Stephanie Muth, University of Medicine and Dentistry of New Jersey

Dr Philip McClure, Arcadia University; Dr Mary F Barbe, Temple University; Dr Richard T Lauer, Temple University

INTRODUCTION: Thoracic spine manipulation is an effective treatment to reduce pain and improve function for people with shoulder impingement, the most common cause of shoulder pain. However, the mechanisms by which manipulation reduces pain and improves function are not well understood.

AIM: The primary aims of this investigation were to assess changes in three-dimensional scapular kinematics and shoulder muscle activity following thoracic spine manipulation in subjects with signs of shoulder impingement.

METHODS: Thirty subjects between the ages of 18 and 45 with signs of shoulder impingement were included in this study. Three-dimensional scapular and clavicular kinematics were assessed using an electromagnetic tracking device (Polhemus Liberty, Colchester VT). Scapular orientation was described in terms of upward rotation, posterior tilt and external rotation. Clavicular positions were described in terms of elevation and protraction. Surface electromyography data (Noraxon Myosystem 1200, Noraxon Inc., Scottsdale, AZ) were collected from the infraspinatus, serratus anterior, and the upper, middle and lower trapezius muscles during loaded humerothoracic elevation. A repeated measures analysis of variance (ANOVA) was used to compare scapular orientation and muscle activity at 30, 60, 90, and 120 degrees of humerothoracic elevation before and after a mid-throacic spine and cervicothoracic junction manipulation.

RESULTS: Small but significant changes in scapular kinematics and muscle activity were observed. Subjects demonstrated less scapular upward rotation and increased middle trapezius activity during humerothoracic elevation post manipulation. No other changes in kinematics or muscles activity were detected.

CONCLUSION: The results of this investigation suggest that thoracic spine manipulation may alter scapular upward rotation as well as activity of the middle trapezius muscles; however, these changes are small and do not likely fully account for the robust findings of decreased pain and improved function associated with thoracic spine manipulation found in the literature.

ACKNOWLEDGEMENTS: Arcadia University, Glenside, Pennsylvania, USA; Temple University, Philadelphia, Pennsylvania, USA; University of Medicine and Dentistry of New Jersey, Stratford, New Jersey, USA

BIOM_O1.2 VALIDITY AND RELIABILITY OF THE SPINEANGEL® AS A LUMBO-PELVIC POSTURE MONITOR DEVICE

Mr Daniel Cury Ribeiro, Centre for Physiotherapy Research, University of Otago / Otago Institute of Sport and Adventure, Otago Polytechnic

Dr Gisela Sole, Centre for Physiotherapy Research, University of Otago; Dr J. Haxby Abbott, Dunedin School of Medicine, University of Otago; A/Prof Stephan Milosavljevic, Centre for Physiotherapy Research, University of Otago

INTRODUCTION: Repetitive, sustained or excessive trunk flexion is considered to be associated with greater risk of work-related low back pain (LBP). The use of postural feedback may help patients avoid postures associated with the onset or maintenance of this disorder. Prior to use of a postural feedback device in a clinical or workplace setting, its reliability and validity needs to be assessed. The Spineangel® is a novel postural monitor and feedback device developed to monitor lumbo-pelvic posture and provide audio-feedback whenever a pre-set postural threshold is exceeded.

AIM: The aims of this study were to determine the between-trial, within-session and between-day reliability as well as the criterion-related validity of the Spineangel® as a lumbo-pelvic posture monitoring device during a wide range of occupational activities.

METHODS: Twenty-five healthy participants took part in this study. They were requested to perform six different functional tasks in random order, with the Spineangel® device attached to the waistband or belt of their normal daily clothing. Lumbo-pelvic posture was simultaneously monitored by the Spineangel® and the Fastrak™ devices. Fastrak™ sensors were placed at T12, L3, S1, and femur. Between-trial, within-session and between-day Intraclass Correlation Coefficients (ICC(3,1), ICC(3,5) and ICC(3,5), respectively) were calculated for Spineangel® measurements. Measurement error was estimated by means of Standard Error of Measurement (SEM) for between-trial reliability and by means of Method Error (ME) for within-session and between-day reliability. Criterion-related validity of the Spineangel® as a lumbo-pelvic monitor was assessed by means of Bland-Altman plots and by means of Pearson's correlation coefficient and paired t-test.

RESULTS: Between-trial, within-session and between-day ICC for the Spineangel® were found to be excellent ($>$ 0.93). The SEM for between-trial and ME for within-session were found to be less than 3.0°, while the ME for between-day reliability was found to be approximately 8.0°. The Spineangel® and Fastrak™ pelvic measurements were found to be strongly correlated ($R = 0.77$), with a mean difference of 6.0° (95% CI: 3.3 to 8.6) between these instruments.

CONCLUSIONS: Our findings suggest the Spineangel® is a reliable and valid device when attached to the belt or waistband for monitoring general lumbo-pelvic movement during a wide variety of functional tasks. Further research is required to determine whether the use of this device is clinically relevant for managing patients with LBP.

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BIOM_O1.3 SILENT PERIODS IN FEMALE PATIENTS WITH WHIPLASH ASSOCIATED DISORDERS AND SUBACROMIAL IMPINGEMENT SYNDROM COMPARED WITH HEALTHY CONTROLS

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INTRODUCTION: A sudden unloading during a voluntary muscle contraction produces brief silent periods in the electromyography (EMG). A sudden unloading of a muscle may inactivate proprioceptors such as muscle and tendon spindles and thus withdraw excitation from the motorneurons and consequently reduce the rate of discharge. Muscle spindles are one type of proprioceptors that play an important role in proprioception, and withdrawal of spindle activity is one factor that could produce a silent period. Proprioceptive disturbances have been reported in patients with Whiplash Associated Disorders (WAD) (1) and in patients with Subacromial Impingement Syndrome (SIS) (2). The Upper Trapezius muscle (UT) acts on both the cervical spine and the scapula and altered muscle recruitment pattern has been found both in patients with chronic neck pain and SIS.

AIM: To investigate the number, length and latency of the UT muscle silent periods in females with WAD and SIS compared with healthy controls (CON).

METHODS: Bipolar surface EMG of the UT muscle was recorded from twelve females with SIS (age 42.0 years), ten females with WAD (age 37.7) and ten females of CON (age 35.9). EMG activity was expressed as percentage of Maximum Voluntary Electromyography activity (%MVE). An arm perturbation task with sudden unloading was performed three times. Silent period was defined as activity below +/- 3% MVE for at least 25 ms within the first 200 ms after unloading. Latency was defined as time from sudden unloading until start of silent period (ms). Length of silent period was defined as the length of time (ms) that the activity stayed below +/- 3% MVE.

RESULTS: The total number of patients (n) with silent periods (percentage) was in WAD n=3/10 (30%), in SIS n=11/12 (92%) and in CON n=7/10 (70%). In patients with silent periods the mean (SD) latency was in WAD 96.67 ms (32.35 ms), in SIS 70.09 ms (16.46 ms) and in CON 117.43 ms (51.85 ms), respectively, but only the difference between SIS and CON was statistically significant (p=0.012). Mean (SD) length of silent periods was in WAD 38.83 ms (12.95 ms), in SIS 47.61 ms (23.19 ms) and in CON 45.71 ms (24.09 ms), respectively, with no significant differences between any of the three groups.

CONCLUSION: These results indicate that patients with SIS tend to have a larger number of silent periods, shorter latency and a longer duration of silent periods, when compared to patients with WAD and CON. This may indicate differences in the underlying disease pathology.

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BIOM_O1.4 ACTIVATION PATTERN OF SERRATUS ANTERIOR AND UPPER TRAPEZIUS IN SUBJECTS WITH SUBACROMIAL IMPINGEMENT SYNDROME COMPARED WITH HEALTHY CONTROLS

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INTRODUCTION: The serratus anterior muscle (SA) is a prime mover and an important stabilizer of the scapula. SA is working in a close force couple with the upper part of the trapezius (UT) during upward rotation (1). Imbalanced muscle activity pattern observed as increased UT activation combined with reduced SA activation may lead to abnormal kinematics in a voluntary movement task and eventually contribute to Subacromial Impingement Syndrome (SIS).

AIM: To investigate potential differences in muscle activity pattern of the SA in relation to UT during a voluntary movement task in subjects with and without SIS.

METHODS: Laboratory case-control study, 31 subjects (16 SIS and 15 No-SIS) (mean age, 41 yrs ±14; 39 yrs ±12.0). Surface electromyography (sEMG) in % of maximum voluntary EMG (MVE) was measured from UT and SA, during standing arm elevation (0-180°) and lowering (180-0°) in the scapular plane, with no-load, 1 kg and 3 kg hand held load. Subsequently, the EMG analyses were performed exclusively between 60-120° (defined as the painful arch). Mean activity was calculated for each muscle, and the activation ratio was calculated as % MVE in UT divided by % MVE in SA. A linear regression model was used to test for group differences. A logarithmic transformation of data was performed and significance level was set at $p<0.05$. Data are presented as means and standard deviations.

RESULTS: Non-significant tendencies to higher activity in SIS compared to no-SIS was found for both SA and UT. The SA muscle activity (%MVE) was for SIS versus No-SIS at no-load (25.1±20 vs. 17.7±13), at 1kg (31.8±21 vs. 24.2±13), and at 3 kg (42.0±28 vs. 37.0±19). The UT muscle activity was for SIS versus No-SIS at no-load (21.0±13 vs. 17.3±11), at 1 kg (28.2±15 vs. 25.6±14) and at 3 kg (40.4±18 vs. 38.0±19). However, no difference in activation ratio was found between the two groups during any of the loads and finally, no differences between groups were observed for arm elevation and arm lowering.

CONCLUSION: Overall no significant differences were observed between SIS and No-SIS. However, subjects with SIS had a tendency for higher activity for both SA and UT compared to no-SIS. This may be a pain related increase in co-activation, possibly due to a higher need for stability during the voluntary movement task.

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BIOM_O2.1 RELATIONSHIP BETWEEN KNEE MUSCLE ACTIVATION AND RATE OF PROGRESSION OF CARTILAGE LOSS IN KNEE OA

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INTRODUCTION: As knee osteoarthritis (OA) cannot be cured, treatments that slow disease progression (i.e. rate of cartilage loss) are a priority. Knee muscle activation has a potential role. Although one theory postulates benefit from enhanced knee muscle co-contraction to augment joint stability; this may speed structural progression by increased joint load.

AIM: This study aimed to investigate, prospectively, the relationship between cartilage loss and co-contraction timing of medial/lateral knee muscles in knee OA associated with varus deformity.

METHODS: Medial (vastus medialis [VM]; semimembranosus [SM]) and lateral (vastus lateralis [VL]; biceps femoris [BF]) knee muscle electromyography (EMG) was recorded in 50 people with knee OA during walking at a naturally selected speed at inception into the study. Medial cartilage volume was measured from MRI at baseline and 12 months. Relationship between loss of medial cartilage volume and duration of co-contraction of medial muscles (VM/SM) at baseline or duration of co-contraction of lateral muscles (VL/BF) at baseline, along with height, weight, age, and gender was evaluated with multiple linear regressions.

RESULTS: Duration of medial muscle (VM/SM) co-contraction was significantly correlated with annual loss of medial cartilage volume (P=0.002). There was a 0.14% greater cartilage loss for each increase in co-contraction duration of 1% of the gait cycle. Duration of lateral muscle (VL/BF) co-contraction was inversely correlated with medial tibial cartilage loss (*P*=0.033; 0.09% cartilage increase for each 1% co-contraction duration increase).

CONCLUSION: The relationship between knee joint cartilage loss and duration of co-contraction of medial and lateral knee muscle co-contraction supports the hypothesis that augmented medial knee muscle co-contraction may underpin faster progression of knee OA in individuals with varus deformity. Increased lateral muscle co-contraction appeared protective for cartilage. Exercise interventions that change knee muscle activation patterns are a possible candidate to slow progression of knee joint OA.

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BIOM_O2.2 LOWER LIMB COORDINATION VARIABILITY IN DANCERS PERFORMING DROP LANDINGS ONTO SURFACES WITH VARIED MECHANICAL PROPERTIES

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INTRODUCTION: The mechanical properties of floors are suspected to contribute to the high injury frequency in the dance population. However, actual causality is yet to be established. Disruption to lower extremity coordination during the support phase of running has been cited as a potential cause of some injuries. In a previous analysis of the data used in this study, dancers' ankle joint mechanics were reported to change during landings in response to a decrease in floor shock absorption, without a corresponding change at the knee joint. This suggests that a harder floor may give rise to asynchronous motion between the knee and the ankle joints, which may provide insight into possible dance injury mechanisms.

AIM: The main aim of the study was to investigate the effect of different shock absorbing properties of floors on lower extremity coordination in dancers.

METHODS: This study is the first of its kind to utilise dynamical systems theory techniques to investigate these aims in relation to dance and different floor surfaces. A vector coding technique was applied to data collected using a 3D kinematic model to analyse knee and ankle joint angle coordination variability in the sagittal plane over repeated single-leg drop landings from a height of 0.2 m. Floor surfaces were quantified with reference to European sports surface standards. Participants were 12 injury free pre-professional dancers.

RESULTS: Dancers demonstrated highly consistent coordination patterns across the entire landing phase and no effect of floor properties was found. However, coordination variability significantly increased across all floors approximately 100 ms after contact with the surface. Results suggest that, under the test conditions, a change in the shock absorption properties of the floor has no effect on knee and ankle joint landing coordination variability. Individuals presented varying responses to harder floor surfaces with some demonstrating increased coordination variability and others decreased.

CONCLUSION: The wide range of values on a single-subject basis suggests that the group data may be masking individual effects. Further investigation of neuromuscular control mechanisms to explain the increase in variability late in the landing phase would be beneficial.

BIOM_O2.3 USING FEEDBACK CONTROL TO REDUCE LIMB STIFFNESS DURING FORCEFUL CONTRACTIONS

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INTRODUCTION: Muscle stiffness increases with force, allowing limb stiffness and stability to be increased by co-activating antagonistic muscles. This intrinsic behavior is appropriate for increasing limb stiffness, but limits the ability to decrease stiffness in tasks that require compliancy, such as maintaining accurate force in the presence of unexpected perturbations. Neural feedback could be used to compensate for intrinsic muscle properties during force regulation, but the limits of that compensation are not clear. Understanding these limits is essential for determining how altered feedback influences force regulation and for determining how to construct man-machine interfaces that optimize forceful interactions between the human and the environment.

AIM: Our aim was to quantify the ability to regulate force and how it depends on the intrinsic properties of active muscles and the behavior of the neural controller.

METHODS: This work had modeling and experimental components, both pertaining to human elbow mechanics. The incorporated muscle models described activation-dependent changes in short-range stiffness, shown to accurately describe human elbow stiffness during isometric contractions. The neural controller was idealized as an optimal linear quadratic regulator with delays, so as to represent the best possible linear control. Optimal was defined in terms of the elbow compliance at different levels of voluntary contraction. The experimental protocol matched the simulated tasks. Subjects were instructed to maintain isometric flexion torques of 0-30% maximum voluntary contraction, while being perturbed stochastically so that elbow stiffness could be estimated. Experiments were repeated for two conditions in which the subject was either instructed to “do not intervene” with the perturbation (DNI) or to “maintain torque” (MT) even when perturbed. Nonparametric system identification was used to estimate elbow stiffness.

RESULTS: The model demonstrated that optimal feedback control could be used to decrease elbow stiffness below that which would be expected with no feedback. This ability decreased substantially with increasing neural delays. The experimental data was consistent. Subjects were able to decrease elbow stiffness during the MT task relative to the DNI task. The observed behavior was similar to the optimal controller with a neural feedback delay of 100-150 ms.

CONCLUSION: Our results demonstrate that humans can voluntarily reduce stiffness to assist in the regulation of torque. The limits on this ability can be adequately described by previously quantified intrinsic muscle properties and neural delays.

ACKNOWLEDGMENT: Work supported by the NSF program in Cyber-physical systems.

BIOM_O2.4 KINEMATIC CHARACTERISTICS OF THE LUMBAR AND PELVIS WHILE WALKING IN HIGH HEELS ON A FLAT FLOOR AND DOWNSTAIRS

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INTRODUCTION: The kinematic and kinetic features of human movements involved in high-heel walking have been discussed with regard to the underlying biomechanics and medical treatment of low back pain. Many past studies have examined the movements of the lower extremity during high-heel walking; however, few studies have focused on spinal and pelvic movements.

AIM: This study aimed to investigate the kinematic and kinetic aspects of the lumbar spine and pelvic movements while walking on high-heeled shoes.

METHODS: This study included 8 healthy female volunteers aged 18–20 years. The women were asked to perform free-speed walking on a flat floor and downstairs (16-cm height) while wearing heels of 4 different heights (0, 3, 6, and 9 cm). The three-dimensional angular displacements of the lumbar spine and pelvis were measured using the Vicon Nexus system. In order to investigate the positional data of the body, infrared light-emitting 35-round markers (plug-in gait model) were attached to the subject's skin. Further, electromyogram (EMG) activities of the external oblique, iliocostalis, and multifidus muscles were recorded by using surface electrodes sampled at 1000 Hz; these activities were synchronized with the kinematic data and processed as integrated EMGs (iEMG). The Kruskal-Wallis test results for each value of angular displacement of the lumbar and pelvis and the iEMG of the trunk muscles were compared in walking trials with different heel heights, and the statistical significances were determined using a critical alpha value of 0.05. The subjects were informed of the aims and methods of the study beforehand, and their consent was obtained.

RESULTS: A significant increase in the sagittal range of pelvic movement during the stance phase was observed while flat-floor walking on high heels rather than on low heels ($p < 0.05$), whereas no remarkable findings were observed in the lumbar movements. In downstairs walking, no significant differences were observed in the lumbar and pelvic movements while walking with heels and without. Few findings were obtained regarding the trunk muscle activities.

CONCLUSION: The findings of the present study indicate that walking on high heels alters the pelvic movement in the sagittal plane, and suggest that the suitable physical substitution may be employed in order to maintain the postural change caused by the high heels.

BIOM_O3.1 THE ROLES OF THE THUMB MUSCLES DURING DIFFERENT FORCE GENERATION TASKS

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INTRODUCTION: Manual therapists frequently employ manual techniques such as posterior/anterior (PA) glide techniques to treat patient with joint hypomobility. Such tasks involve force generation at the tip of the thumb. While pinch tasks, such as lateral and tip pinches, are often used in manual manipulative activities in daily life, and force is generated at the pad of the thumb. However, the exact roles of thumb muscles while performing these two types of manual tasks are not clear.

AIM: The aim of this study was to investigate differential roles of thumb muscles in tasks involving pinching and manual manipulation activities.

METHODS: 33 apparently healthy young subjects (hitchhiker group: 8 males and 8 females; non-hitchhiker group: 8 males and 9 females) participated. Each subject exerted 1) thumb tip force on a 6-axis load cell from 25% to 100% maximum force at a 25% increments with two PA glide techniques (unsupported PA glide, PA1, and PA glide with digits support, PA2); and 2) tip pinch and lateral pinch tasks on a single axis load cell. Surface EMG of extensor pollicis longus (EPL), extensor pollicis brevis (EPB), flexor pollicis longus (FPL), flexor pollicis brevis (FPB), adductor pollicis (ADP), abductor pollicis longus (APL), abductor pollicis brevis (APB), and first dorsal interosseus (1stDI) were collected.

RESULTS: Task main effects were observed on normalized EMG at all force levels except 25%. The FPL and ADP were significantly more active in both pinch tasks than PA glide techniques ($p<0.05$). The 1stDI was least active in unsupported PA glide (PA1) compared with all tasks, especially during maximal force exertion ($p<0.05$). The 1stDI is more active during lateral pinch compared with that of the tip pinch at all force levels while ADP was more active only at maximal force exertion ($p<0.05$).

CONCLUSION: While executing pinch tasks, FPL is required to help distal phalanx of the thumb to resist the index. ADP also serves as a prime mover and is in a mechanically advantageous position so that more activity is observed. While executing PA1 task, the index was free from any constraint and rendered the 1stDI to exhibit its lowest activity. Comparing the two pinch tasks 1st DI muscle is in a position more efficient for exerting force in lateral pinch than the tip pinch. The EMG activity level of the FPB, FPL and ADP suggest that these muscles assume the role of prime movers in pinch type of activity. However, their roles change to that of stabilizers during the performance of PA glide techniques.

BIOM_O3.2 MECHANISMS OF ADAPTATION FROM MULTIPLE TO SINGLE STEPS FOLLOWING FORWARD LOSS OF BALANCE IN OLDER ADULTS

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Dr Peter Mills; A/Prof Rod Barrett; Dr Neil Cronin; Dr Glen Lichtwark

INTRODUCTION: Falls in older adults are a significant public health concern with approximately one in three community dwelling older adults falling each year.

AIM: The purpose of the present study was to use measures of dynamic stability to investigate the balance recovery response in the antero-posterior direction exhibited by older adults who adapt from a multiple, to a single step recovery strategy, following exposure to repeated forward losses of balance of equivalent lean magnitudes.

METHODS: 151 older adults were released from 3 static forward lean magnitudes. Following four trials at the moderate lean magnitude participants were classified as single (n=43), mixed (n=52) or multiple steppers (n=56). Balance recovery was quantified using the Margin of Stability (MoS), which was computed as the anterio-posterior distance between the forward boundary of the Base of Support (BoS) and the vertical projection of the velocity adjusted centre of mass position (XCoM).

RESULTS: Older adults who exhibited a change from a multiple to a single step recovery strategy (mixed group) following repeated exposure to forward loss of balance, were found to have improved dynamic stability at foot contact due an increased BoS, an increased rate of BoS advancement and reduced XCoM. Further, mean rear foot propulsive force from toe off to foot contact was reduced in the single step trials (119±31.5 N) compared to the multiple step trials (139±41.7 N) of the mixed participants, which explained their observed reduction in XCoM.

CONCLUSION: Adaptations occurred within a single test session and suggest older adults can rapidly improve dynamic stability following repeated exposure to a forward loss of balance. This study provides important insight into biomechanical mechanisms of stability that will be useful for the development of falls prevention programs.

BIOM_O3.3 IMPAIRED POSTURAL CONTROL IN KNEE OSTEOARTHRITIS PATIENTS: EFFECTS OF VISUAL AND FEET PROPRIOCEPTIVE INPUT AND DISEASE SEVERITY.

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INTRODUCTION: Knee pain in knee osteoarthritis (KOA) is associated with balance impairments and increased risk of falling. KOA is a disease of progressive joint structure degeneration, but the association between structural disease severity and postural control has not been addressed.

AIM: To investigate the quiet standing balance during different sensory condition in patients with different structural severities of KOA.

METHODS: A group of forty-five patients with KOA were included (age: 62 ± 6 years and body mass index [BMI]: 36 ± 4 kg/m2). Quiet standing balance was assessed using a force platform. Each participant was tested during 4 different sensory conditions, applied 3 times each randomly: (i) eyes open (EO) and firm surface (FS), (ii) eyes closed (EC) and FS, (iii) EO and soft surface (SS), and (iv) EC and SS. During the SF condition, a foam cushion was placed on top of the force platform. Each of the twelve trials lasted for 1 minute while 3 dimensional ground reaction forces were recorded. The centre of pressure (CoP) was calculated from the force platform data, and the range of displacement and speed in anterior-posterior and lateral directions together with the total sway area (area under the CoP trace) were extracted. Structural disease severity was assessed from standard semiflexed standing radiographs. Disease severity in the medial tibiofemoral compartment was graded from 0 (normal) to 4 (end stage KOA) by the Kellgren and Lawrence (KL) score from the radiographs. The patients were divided into groups of “less severe” (KL 1-2) and “severe” (KL 3-4) radiographic disease severity. A mixed 3-way ANOVA (eyes, surface and KL grade with 2 levels each) was used to analyse the results with age and BMI as covariate variables and the Student-Newman-Keuls test was used for multiple comparisons ($\alpha = 0.05$).

RESULTS: During the SS condition, CoP range of displacement and speed in both directions and area were increased when compared with FS condition ($P < 0.01$). EC condition inflicted larger CoP range of displacement and speed in both directions and sway area when compared with EO condition ($P < 0.01$). During EC in SS, medial-lateral range of CoP displacement was larger in the severe KL group, when compared with patients with less severe KL grades ($P < 0.01$).

CONCLUSION: The results suggested that KOA disease severity is associated with poorer balance during quiet stance in conditions without visual input and less proprioceptive input from the feet (i.e. soft surface). The difference in postural control during the high demand task between the KOA severities may relate to impaired proprioception from the knees with severe structural degeneration.

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BIOM_O3.4 IS MOVEMENT OF THE LUMBAR SPINE IMPORTANT TO POSTURAL STABILITY?

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INTRODUCTION: Lumbar spine movement is argued to make a significant and critical contribution to the maintenance of postural stability. Reduced spinal movement and a concomitant compromised postural recovery following postural perturbation were evident in people with chronic low back pain[1]. However, it was not possible to exclude other causes for the compromised postural control, such as poor spine proprioception, which has also been implicated in pain. The effect of manipulation of trunk flexibility on balance control may offer resolution of this question. The only previous study that has manipulated spine flexibility also restricted hip motion[2].

AIM: This study aimed to examine the characteristics of postural recovery with and without restriction of lumbar movement using a rigid lumbar corset.

METHODS: Postural responses following backward and forward anteroposterior support surface translation at three amplitudes (small, medium and large) were investigated in twenty healthy participants with and without a tailor-made corset. The three characteristics during postural recovery examined were 1) Time taken to recover postural stability, 2) postural steadiness (excursion of centre of pressure [COP]) and 3) the number of postural adjustments made during postural recovery.

RESULTS: Postural recovery was compromised when wearing the lumbar corset as evident by significantly increased excursion of COP, the number of postural adjustments made during postural recovery, and the associated time, following perturbation in both directions.

CONCLUSION: These data support the hypothesis that lumbar spine movement is essential for maintenance of postural stability. Despite the preservation of hip motion, motion at this joint was not sufficient to maintain optimal postural recovery. Taken together these data confirm the potential for compromised spinal motion in back pain (either due to passive restraint or active muscle stiffening) to underpin balance dysfunction in this group.

ACKNOWLEDGEMENT: Funding was provided by the National Health and Medical Research Council (NHMRC) of Australia.

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BIOM_O4.1 NEUROMECHANICS OF THE ANKLE JOINT MUSCLES DURING ISOLATED AND COMBINED VOLUNTARY ACTIVATION

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Dr Wolfgang Seiberl

INTRODUCTION: Recently it was found that the torque-angle relationships (T-a-r) of the ankle joint vastly differ in shape as well as in size when the ankle joint muscles perform a maximal voluntary isolated plantar flexion compared to when maximally voluntarily activated during a combined multi-joint leg extension involving co-activation of the knee and hip extensor muscles.

AIM: This study was designed to investigate the effects of systematic variations of joint configurations and activation conditions (isolated vs. combined) on the activity and the torque output of the plantar flexor muscles.

METHODS: T-a-r were obtained for three different protocols: (1) varying ankle joint angles and fixed knee joint, (2) fixed ankle joint and varying knee joint angles and (3) combined variation of ankle and knee joint angles. Each protocol was performed twice, with isolated activation of the plantar flexor muscles and co-activation of all leg extension muscles. Ankle joint torque during maximum voluntary isometric contractions was measured by a dynamometer when subjects sat on the seat of the dynamometer with the right ankle tightly strapped to a foot-plate. Muscle activity and activation patterns during the combined multi-joint contractions were assessed by surface electromyography (EMG) of nine lower extremity muscles.

RESULTS: First results indicate that for protocols (1) and (2) ankle joint torques are higher during the combined activation of the lower extremity muscles compared to the isolated activation of the plantar flexor muscles. This was accompanied by enhanced agonist but also antagonist EMG so that higher activation level of the plantar flexor muscles seems not to be a primary explanation for additional ankle joint torque production during combined activity. For protocol (3) the T-a-r differed in size and shape when comparing isolated and combined muscle activation. Furthermore EMG of the plantar flexor muscles was partly lower during the combined activation even when ankle joint torque exceeded that which was produced during isolated plantar flexor activation.

CONCLUSION: Simultaneous variation of ankle and knee joint angles resulting in physiological combinations of ankle and knee joint configurations induce different ankle joint torque production during co-activation of leg extension muscles compared to isolated activation of the plantar flexor muscles. Redistribution of forces by biarticular muscles, myofascial force transmission and distinct activation patterns are possible candidates to explain our observations. Such distinct joint and muscle function may be of major importance for analysis, modelling and simulation of human movement which should be based on physiological relevant contraction conditions.

BIOM_O4.2 THE USE OF A HIGH-PASS BUTTERWORTH FILTER TO IMPROVE FORCE PREDICTION FROM FOREARM EMG AND WRIST POSTURE

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INTRODUCTION: Difficulties measuring hand grip forces in the workplace are a recognized challenge. Although with limitations, EMG calibrated to force is one method that lends the advantage of measuring EMG continuously over tasks, variety of tools and parts. Potvin & Brown (2004) proposed the use of a high pass filter, with a high cut-off frequency, to improve the EMG-force relationship.

AIM: The purpose of this study was to see if a high pass, Butterworth filter, with a cut-off frequency of 410Hz improved the predicted hand grip force from forearm EMG.

METHODS: Fourteen healthy male rodworkers 18-50 years old were recruited as a part of a larger study. Raw EMG of the extensor carpi radialis brevis (ECRB) was collected at 1000Hz, simultaneously with wrist flexion/extension posture (50Hz) of the dominant arm, using a portable data acquisition unit (Range: 15-450Hz , CMRR: >96dB at 60Hz, Biometrics LTD, UK). Integral dry reusable, bipolar, bar electrodes (2cm inter-electrode distance, Biometrics LTD, UK) were placed on the ECRB after cleaning the area with alcohol [1]. Participants performed four maximal voluntary contractions in three different postures while measures were recorded. Grip force was measured with a grip dynamometer.

A linear model was used to predict grip force from EMG, wrist posture, and force [3]. The same raw EMG signals were processed twice similarly, except that in one model signals were high-pass filtered prior to obtaining the linear envelope, and in the other model, the signals were not. Then, signals were rectified, and low-pass filtered using a Butterworth filter with a cut-off of 1.9Hz.

The root mean square error (RMSE) error was calculated to compare predicted force from both, the high-pass filter (HPF) and the non-high-pass filter models (nHPF), versus measured force (MF).

RESULTS: The linearity between measured and predicted force was improved by the use of the high-pass filter prior to obtaining the linear envelope of the ECRB EMG. The calculated RMSE between HPF and MF was lower than that seen between nHPF and MF (70.0 vs 77.8).

CONCLUSION: High -pass filtering at 410Hz prior to obtaining the linear envelope from raw ECRB EMG has the potential to improve our force prediction model thus improving the ability to estimate gripping force during continuous tasks.

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BIOM_O4.3 EFFECTS OF VISUAL FEEDBACK SIZE ON MULTIDIRECTIONAL FORCE VARIABILITY DURING ISOMETRIC CONTRACTIONS

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INTRODUCTION: Previous studies have investigated force variability and electromyographic activity (EMG), during different multi-directional motor tasks. Visual feedback related to the requested task is one of several factors which can affect the motor control performance. However, at present the effects of changes in the visual feedback in 3D motor tasks are not completely understood.

AIM: To describe the effects of the visual feedback size on force variability and EMG of the muscles involved in contraction.

METHODS: Ten healthy subjects participated in one experimental session. Three-dimensional force signals were acquired during isometric elbow flexion at 5%, 15%, 30% and 50% of the maximum voluntary contraction (MVC). Bipolar EMG signals were recorded from biceps brachii, brachioradialis, triceps brachii, trapezius, and deltoid muscle. The force components were represented by a dynamic circle on a computer screen, and a moving square was used for the visual target. Two different target sizes (small or large) were presented for each contraction level in order to change the required motor control precision. Each contraction level was repeated twice, and average between trials was used in the statistical analysis. Entropy of the 3D force components and the root-mean-square (RMS) of the EMG signals (40 ms window) was calculated in order to quantify the variability of the signals. A two-way repeated measures ANOVA was used to assess the difference between visual feedback sizes and contraction level for each force direction and for the RMS.

RESULTS: The ANOVA showed a significant interaction between contraction level and feedback size in the main direction of contraction (along the z-axis) ($P<0.001$). Post-hoc analysis of the interaction showed that the force entropy at 50% MVC was significantly higher with the small size feedback compared to the large size feedback ($p<0,001$). A similar interaction was significant for the RMS EMG entropy from m. trapezius ($P<0.003$) and m. triceps ($P<0.02$). The post-hoc analysis showed for m. trapezius that EMG entropy at 50% MVC and 30% MVC was significantly higher with the small size feedback compared to the large size feedback ($P<0.001$); for the m. triceps brachii the higher EMG entropy was found at 30% MVC.

CONCLUSION: This study shows that changes in the visual feedback have significant effects on higher levels of contractions on the force in the main direction and EMG from triceps brachii and trapezius. Interestingly, it is mainly the stabilizing muscles which account for most of the force variability in challenging motor tasks.

BIOM_O4.4 SIMPLIFICATION OF EMG DRIVEN BIOFEEDBACK OF SUB-MAXIMAL MULTI-JOINT LEG EXTENSION

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INTRODUCTION: Standardization of muscular activity for the investigation of sub-maximal multi-joint movements is crucial due to motor redundancy which offers an infinite number of task-solving solutions. In single-joint tasks, even with more than one agonistic muscle, feedback control is mostly given by one leading muscle that represents the whole muscle group (e.g. v. lateralis vs. m. quadriceps). In multi-joint setups it is questionable if one muscle is able to represent what happens during complex motion tasks based on intermuscular coordination and a mixture of factors like muscle size, force-length and force-velocity relations of included muscles.

AIM: The aim of this study is to determine the variability of activation patterns during sub-maximal leg extensions in order to explore an EMG driven feedback control, optimized for representing all involved muscles with a minimum of feedback signals.

METHODS: Muscle activation of 9 muscles of the right leg was measured by wireless EMG (myon RFTD, Myon AG, CH) with a floating ground and bipolar surface electrodes (AMBU® Blue Sensor P, Germany) during sub-maximal isometric multi-joint leg extensions in a motor driven leg press (IsoMed 2000, D&R Ferstl, Germany). Over a time period of 30s, intensity was feedback controlled at a level of 30% of maximum voluntary ground reaction force (GRF). A set of 15 repetitions with one minute rest between trials was performed. Subject preparation and placement of electrodes follows the guidelines of SENIAM. Data was amplified no further than 10cm from the recording site, collected at a sampling rate of 3000Hz and bandpass filtered (Butterworth, 10-500Hz). 30s-trials were analyzed at 6 time intervals of 2s. Correlation-matrixes and behavior of standard deviations (SD) were used to identify muscle(s) that represent the overall-activity best.

RESULTS: Preliminary data (n=1) revealed barely any variety of activation patterns to perform sub-maximal leg-extension tasks at an intensity of 30% GRF throughout 15 trials. Correlation coefficients ≥ 0.9 were found between GRF and analyzed muscles. Lowest mean SD was observed in v. lateralis muscle.

CONCLUSION: The aim of this study is to create a feedback system that allows standardizing multi-joint movements using EMG activity. Despite motor redundancy of the lower extremity our first results indicate that submaximal leg extensions can be standardized by biofeedback of a single muscle.

At this stage of our ongoing study, the results reveal that it is possible to standardize multi-joint leg extensions by EMG feedback in order to investigate physiological relevant movement tasks.

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CLINICAL NEUROPHYSIOLOGY

CLNE_O1.1 THE SPATIAL RELATIONSHIP BETWEEN MYOFASCIAL TRIGGER POINTS AND THE INNERVATION ZONE IN UPPER TRAPEZIUS

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INTRODUCTION: Myofascial trigger points (MTrP) have been defined as highly localized and hyperirritable spots located in a palpable taut band of skeletal muscles.

Although their aetiology is not clearly understood, electrophysiological studies indicated that an abnormal electrical activity around the innervation zone (IZ) is more prevalent in the MTrP region. This phenomenon has been described as endplate noise due to an excessive release of acetylcholine and, together with nerve fiber sensitization, constitutes the basis for MTrPs pathophysiology. Thus the hyperirritable spot defined as the sensory component of MTrP is described as overlapping the IZ.

AIM: The purpose of this work is to describe the spatial relationship between MTrPs and IZs in the upper trapezius.

METHODS: Twenty-four patients with neck pain and MTrPs (21 active MTrP and 3 latent MTrPs) together with 24 healthy subjects with latent MTrPs were recruited through the San Raffaele Scientific institute in Milan.

A physiotherapist examined the enrolled subject's trapezius to confirm the presence of MTrPs and to mark their exact location using a special stamp (a circle of 1cm² with a dot in the centre). Subsequently another operator traced a reference system on each subject's upper trapezius to measure the MTrP location. sEMG signals were recorded during an isometric contraction at 20% of the maximal voluntary contraction (MVC) using a 2D electrode array (13 rows x 5 columns) placed on upper trapezius. The IZs were detected through visual analysis of sEMG signals.

Both the MTrP and IZ locations were measured using the same coordinate system. Student t-test was used to evaluate if the distance between IZs and MTrPs was significantly different from zero and to evaluate differences between active and latent MTrPs.

RESULTS: According to our coordinate system 45 MTrPs were included in the 3rd quadrant (bottom left portion of the coordinate axis) except 3 included in 2nd quadrant (top left). IZs were approximately located to the middle of upper trapezius fibers, midway between C7 and the acromial angle. The mean distance between MTrP and IZ was about 10 mm for both active and passive MTrPs (significantly different from zero; $P<0.001$) with IZ located more laterally with respect to the MTrPs. No significant difference was observed between active and latent MTrPs ($P=0.6$).

CONCLUSION: A clear overlapping between MTrPs and IZ was not observed, however both active and latent MTrPs were located medially to the IZs, and their mean distance was about 10 mm. Interestingly MTrPs in upper trapezius seem to be grouped in a well defined area. Our findings raise questions on the nature of MTrP sensory component.

CLNE_O1.2 ENDURANCE AND FATIGUE CHARACTERISTICS OF STATIC TEST OF THE NECK MUSCLES IN PATIENTS WITH CERVICAL RADICULOPATHY.

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INTRODUCTION: Neck muscle function is important for support and control of the cervical spine. With the application of frequency analysis of the electromyography (EMG) signal, the fatigue rate of muscles can be monitored. In several EMG studies, the neck muscles have been shown to fatigue faster in subjects with neck pain. This can be seen when the median frequency (MF) decreases when a contraction is sustained.

AIM: In this experimental study the purpose was to evaluate patients with cervical radiculopathy compared to healthy subjects regarding changes in neck-muscle fatigue during static endurance test in prone and supine.

METHODS: A total of 33 patients (19 women and 14 men) with cervical radiculopathy and 28 healthy subjects (17 women and 11 men) were included in the study. Neck muscle fatigue was studied using EMG with surface electrodes bilaterally on cervical paraspinal and sternocleidomastoid muscle groups with electrode placement according to SENIAM. Measurements of neck muscle fatigue were performed in supine and prone positions until patient perceived time till exhaustion. Subjective neck muscle fatigue was rated on a Borg CR-10 scale while subjective neck pain was measured on 0-10 Visual analogue scale (VAS). Patients with cervical radiculopathy even completed the Neck Disability Index (NDI).

RESULTS: The mean endurance time during static extension between groups was significantly different ($p<0.001$) with cervical radiculopathy patients recording 190 seconds (Sd=119) and the healthy subjects 509 seconds (Sd=213). Differences in mean endurance time during static flexion between groups were non-significant with cervical radiculopathy patients recording 64 seconds (Sd=40) and the healthy subjects 96 seconds (Sd=69). Cervical radiculopathy patients MF EMG slope (-0.039) for the right cervical paraspinal muscles significantly decreased ($p=0.009$) more the healthy subjects (-0.017) during the extension test. NDI significantly correlated with MF EMG slope for both left ($r=-0.631$ $p= 0.001$) and right side (r=-0-496 $p=0.014$) cervical paraspinal muscles during extension for the patient group.

CONCLUSION: Patients with cervical radiculopathy perform similar to healthy subjects with regards to static supine flexion endurance time and cervical muscle fatigue. Patients with cervical radiculopathy however have significantly lower endurance times and fatigue faster in the right side cervical paraspinal muscles during static prone extension.

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CLNE_O1.3 EFFECT OF AN 8-WEEK EXERCISE PROGRAM ON SPECIFICITY OF NECK MUSCLE ACTIVITY IN PATIENTS WITH CHRONIC NECK PAIN

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INTRODUCTION: The activity of the sternocleidomastoid and splenius capitis muscles is increased and less task-specific in patients with neck pain indicating impairment in the neural control of these muscles.

AIM: This study investigates the effect of an eight-week specific training program on the directional specificity of sternocleidomastoid and splenius capitis activity in women with persistent neck pain.

METHODS: Forty-six women with chronic neck pain (duration of pain, mean ± SD: 9.2 ± 6.3 yrs) were included in the study. At baseline the patients completed the Neck Disability Index (score: 0-50), the Patient-Specific Function Scale (average across 3 nominated activities of daily living, 0-10) and performed contractions of the neck in the horizontal plane at 15 N force with continuous change in force direction in the range 0-360º. Surface EMG was recorded bilaterally from the sternocleidomastoid (SCM) and splenius capitis (SC) muscles. Tuning curves of the EMG amplitude (average rectified value, ARV, as a function of the force direction) were computed and the mean point of the tuning curves defined a directional vector, which determined the directional specificity of the muscle activity. After the baseline measurement the patients were randomly assigned either to a training or control group (23 per group). The training group participated in an eight week progressive exercise program for the neck flexor and extensor muscles (Jull et al., 2008). The control group was advised to "act as usual". At week 9, the patients returned to the laboratory and repeated the baseline measurements.

RESULTS: Twenty patients in the control group and 21 patients in the training group completed the trial. A significant reduction in reported neck pain and disability (NDI) was observed for the training group post treatment (pre: 18.2±7.4; post: 11.1±6.5; P < 0.01) but not for the control group (pre: 17.5±6.3; post: 16.6±7.4). Likewise a significant improvement in PSFS scores was observed for the training group post treatment (pre: 4.4±2.1; post: 5.6±2.2; P<0.001) but not for the control group (pre: 3.9±1.8; post: 3.9±1.6).

The mean EMG amplitude for both the SCM and SC during the circular contraction was reduced for the patients in the training group post intervention (average across SCM and SC: pre: 27.4±18.0μV, post: 18.2±10.2μV; P<0.05) but remained unchanged for the control group (pre: 27.7±17.5μV, post: 26.3±17.3μV). Similarly, the training group showed higher specificity of neck muscle activity post intervention (average across SCM and SC: pre: 18.6±9.8%, post: 24.7±14.3%; P<0.05) whereas no change was observed for the control group (pre: 19.4±11.9%, post: 18.2±10.1%).

CONCLUSION: A specific exercise program which aims to enhance motor control of the cervical spine improves the specificity of neck muscle activity and reduces pain in patients with chronic neck pain.

ACKNOWLEDGEMENT: Supported by the Danish Medical Research Council and Gigtforeningen Denmark.

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CLNE_O1.4 REMOTE MONITORING OF PARKINSON'S DISEASE SYMPTOMS USING WEARABLE SENSORS

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INTRODUCTION: Parkinson's disease (PD) is a neurodegenerative disorder affecting more than 500,000 individuals in the US. Longitudinal monitoring of PD symptoms can provide valuable information for clinical management of the disease as well as trials of novel therapeutic interventions. Wearable technology has the potential to enable objective long-term monitoring of PD symptoms in the home.

AIM: To evaluate the efficacy of a wearable remote monitoring system in longitudinally tracking changes in PD symptom severity.

METHODS: Wearable sensor data was recorded from 5 subjects with PD. Data was collected in three visits at intervals of approximately 4 months. Eight wireless sensors with tri-axial accelerometers were placed on the limbs (2 sensors per limb). A system called MercuryLive was developed to enable monitoring subjects in their home. During each visit, data was collected over a period of 2-3 hours in four 10-min sessions. Subjects were allowed to rest for 20-30 min between sessions. Each session involved the performance of tasks from the Unified Parkinson's Disease Rating Scale (UPDRS). Subjects were videotaped as they performed UPDRS tasks. The videotapes were later reviewed by expert clinicians to provide UPDRS scores for each task. To estimate the UPDRS scores from accelerometer data, we extracted a set of features from data recorded during the performance of each task. A feature selection algorithm based on ReliefF and Davies-Bouldin cluster validity index was used to select a subset of features. Finally, we trained a regression Random Forest (RF) to estimate the UPDRS scores. The estimation error was obtained by using a leave-one-out method.

RESULTS: We focused on two particular UPDRS tasks for our analysis, (1) alternating hand movements with right and left hand (AHR/AHL) and (2) leg agility with right and left leg (LAR/LAL). Cluster analysis showed a distinct relationship between severity scores and clusters. Using the feature selection algorithm, we identified a subset of 5 features, which were used to train a regression RF with 20 trees. The average RMS error in the estimation of the UPDRS scores for the two tasks was 0.4 points.

CONCLUSION: Results from our analyses show that, using wearable sensors, we can accurately estimate UPDRS scores. Cluster analysis suggested the possibility of using wearable sensors to derive a continuous measure of symptom severity.

ACKNOWLEDGEMENTS: This work was supported by the Michael J Fox Foundation under the project entitled "Wearable Sensors and a Web-Based Application to Monitor Patients with Parkinson's Disease in the Home Environment".

CLNE_O1.5 THE EFFECTS OF KNEE JOINT SWELLING ON QUADRICEPS CORTICOSPINAL EXCITABILITY, INTRACORTICAL EXCITABILITY AND INTERMUSCULAR COHERENCE IN THE Β-BAND

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INTRODUCTION: Marked weakness of the quadriceps muscles is typically observed following knee injury, knee surgery and in patients with arthritic joint disease. This is partly due to muscle atrophy and partly due to ongoing neural inhibition that prevents the quadriceps from being fully activated, a process known as arthrogenic muscle inhibition (AMI). Intraarticular swelling is known to increase the discharge of knee joint mechanoreceptors, leading to substantial quadriceps AMI despite the absence of factors such as inflammation, pain and structural damage. Research exploring the neural mechanisms behind AMI has largely focused on spinal reflex pathways. However, supraspinal pathways may also play an important role.

AIM: The aim of this study was to explore the effects of experimentally induced knee joint swelling on quadriceps corticospinal excitability, intracortical excitability and intermuscular coherence in the β-band.

METHODS: Fourteen healthy volunteers with at least one uninjured knee joint participated in this study. Transcranial magnetic stimulation was used to measure quadriceps motor evoked potential (MEP) area, short-interval intracortical inhibition (SICI) and intracortical facilitation (ICF). Intermuscular coherence in the β-band (15-35 Hz) was measured using surface EMG recordings during submaximal quadriceps contractions. Experimental joint swelling was induced by injecting dextrose saline into the knee joint until a standardised intraarticular pressure of 50 mmHg was reached. Quadriceps MEP area, SICI, ICF and β-band coherence were measured at baseline, pre joint infusion (10 minutes later) and immediately post joint infusion.

RESULTS: There was no significant difference in any of the dependent variables between the baseline and pre joint infusion measures (all $p > 0.586$). Quadriceps MEP area increased significantly following experimental joint swelling ($p < 0.05$). There was no change in SICI, ICF or β-band coherence (all $p > 0.686$).

CONCLUSION: The results of this study provide no evidence for a supraspinal contribution to quadriceps AMI. Paradoxically, and in agreement with previous observations in patients with chronic knee joint pathology, quadriceps corticospinal excitability was found to increase following experimental knee joint swelling. These findings may be explained by an undetected increase in motor cortex excitability or an increase in the excitability of subcortical structures that transmit a portion of the corticospinal volley to the quadriceps α-motoneuron pool.

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CLNE_O2.1 SAFETY AND IMMEDIATE EFFECT OF NON-INVASIVE TRANSCRANIAL PULSED STIMULATION (TPCS) ON GAIT AND BALANCE IN PARKINSON'S DISEASE.

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INTRODUCTION: Non-invasive electrical stimulation of the brain is being investigated as a valued intervention to enhance motor performance.

AIM: To ascertain the safety and test the ability of transcranial pulsed current stimulation (tPCS) to modulate selected variables of protective stepping and gait of individuals with Parkinson's disease.

METHODS: Ten patients participated in a pilot study. During the first session a tPCS delivered current for 20 min via positive electrode placed over the primary motor area (M1). In week two, subjects walked for 20 min on a treadmill. In week three, tPCS and treadmill for 20 minutes were combined. Identical pre and post testing of gait and protective stepping were administered. Descriptive and inferential statistics compared post-intervention (tPCS alone, treadmill alone, tPCS+treadmill) to pre-intervention data. The three interventions were compared by calculating the post minus pre intervention data. A significance level of $p < 0.05$ was adopted.

RESULTS: Stride length increased from 102.1±24.4 cm to 111.2±22.1 cm (t=3.87; p=0.013) and gait velocity increased from 0.90±0.23 t0 0.985±0.19 m/sec (t=3.07; p=0.013) after 20 min of tPCS. Stimulation with tPCS did not change cadence from pre-stimulation (106.2±11.6) to post-stimulation (107±9.8). Walking for 20 minutes on the treadmill or combining 20 minutes of treadmill with tPCS, did not result in statistically significant changes in the three studied gait parameters. Comparison of the three interventions was done averaging the differences of post minus pre data and applying non-parameric Wilcoxon tests. The tPCS session significantly increased gait velocity compared to treadmill (z=-2.49; p=0.012) or tPCS+treadmill (z=-2.49; p=0.012). Stride length also increased significantly after tPCS compared to treadmill (z=-2.70; p=0.007) or tPCS+treadmill (z=-2.60; p=0.009). Significant increase in protective stepping, a 2.0 cm in forward step length, was found following the treadmill alone session (Z=-2.29; p=0.022). tPCS or tPCS+treadmill post intervention data did not reach significant changes in forward step length compared to pre intervention data. Significantly fewer steps backwards were recorded only after tPCS and forward only after tPCS+treadmill.

CONCLUSION: Non-invasive tPCS over the primary motor cortex had no adverse effects on subjects with longstanding PD and may lead to acute improvement of gait and balance recovery.

CLNE_O2.2 ACUTE NEUROMUSCULAR EFFECTS OF TESTOSTERONE ADMINISTRATION IN HYPOGONADAL MALES

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INTRODUCTION: The role of testosterone (T) in the control of long-term changes in muscle growth and performance is well known. Recent animal experimental data suggested that T can also acutely influence central nervous system and neuromuscular functions throughout various short-term mechanisms. T may rapidly influence behaviour and cognition, motor system and muscle’s electrophysiological/contractile properties and energy metabolism, particularly during acute adaptation to physical exercise. Consequently, hypogonadism in males is also associated with the absence of both long-term and short-term effects of endogenous T on the neuromuscular system.

AIM: The aim of this pilot study was to analyze the acute effect of T on muscle strength and neuromuscular system properties in hypogonadal males by evaluating muscle strength and surface electromyographic signals (sEMG) immediately before and after a brief T administration.

METHODS: Hypogonadal males applied in random order either 80 mg of T gel (Tostrex, Prostakan Ltd, United Kingdom) or a placebo preparation gel (PLA) once a day for 4 consecutive days. After an adequate washout, each subject was then crossed over to the opposite regimen for another 4 days of treatment. Before and 4 hours after the administration of T gel or PLA gel, a maximal twitch, maximal isometric (MVC) and isokinetic (15, 30, 60, 120, 180 and 240°/s) muscle strength of the elbow flexors (EF) were assessed to investigate the torque-velocity relationship. At the end of isokinetic protocol, a single 80%MVC isometric contraction was performed until volitional exhaustion. Reference twitches were evoked before and after the fatiguing task. Average muscle fibre conduction velocity (MFCV) and EMG signals from the biceps brachii muscle were evaluated by means of array electrodes.

RESULTS: Preliminary results in a reduced number of patients suggested that EF maximal torque values may acutely increase after T gel administration, and during MVC and isokinetic tests.

Four hours after T administration, the normalized slope of sEMG median frequency decay at 80% MVC, an index of myoelectric fatigue, was not different from that of the previous attempt. On the other hand, in the placebo experiments, 4 hours after the first fatiguing contraction the normalized slope of the second one was clearly increased. MFCV during the isokinetic exercise at angular speed of 240°/sec and fatiguing tasks was enhanced by T gel administration of almost 10%. Taken together these results seem to confirm an acute increase of motor neuron excitability.

CONCLUSION: Waiting for definitive results, our preliminary data suggest that in hypogonadal men a short-term T gel administration may induce acute modifications in neuronal excitability, as already demonstrated in animals. Rapid effects of T on muscle strength could be partly explained by these neuronal modifications. Even if premature, we could hypothesize that MFCV assessment may be useful to monitor neuromuscular changes during T substitution in hypogonadal individuals.

CLNE_O2.3 AMPLITUDE CANCELLATION REDUCES THE EFFECTIVENESS OF EMG RECTIFICATION FOR THE ESTIMATION OF COMMON OSCILLATORY INPUTS TO THE MOTONEURON POOL

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INTRODUCTION: Corticospinal and intermuscular coherence analyses are two common techniques to estimate the oscillatory inputs (0-35 Hz) that drive the muscle [1]. Both assume that the common synaptic inputs, sampled by the motoneuron (MN) pool and present in their output spike trains (STs), is contained in the surface EMG (sEMG) signal due to the linearity of the convolutive process [2]. Moreover, rectification is used as a preprocessing to enhance the identification of the oscillations [2]. However, the its effectiveness has been challenged recently [3,4].

AIM: We investigated the influence of amplitude cancellation (AC) of motor unit (MU) action potentials on the estimation of oscillations simulated in the STs of a population of MUs with and without EMG rectification.

METHODS: We used a model that incorporated 300 MNs [5] and a sEMG model [6]. The synaptic input was modeled as band-pass Gaussian noises: a common noise component (CN) to all MNs with a narrow bandwidth (20 Hz with 1 Hz side band) and an independent component (IN) with a broader frequency range (0-100 Hz). The mean values of the stochastic input (CN+IN) was selected to result into 3 levels of AC. The total variance of the CN input was scaled in other to match the magnitude of the coherence between simulated MU STs with experimental findings. The amplitude spectra were estimated using one segment (10 s) for the raw (sEMG) or rectified EMG (rEMG). Additionally we calculated the spectrum of summation of the rectified MUAP trains (rMUAPs) that is unaffected by AC. The ratio between the mean amplitude spectrum at the frequencies simulated in the CN and the remaining bandwidth between 0 and 25 Hz was used to quantify the distortion of the signals.

RESULTS: The ratio calculated for rEMG, rMUAPs and sEMG was respectively 1.76, 2.11 and 1.86 for a level of cancellation of 37.5 %. With 51.7 % of cancellation the ratios decreased to 1.34, 2.01 and 1.62. For the highest level (61.4 %), the ratios were 1.02, 2.05 and 1.55.

CONCLUSION: Our results demonstrated that AC influences the estimation of common oscillations from the sEMG and has an even stronger effect on the rEMG. EMG rectification is thus a suitable pre-processing method for extracting common oscillatory inputs to MNs only for low levels of AC. ACKNOWLEDGEMENTS: Bernstein Focus Neurotechnology No. 1GQ0810 and European Research Council Advanced Grant DEMOVE No. 267888.

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CLNE_O2.4 LEVODOPA IMPAIRS POSTURAL REFINEMENT IN PARKINSON'S DISEASE

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INTRODUCTION: Anticipatory postural adjustments (APAs) are centrally initiated elements of postural control and are affected by changes in postural demand. Parkinson's disease (PD) is characterised by postural instability and impairs efficient adaptation to changes in postural support in centrally initiated postural synergies.

AIM: This study examined the ability of this population (on and off levodopa medication) to immediately adapt APAs when postural demands are changed by familiar and novel manipulations of postural support. We also examined refinement of the postural strategy with practice.

METHODS: Fourteen people with mild PD (ON and OFF levodopa) and 14 healthy control participants performed 20 single rapid leg lift tasks in four support conditions: unsupported, bilateral handgrip (familiar), bite plate (novel) and a combined handgrip + bite plate condition. APAs were identified from force plate and support apparatus data. The amplitude and duration of APAs were compared between initial and final repetitions in each support condition.

RESULTS: Familiar and novel external supports were immediately incorporated into the postural strategy in both participant groups. Control participants and PD patients in the OFF state refined the postural strategy with task repetition. People with PD in the ON state failed to refine APAs in any support condition.

CONCLUSION: Immediate gross postural adaptation is intact in people with mild PD, regardless of task familiarity, and is unaffected by levodopa therapy. However, levodopa impairs the ability to refine postural adaptation with practice and may contribute to postural instability in this population.

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CLNE_O3.1 EEG MEASUREMENTS USING TEXTILE ELECTRODES

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INTRODUCTION: EEG is a well established clinical practice in e.g. epilepsy, sleep studies and intensive care. The relatively tedious procedure of applying electrodes for multi-channel EEG-recording has hampered the use of EEG at the clinic and is also a reason for the rare use outside the clinic. A solution to facilitate multi-channel EEG recordings is to integrate the electrodes in a cap. This solution has been introduced at neonatal intensive care units to enable multi-channel EEG recordings from newborn babies. However, the existing caps for babies in newborn and premature sizes may cause a too high pressure at the electrode sites, making them unsuitable for long term recordings. Textile electrodes may be more comfortably to use and may be positioned/incorporated in a textile structure allowing faster and firmer multi channel electrode application

AIM: The aim of this study was to test the feasibility of textile based electrodes for long term recording of (multi-channel) EEG.

METHODS: Weaved and knitted conductive textile was tested as EEG electrodes on a healthy adult subject. The textile electrodes were first tested dry, but it was found that it was necessary to wet them with physiological saline solution to be able to acquire usable signals. They were placed at the approximate electrode locations F3, C3 and P3 (10-20 system) with standard silver electrodes placed close to the textile electrodes for comparison. The silver electrodes were used in combination with a standard electrode gel. The resulting signals were first examined visually by an experienced electroencephalographer and deemed to be of cerebral origin and of sufficient quality for visual interpretation. The signals were then compared mathematically in the time and frequency domain, and the correlations between the signals from the textile and the silver electrodes were computed.

RESULTS: The tested textile electrodes produced high quality EEG signals, good enough for standard visual interpretation. Signals acquired simultaneously using textile and silver electrodes were highly correlated in both the time (correlation over 0.9) and frequency domain.

CONCLUSION: Our results show that it is possible to record EEG using textile electrodes. Two promising types of textile electrodes have now been selected for further investigation and will be tested during over-night recordings in adults and then in neonates. Apart from the obvious benefit, especially in neonatal care, of using the more comfortable textile electrodes, the possibility of integrating textile electrodes in supportive structures for easy application and proper positioning opens up the current use of EEG to also include (self administered) EEG monitoring outside the clinic.

CLNE_O3.2 MOTOR UNIT NUMBER INDEX (MUNIX) VERSUS MOTOR UNIT NUMBER ESTIMATION (MUNE) A DIRECT COMPARISON IN A LONGITUDINAL STUDY OF ALS PATIENTS

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INTRODUCTION: Motor unit number index (MUNIX) is a surface EMG method that aims to provide an index for the number of functioning motor units innervating a muscle. Estimation of the number of motor units is important for disease monitoring as force measurements or the compound muscle action potential (CMAP) are masked by reinnervation. Motor unit number estimation techniques are rather time consuming and require advanced skills. MUNIX has the advantage that it is much easier and quicker to perform than conventional MUNE methods. However, as MUNIX is an index and a gold standard is lacking, it is unknown how MUNIX is related to the actual number of motor units.

AIM: To evaluate how MUNIX is related to the number of motor units as estimated by high-density surface EMG MUNE (HD-MUNE) and to determine the potential of MUNIX for monitoring disease progression in patients with ALS.

METHODS: Both MUNIX and HD-MUNE of the thenar muscles were determined in 18 ALS patients and 24 healthy controls. HD-MUNE was determined using an electrode grid of 9x15 electrodes and by graded stimulation of the median nerve to obtain single motor unit potentials (MUPs). MUPs could be recognized and decomposed by their spatio-temporal profile. MUNIX is determined out of the interference pattern of 2 times 5 consecutive recordings (slight-strong contractions) in combination with the CMAP amplitude. All patients were measured at baseline, within two weeks (to assess reproducibility), and after 4 and 8 months. ALS functional rating scale (ALSFRS) and Medical research council (MRC) scale were scored.

RESULTS: HD-MUNE showed a slightly better reproducibility than MUNIX in patients. There was a significant relation between MUNE and MUNIX in ALS patients ($r=0.49$ at baseline, $r=0.56$ at 4 months, $r=0.56$ at 8 months, all $p < 0.05$), but not in healthy controls. At baseline, MUNIX and MUNE values were significantly lower in ALS patients compared to healthy controls. Longitudinally, after 8 months, both MUNE and MUNIX of the ALS patients decreased significantly more as compared to MRC, ALSFRS and CMAP amplitude ($p < 0.05$). There was no significant difference between the decline in MUNIX and HD-MUNE after 4 and 8 months.

CONCLUSION: MUNIX of the thenar muscle seems related to the number of motor units as estimated by HD-MUNE in ALS patients, but not in healthy controls. MUNIX appears to have an equivalent potential of detecting disease progression after eight months follow-up as compared to HD-MUNE. As MUNIX is performed rapidly and is well tolerated by patients, a multi-muscle approach seems feasible and can potentially further increase the sensitivity of the technique.

CLNE_O3.3 PRELIMINARY RESULTS OF ELECTRICAL STIMULATION OF THE HAMSTRINGS ON STIFF-KNEE GAIT IN CHRONIC STROKE SUBJECTS.

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INTRODUCTION: A stiff-knee gait pattern in subjects after stroke is characterized by a diminished peak knee flexion during the swing phase of gait. Stiff-knee gait often results in insufficient foot clearance and subsequently an increased risk of falling. In clinical practice neuromuscular blocks of the rectus femoris with botulinum toxin are performed to decrease the excessive activity of the rectus femoris muscle during preswing and swing phase. In literature the effects of neuromuscular blocks on stiff-knee gait after stroke are scarce and inconsistent. A possible alternative treatment to improve knee flexion during swing in stroke subjects walking with stiff-knee gait is electrical stimulation of the hamstrings.

AIM: The aim of the present study was to explore the effect of electrical stimulation of the hamstrings on peak knee flexion during the swing phase in chronic stroke subjects with a stiff-knee gait.

METHODS: Sixteen chronic adult stroke survivors were recruited for participation in this exploratory prospective cohort study. All subjects suffered from a stiff-knee gait due to a first stroke at least 6 months prior to recruitment. The recruited subjects received hamstrings stimulation training 3 times a week for 60 minutes during 6 weeks. The Odstock® two channel Stimulator (O2CHS II, Odstock Medical Limited, Salisbury, Wiltshire, UK) system was used for stimulation. 3D kinematics (Vicon®, version 370, Oxford, UK) was recorded with and without hamstring stimulation 1 week before (pre) and 1 week after (post) the 6 weeks of training. First analysis of the recorded data focused at differences in peak knee flexion during walking without (pre) and with (post) hamstring stimulation.

RESULTS: First analysis on 10 out of 16 recruited subjects compared peak knee flexion during walking without hamstring stimulation pre training to walking with hamstring stimulation post training. Results show a mean increase in peak knee flexion of 7 degrees (range: 0-15 degrees). Future analysis of data will focus on range of motion of knee flexion, foot clearance, angular velocity and sEMG of rectus femoris and hamstrings. These parameters will be used to explore a possible therapeutic effect (after 6 weeks of training) and to describe the (direct) orthotic effect (at baseline) of hamstring stimulation.

CONCLUSIONS: The preliminary results suggest that electrical stimulation of the hamstrings in stroke subjects walking with a stiff-knee gait results in a mean increase of 7 degrees on peak knee flexion. These results are comparable to the reported effects of neuromuscular blocks on peak knee flexion.

ACKNOWLEDGEMENT: This research was supported by the Dutch ministry of Health Welfare and Sport.

CLNE_O3.4 AN AUTOMATIC SPIKE SORTING ALGORITHM WITHMLE-BASED MULTIDIMENSIONAL SCALING AND DENSITY-BASED CLASSIFICATION

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INTRODUCTION: Neurons are the functional units of the nervous system, which includes the brain, spinal cord, and peripheral ganglia. These electrically excitable cells process and transmit information mainly by electrical signaling through the generation of action potentials. These action potentials can be recorded in vivo by placing electrodes in the vicinity of the neuron's membrane within the extracellular space. The extracellular action potentials recorded by the electrodes represent spike events generated by an unknown number of neurons. The role of spike sorting is therefore to assign each spike to its neuron.

AIM: The aim of this work was to design an efficient and accurate single-channel spike sorting algorithm.

METHODS: Spike sorting is typically performed using pattern recognition methods which include the following steps: signal conditioning, segmentation (spike detection), feature extraction/reduction, and classification. In the method that we propose, first, the signal was filtered using a band-pass filter with lower and higher corner frequencies of 300 Hz and 10 kHz respectively. The background noise standard deviation (SD) was estimated, thus the detection threshold was set to 4*SD. The 1-ms time-sample segments were then aligned on the highest peak using a high-resolution peak alignment method.Feature reduction was performed using Multidimensional Scaling and the intrinsic dimensionality was identified by Maximum Likelihood Estimator (MLE). The classification was performed by a modified OPTICS (Ordering Points To Identify the Clustering Structure) algorithm that incorporated the refractory period of 2 ms to separate spikes of different clusters.

RESULTS:The performance of the proposed algorithm was assessed using simulated and real data sets. Five simulated data from the publicly available data set Wave_clus and five experimental recordings from the dorsal premotor and posterior parietal areas of rhesus monkey cerebral cortex(German Primate Center, Göttingen) were used to assess the performance of the proposed algorithm. For the experimental recordings, the gold standard was the manually-corrected sorted spikes using the commerciallyavailable Offline Sorter ver. 3 (www.plexon.com).The accuracy of the proposed program was assessed in terms of Type I and Type II errors for estimation of number of active neurons.The averageFalse Negative and Positive Rates were 0% and 5%, respectively. The average percentage of correctly classified neural spikes in the detected clusters was 80%.

CONCLUSION: Although the performance of the proposed spike sorting method is encouraging, its accuracy is expected to further increase including destructive superposition resolution which was not implemented in the current version of the algorithm.

ERGONOMICS

ERGO_O1.1 MUSCLE ACTIVATION DURING THE PACK HIKE TEST AND A CRITICAL WILDFIRE FIGHTING TASK

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INTRODUCTION: Wildfire fighters worldwide use the Pack Hike test to judge the fitness of fire fighters to suppress wildfires. To successfully complete this physical employment test, an individual has to perform a 4.3km hike over level terrain carrying a 20.4kg pack within a 45min period. The Pack Hike test was designed to challenge fire fighters' muscular endurance, strength and cardiorespiratory fitness, however only the cardiorespiratory fitness aspect of the test has been validated against actual fire fighting work.

AIM: To examine the muscle activation of six global muscles during the successful completion of the Pack Hike test and compare this to muscle activations during a critical wildfire fighting task.

METHODS: In-field surface electromyography was recorded from eight male wildfire fighters during the Pack Hike test and the rakehoe task - a critical wildfire suppression activity. Muscle activity was recorded unilaterally from three upper and three lower body muscles. A representative sample of the last 30 s of every five-minute period during the Pack Hike test was identified and processed to obtain peak muscle activation as well as median frequency of the signal. Muscle activity during the rakehoe task was processed and analysed in a similar fashion except the representative sample was obtained from the last 30 s of each minute of the task.

RESULTS: All participants successfully completed the Pack Hike test within the 45min time limit. No significant changes in peak muscle activation levels as well as no significant shifts in median frequency in the six muscle analysed were recorded during the 4.83km hike. Significantly different peak muscle activation levels were recorded in four of the six muscles tested when the Pack Hike test was compared to the rakehoe task.

CONCLUSION: These results suggest the Pack Hike test should not be administered in isolation and other tests that specifically challenge muscle endurance should be incorporated into a battery that accurately assesses the job-specific fitness of wildfire fighters.

ACKNOWLEDGEMENTS: The authors would like to thank the South Australian Country Fire Service.

ERGO_O1.2 TRUNK POSTURES AND UPPER-BODY MUSCLE ACTIVATIONS DURING PHYSICALLY DEMANDING WILDFIRE SUPPRESSION TASKS.

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INTRODUCTION: Fire fighters play an integral role in safeguarding Australians from the annual threat of wildfire. To preserve this indispensable workforce, it is critical the health and safety of fire fighters is maintained. To achieve this, fire organisations must understand the physical work demands imposed on their personnel. At present, there is no literature that has quantified the musculoskeletal demands of this physically demanding occupation. Considering the innate manual handling nature of fire suppression and the high incidence of musculoskeletal injuries, understanding these demands may provide valuable information which could be used to assist in the development of health and safety interventions.

AIM: The aim of this study was to examine the trunk postures and upper-body muscle activations during four wildfire suppression tasks.

METHODS: Nine experienced fire fighters participated in this study. In a randomised order, participants completed four critical wildfire suppression tasks. These included; charged advance (CA), making up on the bight (MOB), fire line construction (FLC) and blacking out (BO). Surface electromyography was recorded from the upper trapezius and lumbar erector spinae. Muscle activations were normalised to participants' maximum voluntary isometric contraction. Synchronised video captured two retro-reflective markers positioned on participants' torso to allow for quantification of time spent in neutral, moderate and severe sagittal trunk flexion.

RESULTS: Simple effects analyses revealed that both CA and BO were performed in the mild postural zone ($p < 0.001$). The majority of time during FLC was spent in severe postural zone ($p < 0.001$), whereas when participants performed MOB, more time was spent in both neutral ($p < 0.001$) and severe ($p = 0.029$) postural zones than in the mild postural zone. Both CA and BO exhibited higher mean muscle activation when compared to MOB and FLC ($p < 0.001$). Greater muscle activations (mean and peak) were evident in the end phase compared to the start phase across all tasks and muscles ($p < 0.001$). BO elicited the greatest peak muscle activation when compared to MOB and FLC ($p < 0.001$).

CONCLUSION: Results of the present study suggest that common hose and hand-tool tanker based wildfire suppression tasks impose significant musculoskeletal demand on fire fighters. The postures assumed, particularly during FLC can be considered potentially injurious. Further, the mean and peak activations suggest all tasks can be classified as being of moderate to high risk to fire fighters. Fire agencies should consider developing interventions to reduce the exposure of their personnel to these potentially injurious musculoskeletal demands; task rotation, task redesign or physical training may be of benefit.

ERGO_O1.3 DEVELOPMENT OF A HYBRID TRANSDUCER OF DISPLACEMENT-MMG WITH EMG ELECTRODES

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INTRODUCTION: To evaluate muscle contraction, it is necessary to measure both electromyography (EMG; input to muscles that will contract) and mechanomyography (MMG; resulting output from contraction). An accelerometer is generally used for MMG measurement, but the target portion or posture must be fixed securely, because of a large artifact caused by body movement. As a result, MMG measurement cannot be widely applied to the field of daily life or sport science like EMG measurement can. The authors have already proposed a displacement-MMG transducer using a photo-reflector (Oka et al. 2008).

AIM: The aim of this study was to develop a wireless MMG transducer with EMG electrodes that can measure both signals simultaneously.

METHODS: In the present study, a new reflector (TCRT1000, VISHAY) and a simplified electronic circuit realized downsizing, and a wireless transmission module was newly added to the system. The reflector (7 x 4 x 2.5 mm) included an infrared emitter (950 nm) and a daylight blocking filter. The bilateral distance between the legs of the transducer housing , which was stuck on the skin, was 30 mm, and the height was 10 mm. EMG bipolar electrodes were located on a unilateral leg. MMG/EMG signals were connected to a logger module (40 x 2 x 55 mm, 35 g including the battery), and they were sampled at 500 Hz and transmitted at 2.4G Hz.

RESULTS: The dynamic range of the transducer was 1-8 mm, and the output was approximated by a cubic equation. The resolution was about 10 μm because of a dark current of the reflector and the electronic circuit noise. The frequency characteristic was good approximately below100 Hz. There was no effect in the output for a shock disturbance. The coefficient of correlation of transducer output under between shading and indoor light was 0.9994. During a voluntary contraction or a twitch caused by an electrical stimulation, the displacement-MMG was smaller than that by a laser displacement transducer (LK-G155, KEYENCE), because it was a relative displacement using the bilateral housing legs as fixed points, but a similar waveform was obtained to that obtained by the laser transducer.

CONCLUSION: The hybrid transducer of displacement-MMG with EMG electrodes that included a wireless transmission module was developed. This transducer should work successfully for MMG/EMG measurement in the field of daily life or sport science, because it is free from the errors resulting from body movements or artifacts.

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ERGO_O1.4 THE EFFECT OF FASTENING A HIP BELT OF A LOADED BACKPACK ON POSTURAL STABILITY, PERCEIVED SENSE OF INSTABILITY AND EXERTION

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INTRODUCTION: Carrying a backpack is a popular mode of load carriage and it is considered the most appropriate way of carrying additional weight. However, carrying a backpack can cause discomfort and affect postural stability. Features such as a hip belt are believed to increase comfort and stability and decrease pain as it helps load distribution over the body.

AIM: to assess the effect of fastening a hip belt on a loaded backpack on centre of pressure (COP) variables, perceived sense of stability and perceived exertion.

METHODS: thirty participants were instructed to stand on a force plate for a period of a minute under three load conditions: no backpack, with a loaded backpack with no hip belt and with a loaded backpack with a hip belt. Three recordings were recorded in each condition. Backpacks were loaded with 20% of participants' body weight. COP average velocity and sway area were measured by a force plate and participants rated their perceived sense of instability on a perceived sense of postural sway and instability scale and their perceived exertion on a Borg scale. The order of conditions were counter balanced and randomised. The variables were analysed using four separate, one-way repeated measures ANOVA.

RESULTS: In comparison with the control of no backpack, both backpack conditions significantly increased COP average velocity, sway area, perceived sense of instability and exertion. Fastening of a hip belt did not have any influence on COP average velocity and sway area. However; by fastening a hip belt, higher levels of stability and lower levels of exertion were perceived by the participants.

CONCLUSION: while fastening a hip belt does not improve postural stability, it helps individuals to feel more stable during standing. A hip belt facilitates shifting a substantial part of the load directly from the shoulders to the pelvis. In this way, a significant amount of load is transferred from the weaker structures of the shoulder to the larger and stronger structure of the pelvis and lower extremities. This may cause less muscular activity which is required to stabilize the pack on the spine and as a result a higher sensation of stability.

ERGO_O2.1 HOW DOES NEW CONCEPT OF TRANSFER BOARD REDUCE MUSCULAR LOAD OF HEALTH CARE WORKERS DURING TRANSFER ASSISTANCE IN SITTING POSITION?

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INTRODUCTION: To enhance the usefulness of assistive products in transfer assistance, we have proposed a new design concept for a transfer board to reduce physical load for health care workers. Its novel structure is similar to a conveyer belt, with duralumin rollers and a resin belt. It reduces friction between the board and the patient's body. A prototype of the new transfer board was developed for transfer assistance in a sitting position. The prototype was also evaluated by health care workers in a nursing home. It was sufficiently lightweight for use, and permitted easy transfer while a patient sat on the prototype. However, the effects on physical load for health care workers have not been investigated quantitatively with the use of the prototype.

AIM: We investigate how muscular load is reduced for health care workers with the use of the prototype, by measuring surface electromyography.

METHODS: Two healthy young male subjects participated in the experiment. They played the roles of the patient and the health care worker alternately. The patient was transferred by the worker from the wheelchair to the bed and vice versa. In addition to the prototype, we used a commercially available board made of solid plastic. Surface electromyography was measured bilaterally with the MyoSystem 1200 (Noraxon, USA), with the procedure performed on the worker's erector spinae, rectus abdominis, multifidus lumborum and latissimus dorsi muscles. Measured signals were digitized at 1kHz, and stored on a personal computer. We estimated the root mean square (rms) values of the EMG data during transfer assistance.

RESULT: Measured rms values were greater in transfer assistance from the wheelchair to the bed than in transfer assistance from the bed to the wheelchair. They were also greater during use of the commercial board than during use of the prototype. When the patient was sat on the chair, the seat of the chair was slightly bent. The patient's hip was lower than the initial height of the chair. The worker first lifted the patient's body slightly from the chair and then transferred it to the bed. In the lifting phase, muscular load was not varied between the prototype and the commercial board. In the transferring phase, the commercial board was unstable because the friction coefficient between the board and the patient was higher than that of the prototype. The worker had to produce excessive muscular force when using the commercial board. In transfer assistance from the bed to the wheelchair, rms values did not vary between the prototype and the commercial board. In this motion, the lifting phase was not required for the worker because the patient's body was not lowered from the initial height of the bed.

CONCLUSION: The transfer board prototype reduced muscular load for the health care worker when assisting the patient to transfer from the wheelchair to the bed.

ERGO_O2.2 PUSH TASK BODY KINEMATICS TO MINIMISE SLIP RISK: HOW YOU USE YOUR BODY AFFECTS SHEAR-COMPRESSION RATIO AT FOOT-FLOOR CONTACT.

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INTRODUCTION: A previous study simulated a lateral patient transfer, with three different strategies of body movement. Push strategies with a preparatory backwards and forwards movement of the pelvis (rockback push) or leaning into the task (spontaneous push) had lower perceived effort and higher success rate of pushing high loads than pushing with back straight and bent knees (squat push). It was unknown how the risk of slipping would compare between these three push strategies.

AIM: To determine whether the strategy of body movement in pushing influences the shear/vertical ground reaction force (Fz) ratio at foot-floor interface.

METHODS: Eleven healthy adults [4 males, age: 23(3) years, height: 167(8) cm, weight: 61(13) kg] performed lateral patient transfers of a 84 kg person lying supine on a slide sheet using a spontaneous push strategy, and were then trained in random order to perform that task using a squat push strategy, or rockback push strategy. Two forceplates (Bertec) recorded sagittal-plane shear and ground reaction force at each foot. The ratio of shear/Fz at the time of maximum shear force was calculated. Repeated measures ANOVA with Duncan's post hoc test were used to compare the strategies.

RESULTS: The squat (0.27 (SD 0.07)) and rockback (0.28 (SD 0.07)) push strategies had lower shear/Fz ratios compared to the spontaneous strategy (0.32 (SD 0.06)) (P=0.005 & P=0.035, respectively).

CONCLUSION: A lower shear/Fz ratio equates to a greater angle between the resultant ground reaction force and floor. Both squat and rockback push strategies could therefore reduce slip risk compared to the spontaneous strategy.

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ERGO_O2.3 ERGONOMIC EVALUATION OF A PRODUCTION LINE BY MEASURING MUSCULAR LOAD AND POSTURES AND MOVEMENTS OF HEAD, BACK, ARMS AND WRISTS

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INTRODUCTION: Work in the manufacturing industry is often forceful and repetitive and may also involve constrained postures. These conditions are well-known risk factors for developing musculoskeletal disorders (MSDs). Surveys, using checklist and observations, are suitable for identifying jobs and tasks that may be harmful for the workers and that should be altered. However, for quantifying workload and evaluating the effect of interventions, checklists and observations may not be sufficient; rather, technical measures may be preferable for deriving quantitative measures in generic units.

AIM: To: (1) quantify the major aspects of workload by generic measurement methods, for a production line with manual assembly of medium size (15-30 kg) roller bearings; (2) present and appraise the load in relation to other types of work; (3) measure the effect of assembling bearings of different type and size; and (4) estimate the effect of an increased production rate on the workload as well as on risk of MSDs.

METHODS: Bipolar surface EMG was used for bilateral recording of trapezius and forearm extensor muscle activity. Normalisation was made to maximal voluntary contractions MVE. Fraction of time with muscular rest (EMG < 0.5 %MVE) and percentiles of the amplitude distributions were used as summary measures. Inclinometers were used for recording the flexion/extension of the head and the elevation of both upper arms; percentiles of angular distributions were used as measures. Electrogoniometers were used for bilateral recording of wrist angles and movement; percentiles of the angular and angular velocity distributions were used as measures. The measurements were performed for nine workers at their ordinary workplace during normal production.

RESULTS: Load during work on the production line (e.g., right trapezius muscular rest 16%, right forearm extensor peak load [90^{th} percentile] 19 %MVE, head flexion [90^{th} percentile] 53°, right upper arm elevation [99^{th} percentile] 78°, and right wrist flexion angular velocity [50^{th} percentile] 15°/s) was evaluated and compared to other types of work. Similarly, the difference in load for mounting "small" and "large" bearings was quantified. Increasing the production rate by 10% was predicted to increase the wrist angular velocity by 3°/s. Based on data on the relation between wrist velocity and prevalence of wrist/hand pain, this increase in wrist velocity was estimated to increase the risk of reporting pain in the wrist/hand by 2%.

CONCLUSION: Technical measurements at the workplace are feasible for acquiring detailed quantitative data on workload. Such information is needed for comparing the load with other jobs and tasks, evaluating the effect of interventions, and estimating the risk of MSDs.

ERGO_O2.4 PROGRESSIVE INDIVIDUALIZED EMG BIOFEEDBACK TRAINING FOR WOMEN

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INTRODUCTION: The use of EMG biofeedback in workplace ergonomic intervention is well established. Its systematic application in tailored neck pain rehabilitation is, however, less developed.

AIM: To introduce a tailored and gradually progressive biofeedback training program for trapezius myalgia and to assess the feasibility and the subjective experience of the program.

METHODS: The study sample was a subgroup in an ongoing randomized controlled trial (RCT) to evaluate 11-weeks of individualized neck pain rehabilitation in women with at least six weeks of work related nonspecific neck pain (target number of participants 105, ISRCTN49348025). The intervention period included 27 treatment sessions. The treatment decision model for the individualization of the RCT included five main treatment components of which biofeedback training was one. Each subject was assigned two treatment components at minimum. Criterion for being assigned biofeedback training was a diagnosis of trapezius myalgia and a cut off level of pain pressure threshold, defined by previous cross sectional data. The biofeedback treatment program consisted of eight standardized exercises with gradual progression of difficulty level followed by functional training in specific tasks individualized for each subject. The latter were disentangled with the Problem Elicitation Technique (Bakker et al. 1995) and indicated the activities that were most important to the individual and most difficult to do because of the neck pain. In the functional training, principles of motor learning were applied in order to enhance retention of the training tasks and transfer to new tasks and environments. The ability to perform three standardized biofeedback exercises and the clinical applicability of the individualized program was evaluated by subjects and therapists (n=4).

RESULTS: Preliminary result from the therapist evaluation shows a positive opinion about the biofeedback program. To date, 60% of the 105 subjects planned for the RCT have been recruited. Based on the number of subjects fulfilling the criterion so far for biofeedback training, we expect the final sample to be around 18 subjects. Results will be ready in June 2012.

CONCLUSION: This study will provide valuable information on the feasibility and applicability of gradually progressive biofeedback training as part of an intervention program addressing work related non-specific neck pain.

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FUNCTIONAL ELECTRICAL STIMULATION

FEST_O1.1 COMPARISON OF THE STIMULUS-RESPONSE CURVE RESULTING FROM MUSCLE VS. NEUROSTIMULATION IN THE QUADRICEPS MUSCLE

Dr Javier Rodriguez, Public University of Navarra

Dr Nicola Maffiuletti; Dr Nicolas Place

INTRODUCTION: Surface electrical stimulation can be done directly, by using electrodes placed over the muscle so that electrical pulses provoke the muscle contraction via the axonal branches (muscle stimulation) and indirectly, by using electrodes positioned over a major motor nerve (nerve stimulation).

AIM: To compare the effects of muscle vs. nerve stimulation on the characteristics of the stimulus-response curve in two quadriceps muscles, the vastus medialis (VM) and vastus lateralis (VL), with a view to obtain deeper insight into the biophysical and morphological factors determining the activation of motor units during each of these stimulation modalities.

METHODS: Twenty two healthy subjects (29±2 yrs) were recruited for this study. The twitch amplitude and time to peak twitch from the quadriceps muscle as well as the compound muscle action potential (CMAP) amplitude from the VL and VM muscles were obtained for stimulus of increasing intensity using muscle and nerve stimulation. The resulting stimulus-response curves (SR curves) were analyzed.

RESULTS: Nerve stimulation of the VM and VL resulted in SR curves of rather similar shapes and absolute range widths. On the contrary, VM and VL reacted markedly differently to increasing stimulus intensity injected via muscle stimulation (large discrepancies in the corresponding SR curves). Peak twitch and CMAP Vpp for VL and VM muscles were comparable at maximal stimulation intensity. Time to peak twitch decreased monotonically with stimulus intensity at approximately the same rate for both stimulation methods. Muscle stimulation resulted in lower discomfort than nerve stimulation.

CONCLUSION: Nerve stimulation of muscles whose main axons course through the same motor nerve, such as the VM and VL, appears to result in similar MU recruitment patterns. Muscle stimulation, more dependent upon the spatial organization of the axonal terminal branches within the muscle, leads to some differences in MU activation order in the VM and VL and, therefore, can be considered as more muscle-specific. The CMAP Vpp for VL and VM muscles as well as the peak twitch evoked at maximal intensity were similar for the two stimulation modalities. Finally, time to peak twitch evoked with both stimulation methods decreased monotonically with stimulus intensity at approximately the same rate, indicating that motor units were not recruited in reverse order during muscle and nerve stimulation.

FEST_O1.2 CHANGE OF CEREBRAL CORTEX EXCITABILITY AFTER EMG TRIGGERED FES COMBINED WITH MIRROR THERAPY IN HEALTHY SUBJECTS

Mr Yuji Inagaki, Hokkaido University

Prof Katsunori Ikoma; Dr Yuji Urakami; A/Prof Hitoshi Makino; Dr Kazunori Seki

INTRODUCTION: In this study, we used Electromyogram (EMG) triggered electrical stimulation (ETES) to move unilateral hand synchronously with contralateral voluntary hand movement while performing mirror therapy and investigated relationships between hemodynamic responses in the brain and neural activities after performing the tasks with mirror and ETES in the healthy subjects.

METHODS: Nineteen neurologically healthy subjects participated in the study. Hemodynamic responses were detected by functional near infrared spectroscopy (f-NIRS). The regions of interest (ROI) were the precentral gyrus (PrG), postcentral gyrus (PoG), supramarginal gyrus (SMG), superior parietal lobule (SPL) and middle frontal gyrus (MFG). The subjects performed 7 tasks as below: observation of a mark without movement (Rest), observation of a mark with only left hand flexion movement (Task1), observation of resting right hand added to Task1 (Task2), observation of mirror reflection of left hand movement added to Task1 (Task3), observation of a mark and right hand movement induced by ETES (Task4), observation of moving right hand added to Task4 (Task5), and observation of mirror reflection of left hand movement added to Task4 (Task6). All of the tasks were performed in random order.

RESULTS: The left SMG, the left MFG, the bilateral PrG and PoG were activated in Task2, 3, 5 and 6 comparing to Rest. The left PrG, PoG, MFG were activated in Tsk3 comparing to Task2. The left PrG, PoG, MFG, SMG were activated in Task6 comparing to Task5. In addition, the left SMG was activated in Task6 comparing to Task3.

CONCLUSION: These results suggest that mirror therapy can activate mirror neuron, which is usually activated by motor observation and imitation, and ETES combined with mirror therapy has a possibility to elicit excitability of mirror neuron more effectively than traditional mirror therapy.

FEST_O1.3 THE EFFECT OF FUNCTIONAL ELECTRICAL STIMULATION ASSISTED CYCLING ON MUSCULAR ACTIVATION AND CORTICAL EXCITABILITY

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Prof Jia-Jin Jason Chen; Mr Li-Ming Liu; Mrs Chao-Chen Pearl Lo

INTRODUCTION: Stroke patients usually exhibit asymmetrical movement patterns due to hemiparesis. Cycling, as an alternative method of gait training for those inabilities of walking safely, has been used with electrical stimulation (ES) to further help the movement rehabilitation in stroke patients. However, there is still lack of direct evidence for the residual function on peripheral nervous system in aspect of electromyography (EMG) due to the interference of ES signal. In addition, the effect of ES-assisted cycling related to the brain plasticity which can be evaluated by near infrared spectroscopy (NIRS), a novel neuroimage technique by understanding the hemodynamic response, has not well understood.

AIM: The aim of this study is to develop a suitable recording system for ES-assisted cycling and investigate the relationship between cortical activation and cycling performance from biomechanics aspects.

METHODS: The system is composed of biphasic constant-current stimulator, EMG recording sub-system with stimulus artifact suppressor, data acquisition unit, laptop, ergometer, and NIRS recording system. The key point for EMG recording under the condition of ES is the stimulus artifact suppressor, which is used to prevent the saturation on the amplifier by stimulation input. For evaluating the motor performances, numerous indices were used to quantify the cycling performance in aspect of biomechanical analysis, including asymmetries in EMG activity, cycling power, as well as cycling smoothness from indices designed in this study: shape symmetry index (SSI), area symmetry index (ASI), and roughness index (RI). To detect the cortical activation during pedaling movement, the optodes of frequency domain NIRS (FD-NIRS) system-Imagent with custom-made holder and cap were placed on frontal parietal skull surface.

RESULTS: The results showed that the volitional EMG and stimulus EMG can be extracted by digital signal process successfully recorded by our system. There is an increase in oxyhemoglobin during cycling in region of interest, which indicated the increase in cortical activation.

CONCLUSION: The volitional EMG and stimulus EMG. can be processed to obtain coordination of muscle activity and residual force of stroke patient. Biomechanical indices are essential for evaluating the cycling asymmetry, In addition, cortical activation measured by NIRS can be an indicator of cycling training effect on central nervous system. The application of NIRS is necessary to monitor the correlated changes between the levels of oxygenated (HbO) and deoxygenated hemoglobin (HbR) in a dynamic movement condition which will be essential for design brain-based training protocol for stroke patient especially at earlier stage.

FEST_O1.4 THE SPATIAL DISTRIBUTION OF MOTOR UNITS RECRUITED WHEN ELECTRICAL STIMULATION IS APPLIED OVER A MUSCLE BELLY COMPARED TO A NERVE TRUNK.

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INTRODUCTION: Neuromuscular electrical stimulation is used to generate contractions after central nervous system trauma. Tibialis anterior (TA), an ankle dorsiflexsor, is a common target for stimulation. To activate TA, stimulation can be applied over the TA muscle belly or the common peroneal nerve trunk; however, it is not known whether there is a difference in the spatial distribution of motor units recruited when stimulation is delivered at these two locations. The distribution of motor units recruited during muscle belly stimulation has been studied indirectly using imaging techniques, surface electromyographic (EMG) recordings and computer simulations, with the general consensus being that superficial motor units are activated preferentially. Currently there are no comparable data on the spatial distribution of motor units recruited during nerve trunk stimulation.

AIM: In the present study, we compared the spatial distribution of motor units recruited in TA during muscle belly versus nerve trunk stimulation.

METHODS: Fine-wire EMG recording electrodes were inserted into superficial and deep portions of TA using ultrasound for visual feedback. We compared M-wave recruitment curves between these two recording sites for both stimulation locations. Forty to eighty single pulses were delivered at each stimulation location to compare motor unit recruitment over a range of stimulation amplitudes from below motor threshold to ~1.5x the current required to elicit a maximal M-wave (Mmax).

RESULTS: During muscle belly stimulation, recruitment of muscle fibres progressed from superficial to deep with increases in stimulation amplitude and Mmax was not reached at the deep recording site at maximal stimulator output (100 mA) in 3 of 9 participants. In contrast, recruitment during nerve trunk stimulation was evenly distributed throughout the muscle, regardless of stimulation amplitude, and Mmax was reached at both recording sites in all 9 participants. For the group, Mmax recorded at the superficial recording site was not different between stimulation locations. In contrast, Mmax recorded at the deep recording site was significantly smaller during muscle belly stimulation compared to nerve trunk stimulation.

CONCLUSIONS: During stimulation over the TA muscle belly, superficial motor units are recruited preferentially and deep motor units are recruited only with increases in current amplitude, if at all. During stimulation over the common peroneal nerve trunk, a given current amplitude recruits superficial and deep portions equally. These results contribute to our understanding of how electrical stimulation generates muscle contractions and provides further evidence that where stimulation is delivered markedly affects how contractions are produced.

ISEK/ISB

ISBI_O1.1 COMPARISON OF PREDICTED MUSCLE STIMULATION PATTERNS FOR THE CORRECTION OF A RANGE OF SCOLIOTIC CURVES

Mr Maurice Curtin, University College Dublin, Ireland

Dr Madeleine Lowery

INTRODUCTION: Current approaches to treating scoliosis including surgical and non-surgical interventions. Non-surgical treatments include bracing and electrical stimulation of back and paravertebral muscles. Electrical stimulation has had a lower success rates than bracing and has received little attention in recent years. While computer simulations have shown potential for electrical stimulation, inconsistencies in clinical outcomes resulted in the dismissal of the treatment as a viable option.

AIM: The aim of this study was to reinvestigate the potential of muscle stimulation as an adjunct therapy for the correction of scoliosis over a range of spinal curves incorporating different combinations of deep and superficial muscles. The 5 King's Classifications of scoliosis were investigated ranging from moderate to severe curves.

METHODS: A musculoskeletal model of the thoracolumbar spine and ribcage was constructed incorporating lumbar and thoracic muscle architecture. The model was adjusted to simulate the 5 Kings Classifications of scoliosis. Each Classification ranged over Cobb angles from 10-60 deg. The most effective activation patterns for minimising the degree of curvature were identified for each configuration using optimisation. Optimisations were conducted under three conditions: all muscles available to the optimizer, superficial muscles available and deep muscles available.

RESULTS: The identified activation patterns and reduction in curvature varied according to classification, reflecting the complexity of the curves. When all muscles were available, the greatest reduction in objective function across the range of Cobb angles occurred for Classification 4. The results obtained when only superficial muscles were available were similar to those incorporating all muscles. In the case of deep muscles, the correction was less than that obtained using either all or superficial muscles. Similar muscle groups were targeted across all Cobb angles within a Classification. Key muscle groups were also identified across all Classifications including the psoas, trapezius and quadratus lumborum. Variations were observed in the distribution of muscles activated on the convex and concave side of the curves. For Kings Classifications 1-3, the majority of muscles activated were on the convex side, while for Classifications 4 and 5 bilateral activation was predicted.

CONCLUSION: The potential of electrical stimulation for scoliosis correction has been reinvestigated for a wide range of curves and with the inclusion of deep muscles. A reduction in curvature has been shown across all classifications examined. While consistent with clinical electrode placements, the results suggest a variation in optimal stimulation patterns based on curve type.

ISBI_O1.2 EFFECT OF AGE AND GENDER ON BALANCE CAPACITY AFTER SUDDEN PERTURBATION

A/Prof Rita M. Kiss, Budapest University of Technology and Economics

INTRODUCTION: Measurement of balance capacity is an important issue for both elderly and young subjects. A high level of complex coordination is required to regain balance after a sudden impulse or a change in direction, either in a static posture or during motion. An unstable oscillatory platform can be used for modelling balance capacity.

AIM: Our aim was to determine the effects of age and gender on balance capacity after sudden perturbation in 143 healthy subjects.

METHODS: Sudden changes in direction were modelled using the commercially available PosturoMed© device. The motions of the rigid plate of the device were recorded using a ZEBRIS CMS10 ultrasound-based motion analysis system, with single individual markers attached to the side of the rigid plate. The plate has 20mm of translation relative to the medium position and can also be fixed in position by the provocation unit. By releasing the unit, the rigid plate can be set into motion because the platform swings back into its resting position, simulating sudden disturbances during stance. For this study, healthy male and female subjects with a normal body mass index (25-30kg/m^2) were divided into seven age groups, ranging between 25 and 80 years. Participants were asked to counterbalance the sudden disturbances simulated by the rigid plate, using compensatory equilibrium reactions during double limb and single limb stance. Having a participant stand on the oscillated rigid platform damps the system, a phenomenon which can be characterized by the Lehr's damping ratio. To analyse the influence of gender, the two-sample t-test was used, and to analyse the influence of age, the Pearson product-moment correlation coefficient (r) was applied. The significance level was $p \leq 0.05$.

RESULTS: In the comparison between males and females, in all three trials in all age-matched groups the Lehr's damping ratio measured on females significantly higher that the values measured on males . In both males and females, the Lehr's damping ratio significantly decreased with increasing of age in all three trials.

CONCLUSION: Gender significantly influenced balance capacity after sudden perturbation. Women's superior balance capacity can be attributed to better anthropometrical ratios and women having more flexible joints. The significant gender-related differences observed among elderly subjects can be caused by the different decline rates of the motor and sensory systems with age between genders. The decreasing balance capacity associated with advancing age can be attributed to slower muscle response, longer response time and deterioration in vestibular and somatosensory functions.

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ISBI_O1.3 EFFECTS OF CLASSIFICATION-SPECIFIC VERSUS NON-SPECIFIC TREATMENT ON FUNCTION IN PEOPLE WITH CHRONIC LOW BACK PAIN

Dr Linda van Dillen, Washington University

Dr Barbara Norton, Washington University; Dr Shirley Sahrmann, Washington University; Dr Marcie Harris-Hayes, Washington University; Dr Gregory Holtzman, Washington University; Ms Jeanne Earley, The Rehabilitation Institute of Saint Louis; Dr Michael Strube, Washington University

INTRODUCTION: Researchers have suggested that treatment outcomes for people with chronic, non-specific low back pain (LBP) would be improved if treatment was targeted at the specific clinical characteristics of homogeneous subgroups.

AIM: Our aim was to examine the effect of a classification-specific treatment (CSp) versus a non-specific (NSp) treatment in people with chronic LBP over a one-year period.

METHODS: All subjects (48 males, 51 females; mean age 43.0± 11.2 years) were classified based on the Movement System Impairment Model for LBP. Both groups received treatment 1x/week for 6 weeks; treatment included exercise and training in performance of functional activities. Functional activity training in both conditions focused on maintaining a neutral lumbar spine alignment. The modified Oswestry Disability Index (ODI) was measured at baseline, after treatment, and 6 and 12 months later. Adherence to exercise, and to functional activity training were measured during treatment and 6 and 12 months later. Data were analyzed with hierarchical linear modeling (HLM).

RESULTS: For both groups, ODI scores demonstrated a significant curvilinear pattern (HLM quadratic effect, $p<.05$) with initial, clinically important improvement with treatment (pre: 22.45%±8.79%, post: 14.40%±5.85%; HLM linear effect, $p<.05$). Improvements continued after treatment with a leveling off at 6 months (8.79%±4.25%), followed by a gradual reversal at 12 months (9.76%±4.56%; HLM quadratic effect, $p<.05$). Exercise adherence declined to a greater degree (80% to 40%) than functional activity adherence (79% to 64%), and the rate of decline was much greater for exercise adherence than for functional activity adherence. Specifically, functional activity adherence was stable at the end of treatment (HLM linear effect, $p>.05$) but began to gradually decline about 6 months after treatment (HLM linear effect, $p<.05$); a similar pattern to that observed in ODI scores. Exercise adherence began to decline in the treatment phase (HLM linear effect, $p<.05$) and continued to decline throughout the 12 month period (HLM linear effects at 6 and 12 months, $p<.05$). Adherence to functional activity training also had a unique, independent effect on ODI scores above and beyond the effect of exercise ($p < .05$). A marginally significant interaction of treatment group and adherence ($p<.065$) indicated that the influence of functional activity adherence was nearly twice as large in the CSp group as in the NSp group.

CONCLUSION: Both CSp and NSP groups improved by 13.50 points on the ODI. The pattern of improvement in ODI scores, however, depended on 1) how much a person adhered to training in functional activities, and 2) the specific type of training in functional activities, CSp versus NSp.

ISBI_O1.4 INTER-RATER RELIABILITY OF A MOTORUNIT IDENTIFICATION PROGRAM TO OBTAIN AVERAGE DISCHARGE RATES FOR ISOMETRIC CONTRACTIONS AT 40, 60, 80 AND 100% MVC

Mr J Greig Inglis, Brock University

Ms Lara Green, Brock University; Mr Justin Parro, Brock University; Dr David A. Gabriel, Brock University

INTRODUCTION: Accurately identifying motor unit action potentials (MUAPs) in EMG signals from human muscle is a challenge for researchers studying the neural control of movement. Each trial containing multiple MUAPs must undergo tremendous scrutiny until the researcher can report 100% confidence in the final results. Many software packages, either privately developed or commercially available, are utilized during identification to make the process more accurate and efficient. Despite the software's source, results must be rigorously tested to ensure they are reliable for multiple users.

AIM: The purpose of this study was to evaluate inter-rater reliability of averaged motor unit discharge rates obtained with an interactive motor unit identification program (EMGlab).

METHODS: Seven participants (2 females, 5 males) performed isometric dorsiflexion contractions of the human tibialis anterior in a seated position. Three observers decomposed the seven participant's isometric contractions at 40, 60, 80, and 100% of maximal voluntary contraction (MVC). Each observer independently identified motor units in each contraction. Once decomposition was complete, a two second sample window was set for each contraction based on the most stable portion of the force trace (+/- 2.5%). From the sample window the instantaneous discharge rates for each identified motor unit were averaged for each observer. An intraclass correlation coefficient (ICC)(model 2, k) was used to calculate the inter-rater reliability between observers.

RESULTS: The ICC (2, k) ranged from 0.95 – 0.98 across force levels. A one-way analysis of variance revealed no significant differences in the averaged motor unit discharge rates between observers at 40, 60, 80, and 100% of MVC ($p > 0.05$).

CONCLUSION: Inter-rater reliability was excellent between observers when using computer interactive software to identify motor unit action potentials to determine averaged motor unit discharge rates at 40, 60, 80 and 100% of MVC in the tibialis anterior.

ACKNOWLEDGEMENTS: This research was supported by a NSERC grant.

ISBI_O1.5 INCREASED NECK MUSCLE ACTIVITY AND IMPAIRED BALANCE IN FEMALES WITH WHIPLASH RELATED CHRONIC NECK PAIN - A CASE CONTROL STUDY

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Miss Rikke Vikær Jensen, University of Southern Denmark; Mr Brian Clausen, University of Southern Denmark; Mrs Inge Ris, University of Southern Denmark; Mr Rasmus Fischer Steffensen, University of Southern Denmark; Mr Shadi Samir Chreiteh, University of Southern Denmark; Mrs Marie Birk Jørgensen, National Research Centre for the Working Environment; Prof Karen Søgaard, University of Southern Denmark

INTRODUCTION: Individuals with Whiplash Associated Disorders (WAD) and chronic neck pain have increased muscle activity in the superficial cervical flexor muscles during neck-arm tasks. They also present alterations in postural control during closed eyes balance tasks.

AIM: To investigate neck muscle activity and postural sway simultaneously in patients with WAD compared with healthy controls (CON) during static balance and arm perturbation.

METHODS: Ten females with WAD (age 37.7 years, neck pain >2 years and Neck Disability Index (NDI) >10) and ten CON (age 35.9 years, NDI <6). Muscle activity was measured with surface electromyography of the anterior scalene, sternocleidomastoid, neck extensors and upper trapezius muscles, and expressed as mean relative activity related to Maximum Voluntary Electromyography (%MVE). On a force plate three balance tasks (Romberg stance with open and closed eyes, one-legged stance), and an arm perturbation task with sudden unloading, were performed. Total sway, slow and fast components of sway areas (mm2) and range of displacement (mm) were calculated.

RESULTS: During balance tasks with closed eyes and one-legged stance the relative mean activity of all four muscles was significantly increased in subjects with WAD compared with CON, and correspondingly, the postural sway was significantly increased.

CONCLUSION: Increased neck muscle activity and increased postural sway during simple balance tasks indicate disturbed sensory feedback patterns in subjects with WAD, which may have negative consequences for them when performing daily activities.

ISBI_O1.6 SEX DIFFERENCES IN WEIGHT BEARING KNEE JOINT MUSCLE ACTIVATIONS

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Mr Andrew Smith, University of Ottawa; Dr Daniel Benoit, University of Ottawa

INTRODUCTION: Knee joint stability results from integrating articular geometry, soft tissue restraints and loads from muscle action and bearing weight. Of these, muscles are the only dynamic regulators of knee joint stability. Females have higher incidences of non-contact ACL-injuries and are suggested to have a decreased ability to stabilize the knee with muscular support compared to males . Thus investigating muscle action as it relates to sex may shed light on mechanisms of joint injury.

AIM: To evaluate sex-related differences in neuromuscular function during a highly specific weight-bearing force control task.

METHODS: 41 healthy active young adults stood with their dominant foot fixed to a force plate. While controlling applied body weight, participants applied loads in various horizontal directions against the force plate to move a projected cursor over a target. This required 50% body weight and 30% of peak horizontal effort. Targets randomly appeared one at-a-time in locations representing horizontal loading directions at the force plate. Electromyographic data of eight muscles were plotted in polar coordinates to display muscle activation patterns. Significant differences were evaluated for mean magnitudes and directions of muscle activations. A statistical test for pattern asymmetry was also conducted. GRFs and motion capture data were recorded to compute lower limb joint angles and moments.

RESULTS: GRFs ranged from 0.48-0.58 N/kg and were comparable across sexes. Females demonstrated (1) higher knee adduction moments, (2) greater rectus femoris (RF) activation, and (3) asymmetrical activation of the vastus medialis (VM) compared to males. In both sexes, vastus lateralis' (VL) activation patterns were symmetrical (similar activation magnitudes at all target locations) while RF, semitendinosus (ST), and biceps femoris (BF) were asymmetrical. BF demonstrated preferential activation in directions opposite of its moment arm orientation.

CONCLUSION: Our protocol elicits GRFs comparable to functional activities suggesting we are observing physiologically relevant neuromuscular support strategies. Based on our results, we classified muscles as moment actuators (RF, ST), general joint stabilizers (VL, VM of males) or specific joint stabilizers (BF, VM of females). Joint stabilizers are thought to increase joint compressive forces and create a stable mechanical system from which moment generators can initiate directed forces. Our observed sex-related differences in knee muscle action may provide insight into ACL injury mechanisms.

ACKNOWLEDGEMENT: This research was supported by NSERC, the CFI, the Province of Ontario and the University of Ottawa.

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ISBI_O1.7 THE IMPLICATIONS OF THE SERIAL ARRANGEMENT OF MUSCLE FASCICLES

Prof John H Challis, Penn State University

Dr Benjamin Infantolino, Penn State University

INTRODUCTION: The architecture of isolated muscle fibers is often used to infer the function of whole muscle. Typically from dissected muscles the number of sarcomeres comprising fibers is counted, from which the optimal length of the fiber and the maximum velocity of shortening are determined. In vivo the behavior of the muscle does not always match the behavior predicted by the properties of the isolated muscle fibers.

AIM: The aim of this study was to examine how, for the First Dorsal Interosseous (FDI) muscle, the architecture of cadaver muscles predict in vivo behavior.

METHODS: Eighteen FDI muscles, from cadaver dissections, were examined to determine muscle pennation and cross-sectional areas, and tendon lengths. In individual muscle fibers imaging was used to determine the number of sarcomeres in each fiber, and thus fiber optimum length and maximum velocity of shortening. Magnetic Resonance Imaging (MRI) of three whole FDI muscles was used to determine the relative arrangement of the fascicles. Finally three subjects produced maximum isometric and isokinetic index finger abductions.

RESULTS: Simulation of maximum isometric and isokinetic index finger abductions based on the muscle properties from the cadaver dissections did not match the in vivo properties. Specifically the force-length curve had a different shape and the maximum velocity of shortening was too low in the model to predict the experimental isokinetic data. Analysis of the MRI images revealed 10% of the approximately 100 fascicles comprising each muscle were in series. Simulations of the maximum isometric and isokinetic index finger abductions allowing for 10% of the fascicles existing in series were able to accurately re-produce the moment-angle curves.

CONCLUSION: Fascicles arranged in series potentially operate like one long fascicle. In this study it was only feasible to accurately reproduce experimentally determined moment-angle curves if the serial arrangement of fascicles was accounted for. In the model the serial arrangement of some of the fascicles increased the muscle maximum velocity of shortening, in addition it caused a skewing of the force-length curve. This study has demonstrated the potential importance of the relative orientation of the fascicles comprising a muscle on the performance of whole muscle.

ISBI_O1.8 PRECISION OF TRUNK POSTURAL CONTROL IN LOW-BACK PAIN PATIENTS

Miss Nienke Willigenburg, VU University Amsterdam

Prof Jaap van Dieën; Dr Idsart Kingma

INTRODUCTION: Proprioception of the trunk appears to be affected in low-back pain (LBP) patients. This might lead to reduced precision in control of trunk posture and findings of increased cocontraction could be explained as a compensatory strategy to deal with this.

AIM: To compare precision of trunk postural control between LBP patients and healthy controls and to study the effect of disturbing proprioceptive information from the low back through paraspinal muscle vibration on precision.

METHODS: Eighteen subjects with a-specific LBP and 13 healthy controls with no (history of) LBP participated. Subjects performed two tasks requiring high precision of control over trunk orientation. In task 1, a medium-sized target moving slowly over a spiral-shaped trajectory was tracked by making circular movements of the trunk with continuous visual feedback of target and actual trunk orientation. In task 2, subjects maintained upright trunk orientation within a static small or large target. Visual feedback of trunk orientation was given only when orientation was outside the target. In both conditions subjects were instructed to in the target. Both tasks were performed with and without paraspinal muscle vibration. In task 1, the mean distance to the orientation corresponding with the center of the target (error) was used as an index of precision. In task 2, both the mean distance to target center and the SD of the trunk orientation were calculated. Surface-EMG was used to obtain the ratio of antagonist over agonist EMG amplitudes as an index of cocontraction. Mixed design ANOVAs were used for statistical comparisons.

RESULTS: In task 1, errors were significantly higher in patients and an interaction of group with condition, showed that vibration degraded performance in healthy subjects only. In task 2, accuracy and precision were not significantly different between groups, but were degraded by vibration in both groups. No indications for increased cocontraction in patients were found.

CONCLUSION: Precision of trunk control was reduced in patients and not affected by muscle vibration when constant visual feedback (task 1) was present. In contrast, when visual feedback was absent (task 2, large target) or intermittent (small target), precision was not impaired in patients and was affected by vibration in both groups. These results suggest that patients reduce weighting of proprioceptive information from the low back when visual feedback is available, which reduces precision. In absence of visual feedback, proprioceptive information from the low back appears to be used and precision is maintained suggesting that the proprioceptive information itself is valid.

MODELLING & SIGNAL PROCESSING

MOSP_O1.1 OPTIMAL MUSCLE ACTIVATION PATTERNS FOR WRIST MOVEMENTS CONSIDERING INHERENT VISCOELASTICITY IN MUSCLE DYNAMICS

Dr Hiroyuki Kambara, Tokyo Institute of Technology

Dr Duk Shin, Tokyo Institute of Technology; Dr Yasuharu Koike, Tokyo Institute of Technology

INTRODUCTION: One of the great abilities of the neural motor control system is that it can effortlessly solve redundancies inherent in motion control. Although infinite muscle activation patterns can result in the same joint motion, stereotypical patterns are often observed.

AIM: To understand the neural mechanism in which particular muscle activation pattern is favored among infinite possible alternatives, we propose a motor control model and apply it to step-tracking wrist movement. We show that out model can predict a variety of EMG patterns observed by the experiment of Hoffman and Strick (1999).

METHODS: For the computer simulation, the wrist is modeled as a 2-DOF (flexion-extension and radial-ulnar deviation) linear system actuated by five muscles, ECRL, ECRB, ECU, FCU, and FCR. Each muscle is modeled as 2nd-order nonlinear system including the viscoelastic property. The wrist musculoskeletal system is controlled by the motor control model consists of three modules, ISM (inverse statics model), FBC (feedback controller), and FDM (forward dynamics model). ISM generates a feed-forward command signal that shifts the wrist's equilibrium to the final target position. FDM predicts future state of the wrist given the current state and the outgoing motor command signal. Finally, FBC generate feedback command signal according to the deviation between final target and predicted future state. The ISM and FBC are implemented by normalized radial basis function networks of which weight parameters are trained to minimize end-point error and square of total command signal.

RESULTS: Step-tracking wrist movements from a neutral position to 16 different targets located radially around the neutral position were simulated. The command signals generated by the motor control model are considered as 'quasi' EMG signals. For each of the five muscles, quasi EMG signals integrated within agonist and antagonist burst intervals were well fitted by cosine functions of target direction. This result is consistent with the experimental data of Hoffman and Strick (1999). In addition, the quasi EMG signals included several characteristic temporal features observed in the experimental data, but not predicted by other models using simple linear muscle dynamics.

CONCLUSION: The results of the simulation suggest that the CNS is solving the redundancy in muscle activity under the trade-off between end-point error and energy consumption taking into account the viscoelastic property of the muscles.

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MOSP_O1.2 REDUCTION IN MOTION ARTIFACT IN PELVIC FLOOR ELECTROMYOGRAPHY WITH NOVEL ELECTRODE

Ms Joanne Hodder, Queen's University

Dr Linda McLean, Queen's University

INTRODUCTION: Most intravaginal electrodes designed to record electromyograhic (EMG) activity from the pelvic floor muscles (PFMs) consist of stainless steel bars mounted on intravaginal probes. Actions such as coughing cause an abrupt increase in intra-abdominal pressure that may cause motion between the electrodes and the vaginal wall and may result in motion artifact (MA) contamination of EMG recordings. We have developed a differential suction electrode (DSE) to optimize the quality of EMG recordings from the PFMs. Two prototypes have been developed: the first with electrodes located along the rim of the suction head, and the second with them recessed into separate cavities filled with conductive paste.

AIM: The purposes of this study were to determine (i) whether EMG recordings using the DSE have less MA than those recorded using the FemiscanTM intravaginal probe electrode, and (ii) if the second prototype offers improvement over the first.

METHODS: Data analyzed were previous recordings using the Femiscan (n= 328 files), the first prototype DSE (n=340 files) and the second prototype DSE (n=256 files) when 18 healthy continent (26±7 years, 24.7 ± 9.3 kg/m2) and 15 women with stress urinary incontinence (46 ± 14 yrs, 28.6 ± 8.7 kg/m2) performed standing maximal cough efforts. EMG data were recorded from left and right PFMs using DelsysTM AMT-8 pre-amplifiers (bandwidth 20-450Hz, input impedance > 100MOhm, CMR ratio >120dB at 60Hz, Gain X1000) at a sampling rate of 1000Hz. Data were notch filtered using a 5th order Butterworth filter, with corner frequencies at 58 and 62 Hz. Files were considered contaminated with MA if: i) peak spectral density in the 0-20 Hz range was greater than peak density from 20-250 Hz (DeLuca, 2002); and ii) deviation in EMG signal away from baseline was >5 ms (Konrad, 2005). The proportion of files contaminated with MA recorded using each electrode was compared using Z-scores.

RESULTS: The FemiscanTM electrode had 29.3% (96/328) of recordings contaminated with MA, significantly more than the 14.4 % (49/340, z=4.7, p<0.0001) and the 13.3% (34/256, z=4.9, p<0.0001) by the first and second prototype DSEs respectively. The first and second prototypes of the DSE did not record significantly different proportions of files contaminated with MA (z= 1.960, p=0.70).

CONCLUSION: Both prototype DSEs resulted in a significant improvement over the FemiscanTM in terms of MA contamination. Recessing electrodes on the DSE did not markedly improve performance in terms of MA. MA cannot be completely eliminated since the DSE does not prevent motion of the muscle relative to the skin surface, or motion of the leads or wires.

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MOSP_O1.3 ISOMETRIC VALIDATION OF A DETAILED NECK MODEL WITH IMPROVED MUSCLE GEOMETRY

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INTRODUCTION: There are a number of biomechanical head and neck models available which use either forward or inverse dynamics. The latter models have the advantage that calculations can be done quite quickly and muscle recruitment can be dealt with through a minimization criterion. A forward dynamics model can cope with a larger anatomical detail at a cost of a larger calculation time. This makes isometric validation of a forward dynamic model challenging. To the author's knowledge, adequate isometric validation has not been shown for a forward dynamics model including non-linear translational joint compliance.

AIM: This study aims to obtain an isometrically validated forward dynamics neck model with a large anatomical detail. In this study, a forward dynamics MADYMO 50th percentile male neck model is used with 7 free joints and nonlinear joint and ligament stiffness. Isometric validation is performed for maximum head forces in the transversal plane. Preliminary analyses had pointed out a weakness of the model in forward flexion. Newly obtained muscle geometry has therefore been implemented in the model and a method has been developed to optimize muscle recruitment patterns for maximum isometric contractions for this model.

METHODS: Theoretically, the individual muscle activations could be derived using non-linear optimization. However, the large calculation time of the non-linear model and the numerous muscle elements (258) makes this extremely time consuming.

Instead, first approximate rotation points are derived and approximate moment arms are calculated. A traditional inverse dynamic solution is calculated using a quadratic load sharing criterion and the result is verified using the non-linear model.

RESULTS: With joint excursions less than plus minus 2 degrees, the rotation points found are comparable to those found in literature. The model shows an improved maximum voluntary isometric contraction, especially in flexion.

CONCLUSION: This method is effective in obtaining muscle recruitments for simulation of maximum isometric contractions. The new muscle geometry can account for the low flexion force in the earlier model.

ACKNOWLEDGEMENT: This research is supported by the Dutch Technology Foundation STW, which is the applied science division of NWO, and the Technology Programme of the Ministry of Economic Affairs. (See www.neurosipe.nl - Project 10736: TORTICOLLIS)

MOSP_O1.4 ANALYSIS OF SURFACE ELECTROMYOGRAPHY SIGNALS USING CONTINUOUS WAVELET TRANSFORM FOR FEATURE EXTRACTION

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INTRODUCTION: A number of Digital Signal Processing techniques are being applied to Surface Electromyography (SEMG) signals for classification using feature extraction. Traditional analysis methods such as Fast Fourier Transform (FFT) could not be used alone because muscle diagnosis requires time-based information. Continuous Wavelet Transform (CWT) was selected for extracting efficient features of the SEMG signals in this research. CWT includes time-based information as well as scales, which can be converted to frequencies, making muscle diagnosis easier. CWT produces a scalogram plot along with its corresponding time-frequency based spectrum plot. Using the extracted features of the dominant frequencies of the wavelet transform and the related scales, we were able to train and validate an Artificial Neural Network (ANN) for signal classification.

AIM: To analyse the SEMG signals to obtain 'time-based' information for a particular frequency content using Short Time Fourier Transform (STFT) and CWT for more detailed analysis and produce a better time-frequency resolution.

METHODS: For the feature extraction process, a part of the raw SEMG signals was selected. The selected region is a four second interval after the first peak signal activation. The first two seconds were not processed and analysed to allow changes in the muscle tension at the beginning of the muscle contraction. The next two seconds was the region to be processed and analysed. There was no muscle fatigue present in this region and was assumed to be quasi-stationary, which is stationary during short time intervals. Under this assumption spectral analysis for feature extraction can be applied.

RESULTS: The results showed that by using the scalogram and the frequency-time based spectrum plot, the extracted features of the dominant frequencies and the related selected scales of the CWT analysis can be used to train and validate a signal classifier based on an ANN.

CONCLUSION: Signal processing, analysis and feature extraction of the SEMG signals was found to be more flexible in LabVIEW. The reason for this claim is the versatility of being able to control the region of the signal to be analysed from the front display panel of the VI's without going into the core programming block chart, hence minimising programming error.

ACKNOWLEDGEMENT: The authors would like to thank Grant Mawston for valuable comments.

MOSP_O1.5 VALIDATION OF A NOVEL METHOD OF CARDIAC ARTEFACT REMOVAL FROM TRUNK MUSCLE ELECTROMYOGRAPHY

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INTRODUCTION: Cardiac (ECG) artefact can be a significant source of contamination in trunk muscle electromyography (EMG), particularly for time domain analyses of the muscle at rest or during low amplitude contractions. The majority of existing methods for ECG artefact removal are computationally intensive and not suitable for applications such as biofeedback that require online artefact removal.

AIM: We describe a novel method of ECG artefact removal, and compare it with existing methods that share the advantage of rapid processing time.

METHODS: The novel method of ECG artefact removal isolates the artefact by applying a 20Hz low-pass filter to the raw EMG signal. Heart beats are identified using a separate electrocardiograph (ECG) channel, and heart beat artefacts in the filtered EMG signal are then subtracted out of the raw signal during periods of ECG contamination. This method was compared to an averaging method that subtracts the averaged waveform derived from a series of ECG artefacts from periods of contamination in the raw signal. The root mean square (RMS) amplitude obtained with these processing methods was compared to the RMS of the raw signal prior to artefact removal, and to the gated signal in which all periods of ECG contamination were removed to estimate the amplitude of the uncontaminated EMG. 90-s EMG recordings from the resting left trapezius in 15 healthy participants were analyzed.

RESULTS: A repeated measures analysis of variance indicated a significant effect of processing method on RMS amplitude ($F=52.2$, $p<0.001$). RMS of the gated (uncontaminated) signal was 25% lower than the raw (contaminated) signal ($p<0.001$). Both methods of artefact removal reduced RMS compared to the raw signal ($p<0.001$). RMS for the 20Hz filtering method was not different from the gated signal amplitude ($p=0.328$), whereas RMS was higher for the averaging method compared to gated signal ($p<0.0001$).

CONCLUSION: ECG artefact has a large effect (25% increase) on the amplitude of the resting trapezius EMG signal. The 20Hz filtering method has a statistically similar effect on signal amplitude as gating, while minimizing loss of EMG data during periods of ECG contamination. The averaging method significantly reduces ECG artefact, but does not completely remove it. The 20Hz filtering method is recommended as a valid option for rapidly removing ECG artefact for time domain analyses of trunk muscle EMG. Implications for biofeedback applications and occupational exposure analyses of EMG gaps and muscle rest are discussed.

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MOSP_O1.6 TOWARD A MULTISCALE PHYSIOLOGICAL MODEL OF THE UTERINE MUSCLE ACTIVITY

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INTRODUCTION: During pregnancy, early recognition of uterine contractions leading to preterm delivery is crucial for preventing premature birth. Unfortunately, early assessment of preterm delivery is still a major issue for gynecologists. Surface measurement of the uterine muscle electromyogram, commonly referred to as electrohysterogram (EHG) has been previously demonstrated promising for uterine activity assessment, but the value of the EHG for predicting preterm delivery has not been established. The main obstacle is that some aspects concerning the physiology of contractions and their link to the EHG are not fully understood. A comprehensive model of the uterine muscle electrical activity would permit understanding the important link between the genesis and evolution of the action potential at the cell level and the process leading to delivery.

AIM: This study aims at a preliminary electrophysiological model that describes the multiscale evolution of the uterine electrical activity, from its genesis at the cell level, through its propagation along the uterine muscle tissue cells and the volume conductor, up to the EHG as recorded on the surface of the abdomen.

METHODS: A new physiology-based model of the electrical activity generation at the cell level is here obtained based on a previously validated extended mathematical model of the transmembrane potential as a function of the involved ionic channels and currents. An analysis of the extended model dynamics permitted reduction of the model from 10 to 6 variables. After further reduction to 3 variables, propagation of electrical activity over rectangular tissue samples was simulated using a gap junction model based on the reaction-diffusion equation. At the organ level, to simulate the EHG as recorded on the abdominal surface, the volume conductor was modeled by solving the Poisson equation at the 4 interfaces of the abdominal tissues (abdominal muscles, fat, and skin) interposed between the uterine muscle and skin surface.

RESULTS: At the cell scale, good agreement is found between the reduced 6-valiable model and the extended model. Further reduction from 6 to 3 variables does not significantly affect the potential spike and its global behavior (RMS error=11.2%) but allows for 50% faster computation of the tissue model. A qualitative validation of the multiscale model is provided by the agreement observed between the simulated signal at the abdominal skin surface and a real EHG recorded by a high density electrode grid during labor.

CONCLUSIONS: This study provides a preliminary step toward a comprehensive physiological multiscale model of the uterine electrical activity, which can lead to more effective tools for the prevention of preterm delivery.

MOSP_O1.7 EXTRACTING SINGLE MOTOR UNIT PARAMETERS USING SPIKE TRIGGERED AVERAGING OF THE SURFACE ELECTROMYGRAM

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INTRODUCTION: In human muscles, single motor unit (MU) activity is typically obtained using intramuscular (IM) EMG recordings. However, this IM technique can only detect a limited number of MUs at any given force level, is time consuming to implement, and electrode insertion induces pain to the subjects. A novel surface EMG (sEMG) electrode array recording (Delsys, Inc.) and decomposition method has recently been developed (Nawab et al. 2010) and it yields a large number of MU signals simultaneously over a relatively large force range.

AIM: The objective of this study was to characterize the properties of single MU signals recorded with the Delsys decomposition system using an analytical method based on the spike triggered average (STA) of the sEMG. In this way, we plan to determine MU signal parameters for different MUs, at low and high forces.

METHODS: To estimate the STA action potential (AP) properties, the time of firing of the decomposed MUs was used as the trigger signal to collect a signal average from the sEMG. Two criteria were used to identify MUAP's reliably: the stability of the STA estimated AP shapes, and the correlation between the STA estimate and the estimated AP templates. To estimate the stability of STA AP shapes, the waveforms were assembled using a moving window of 8 s that yielded approximately 100-200 firing events in each window. This window was then shifted using a step size of 1 s on the EMG data. The variability (coefficient of variation (CV)) of the AP peak-to-peak (P-P) amplitude across the different windows was calculated as a measure of stability. The maximum linear correlation between the STA and Delsys template pairs was also calculated across the whole sample duration. Through a sensitivity analysis, the MUs that have CV of P-P smaller than 0.3 and correlation larger than 0.7 were identified as reliable MUs.

RESULTS: Using the Delsys decomposition and STA MU selection criteria, we were able to extract the morphological characteristics of the APs and firing activities of up to 29 MUs of the first dorsal interosseous muscle in a single contraction. An average of 166 MUs (a total of 8 trials) was extracted from 8 subjects.

CONCLUSION: The analytical method described combined with the surface template decomposition system provides an efficient way to identify a large number of MUs that can be used to systematically examine the MU pool organizational properties in healthy individuals and populations with neuromotor disorders.

MOSP_O1.8 SIGNAL GENERATION MODEL OF SURFACE ELECTROMYOGRAPHY (SEMG): PRELIMINARY RESULTS.

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INTRODUCTION: The problem of simulating surface electromyography signals (SEMG) has been addressed by several groups of researchers from the international scientific community resulting in multiple models [Merletti, 1999, Farina, 2004, Duchene, 2000, Wheeler, 2010]. The main motivation for addressing this problem lies in understanding the physiological relationships involved in the generation of signal registration on the surface of the skin, under certain conditions, providing an environment of control over this phenomenon. Having simulated signals, controlling the parameters involved in their generation provides advantages for testing procedures and processing techniques, obtaining results considered a priori knowledge for later use these procedures and techniques with real signals.

AIM: To propose a SEMG signal model that includes more complete anatomical and physiological elements, such as the spatial distribution of muscle fiber type (I and II).

METHODS: Once described the Single Fiber Action Potential (SFAP), we applied the transformations due to the electrical volume conductor surrounding fibers and the detection system used to record SEMG signal. We used the characteristics of the motor unit (UM) such as: firing rate, muscle fiber diameter and locations of the MU in the volume conductor conditioned by the type of fibers belonging to it and the MU recruitment due to different levels of voluntary contraction; to generate the motor unit action potentials (MUAP) and to get from these MUAP, the SEMG signal. We compared the RMS values and the level of agreement between the records obtained from the biceps brachii of 15 healthy subjects and simulations considering experimentally determined values obtained directly from the registered subjects and from data published by some authors [Wheeler, 2010].

RESULTS: We determined the RMS value of 60 SEMG signals recorded in 15 healthy subjects and SEMG simulated with the SEMG model proposed here. We determined the mean difference and the level of agreement between them, obtaining an agreement of 0.05 ± 0.02 of the normalized RMS value.

CONCLUSION: The preliminary results show a high level of agreement (0.05± 0.02) between the simulated signals and that experimentally recorded, because our SEMG model considered experimental values in the anatomic and physiologic characteristics of generation and the spatial distribution determined by the type muscle fiber (I and II), which seems to favor the performance of the model here presented.

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MOSP_O2.1 PATTERN RECOGNITION OF INTRAMUSCULAR EMG AFTER TARGETED MUSCLE REINNERVATION FOR CONTROL OF MYOELECTRIC PROSTHESES

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INTRODUCTION: Targeted muscle reinnervation (TMR) has been an important advance for the function of myoelectric prostheses. Surface electromyography (sEMG) recorded from TMR muscle has been successfully used for both traditional amplitude-based myoelectric control and for novel pattern recognition-based control. However, intramuscular EMG (imEMG) of TMR muscle has not been previously characterized. Furthermore, it is unknown whether imEMG of TMR muscle may be used to successfully train pattern recognition algorithms originally developed for sEMG.

AIM: To describe the signal properties of imEMG recorded from TMR muscle, and to determine whether such signals may be used to train a pattern recognition system with proportional control that was previously shown successful with sEMG.

METHODS: Fine wire electrodes were inserted into reinnervated muscles of TMR patients at multiple orientations and interelectrode distances. The imEMG was recorded during 8 classes of contraction. Linear discriminant analysis classifiers were trained from time-domain features of the imEMG, and classification accuracies were compared to those obtained with sEMG. Subjects were also guided through contractions of linearly increasing intensity, from which a mean absolute value (MAV)-based proportional control algorithm was evaluated.

RESULTS: imEMG signal properties of TMR muscle varied with reinnervated site. Though some sites showed interference patterns, others had fewer than expected motor unit action potentials (MUAPs). Such signals contained trains of discrete spikes, often with large amplitudes. Pattern classification using TMR signals had accuracies ranging from 65.9% (4 degree of freedom (DoF) classifier) to 80.0% (2 DoF classifier), whereas accuracies using sEMG from the same reinnervated sites ranged from 83.3% (4 DoF classifier) to 88.8% (2 DoF classifier). MAV-based proportional control using imEMG also showed variability in approximating the MAV of sEMG. Poor approximations were seen in signals with few motor units, as recruitment of large MUAPs caused substantial non-linear increases in MAV. Classification accuracy and proportional control did not improve by modifying interelectrode distance and orientation.

CONCLUSION: Reinnervation after TMR was shown to produce a variety of imEMG signal types. Signals with sparse motor units and signals resembling healthy muscle imEMG were both seen. For TMR subjects, pattern classification and proportional control algorithms had poorer performance using imEMG than using sEMG. Improvement in control may require modifying current control algorithms or sampling additional motor units (either by targeting areas with more motor units or by increasing the number of intramuscular recording sites).

MOSP_O2.2 THE NUMBER OF TRIALS REQUIRED FOR REPRODUCIBILITY OF FORCE AND SEMG TRACES DURING MAXIMAL ISOMETRIC STRENTH ASSESSMENT

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INTRODUCTION: Experimental designs involving maximal strength assessment include a familiarization session to stabilize force and muscle activity and ensure that participants are generating maximal effort contractions. Calder and Gabriel (2007) demonstrated that performance changes were equivalent if 15 trials were performed in one session or distributed across three sessions.

AIM: The purpose of this study was to determine the number of contractions necessary for participants to become familiarized with generating maximal isometric contractions within a single session.

METHODS: Eight college-aged males performed 15 maximal voluntary isometric contractions of the tibialis anterior. Each contraction was 5 seconds in duration with two minute intertrial rest periods. The sEMG activity of the tibialis anterior and soleus were recorded with Ag/AgCl electrodes in a bipolar configuration. The sEMG signal was amplified and band-passed filtered (3-1000 Hz) prior to digital recording at 2 kHz. Dorsiflexion force was recorded concurrently at the same sampling rate; it was then low-passed filtered (15 Hz) using a dual pass second-order Butterworth digital filter. Mean force and root-mean-square (RMS) amplitude of the sEMG signals were obtained from 500 ms window before the middle of the contraction. To evaluate the reproducibility, the variance ratios (Kadaba et al., 1989) of the force and sEMG traces were calculated after each trial was interpolated to 8000 points. The sEMG activity was linear envelope detected at 15 Hz prior to interpolation.

RESULTS: Repeated measures ANOVAs were conducted on the 15 trials by grouping them into 3 blocks of 5 trials. The omnibus F-test revealed a significant decrease in the variance ratio across Blocks for both the force and sEMG traces ($p<0.05$). Post-hoc analysis then showed that only Block 1 was significantly different from Blocks 2 and 3. There was no significant ($p>0.05$) difference in mean force but there was a significant ($p<0.05$) decrease in tibialis anterior and soleus RMS sEMG amplitude from Blocks 1 to 3.

CONCLUSION: The non-significant change in variance ratio from Blocks 2 to 3 for both force and sEMG indicates that only two blocks of five contractions are required to learn the specific task. The decrease in RMS sEMG amplitudes may indicate that, although sufficient rest periods were given, fatigue was present. Alternatively, the decrease in soleus RMS sEMG (reduced antagonist coactivation) may allow for the same force to be generated with less activation from the tibialis anterior (agonist).

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MOSP_O2.3 A SEMI-AUTOMATIC METHOD FOR MUSCLE ONSET DETECTION BASED ON EMG

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INTRODUCTION: Thresholding EMG envelopes is a basic way to determine muscle activity during gait, for example, via the average activity plus two standard deviations [1]. the proposed automatic method for EMG onset detection works by 'learning' from the experts' evaluation, which is acknowledged as being the golden standard.

AIM: Improve the quality and the level of automatic EMG onset detection using thresholds learned from the combined knowledge of multiple experts.

METHODS: EMG was collected during gait analysis of the gastrocnemius, tibialis anterior, medial hamstrings, rectus femoris and soleus muscles for five subjects (137 strides). EMG was pre-processed by filtering (zero-phase bandpass filter, 20-500 Hz, 6th order Butterworth), determining the RMS value (window length = 25 ms) and normalization on a stride-by-stride basis to the average amplitude of the 2.5 % highest samples of the stride. To develop and validate the automatic method, three experts manually determined the on/off signals of all gait cycles. All RMS samples of each stride in the learning set (97 strides) were sorted in two bins, the first containing those labeled 'on' by the experts, the other those labeled 'off'. The point of highest separation between both bins was chosen as the learned threshold for each stride and muscle. The average of these thresholds yields the threshold to be used in future processing of new data. The validation is based on the number of false classifications when applying the thresholds on strides not included in the learning set (40 strides). Performance is compared to the methods of Di Fabio [1] and of Staude [2].

RESULTS: When calculating the positive and negative predictive (PPV and NPV) values for all methods. The proposed method on average had a PPV of 76,30 and an NPV of 94,42, compared to 57,13 and 70,64 for the method by Di Fabio [1] and 64,04 and 68,69 for the method by Staude [2].

CONCLUSION: The proposed method performs significantly better than the others. However, the proposed method expects a certain amount of both on- and offset, requires manual intervention, which is time consuming and assumes that the experts knowledge is the ground truth.

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MOSP_O2.4 APPLICATION OF COMPLEX DEMODULATION METHOD FOR CLASSIFICATION OF MOTOR UNIT ACTION POTENTIALS

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INTRODUCTION: EMG signal decomposition need a lot of properties of MUAP waveforms to classify them into their trains. However, MUAP waveforms have not so much information to classify because different MUAP waveforms are mostly similar with each other. Complex demodulation method (CDM) has recently been focused from sleep stage EEG analysis or biological signal analyses to classify each waveform owing to higher feasibility and light calculation. Therefore, we should apply EMG signals .

AIM: The purpose of this study is to investigate whether or not CDM can increase information or benefits for classification of MUAP waveforms.

METHODS: There are a lot of methodologies to calculate time-frequency domain components, i.e. traditional fourier transforms, wavelet analysis. Especially, CDM is a methodology as frequency domain analysis which is mostly applied to communication technologies. CDM has higher temporary resolution and lower calculation cost than ordinary frequency domain analyses owing to simplicity of CDM equation. In this study, we actually compared CDM with traditional time-frequency domain analyses, FFT and wavelet analysis.

RESULTS: Our result showed that CDM extracts not only broader band frequency domain components from DC to around 1kHz of MUAPs but also narrower temporary band, which is almost the same as the MUAP durations, than those of FFT and wavelet analyses. Any MUAPs have the same characteristics of broader frequency band from DC component to around 1kHz within narrow time band. Even if MUAPs have only lower signal-to-noise ratio, their characteristics are maintained.

CONCLUSION: For extraction of MUAP feature, our results indicate that CDM is very useful for classification of MUAP train because single MUAP waveform have few information to be classified into any trains. CDM has the capability, with higher temporary resolution, to calculate frequency domain components as compared with other traditional time-frequency analyses. Then, in low signal-to-noise EMG signals, MUAP waveforms cannot efficiently be detected. CDM makes us easier to detect visibly and computationally because MUAP frequency domain component distributes broader frequency band than any noise signals. Then, CDM also can extract finite range sinusoidal signal into the specific frequency band. Therefore, CDM is also useful for detection of sinusoidal artifact, for example commercial source, as compared with other frequency domain analyses.

Property of CDM frequency components of a single MUAP with higher temporary resolution lets us perform EMG signal decomposition more efficiently because CDM provides plenty of information to classify MUAPs into any trains.

MOTOR CONTROL

MOTC_O1.1 REGULATION OF CONTROL BANDWIDTH DURING STICK BALANCING

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INTRODUCTION: Why can we balance a yardstick but not a pencil on the tip of our finger? This is because, like physical control systems, human motor control also has bandwidth limits. By bandwidth limit, we mean that the dynamics of the system we want to stabilize are outside the capacity of the control system. Stated differently, the control system cannot respond fast enough to stabilize the object. Highly responsive control systems have high bandwidths; whereas “sluggish” control systems have lower bandwidths. One factor that affects the responsiveness of human motor control is the stiffness in the muscle-tendon unit (Cavanagh). Low stiffness decreases the rate of force development, making the control system less responsive, resulting in a lower bandwidth limit. When a muscle is at rest, the muscle-tendon unit is very compliant, but with higher muscle activation stiffness gradually increases (Huxley). We hypothesized that the central nervous system (CNS) regulates control bandwidth by adjusting the level of muscle activation in both the agonist and antagonist muscles. Increased agonist-antagonist muscle coactivation allows human motor control to be responsive to sudden changes in direction.

AIM: The aim of the project was to test our hypothesis using a simple stick balancing task.

METHODS: Nine subjects performed stick balancing in which an attached mass was progressively lowered in subsequent sets of trials. The position of the stick, and EMG signals of forearm and trunk muscles were collected during stick balancing.

RESULTS: Reducing the mass resulted in a larger average stick displacement during the trial ($p<0.001$). Both agonist and antagonist muscle activation in the forearm as well as the trunk increased as the mass was lowered (all $p<0.001$).

CONCLUSION: Reducing the mass height resulted faster movements of the stick (higher dynamics) as indicated by the larger average stick displacement during stick balancing. Faster movements of the stick required that the control system be more responsive (i.e., higher rate of force development) to keep the stick upright. To improve the responsiveness of the control system, muscle coactivation in the forearm and trunk muscles increased. Therefore, the data supports our hypothesis that CNS regulates motor control bandwidth by adjusting the level of coactivation. The data suggests that the CNS adapts human motor control to ensure task stability, by regulating bandwidth control, while at the same time minimizing excessive muscle coactivation, which can be metabolically costly.

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MOTC_O1.2 CHANGES IN CONSTRAINT OF PROXIMAL SEGMENTS AFFECTS TIME TO TASK FAILURE AND ACTIVITY OF PROXIMAL MUSCLES IN A POSITION-MATCH TASK

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INTRODUCTION: Time to task failure in limb muscles is longer for tasks that maintain a constant submaximal force against a rigid constraint (force-match task) than a constant joint angle with an equivalent load (position-match task). Differences in motor unit recruitment and muscle spindle sensitivity have been proposed to underlie this difference. Differences in activity of muscles other than the agonist, such as those used to support the test limb, could also contribute. Some previous studies have involved greater limb support (postural constraint) provided by the experimental set-up in force- match task. This could explain longer time to task failure.

AIM: This study investigated the effect of varying postural constraint on time to task failure during a position match task and compared time to task failure between position- and a force-match tasks in which constraint was equivalent.

METHODS: Seventeen healthy adults (32 ± 7 year) performed three 'isometric' knee extension tasks on separate days. In supine with the right hip and knee at 90°, participants maintain either target force (mean [SD], 89.0 [34.9] N) or 90° knee angle (with 89 [35] N inertial load: P = 0.066) until task failure. Two wide straps were applied to the upper thigh and pelvis in the constrained tasks. Electromyography (EMG) was recorded from vastus medialis and lateralis, tensor fascia latae, biceps femoris and semitendinosus.

RESULTS: Time to task failure was shorter for the unconstrained position-match task (161 [55] s) than the constrained tasks (position (184 [51] s, force (216 [56] s). Shorter time to failure was accompanied by greater EMG amplitude of the primary, proximal and antagonist muscles towards and at the end of the contraction. EMG median frequencies decreased over time in all muscles, but did not differ between tasks. Variability in position around the target was greater in the unconstrained position-match task than the constrained position-match task.

CONCLUSION: These findings indicate that absence of constraint increases task difficulty, with higher muscle activity of muscles acting at the primary and more proximal limb joints. As task performance remained shorter in position-match (compared to the fore match) task, even when performed with equivalent constraint, other factors such as motor unit recruitment and muscle spindle input are also likely to contribute to the reduced time to task failure in position match tasks.

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MOTC_O1.3 USE-DEPENDENT LEARNING GENERALIZES IN EXTRINSIC COORDINATES AND CAN BE EXPLAINED BY ALTERED SYNAPTIC WEIGHTS IN A POPULATION CODING MODEL

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A/Prof Stephan Riek, The University of Queensland; Dr Aymar de Rugy, The University of Queensland; Dr Timothy Carroll, The University of Queensland

INTRODUCTION: Human motor learning involves both error-based corrections and a use-dependent component that biases subsequent movements towards those repeated during practice.

AIM: In an isometric forearm aiming task, we tested for bias in force direction in multiple areas of the workspace in response to a single training direction, and determined whether this bias is represented in an extrinsic or muscle-based reference frame.

METHODS: Training involved 40 maximal-force ballistic contractions toward a single target. The effects of training were tested in a low-force task that required subjects to move a cursor from the centre of a two-dimensional display towards radial targets (movement time = 150 - 250ms). During the low-force task, subjects received online feedback of the magnitude of force via an expanding circle, but not the direction. Angular deviation from the target direction was calculated at 95% of the target distance.

RESULTS: In experiment 1 (n=10), we found that aiming direction was broadly biased towards the training direction according to a function that was predicted by a rescaling of synaptic weightings in a population coding model of cortical processing. Specifically, the observed bias was well fit by the model when synaptic weightings of neuronal outputs were increased as a linear function of their firing rates during production of force in the training direction. In experiment 2 (n=12), when both the aiming task and training were conducted in the same (neutral) forearm posture, there was aiming bias for high-force, but not low-force training. When the training contractions were performed in a 90o pronated forearm posture, whereas the aiming task was performed in a neutral forearm posture, there was aiming bias toward the training direction defined in extrinsic space, even for targets where this resulted in errors away from the pulling direction of the trained muscles.

CONCLUSION: The effects of use-dependent learning in isometric aiming generalize broadly to untrained movement directions, are represented in an extrinsic rather than muscle-based reference frame, and are facilitated by training involving strong neural drive.

MOTC_O1.4 GAIN MODULATION OF LONG LATENCY REFLEX IN HUMANS

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INTRODUCTION: When upper limb muscles in humans are perturbed to induce a stretch reflex, two distinct reflex peaks are observed in the electromyographic (EMG) activity recorded from the stretched muscles. The short latency component (M1; onset of approximately 25 ms) is mediated largely by the spinal monosynaptic reflex while the longer latency reflex (M2; duration approx 55 – 100 ms) is suggested to involve a transcortical pathway. The question whether the magnitude of M2 can be changed by "central set" at the supraspinal level, or by superposition of non-reflex activity at the spinal level, is not resolved.

AIM: We hypothesize that the gain modulation observed for M2 results from superposition of very fast voluntary reaction-time activity onto M2.

METHODS: To test this hypothesis, the right wrist flexors were stretched with a perturbing pulse applied with a torque motor while EMG was recorded from right and left wrist flexors and extensors. The subjects were instructed (1) not to react to the perturbation (passive task); or (2) to flex both their wrists simultaneously, as fast as possible, when they perceived perturbation to the right wrist (active task).

RESULTS: During the active task, reaction time (RT) activity in the right flexors was preceded by M1 and M2 while the left hand reaction time activity was observed without interference from reflexes. It was noted that in many subjects, RTs on the unperturbed left side were frequently as short as 75 ms and on occasion, were less than 60 ms. If one assumes that the RTs on the unperturbed side are at the most equal, if not longer than on the right hand perturbed side, then M2 magnitude should be enhanced by contribution from voluntary activity associated with short reaction times. We observed that the gains of M2 were low during the passive task and were increased substantially during the active task in subjects with very short reactions times as estimated from the left wrist flexors. In subjects with long RTs, there was no significant difference in the magnitude of M2 between the active or passive tasks.

CONCLUSION: Based on these findings, it is concluded that the increased magnitude of M2 during the active task receives a large contribution from voluntary activity, though changes in the excitability of the central pathway cannot be ruled out.

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MOTC_O2.1 ERGOGENIC AND NEURAL EFFECTS OF A CAFFEINATED DRINK STUDIED BY TRANSCRANIAL MAGNETIC STIMULATION

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INTRODUCTION: Caffeine supplementation has been shown to enhance exercise performance, initially thought to be due to enhanced lipolysis and carbohydrate sparing via adrenergic stimulation, but more recently the adenosine receptors and neural effects have been implicated.

AIM: This double-blind repeated measures placebo-controlled experiment examined the effects of caffeine ingestion on central excitability and muscle performance before, during and after repeated maximal voluntary isometric dorsiflexion contractions (MVC) to fatigue.

METHODS: 11 volunteers (24±1.4y, 73±3.4kg, 175±1.7cm) completed an exercise protocol consisting of brief ankle dorsiflexion contractions at different intensities before, one-hour after consuming a drink either with (CAF, 6mg/kg) or without (PL) caffeine and after intermittent 2s-MVCs to fatigue . Torque was recorded in parallel with the surface compound motor evoked potentials (MEP) from m. tibialis anterior (TA) in response to suprathreshold single pulse transcranial magnetic stimulation (TMS). Central excitability was quantified by the MEP parameters and cortical silent period duration (SP). Voluntary activation (VA) and muscle contractility were assessed by the time-amplitude parameters of the TMS-evoked twitches. Statistical data analysis was performed by 2way ANOVA (condition vs time).

RESULTS: Data are reported as mean±SEM (CAF vs PL). One-hour after caffeine consumption corticospinal excitatory input to relaxed TA was increased (MEP amplitude: 18.1±9.6 vs -21.1±7.8%, $p=0.025$), but during MVC neither torque nor MEP parameters were altered despite a tendency for increased intracortical inhibition (SP: 15.6±6.1 vs 8.7±4.6%, $p=0.069$). MVC torque (-45±4 vs -44±3%, $p<0.0001$) and TA EMG activity (RMS amplitude: -22±3 vs -25±2%, $p=0.003$) declined to a similar extent at fatigue, but exercise duration (425±87 vs 350±43s) and the number of repetitions completed to reach fatigue (120±24 vs 98±10) tended to be greater in the CAF trial (both $p> 0.05$). Although VA was lower at fatigue in both trials (-9.8±3.2 vs -17.2±4.6%, $p=0.002$), central fatigue was attenuated in the CAF trial both at fatigue ($p=0.064$) and immediately post (VA:-0.3±3.0 vs -16.6±8.6%, $p=0.044$). Muscle contractility was enhanced in CAF whilst decreasing in the PL trial (relaxation rate: 37.6±27.9 vs -32.8±6.9%, $p=0.002$). Despite these differences, the post-exercise decline in corticospinal excitability (TA MEP amplitude: -15.3±6.2 vs -20.0±6.0%, $p=0.10$) was similar between trials.

CONCLUSION: The ergogenic effects of caffeine seem to rely upon both increased peripheral contractility and better maintained voluntary activation (neural input to the muscle). These effects are dependent upon the state of the muscle; fresh or fatigued, relaxed or contracting.

MOTC_O2.2 RTMS OVER HUMAN MOTOR CORTEX CAN MODULATE TREMOR DURING MOVEMENT

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INTRODUCTION: Abnormally large tremor during movement is a symptom of many movement disorders and can significantly impair activities of daily living.

AIM: To investigate if repetitive magnetic brain stimulation (rTMS) can reduce tremor size during human movement. rTMS is a non-invasive method of stimulating the brain of conscious humans through the scalp. It is used to transiently alter neural circuitry involved in movement. We hypothesised that inhibitory rTMS over motor cortex would reduce tremor size during subsequent movement.

METHODS: The experiment involved 26 healthy young adults (21±2 yrs) and began with application of single stimuli to measure baseline corticospinal excitability. The response to stimulation was recorded in hand muscles with electromyography (EMG). Subjects then performed a 3-min task to measure baseline tremor during movement. This involved matching index finger position with a moving target on a computer screen. Tremor was recorded with an accelerometer on the fingernail. Finger acceleration was analysed with fast-fourier transform to quantify tremor in the physiological frequency range (8-12 Hz). Subjects then received 10 mins of real (n=13) or sham (n=13) rTMS (intermittent 6 Hz stimulation, subthreshold intensity, total 600 stimuli). Tremor and corticospinal excitability were then remeasured.

RESULTS: Real rTMS significantly decreased corticospinal excitability by ~30% (P=0.022) and increased the amplitude of tremor during movement by ~84% (P=0.047) relative to sham rTMS (significant group-by-time interaction). However, the direction of tremor change was opposite to that hypothesised for inhibitory rTMS.

CONCLUSION: rTMS may alter tremor through stimulation-induced changes in corticospinal excitability, central oscillations of brain activity, and/or pulsatile control of opposing finger muscles. Future research will involve utilising excitatory rTMS to potentially reduce tremor size with a view to developing new therapeutic avenues for treatment of abnormal tremor.

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MOTC_O2.3 FUNCTIONAL CONNECTIVITY BETWEEN SUBPARTS OF TRAPEZIUS AND SERRATUS ANTERIOR MUSCLES AMONG SUBJECTS WITH AND WITHOUT SHOULDER IMPINGEMENT

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INTRODUCTION: Normal function in the shoulder region requires a balanced activation of main stabilizing muscles. Due to the extensive degree of freedom in shoulder muscle synergies a suboptimal balance is assumed to cause lack of stabilization and be the underlying cause of functional disabilities such as impingement. A recent study suggested that functional connectivity within trapezius muscle subdivisions could be revealed by mutual information (MI) detecting linear and non linear dependencies between time series and further, showed enhanced connectivity in presence of delayed onset muscle soreness (DOMS)(1).

AIM:The present study investigates the differences in functional connectivity within the upper (UT), middle (MT), lower (LT) trapezius and Serratus muscles among subjects with (SIS) and without shoulder impingement (NO-SIS).

METHODS: Laboratory case-control study, 31 subjects (16 SIS and 15 No-SIS) (mean age, 41 yrs ±14; 39 yrs ±12.0). Surface electromyography in % of maximum voluntary EMG was recorded from UT, MT, LT and Serratus, during standing arm elevation (0-180°) and lowering (180-0°) in the scapular plane, with 0, 1 and 3 kg hand held load. For all 6 possible muscle pairs (Serratus and UT, MT and LT, respectively, and UT-MT, MT-LT and UT-LT) normalized MI as a measure of dependence was calculated based on the density function estimated from a histogram constructed of 64 bins (1). Non overlapping epochs of 0.5 s were used to compute the normalized MI between muscle pairs. For each pair the median value of estimated normalized MI was extracted.

RESULTS: MI for MT-LT was about twice as large as for all other combinations (0.052 versus range from 0.026 to 0.035($P<0.05$)). MI was larger for SIS than No-SIS (0.034 versus 0.032 ($P<0.05$)) for all combinations of muscles or muscle subdivisions. Among No-SIS, MI in all muscle pairs increased with increasing loads (0.029, 0.032 and 0.035 for 0, 1 and 3 kg, respectively, while this was not the case among SIS (0.042, 0.032 and 0.040 for 0, 1 and 3 kg, respectively).

CONCLUSION: These results show similarly for SIS and No-SIS the highest functional connectivity between MT and LT. In line with earlier results on DOMS, the present findings in SIS support a pain associated increase in functional connectivity in activation pattern unrelated to the actual load and maybe indicating over stabilization.

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MOTC_O2.4 BRAIN MOTOR CONTROL ASSESSMENT OF UPPER LIMB FUNCTION AFTER SPINAL CORD INJURY

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Prof Mary Galea; Prof David Morgan

INTRODUCTION: Neuropathological examination of patients with spinal cord injury (SCI) reveals that lesions are variable with regard to severity, and the extent to which descending tracts are spared. Detailed characterization of the impact of SCI on motor control processing is a very complex and difficult task. The Brain Motor Control Assessment Protocol (BMCA) is a surface electromyography (sEMG)-based measure of motor output from the CNS during a variety of reflex and voluntary motor tasks performed under strictly controlled conditions. This test has been used to evaluate lower limb functions after SCI. However, such a protocol does not exist for upper limb evaluation.

AIM: 1) to develop a BMCA protocol to evaluate upper limb function; 2) to calculate the voluntary response index (VRI) from quantitative analysis of sEMG data during defined voluntary movement in healthy people for comparison with that of SCI patients.

METHODS: The BMCA protocol included seven parts: relaxation, reinforcement manoeuvres, voluntary tasks, passive movement, tendon-tap reflex response, clonus and vibration responses. EMG was recorded from the following muscles on both sides: deltoid, biceps, triceps, wrist flexor muscle group, wrist extensor muscle group, opponens pollicis and pectoralis major. The VRI comprised two numeric values from 9 neurologically intact subjects, one derived from the total muscle activity recorded for the voluntary motor task (magnitude), and the other from the sEMG distribution across the recorded muscles (similarity index - SI). To evaluate the protocol, the VRI was obtained from a SCI subject after 6 weeks of task-specific upper limb exercise program.

RESULTS: Unpaired T-tests comparing EMG magnitude values from right and left sides for normals showed no significant difference between the two sides ($P > 0.05$). Therefore these values were pooled before calculation of SI values. SI values showed that on a per task basis, the best match to prototype was unilateral elbow flexion (94% > 0.95) followed by unilateral wrist flexion (78% > 0.95). No subject produced SI values of greater than 0.95 for more than 64% of the tasks. However, 4 subjects produced SI values greater than 0.95 for more than 45% of the tasks. Also, SI values for five subjects were greater than 0.90 for 60% of tasks. After the 6-week upper limb exercise program, the SCI patient showed improvement in SI values for right shoulder abduction/adduction (0.84 to 0.9 / 0.5 to 0.7) and left elbow flexion/extension (0.95 to 0.99 / 0.5 to 0.8) respectively.

CONCLUSION: To validate this index for clinical use, serial studies using larger numbers of patients should be performed.

ACKNOWLEDGEMENTS: This project was supported by the Victorian Neurotrauma Initiative (VNI).

MOTC_O2.5 CONTRALATERAL EFFECT OF UNILATERAL EXERCISE ON MUSCLE STEADINESS AND MOTOR UNIT ACTIVITY

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INTRODUCTION: The ability to produce steady muscle contraction force is affected by the contraction intensity. Whether and how the steadiness of contraction will be affected by the muscle activity of the contralateral limb requires further study.

AIM: To determine 1) whether the steadiness in precision contractions of one limb would be affected by muscle contractions of the contralateral limb; and 2) whether the motor unit firing rate (MUFR) would be affected by muscle contractions of the contralateral limb.

METHOD: Twelve healthy volunteers (6 M and 6 F, age range 20-35 years) performed 12 s static knee extensions at 10% and 30% of the maximal voluntary contraction (MVC) force using the left leg, while the right leg was at rest or performed static knee extensions at 10% or 30%MVC 6 s after the commencement of the left leg contraction. The steadiness of contraction was assessed by the standard deviation (SD) of force variation against the target level. Motor unit action potentials were recorded from the left vastus lateralis muscle using a custom-made high-impedance quadrafilar needle electrode, and identified using custom-written software for multichannel spike recognition (Kamen et al. 1995). An average of 154 motor units from each subject was analysed. The MUFR for each spike train was calculated for the first 6 s and the second 6 s period of each contraction. ANOVA with repeated measures and post-hoc analysis with Bonferroni adjustment were performed to evaluate the main effect of individual conditions (ie. left leg force, right leg force and unilateral vs bilateral) and interactions between these conditions.

RESULTS: A significant effect ($P<0.05$) of the left leg force on steadiness was detected with the SD higher in the 30%MVC contractions. A significant two-way interaction was found, indicating that the SD of the left leg force was greater when the right leg muscle contracted. There was also a significant effect of left leg force on the mean MUFR with a higher value found at 30%MVC. The variation of motor unit firing rate (SD) was affected by the left leg force with a higher SD found at 30%MVC. There was also a significantly higher MUFR variation when performing bilateral contractions. Furthermore, there was a significant effect of right leg force on the MUFR variation of the left leg, with a higher SD found at 30%MVC.

CONCLUSION: This study provided new evidence indicating that the steadiness of muscle force production could be affected by muscle contraction of the contralateral limb. The MUFR and its variation were also affected by the muscle contraction in the contralateral limb.

MOTC_O3.1 INTRATESTER RELIABILITY FOR QUANTIFYING THE NEUROMUSCULAR CONTROL OF THE QUADRICEPS DURING SEMI-SQUAT.

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INTRODUCTION: Patellofemoral Pain Syndrome (PFPS) is one of the most common knee conditions in sports medicine clinics. Exercise therapy consisting of motor retraining of m. quadriceps femoris has shown to be effective for treating PFPS [1] but there is a lack of tools for assessing the effects of motor retraining. Myoelectric signals are stochastic by nature and nonlinear methods such as entropy may be more adequate to describe neuromuscular adaptations of the quadriceps.

AIM: to examine the reliability of an isometric holding test for assessing neuromuscular control of the quadriceps muscles.

METHODS: 18 healthy subjects aged 18-40 were tested twice with two days between. All subjects had to be physically active for at least 2.5 h/week and pain-free in the lower extremity and back. Bipolar surface electrodes were placed on the muscle bellies of VM and VL according to Cowan et al. [2]. The isometric holding test was semi-squat. Subjects were positioned in 90-degree knee angle with their arms extended in front of them. Subjects performed one practice trial of 5 sec. followed by 2min. of rest. Afterwards 20 sec. semi-squat was recorded.

Sample entropy (SaEn) was used to quantify the structural variability of the electromyographic (sEMG) time series [3] during the semi-squat. The sEMG-signal was divided into 5 cycles consisting of 4 sec each to account for possible time-dependant changes in the sEMG-signal. Intratester interday reliability was estimated using two-way mixed-model, absolute agreement-type intraclass correlation coefficients (ICC(3,1)) and standard error of the measurement(SEM). SEM was calculated as SEM = pooled SD x (1 - ICC)0.5. Minimal detectable difference (MDD) was calculated as 1.96*2^0.5*SEM.

RESULTS: Average SaEn from VL and VM were close to 0.11. Reliability from VL showed fair reliability with ICC of 0.68 from the first cycle and between 0.80 and 0.86 for the next four cycles. ICC from VM showed similar reliability with ICC values of 0.70 to 0.89. SEM for VL was between 0.006 and 0.01 corresponding to MDD of 13.8-24.3% of the mean of the first test. SEM for VM was between 0.006 and 0.01 corresponding to MDD of 15.1 to 25.0 % of the mean of first test.

CONCLUSION: The results from this intratester reliability study of SaEn based on sEMG-signals from VM and VL during semi-squat proves to be reliable and appropriate to detect small changes in SaEn. Further studies on motor control strategies in e.g. patients with PFPS are warranted.

ACKNOWLEDGEMENTS: The Association of Danish Physiotherapists Research Fund; Danish Rheumatism Association

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MOTC_O3.2 SINGLE-SUBJECT ANALYSIS REVEALS VARIATION IN KNEE MECHANICS DURING STEP LANDING

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INTRODUCTION: Evidence concerning the alteration of knee function during landing suffers from a lack of consensus. This uncertainty can be attributed to methodological flaws, particularly in relation to the statistical analysis of variable human movement data.

AIM: The aim of this study was to compare single-subject and group analysis in quantifying alterations in the magnitude and within-participant variability of knee mechanics during a step landing task.

METHODS: A group of healthy men (N = 12) stepped-down from a knee-high platform for 60 consecutive trials, each trial separated by a 1-minute rest. The magnitude and within-participant variability of sagittal knee stiffness and coordination of the landing leg were evaluated with both group and single-subject analyses.

RESULTS: The group analysis detected significant reductions in MARP1 magnitude. However, the single-subject analyses detected changes in all dependent variables, which included increases in variability with task repetition. Between-individual variation was also present in the timing, size and direction of alterations to task repetition.

CONCLUSION: The results have important implications for the interpretation of existing information regarding the adaptation of knee mechanics to interventions such as fatigue, footwear or landing height. It is proposed that a familiarisation session be incorporated in future experiments on a single-subject basis prior to an intervention.

MOTC_O3.3 CONTRALATERAL SPINAL EXCITABILITY AFTER UNILATERAL LOCOMOTOR ADAPTATION

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INTRODUCTION: Evidence for a direct interlimb communication pathway between soleus muscles in human locomotion has recently been presented (Stubbs PW., Nielsen JF., Sinkjær TS. and Mrachacz-Kersting N. Phase Modulation of the Short-Latency Crossed Spinal Response in the Human Soleus Muscle J. Neurophysiol 105: 503–511, 2011). Investigation on the possible relevance of this connection in clinical rehabilitation is needed, for example in the perspective of inducing cross education in hemiparetic patients using locomotor training of the non-affected limb.

AIM: Investigate the existence of contralateral spinal plasticity after one session of unilateral locomotor training.

METHODS: Subjects (n=19) performed 15 minutes of unilateral backward walking training. Soleus H-reflex was recorded from the contralateral leg during unilateral forward walking before and after training. The mean peak-to-peak amplitudes was quantified during the first minute (10 sweeps, with 4s of inter-stimulus interval (ISI)) and the first three minutes (30 sweeps, 4s ISI). Since our aim was to detect potential fast and short lasting changes in contralateral spinal excitability one single value on the ascending part of the of the H-reflex I-O curve (50% H-max) was evaluated at 30% of the gait cycle, during stance phase.

RESULTS: A reduction in the 50%H-max, more evident during the first minute of contralateral walking after ipsilateral training has been observed. However this reduction was not significant (p=0.265 for the first minute and p=0.394 for the first three minutes).

CONCLUSION: Significant changes in contralateral spinal excitability after unilateral walking training have not been observed. However a significant decrease in H-max has previously been reported after five weeks of unilateral dorsiflexion resistance training (Dragert K. and Zehr P. Bilateral neuromuscular plasticity from unilateral training of the ankle dorsiflexors. Exp Brain Res. 208:217–227. 2011). Two main differences between these studies might have led to the different results: type of training (isometric contractions vs. locomotion) and duration of training (five weeks vs. single session). However since, in the cited study, only H-max showed significant changes after training it might be possible that higher threshold motor units are more involved in contralateral plasticity. Further investigations would be necessary to verify these hypotheses.

MOTC_O3.4 SURFACE POTENTIALS PRODUCED BY DEEP MOTOR UNITS. A SIMULATION STUDY

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Prof Roberto Merletti, LISiN, Department of Electronics, Politecnico di Torino

INTRODUCTION: For superficial muscles, it is possible to detect motor unit (MU) potential (MUP) propagation between longitudinally displaced surface electrodes. On the contrary, the surface EMG signals recorded from a wide area above the deep human erector spinae muscle appear often very similar, with no apparent propagation. The suggested possible reasons for this phenomenon were very short fibres, crosstalk, pinnation of fibres, or end-of-fibre effects. While all these suggestions are reasonable, we expect that even without crosstalk, MUs comprising only straight fibres that are parallel to the surface will generate similar-shape potentials over a large surface area if the MUs were deep.

AIM: To explore the differences in MUP properties due to different distances from the active fibres.

METHODS: We simulated MUPs and potential fields generated around single fibres and MUs at different moments of time after initiation of excitation. We explored MUs with different morphologies and fibres straight and parallel to each other and to the surface. We used intracellular action potentials (IAPs) and muscle fibre propagation velocities (MFPV) typical for non-fatigued or fatigued muscles. The simulated MUPs corresponded to detection by monopolar or longitudinal single differential (LSD) point electrodes from a wide area above the MU (high density EMG detection). Neither crosstalk nor other external disturbances were involved in our model.

RESULTS: We have shown that the electric field generated by deep MUs is more homogenous than the one generated by superficial MUs. This followed from the fact that the distances between any electrode pole and the source propagating along the fibres differ much less for deep than for superficial muscles and could readily explain the similarity of MUPs and lack of MUP propagation for deep MUs. Correct MFPV estimation was not possible at large fibre-electrode distances neither for monopolar, nor for LSD detections. The involvement of short or asymmetrically innervated fibres in the model brought up more complex MUP shapes, mainly due to the interference between terminal phases. We have also shown that for deep muscles, the great increase of the relative weight of MUP terminal phases, whose shape is closely related to that of the IAP, could give a good opportunity to non-invasively assess the changes in membrane depolarization due to fatigue or pathology, using spectral indices like FInsm5.

CONCLUSION: The main features of MUPs are strongly dependent on the average fibre-electrode distance. The assessment of MUP terminal phase changes could provide valuable information about membrane property changes even at large distances from the active fibres.

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MOTOR PERFORMANCE & SPORTS SCIENCE

MPSS_O1.1 EVALUATION OF TRAINING TYPES IN SQUAT EXERCISE BASED ON MUSCLE SYNERGIES

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INTRODUCTION: During the squat exercise, a similar behavior to motor control by agonist/antagonist muscle pairs is expected. Squat exercise is identified by the difference in depth of squat during athletic training. The training strategies used to deepen the squat remain imprecise.

AIM: The aim of this study was to evaluate muscle synergies during squat exercises at different depths, and to compare the muscle activation patterns between active and novice participants.

METHODS: Five mature active rugby members and five immature University students participated in this study. Knee joint function was measured during three types of squat exercise: quarter squat (QS), parallel squat (PS), and full squat (FS). During a squat exercise, the subjects were asked to try to control the knee-joint extension and flexion every 4 s for up to 100 contractions of the knee. Particpants reported their level of percieved exertion (RPE) using a Brig's RPE following every five squats. Muscle activity [surface electromyography (EMG)] was recorded using a 16 channels wireless unit (Myomonitor IV, Delsys) with active two-bar electrodes (DE2.3, Delsys) from eight agonist/antagonist lower limbs muscles. Knee joint angle was measured using goniometors (ShapeSensor S700, Measurand). Data were acquired by the attachment software (EMGworks 4.0, Delsys) with the sampling frequency at 2048 Hz.

The level of muscle activity was normalised to maximum coluntary contractions. %RMS from SEMG signals was first estimated. %RMS time-series (%RMS profile) for a period were further estimated by a sliding-block procedure: block length and shift were 500 and 10 ms, respectively. For comparing the behavior of agonist/antagonist muscle pairs, %RMS profile, in which the individual muscles were active at different times, was normalized as a function of stroke period to obtain the averaged %RMS profile.

A trial was divided into early, middle, and late phases. The averaged %RMS profiles were evaluated for each phase including several tens of consecutive contractions. Then, we estimated muscle synergies by the Non-negative Matrix Factorization, and compared the correlation coefficients between muscle synergies of each subjects.

RESULTS: Based on the skill level, each subject showed a different habit to compensate muscle fatigue. The habit included multi-joint control for sustaining the posture against muscle fatigue. The third synergy showed peak at maximum knee flection against first synergy like a co-contraction during FS; that was different from those during QS and PS.

CONCLUSIONS: Since biceps femoris (BF) showed explicit significant difference in the correlation coefficient at first and third synergies during FS, the muscle synergy pattern of BF could be an effectual evaluation index for understanding the skill of training.

MPSS_O1.2 EFFECT OF POWER AND CRANKING RATE ON MOTOR CONTROL OF UPPER BODY IN HIGH LEVEL ATHLETES

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Dr Leonardo Gizzi; Mr Anders Kilen; Prof Bente Rona Jensen; Prof Nikolai Nordsborg; Prof Dario Farina

INTRODUCTION: Movement is the only way alive creatures have to interact with environment; recent studies suggest that the complexity of motor control can be achieved by means of a reduced set of motor commands and a neural circuitry devoted to the balancing of muscular intervention (muscular weighting network) in a flexible, task dependent manner. Rhythmic activity can be achieved by the interaction of the muscular weighting networks and rhythm-generating networks (also called central pattern generators, CPG). Studies on locomotion suggest that the activity of CPG recruiting muscles can be influenced by speed whilst studies on arm cycling report consistent motor modules across different levels of mechanical power requested to the subject.

AIM: to assess the effect of speed on motor control of upper limb cyclic movement in a highly trained population.

METHODS: Eight healthy male high level swimmers were recruited.

Exercise protocol:

Each subject performed an arm cranking test on an Angio armergometry system with automatic stand (Lode, An Groningen, The Netherlands). After a five minutes warm up at 50 W and 60 revolutions per minute (RPM), subjects performed six one-minute periods of arm cranking, randomized between 50 RPM and 80 RPM and power outputs of 60 W, 80 W and 120 W. A four minutes rest in between each work period was administered.

Surface EMG signals were recorded in bipolar derivation on eight muscles per body side.

Non negative matrix factorization (NMF) was applied to extract motor modules (MM) and activation signals (AS). One to 5 modules were extracted and reconstruction quality was assessed by means of variation accounted for (VAF), reconstruction quality was set to 85% minimum.

Similarity of motor modules among individuals for different combinations of speed and power was evaluated.

RESULTS: Three motor modules, shared across subjects and conditions (mean similarity 0.81 ± 0.14), were identified (average VAF for three modules 92.1 ± 5.4%). Associated activation signals showed the typical burst-like activity reported for locomotion and lower limb cycling. Despite inter-individual differences in burst timing (probably due to different anthropometric characteristics of subjects) the effect of cranking rate, rather than power, resulted in a phase shift of the burst of one of the activation signals. This is in agreement with findings on treadmill and overground walking in healthy humans.

CONCLUSION: These findings in agreement with literature, are suggestive of the presence of muscle weighting networks and rhythm-generating networks who are involved in cyclic movement for upper limb, with a set of fixed modules for movement execution whose recruitment is modulated, as in walking, by speed rather than power.

MPSS_O1.3 ACUTE EFFECTS OF CONCURRENT EMG FEEDBACK ON KNEE EXTENSOR STRENGTH AND ACTIVATION

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INTRODUCTION: Maximal voluntary knee extensor strength is limited by suboptimal neural activation despite maximal effort (Westing et al., 1990). Recently, concurrent EMG-feedback from vastus medialis was shown to acutely enhance knee extensor strength but also to increase antagonist activation (Ekblom & Eriksson, 2011). With real time feedback from both agonists and antagonists, subjects may be able to improve their strength without increased antagonist activation.

AIM:To investigate possible acute effects of multiple thigh muscle EMG-feedback on strength, level of activation (LOA) and EMG activation, in isokinetic maximal voluntary knee extensor actions (MVCs).

METHODS: Nineteen moderately active subjects performed two sets of isokinetic concentric and eccentric unilateral knee extensor MVC:s at 20 deg/s through a 60 deg range of motion of the knee joint (120 to 180 deg). EMG-feedback, based on surface measurements, was provided visually on a computer screen indicating in real-time the activation of the vastus lateralis (VL), vastus medialis (VM), rectus femoris (RF) and hamstrings (HAM) muscles. Feedback was given only for the right leg during the second set.

For each set, leg and action type, knee extensor strength, LOA and EMG of the VM, VL, RF and HAM muscles were measured during movements. Electrical stimulation of the femoral nerve was applied to evoke interpolated twitches (IT) during MVCs and resting twitches (RT) during passive movements of the leg. LOA was calculated as 100 x (1-(IT/RT)).

RESULTS: Knee extensor strength increased significantly (by 8 %) from 141.3 ± 47.8 Nm with no feedback to 152.5 ± 53.3 Nm with feedback. The LOA of the knee extensors increased significantly (by 9 %) from 74.6 ±15,2 % with no feedback to 81,4 ± 15,3 % with feedback. Improvements in strength and LOA were similar between action types. Feedback did not affect agonist or antagonist EMG.

CONCLUSION: Multiple thigh muscle EMG feedback can acutely enhance strength and voluntary activation in both eccentric and concentric knee extensor MVCs without advert effects on antagonist activation. Feedback was provided already during an isometric preactivation phase prior to onset of movement, whereas the results presented here are based on measurements during the movements only. Catch like muscle properties and postactivation potentiation, due to increased agonist activation during the isometric preactivation phase, might explain the improved strength and LOA despite no change in agonist EMG seen with feedback.

ACKNOWLEDGEMENT: Financial support to this study was granted from the Swedish Center for Sports Research.

MPSS_O1.4 MECHANICAL AND SEMG ASSESSMENT OF TRAINING EFFECTIVENESS BASED ON FLYWHEEL DEVICES. PRELIMINARY RESULTS.

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INTRODUCTION: One alternative modality to free weight resistance training is provided by flywheel (FW) inertial resistance.

AIM: The aims of the study were to: characterize the time course of the learning period with FW; characterize the neuromuscular activity of FW exercise; and compare the biomechanics of two modalities of hip belt squat (HBS), one made with FW and the second made with standard weight (SW) resistance.

METHODS: Six strength-trained athletes followed 4 weeks of training, 3 times a week, performing HBS with FWE device. Training load (FWE mass, number of repetitions) increased during the time. Ground reaction force, tension force at the strap connected to the FW, power, knee angular velocity, and FW angular velocity were collected in each session. The coefficient of variation (COV) of maximal power exerted in each series has been identified to quantify the stability of exercise execution. One session a week, sEMG was recorded from vastus medialis and lateralis, gastrocnemius, and semitendinosus muscles using linear arrays of 8 electrodes. During the last training session, four additional sets of SW hip belt squat (with an overload equal to body weight) were performed with maximal effort (i.e. at maximal velocity) to compare FW with respect to SW resistance.

RESULTS: From a biomechanical point of view, preliminary findings showed a wide pattern of learning among subjects, with increased or stable output performance during training period. EMG findings confirmed this wide range of adaptation. Wilcoxon test showed a statistically significant increased of maximal power exerted between the first and the sixth training session (12% in concentric, $p=0.06$; 14% in eccentric, $p=0.03$). COV of power was found decreased (-46% in concentric, $p=0.03$) between the first and sixth session.

CONCLUSION: Both FW and SW exercises were performed with maximal efforts, the differences between the two exercises could be fixed in the amount and shape of exerted force, which will be described in a subsequent analysis. The learning period on flywheel device was characterized by heterogeneous behaviour among athletes, confirming that a wide range of adaptation is possible in high skilled athletes. A general trend of increased performance, probably due to learning effects, was noticed within six training sessions. Learning effects was confirmed by the increased stability of output performance.

MPSS_O1.5 MUSCLE SYNERGIES ARE NOT ALTERED BY EXPERIMENTAL PAIN DURING WALKING

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INTRODUCTION: The central nervous system (CNS) appears to simplify motor control of walking by generating motor commands through a linear combination of 4 to 5 muscle synergies, which have been shown to be stable across various ranges of walking and running speeds. A range of observations implies that the CNS adapts movement to reduce further pain/injury in response to acute pain. It is unknown whether pain alters motor control of walking.

AIM: To investigate whether experimentally induced pain alters the muscle synergies used to coordinate walking and whether this differs between pain induced in a power producer muscle of the leg (medial gastrocnemius) or a muscle of the back (erector spinae).

METHODS: Seventeen healthy volunteers participated. EMG activity was recorded on the right side from 12 muscles with surface electrodes (medial/lateral gastrocs, soleus, medial/lateral vastii, rectus femoris, biceps femoris, semimembranosus, medial/maximal gluteus, tensor fascia latae, erector spinea at L3) and 4 muscles with fine wire electrodes (obliquus internus and externus abdominis, longissimus at T12 and Iliocostalis at L3). Participants walked on a treadmill at 3.4 km/h for ~5 min in 5 conditions: control, low back pain (LBP), washout LBP, calf pain and washout calf pain. Order of pain conditions was randomised. Pain was induced by injection of hypertonic saline in medial gastrocnemius or the erector spinae on the right side. Fifteen gait cycles were selected for analysis. The decomposition algorithm, (non-negative matrix factorization) used to identify muscle synergies was based on two components: “muscle synergy vectors” (relative weighting of each muscle within each synergy); and “synergy activation coefficients” (relative activation of the muscle synergy across cycle/movement). Robustness of the extracted synergies across condition was checked with a cross-validation procedure.

RESULTS: Whatever the condition, 5 muscle synergies accounted for more than 90% of variance accounted for (VAF), i.e., 91.4±1.6% of VAF across conditions. In addition, there was a robust consistency of both muscle synergy vectors (or weightings, mean r=0.87±0.06) and synergy activation coefficients (mean r_{max}=0.94 ±0.03). The cross-validation procedure indicated that muscle synergy vectors extracted for the control condition were sufficient to explain EMG patterns in all other conditions (VAF>89%).

CONCLUSION: These results show that muscle synergies (and thus motor control during walking) are not or very few affected by experimental pain, whatever its location. However, synergies were extracted from peak normalised EMG patterns across cycles, and thus the degree of muscle activity was not taken into consideration. Further investigations are necessary to determine whether pain would induce adaptations of muscle activity level, i.e., compensation between muscles.

ACKNOWLEDGEMENT: Funding was provided by the National Health and Medical Research Council (NHMRC) of Australia.

MPSS_O1.6 ARE THERE FUNCTIONALLY INDEPENDENT SEGMENTS WITHIN GLUTEUS MINIMUS AND GLUTEUS MEDIUS? AN EMG INVESTIGATION.

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INTRODUCTION: Gluteus minimus (GMin) and gluteus medius (GMed) are reported to consist of uniquely oriented segments with potential for independent function. There is only one previous electromyographic (EMG) investigation into GMin, which is more than thirty years old, and doesn't differentiate between the potentially independent anterior and posterior segments. Attempts at assessing differences between anterior, middle and posterior segments of GMed have failed to use verified intramuscular EMG guidelines for accurately locating these structurally unique segments.

AIM: To establish the evidence of independent segmental function within GMin and GMed using verified intramuscular EMG electrode placement guidelines.

METHODS: The gluteal regions of fourteen healthy participants (males, 9; females, 5; mean age, 22.5 years) were marked for bipolar, fine wire electrode insertions into uniquely oriented segments of GMin and GMed based on previously verified guidelines. The electrodes were inserted with the aid of needles under the guidance of ultrasound imaging. Participants completed a series of maximum voluntary isometric contractions (MVIC) for five different hip actions (extension, abduction, abduction in internal rotation, internal rotation, and clam) and also completed 4 walking trials over a 9 m walkway. For each MVIC action performed, segmental muscle activity (root mean squared) was expressed as a per cent of the maximum value recorded by that segment across all actions. This measure of relative intensity was compared between segments for each action. In addition, temporal and amplitude EMG characteristics within the gait cycle will be compared between muscle segments (analysis currently underway).

RESULTS: Preliminary analysis of the MVIC trials reveals that anterior and posterior GMin fascicles activate at largely different intensities during maximum resisted hip abduction in internal rotation. Anterior, middle and posterior fascicles of GMed activate at different relative intensities during a maximum resisted clam exercise. This data will be supplemented with further segmental comparisons during the gait cycle.

CONCLUSION: This is the first study to provide evidence of segmental activation properties in uniquely oriented segments of GMin and GMed based on verified EMG electrode insertions. Preliminary results suggest that these muscles are composed of functionally independent segments. Further EMG research should therefore consider assessing activity from all these segments in order to gain a more complete understanding of their function.

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MPSS_O1.7 TEXTING AND WALKING: STRATEGIES FOR POSTURAL CONTROL AND IMPLICATIONS FOR SAFETY

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INTRODUCTION: People tend to use their mobile phone while walking. However, there are consequences with this dual tasking. It has been reported that people deviate from a straight walking path, fall, and collide with fellow pedestrians. Although it is clear that this risk is largely explained by diversion of attention from the surroundings by looking at the phone, it remains unclear how gait coordination is affected by phone use and the consequences for street safety. It is also unclear whether the effects of writing a text differ from that associated with reading a message.

AIM: This study aimed to investigate how gait coordination is affected when phone is concurrently used for reading and texting.

METHODS: Twenty-six subjects (7 male; age 28.7± 10.8 years) performed three conditions while walking at their comfortable pace; 1) normal walking, 2) reading a text when walking, and 3) writing a texting when walking. Subjects were asked to walk in a straight line over a distance of ~9 m. Walking speed, deviation from the straight line, range of motion (ROM) of the head and thorax in space, relative head ROM and phase relations of the rotations (all horizontal plane) were derived from kinematical data measured with a Vicon 3D movement analysis system. Repeated measures ANOVA was used to test differences between conditions (Bonferroni post hoc).

RESULTS: Speed was slower during reading (1.15±0.14, P<0.001) and texting (1.01±0.17, P<0.001) than control (1.31±0.15), and was slower during texting than reading (P<0.001). Subject's walking path deviated more from a straight line when texting than reading (P<0.001) and control (P=0.001). Head was held more flexed during reading (28.96°±9.32°, P<0.001) and texting (31.54°±10.28°, P<0.001) than control (0.29°±4.90°), and mean head rotation ROM in space was greater during reading (6.54°±2.78°, P=0.001) and texting (5.95°±2.71°, P=0.045) in the horizontal plane than control (4.83°±1.63°). Relative head ROM was less during reading (4.64°±1.31°, P=0.001) and texting (3.69°±1.05°, P<0.001) than control (5.46°±1.51°) and was less during texting than reading (P=0.002). Head and thorax rotations were more in-phase during reading (19.08°±18.39°, P=0.010) and texting (14.19°±12.70°, P=0.001) than control (34.75°±28.57°), and phase variability was less during reading (13.75°±13.18°, P<0.001) and texting (12.03°±8.59°, P<0.001) than control (22.92°±10.89°).

CONCLUSION: Subjects walked progressively slower with task complexity perhaps to reduce risk for accidents. Slower speed and deviations from the straight line during texting compared with reading suggests that texting affects normal walking more than reading. Head rotation in space was greater during texting and reading and this may compromise balance. In addition relative rotation was smaller due to the more in-phase relation between the head and thorax rotations and rotations were also more phase-locked. This suggests higher stiffness between the head and thorax, which could also negatively affect the ability to respond to external perturbations.

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MPSS_O1.8 EMG AMPLITUDE BEHAVIOUR OF LOWER LIMB MUSCLES DURING FAMILIARISATION TO SLIPPING EPISODES IN CUTTING MANOEUVRES

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INTRODUCTION: Cutting maneuver protocols are often used to investigate lower limbs under functional task performance and also identify strategies used under unexpected situations. However, since it requires a good coordination, it may be argued that comparisons are compromised along execution of the task.

AIM: Verify the behavior of lower limb electromyographic amplitude, duration of stance phase and its sub-phases during cutting manoeuvres performed over time.

METHODS: Eleven physically active male subjects (24.5±3.5 years old, 1.76±0.06m, 70.7±4.8kg) performed cutting manoeuvres under two different conditions: 10 baseline (BASE) trials with no platform movement and 12 trials with randomly ordered unperturbed (UNP) execution or forward platform movement of either 4 (4-P) or 8cm (8-P). Stance duration (STC), absorption (ABS) and propulsion (PRP) periods were defined from the vertical force component. Surface EMG data were recorded from tibialis anterior (TA), gastrocnemius medialis (GM), soleus (SO), vastus lateralis (VL), vastus medialis (VM), biceps femoris (BF), gluteus maximus (GMx) of the right leg. Individual integral of EMG (iEMG) envelopes were normalized and averaged in three different periods related to the stance phase: 50 ms before right foot contact on the platform (PRE), first 50ms of stance (EARLY) and between 50 and 150 ms of stance (MID). One-way ANOVA was performed to compare STC, ABS and PRP duration among platform conditions; and iEMG was investigated by two-way ANOVA (3 epochs X 4 platform conditions) with significance level at $p<0.05$.

RESULTS: No significant differences for STC (BASE=283±33ms, UNP=276±46ms, 4-P=272±38ms 8-P=273±39ms), ABS (BASE=88±20ms, UNP=78±26ms, 4-P=85±21ms, 8-P=81±23ms), PRP (BASE=196±40ms, UNP=198±54ms, 4-P=187±40ms, 8-P=191±45ms) duration. Besides the expected differences between iEMG among epochs, there was no significant difference for any muscle when comparing platform conditions (TA_BASE=43.5±19.6, TA_UNP=37.8±121.2, TA_4P=37.8±19.4, TA_8P=39.7±18.7, GM_BASE=32.8±14.0, GM_UNP=26.32±11.7, GM_4P=26.09±10.92, GM_8P=28.4±11.5, PL_BASE=47.0±14.9, PL_UNP=43.9±17.88, PL_4P=47.52±19.09, PL_8P=44.92±17.33, VM_BASE=48.6±21.5, VM_UNP=42.3±23.3, VM_4P=43.8±23.2, VM_8P=46.4±22.7, VL_BASE=42.69±16.51, VL_UNP=39.1±19.1, VL_4P=38.9±13.4, VL_8P=42.8±19.1, BF_BASE=46.013.8, BF_UNP=47.0±14.6, BF_4P=38.6±13.4, BF_8P=41.7±15.3 GMx_BASE=38.4±16.0, GMx_UNP=34.2±20.84, GMx_4P=31.52±16.0, GMx_8P=33.8±17.9 % of max iEMG).

CONCLUSION: Perturbed cutting movements require coordination skills to be performed. Our results suggest that they can be easily learned by physically active subjects implying this task as a suitable tool to study lower limb muscle activation and timing parameters during unexpected slipping conditions.

MPSS_O1.9 MIRROR VISUAL FEEDBACK AND MOTOR SKILL ENHANCEMMENT: A RANDOMISED CONTROL TRIAL IN HEALTHY YOUNG ADULTS

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INTRODUCTION: Studies into therapeutic mirror visual feedback (MVF) have provided encouraging results for its use to treat phantom limb pain (PLP), chronic regional pain syndrome (CRPS) and post-stroke movement deficits and pain. Interestingly, while PLP and CRPS are thought of as pain conditions rather than conditions of movement restriction, the pain has been linked to changes in the motor cortex. MVF allows the illusion of pain free movement of the affected limb, which might restore the motor cortex to a state allowing pain reduction. Research investigating MVF is hindered by confounding factors such as health complications, other concurrent therapy, natural recovery and MVF being perceived as a more credible treatment than control conditions.

AIM: To remove these confounding factors we studied the use of MVF by healthy young adults to learn a novel functional motor task.

METHODS: Healthy right handed young adults were randomly assigned to perform either MVF training (n=20), left hand training (LHT, n=10) or right hand training (RHT, n=11) to learn to perform a novel functional task with their left hand. Task improvement was measured.

RESULTS: 3 way ANOVA showed a significant time effect ($p<0.0001$) with all groups improving between baseline and follow-up, as well as a side effect ($p<0.0001$), but not a group effect ($p=0.691$).

Because there was high degree in variability in baseline measures of motor skills with both left and right hands, we reduced the model to a comparison between group and time, with side being reduced to a difference and ratio score between left and right hands. An increased right–left difference indicates the performance of the task on the right improved more than performance on the left. ANCOVA, with baseline scores as the covariate, revealed a significant group effect for both right-left differences ($p=0.035$) and ratios ($p=0.011$) at follow up. Post-hoc pairwise comparisons revealed differences between MVF and LHT and RHT and LHT, but not MVF and RHT, suggesting that the MVF was no better than RHT to improve left-handed task performance.

CONCLUSION: MVF training did not enhance learning a new task in healthy young adults, which raises a question regarding the underlying mechanisms of MVF induced improvements in conditions such as stroke.

MPSS_O1.10 PATELLOFEMORAL AND TIBIOFEMORAL RADIOGRAPHIC OSTEOARTHRITIS PREVALENCE IN PEOPLE WITH CHRONIC ANTERIOR KNEE PAIN: DATA FROM A RANDOMISED CLINICAL TRIAL

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INTRODUCTION: Chronic anterior knee pain (AKP), or patellofemoral joint (PFJ) pain, impacts significantly on participation in a physically active lifestyle and may precede PFJ osteoarthritis (OA). However, there is a dearth of evidence regarding the relationship between them. Thus, there is a clear need for studies to quantify the prevalence of radiographic OA in the PFJ, and the tibiofemoral joint (TFJ) in individuals with chronic AKP.

METHODS: Individuals with chronic AKP were recruited as part of a randomised clinical trial. Inclusion criteria: (i) aged > 40 years; (ii) AKP aggravated by >2 activities that load the PFJ; and (iii) pain during these activities most days of the month. Exclusion criteria: (i) concomitant pain from other knee structures; (ii) current or previous physiotherapy for knee pain (12 months); and (iii) knee or hip arthroplasty or osteotomy.

Radiographic severity of TFJOA was assessed from a semiflexed, posteroanterior weight-bearing radiograph (feet externally rotated 10°). Radiographic severity of PFJOA was assessed from weight-bearing skyline radiographs, with 30-40°knee flexion. Severity of radiographic OA was assessed by two examiners (KMC, RSH) from digital images, with meetings to obtain consensus when required. The Kellgren and Lawrence (K/L) score was assigned to the TFJ and to the PFJ Separate gradings were conducted on medial and lateral PFJ components (inter-rater reliability (κ): 0.745-0.843).

RESULTS: 224 individuals with chronic AKP (115 (51%) women, mean±SD: age 54±10 yrs, height: 1.69±0.10 m; weight 79±15 kg) were recruited. 67 (30%) had no radiographic OA, 57 (25%) had isolated PFJOA, 2 (9%) had isolated TFJOA and 98 (44%) had combined PFJ/TFJOA.

In those 80 participants who were aged between 40 and 50 yrs (38 (48% women, age 45±3 yrs; height 1.70±0.10 m, weight 79±17 kg), 36 (45%) had no radiographic OA, 21 (37%) had isolated PFJOA, 1 (1%) had isolated TFJOA and 22 (28%) had combined PFJ and TFJOA.

CONCLUSION: The majority (70%) of people presenting to this trial with chronic AKP had radiographic signs of OA. The prevalence of PFJOA (67%) was greater than the prevalence of TFJOA (51%), and the medial and lateral PFJ appeared to be affected similarly. The prevalence of radiographic OA was still considerable (55%) in individuals aged 40-50 years, with high rates of PFJOA (54%). PFJOA appears to be an important problem in individuals with chronic AKP and future studies need to investigate the link between AKP in individuals less than 40 years and the development of PFJOA.

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MOTOR UNITS

MOTU_O1.1 FUNCTIONAL DETERMINANTS OF MOTOR UNIT PROPERTIES IDENTIFIED BY EVOLUTIONARY ALGORITHMS

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INTRODUCTION: Characteristics of motor unit (MU) populations vary across muscles but the full extent and functional significance of this variability are not fully known. In particular, it is unknown how population properties are associated to muscle performance demands.

AIM: The study aimed at exploring the functional determinants of the variability in MU properties by using evolutionary algorithms to optimize MU populations in relation to specific muscle functions.

METHODS: 36 vectors defining MU properties were iteratively refined by selective survival and mutation. Each vector included random values for the number of MUs (range: 1-600), total number of muscle fibers (10^3-10^5), innervation numbers (IN), twitch contraction times (20-140 ms), recruitment thresholds (0.1-50 au), and minimum and peak discharge rates (5-16 and 17-60 pps). A fitness function was defined as linear combination of four criteria: force steadiness at 2 N and 25% MVC, maximum rate of force development, fatigue-resistance (fraction of force at 25% MVC generated by MUs with contraction time > 45 ms), and maximum muscle force. In each iteration, the parameters of the six vectors with the highest fitness were combined to generate six new vectors that replaced the least fit ones and a subset of the parameters of the new ones were adjusted randomly. This process was repeated until convergence of the mean fitness. The weights of the criteria were derived from long-term EMG recordings from different muscles in everyday living [Kern et al. 2001]. In this way, a typical leg muscle (weights: 0.2, 0.3, 0.25, 0.25) and a typical hand muscle (0.4, 0.25, 0.25, 0.1) were considered.

RESULTS: For both the leg and hand muscle the distributions of IN were skewed towards low values (most MUs with few fibers). The average number of muscle fibers per MU was highest for the leg muscle (457 vs 195 per MU). For both muscles there was a positive relation between IN and recruitment threshold (size principle) with the recruitment range being more compressed for the hand muscle (leg: 26±1 and 34±12 au for the 50% low and 50% high-IN MUs, respectively; hand: 25±1 and 30±3 au) and an inverse relation between IN and contraction time (leg: 80±2 and 44±17 ms; hand: 75±1 and 61±6 ms). Only the leg muscle showed a relation between IN and peak discharge rate (39±1 and 51±5 pps).

CONCLUSION: Although the parameters had wide variation ranges, by imposing simple fitness criteria the MU properties converged to solutions in perfect agreement with physiological values and reflecting known associations. The results showed that these associations arise as a consequence of the functional demands of the muscle and that differences across muscles can be predicted by their functional demands.

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MOTU_O1.2 AN EXAMINATION OF MOTOR UNIT POOL ORGANIZATION THROUGH ANALYSIS OF THE SURFACE ELECTROMYGRAM

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INTRODUCTION: Voluntary muscle force generation is accomplished jointly by motor unit (MU) recruitment and by increasing MU firing rates. Typically, MU recruitment and firing rate features are routinely assessed using intramuscular EMG recordings or by a combination of intramuscular and surface EMG (sEMG) recordings. A novel sEMG electrode array recording and decomposition system (Nawab et al. 2010) has recently been developed and appears to have promise in helping researchers characterize recruitment and firing rate properties.

AIM: Based on an analytical verification of the published decomposition techniques, the objective of this study was to examine the recruitment and firing organization in relation to the putative motoneuron (MN) size.

METHODS: sEMG of the first dorsal interosseous muscle was recorded from 8 healthy individuals. The subjects performed sustained trapezoidal time course isometric abductions at 4 different force levels (20%, 30%, 40%, and 50% of maximum voluntary contraction) each with 2 repetitions. Single MU firing activities were decomposed from the sEMG using the decomposition system (Nawab et al. 2010). A spike triggered average (STA) on the sEMG was performed to estimate the action potential (AP) shapes and sizes, and the trigger was set from the time of firing of the decomposed MUs. Reliable MUs were selected for further analysis based on two criteria: stable STA AP shapes across the duration of the contraction trial and high correlation between the STA and Delsys estimated APs. The peak-to-peak amplitude of the STA AP was calculated as the estimated size of the MN.

RESULTS: In 1325 MUs from 8 subjects, the MU recruitment force threshold increased linearly with the MUAP size (i.e., in accordance with the size principle) at each individual force level (Fitted R2 ranged from 0.35 to 0.79). The mean firing rate (MFR) at a steady force revealed decay (from 30 to 10 imp/sec) in a negative power function with the size of MUAP, and the MFR also declined linearly with the recruitment threshold (R2 ranged from 0.46 to 0.85). In addition, at higher force contraction levels, more MNs of larger size were recruited at relatively smaller threshold forces and higher MFRs were maintained to accommodate the task requirement.

CONCLUSION: Using a sEMG recording and decomposition system, we were able to capture the recruitment and firing patterns of the MU pool during a single contraction in intact human subjects.

MOTU_O1.3 MODEL ASSESSMENT OF MOTOR UNIT NUMBER INDEX (MUNIX)

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INTRODUCTION: A recently developed technique by Nandedkar et al uses the maximum M wave and different levels of voluntary surface electromyography (EMG) signals to derive an index associated with the number of motor units in a muscle. This method, called motor unit number index (MUNIX), is easy and quick to perform, and induces minimal discomfort. Recently, the method has attracted increasing applications.

AIM: The aim of this study was to perform a systematic assessment of MUNIX methods using simulations of the motoneuron pool and the surface EMG.

METHODS: To investigate the sensitivity of the MUNIX to changes in motoneuron and muscle prop¬erties, four parameters describing such properties were specifically investigated. These parameters include the number of motor units contained in the muscle, motor unit recruitment range, motor unit firing rates, and the motor unit action potential (MUAP) amplitude. Each parameter describing these properties was adjusted, and the variation of the MUNIX with this parameter was investigated systematically. Each time when one parameter was adjusted, the other parameters remained the same as their initial assign¬ments.

RESULTS: If varying the input motor unit numbers to the model while keeping the other motoneuron pool and muscle parameters unchanged, the MUNIX estimates can appropriately characterize changes in motor unit numbers. Reduction of motor unit firing rates or alteration in motor unit recruitment range does not have a significant effect on the MUNIX estimates. If we reduce the amplitude of each MUAP rather than reduce motor unit number, the MUNIX measurements substantially underestimate the motor unit numbers in the muscle, and the ratio of such underestimation closely correlates with the ratio of MUAP amplitude reduction.

CONCLUSION: The current MUNIX definition is most suitable for motoneuron diseases that demonstrate secondary evidence of muscle fiber reinnervation. When MUNIX is applied, it is of much importance to examine motor unit size index (MUSIX), defined as the ratio of the maximum M wave amplitude to the MUNIX. However, there are potential limitations in the application of the MUNIX methods in atrophied muscle, where it is unclear whether the atrophy is accompanied by loss of motor units or loss of muscle fiber size.

MOTU_O1.4 A MODEL FOR THE INFLUENCE OF FORCE TWITCH ON MOTOR UNIT BEHAVIOR

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INTRODUCTION: The control of motor units (MUs) and the regulation of muscle force are still subject to debate.

AIM: The aim of this study was to develop a model of motoneuron behavior and force generation in the first dorsal interosseous (FDI) and vastus lateralis (VL) muscles to investigate the regulation of force during isometric tracking tasks. The model was validated by comparing the simulated MU and force behavior with empirical evidences from a similar contraction protocol [1-2].

METHODS: The model describes a non-linear relation between the excitation to the motoneuron pool and the MU firing rates [3], which are transformed into time-varying impulse trains with inter-pulse intervals modeled as Gaussian random variables to introduce synaptic noise [4]. It generates the MU mechanical responses (force twitches) [5], whose amplitude is altered with contraction time to replicate the initial increase and subsequent decrease in force generating capacity reported during sustained muscle activation [1-2]. The force contributions of MUs are computed by convolving the impulse trains with the MU force twitches, and are summed to obtain the simulated muscle force. A feedback loop maintains the simulated force at a given target level.

RESULTS: For both muscles, the model predicts the initial decrease and subsequent increase in MU firing rates which occur during sustained muscle activation as MU twitch amplitude varies. A greater number of MUs is progressively activated as the simulation approaches the endurance limit. Increasing force fluctuations can be observed as fatigue develops, likely due to the recruitment of higher-threshold higher-twitch amplitude MUs. The VL force is smoother than the FDI force, probably due to the different mechanical characteristics of the two muscles. The results of the simulations agree with previous observations [1-2, 6].

CONCLUSION: The model is able to maintain the output force at a required target level and to reproduce the empirical observations during a similar protocol of repeated contractions. MU twitch amplitude is the only parameter allowed to change with contraction time. Results strongly suggest that, during voluntary isometric contractions, the excitation to the motoneuron pool is adjusted to compensate for the varying muscle-force generating capacity.

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MOTU_O1.5 ESTIMATION OF THE AFTER-HYPERPOLARIZATION (AHP) DURATION IN MOTONEURONS THAT INNERVATE PARETIC HUMAN MUSCLE.

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INTRODUCTION: The AHP is a primary determinant of motoneuron firing rate, and any increase in its duration or amplitude could alter normal motor unit (MU) firing rate properties in stroke. The relative variability of discharge in motoneurons is dependent upon both the AHP size and time course, and the amplitude and frequency content of concurrent synaptic noise. While statistical methods have been used to estimate the AHP duration in neurologically intact human subjects (Matthews, 1996), such data is lacking in stroke survivors.

AIM: To characterize discharge properties of motoneurons that innervate paretic muscle of stroke survivors, including interval histograms and estimates of AHP duration as a means to determine whether AHP changes contribute to lower firing rates in paretic muscles.

METHODS: Data was collected from both sides of three hemiparetic stroke subjects, who performed isometric abduction or flexion force tasks using the index finger. Force generated in both the abduction (x) and flexion (y) directions was recorded. EMG data was collected using a novel surface EMG sensor array (Delsys,Inc) from the first dorsal interosseous (FDI). Analysis of motor unit (MU) events was performed in MATLAB. Interval histograms of individual MUs were transformed into estimated AHP trajectories using death rate analysis of the intervals (Matthews, 1996).

RESULTS: Long strings (average of 2000 spikes) of continuous trains of MUAPs were collected from both hands of stroke survivors. A total of 27 MUs derived from the paretic side of all three subjects and 17 MUs from the contralateral side were analysed. The average firing rates at which the death rate analysis converged for MUs on the paretic side was lower than the corresponding firing rates on the contralateral side. Accordingly, the average AHP duration on the paretic side, pooling all subjects, was substantially longer than the average AHP duration on the contralateral side.

CONCLUSION: Our preliminary findings suggest that AHP duration is longer on the paretic hand muscles of hemiparetic survivors as compared to the contralateral side. Thus, reported lower firing rates (Gemperline, et.al, 1995) exhibited in paretic muscle may be a result of longer AHPs. Additional analysis of the shape and depth of the AHP will give further insight as to why these differences are present. Overall, these preliminary findings indicate that AHP estimates can be acquired from paretic muscles using the novel sEMG sensor array, and these estimates can lead to new information about MU control in stroke.

MOTU_O1.6 MODULATION OF MOTOR-UNIT RECRUITMENT AND FIRING RATE DURING POSTURE AND SLOW MOVEMENT OF THE ELBOW

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INTRODUCTION: The way in which the nervous system modulates motor-unit recruitment and firing rate during postural tasks and during slow movements is not fully understood.

AIM: We investigated the neural control of the elbow flexors during postural tasks and slow movements against gravity in the sagittal plane.

METHODS: Fine-wire EMG signals were recorded from the biceps brachii, brachialis, and brachioradialis muscles of four subjects while holding the forearm against gravity at different elbow angles and while slowly flexing and extending the forearm against gravity. The signals were decomposed into motor-unit action potential trains using the EMGlab computer-aided decomposition program.

RESULTS: During static posture, firing rates in all three muscles were largely constant, independent of elbow angle. During continuous movement, firing rates in brachialis and brachioradialis were highly correlated with the angular velocity of the movement, while in biceps they were highly correlated with elbow angle. Biceps was recruited during elbow extension and was silent during elbow flexion, in contrast to its conventionally assumed role as an elbow flexor. During movements with pauses, the firing rates jumped abruptly between the postural and movement values at each transition between posture and movement.

CONCLUSION: These results are consistent with the idea that the activation of the three muscles is related to the biomechanical requirements of counteracting the weight of the forearm and overcoming the viscoelastic resistance of the arm to movement. During static posture, weight support is shared between all three muscles. During movement, brachialis and brachioradialis are modulated to counteract the viscoelastic resistance and drive the movement, while biceps balances the weight support. Muscle activation cannot always be simply understood in terms of a muscle's conventional label as a flexor or extensor, but requires a more detailed understanding of the biomechanical requirements of the task.

MOTU_O1.7 REFLEX RESPONSES OF HUMAN MASSETER MOTOR UNITS TO MECHANICAL STIMULATION OF THE TEETH

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INTRODUCTION: Previous studies to indicate the importance of these receptors in feedback control of mastication can be criticized since they have been performed either on anaesthetized animals or on human subjects using probability-based analyses.

AIM: Our aim was to investigate the jaw reflexes using both the probability- and the discharge rate based analysis methods.

METHODS: Twelve consenting volunteer subjects participated in this study. Subjects bit gently so that one selected single masseter motor unit discharged at about 10 Hz. While the subject fired the motor unit, either rapid- or slow-rate 4N stimuli were delivered to the upper right central incisor. For each trial 300 stimuli were given and once a trial was completed, local anaesthetic block was applied around the stimulated tooth and the experiment was repeated.

RESULTS: While preceding local anaesthesia the rapid-rate stimuli (tap) generated substantial inhibitory reflex responses, during local anaesthetic block, they induced excitatory reflex responses in the probability-based methods but not in the discharge rate based method. Slow-rate stimuli (push) on the other hand usually generated an excitatory response which disappeared during the local anaesthetic block. Since the classical methods rely upon the number of action potentials, they generate significant count and synchronization related errors as the action potentials are phase advanced or phase delayed by the stimulus-induced synaptic potentials. Discharge-rate method is free from such errors as it is not affected by the number and density of action potentials at any particular time after the stimulus.

CONCLUSION: Usage of discharge rate based analysis for bringing out the genuine synaptic activity is essential for building the accurate wiring diagram for the human central nervous system. These pathways are used for determining stability, damage and recovery from damage of the central nervous system.

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MOTU_O1.8 MOTOR UNIT IDENTIFICATION FROM HIGH-DENSITY SURFACE EMG AT HIGH ISOMETRIC MUSCLE FORCES

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INTRODUCTION:

AIM: The aim of the study was to investigate the feasibility of accurate identification of motor unit activity from high-density surface EMG (HDsEMG) at high isometric contraction forces.

METHODS: Seven healthy men (age range 24-36 years) participated in the study. Surface and indwelling EMG (iEMG) were acquired concurrently from the dominant tibialis anterior muscle, during isometric constant force contractions (15-s long) at 50 %, 60 % and 70 % of the maximal force. Surface EMG was acquired by a bi-dimensional array of 90 electrodes (10 rows × 9 columns, inter-electrode distance 5 mm). Indwelling EMG signals were recorded by three pairs of wire electrodes inserted into the muscle with a 25 G needle.

The signals were amplified, band-pass filtered (10-500 Hz for HDsEMG, 100 Hz - 5 kHz for iEMG), sampled at 10000 Hz and decomposed by the Convolution Kernel Compensation technique [Holobar & Zazula, 2007] (HDsEMG) and by the EMGLAB decomposition tool [McGill et al. 2005] (iEMG). For motor units identified by both decomposition techniques, the rate of agreement (RoA) was computed as $RoA_j=A_j/(A_j+I_j+S_j)$, where A_j, I_j and S_j are the numbers of discharges of the j-th MU that were identified from both HDsEMG and iEMG, from iEMG only, and from HDsEMG only, respectively. The discharge time tolerance was set to ±0.5 ms.

RESULTS: On average, 25±7 motor units per contraction were identified from three channels of iEMG, but only 7±3 motor units with regular discharge pattern and clearly distinguishable action potentials were used for further analysis. At the same time, 16±6 motor units per contraction were identified from HDsEMG. Due to the strict selection of the motor units from iEMG, the number of motor units identified commonly by both techniques was limited to 1±1 per contraction. For these motor units, the average RoA was 92 ± 5 %.

CONCLUSION: The motor unit discharge patterns identified simultaneously from HDsEMG and from iEMG demonstrated high rate of agreement. Compared to iEMG, the decomposition of HDsEMG proved to be more robust to highly interferential waveforms in high-force contractions. These results constitute an important experimental validation of the use of HDsEMG in the analysis of individual motor units during isometric high-force contractions.

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MOTU_O1.9 MOTOR UNIT FIRING RATES IN ISOMETRIC AND DYNAMIC ACTIONS AT DIFFERENT FORCE LEVELS IN SOLEUS MUSCLE

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INTRODUCTION: The recruitment of new motor units has been shown to continue up to 50-80% maximal voluntary contraction (MVC) after which the additional force is achieved only by the increased firing rate (FR) of the active units. In small muscles the recruitment threshold and FR may differ between isometric and dynamic conditions but less is known about the activation patterns of larger muscles, which are important for locomotion.

AIM: To study if the single motor unit FR behavior differs between isometric, eccentric and concentric actions with increasing force levels in a large leg extensor muscle, the soleus.

METHODS: 11 young males performed isometric (ISO), slow (10deg/s) eccentric (ECC) and concentric (CON) plantarflexions with 10, 20 and 40% isometric MVC in all contraction types, and 60, 80 and 100% isometric MVC in ISO. Intramuscular EMG was collected with wire-electrodes and single motor unit FR was calculated from decomposed action potential trains. The average number of motor units analyzed in each condition ranged from 5 to 39.

RESULTS: The FR in CON was significantly higher ($P<.01$) than in ISO or ECC in 10%MVC (CON: 10.88, ISO: 8.46, ECC: 7.26/s), in 20%MVC (CON: 11.60, ISO: 8.13, ECC: 7.97/s) and in 40%MVC (CON: 12.23, ISO: 9.18, ECC: 7.58/s). In ISO contractions the average FR increased significantly with increasing force from 20 to 40 ($P<.05$), and 80 (12.07/s) to 100%MVC (18.39/s, $P<.01$) while no significant changes were observed between 60 (10.57/s) and 80%MVC ($P=.09$).

CONCLUSION: A higher average FR in soleus muscle in CON is in line with previous results from tibialis anterior muscle. Higher MU activation is required in CON since the same % of isometric MVC force corresponds to a higher relative force in CON. Recruitment of additional motor units with increasing load was observed especially in low force levels. The low initial FR of these units seems to be the main reason for the minimal increase in average FR at low force levels. In ISO FR remained similar between 60 and 80% MVC and increased from 80 to 100% MVC. This suggests that additional MUs were recruited up to 80% and the final increase in force was achieved by increased FR as has been shown earlier with smaller muscles.

MOTU_O1.10 DOES EXPERIMENTALLY INDUCED PAIN AFFECT SINGLE MOTOR UNIT DISCHARGE CHARACTERISTICS OF THE KNEE EXTENSOR MUSCLES DURING A POSITION MATCH TASK?

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INTRODUCTION: Single motor unit (SMU) discharge characteristics are altered during voluntary movement tasks with pain. During voluntary isometric muscle contraction in which force is matched between pain and non-pain conditions changes include decreased or complete cessation of discharge of some SMUs and increased discharge (including recruitment of new motor units) in others. More posturally focused tasks in which joint position is matched between trials involve some differences in SMU recruitment. It remains unknown whether SMU discharge properties change in the same manner in this type of task.

AIM: The purpose of this study was to investigate the effect of acute pain on SMU discharge rate during a position-match task.

METHODS: Eight healthy adults (30 ± 6 years) lay supine with their right leg supported with wide straps at the level of the pelvis and upper thigh, ensuring a 90° hip angle. During 6 x 30 s contractions, participants were required to maintain a 90° knee angle (angle feedback was provided on a screen ~ 1m away). Small weights (~ 12.8 [4.0] N) were added to the ankle to provide sufficient inertial load such that ~4-7 SMU's were observed to discharge in intramuscular (fine-wire) electromyographic recordings from the medial and lateral heads of the vastii muscles. After completion of baseline contractions, pain was induced by single bolus injection of hypertonic saline (0.25 ml, 5% NaCl) into the infrapatellar fat. SMUs were discriminated based on unit morphology (EMGlab) from the middle 5 s of each contraction. SMU profiles were compared visually to determine if the same unit was present during both the non-painful and painful conditions. A paired t-test was used for statistical analysis.

RESULTS: The mean discharge rate of 44 SMUs that discharged during both the non-painful and painful contractions decreased during pain (8.56 [2.03] Hz to 8.01 [1.95]; p=0.005). Despite the general trend for decreased discharge rate, the rate increased by more than 10% in a small population of units (3/43 units).

CONCLUSION: Pain reduced SMU discharge rate in the knee extensor muscles during a posturally focused position-match task in which force is kept constant as a consequence of maintenance of a consistent joint position. As motor unit discharge rate is decreased in the primary agonist muscles during pain, other control strategies must be used to help maintain position during pain. There is some evidence that the motor unit pool is not uniformly inhibited as discharge rate increased in a small proportion of units. This is consistent with that observed during tasks in which voluntary effort is focused on maintaining the force of muscle contraction with pain.

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MUSCLE FATIGUE

MUSCLE FATIGUE

MFAT_O1.1 MUSCLE FATIGUE IN VIBRATION EXERCISE

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INTRODUCTION: Extensive research has been carried out in the past to assess the value of vibration exercise for strength training. In particular, the effects of vibration exercise on muscle activation have been extensively investigated by means of electromyography (EMG). Despite a substantial agreement on the increase in neuromuscular activity induced by vibration exercise, the underlying neuromuscular processes are not fully understood, limiting the ability to prescribe effective training routines.

AIM: This study aims at determining the fatiguing effects induced by vibration exercise at varying frequencies when superimposed to high contractile loads. We hypothesize a larger degree of fatigue during vibration as compared to non vibration. We also hypothesize fatigue to be affected by vibration frequency.

METHODS: An electrical training device was built to enable the application of a constant force with superimposed vibration at frequencies up to 50 Hz. The applied force was calibrated by an embedded load cell. Eight volunteers (age=24.4±2.2) performed a randomized sequence of 5 isometric (90 degree elbow) sustained (20 s) contractions of the biceps brachii. The applied force corresponded to 80% of the maximum voluntary contraction (MVC). A sinusoidal force (zero mean, 40 N amplitude) at 0 (no vibration), 20, 30, 40 and 50 Hz was superimposed. The recovery between tasks was 15 min. MVC was assessed by the load cell. Myoelectric and mechanical fatigue were assessed by estimation of EMG conduction velocity (CV) and MVC, respectively. EMG was measured by a high-density grid of 64 electrodes (Refa128 amplifier, TMS International, Netherlands). CV was estimated by a maximum likelihood approach. The vibration frequencies and their harmonics were adaptively removed from the EMG to avoid motion artifacts to affect the estimated CV. Myoelectric fatigue was estimated as the (negative) slope of the regression line fitting the CV evolution during each task. Mechanical fatigue was estimated as the drop in MVC produced by each task.

RESULTS: A good agreement between myoelectric and mechanical fatigue was found (correlation coefficient $r=0.71$, $p<0.05$). The assumption of a linear decrease in CV was confirmed by the average correlation coefficient of the linear regressions $r=0.87\pm0.11$. 30 Hz vibration caused the largest degree of fatigue as identified by both MCV and CV measurements.

CONCLUSION: This study contributes to a better understanding of the effects induced by vibration exercise. In particular, our results suggest vibration exercise to be more fatiguing than exercise at constant muscle tension, supporting the hypothesis that vibration determines higher neuromuscular demands. Furthermore, it seems that 30 Hz produces the largest fatigue in the biceps brachii.

MFAT_O1.2 EFFECTS OF LOCAL CRYOTHERAPY ON MUSCLE RECOVERY SUBSEQUENT TO STRENUOUS ECCENTRIC EXERCISE: A MULTI-CHANNEL EMG AND MRI STUDY

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INTRODUCTION: Exercise-induced muscle damage (EIMD) mainly occurs during return to training, changes in contents or increase of muscular exercise. Since EIMD persist after the sore phase resulting from these perturbations, muscle deficits are often underestimated when soreness disappears. Such process represents a non-negligible risk of trauma for musculoarticular complex. The study of innovative methods aim at improving muscle recovery appears therefore relevant from both a clinical and sport's performance point of view.

AIM: The present study aimed (i) to determine recovery kinetic of various mechanical (e.g. force) and physiological (e.g. edema, high-density myoelectrical activity) indexes following a strenuous eccentric exercise and (ii) to quantify the effects of local air pulsed cryotherapy treatment (-30°C) on this kinetic.

METHODS: 24 subjects were included either in a control group (C, n = 12) or a « cryotherapy » group (CRYO, n = 12). Both groups performed an eccentric session of 3 sets of 20 maximal isokinetic eccentric contractions of elbow flexors. CRYO group underwent a cryostimulation (3 x 4 min at -30°C) immediately after and 1, 2 and 3 days after the eccentric session. Cryostimulation respected the literature recommendations to obtain a sufficient decrease of skin and muscle temperature. The day before and 1, 2, 3, 7 and 14 days after exercise, biceps brachii edema level (i.e., T2 assessed by low-field MRI), maximal isometric force (MVC) and its associated maximal high-density EMG activity, conduction velocity, Delayed Onset Muscular Soreness (DOMS) and creatine kinase activity (CK) were quantified. Differences between groups were tested by repeated measures ANOVAs.

RESULTS: C and CRYO groups exhibited similar decreases in MVC and maximal EMG activity level, and similar increases in T2 level, DOMS and CK activity. Conduction velocity calculated from high-density EMG decreased only for C group.

CONCLUSION: Local air pulsed cryotherapy does not have any significant positive effect on muscle recovery following strenuous eccentric exercise whatever the index considered. Nevertheless, there was a high interinvidual varibility in level of edema. Then, when considering reasonable EIMD characterized by a moderate level of edema, our results demonstrated that, repeated cryostimulations allowed for a faster recovery of muscle function from the first day after eccentric exercise. These findings may have several implications in the management of EIMD and recovery strategies after heavy muscle exercise such as resistance training session. Further researches are needed to investigate the effects of local cryotherapy on less superficial muscle (e.g. brachialis).

ACKNOWLEDGEMENTS: This project was funded by the French Ministry of Sports.

MFAT_O1.3 LUMBAR SPINE KINEMATICS AND ERECTOR SPINAE MUSCLE FATIGUE IN YOUNG AND MIDDLE AGED ADULTS DURING REPETITIVE LIFTING.

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INTRODUCTION: It has been suggested that older workers have a greater incidence of low back injury during repetitive manual handling activities than their younger co-workers. Two of the factors that may contribute to this increased risk of injury when repeatedly lifting are increased spinal flexion and the onset of trunk muscle fatigue. However, few studies have investigated the changes in spinal kinematics and paraspinal muscle fatigue when repetitive lifting in young and middle-aged adults.

AIM: The purpose of this study was to investigate changes in lumbar spine posture and erector spinae muscle fatigue in young and middle aged adults during repetitive lifting.

METHODS: 11 young (20-36 years) and 11 middle aged (43-54 years) males were required to lift and lower a 13 kg box 10 times per minute for 20 minutes or until they became fatigued. Lumbar angular motion and peak lumbar angle was recorded throughout the task using 3D motion analysis. Electromyographic (EMG) data from upper and lower divisions of the erector spinae muscles were also collected during a static back extension performed at 60% of maximal force production for a period of 30 seconds, before and immediately after the lifting task. The median frequency of each consecutive 500 ms EMG epoch was calculated throughout the static extension task. Generalised estimating equations were used to compare temporal changes in lumbar spine kinematics and median frequency between the two age groups.

RESULTS: The young adults significantly increased peak lumbar flexion throughout the lifting task to near 100 percent of maximum ($P<0.05$), whereas middle-aged group only showed a minor increase in lumbar flexion reaching approximately 80% of their maximum flexion. Both groups showed no evidence of local muscle fatigue of the upper erector spinae following the lifting task. However, following repetitive lifting in young adults there was a significant decrease in the median frequency of lower erector spinae when compared to pre-lifting ($P<0.05$).

CONCLUSION: The increased spinal flexion and lower erector spinae muscle fatigue exhibited by the younger adults suggests greater susceptibility to fatigue during repetitive lifting than older adults. This may put younger individuals at greater risk of injury during repetitive manual handling tasks.

MFAT_O1.4 ANTAGONIST GROUP III/IV MUSCLE AFFERENTS REDUCE VOLUNTARY ACTIVATION AND FORCE OF ELBOW FLEXORS.

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INTRODUCTION: During muscle fatigue, the firing of group III/IV muscle afferents can decrease voluntary activation to the fatigued muscle (1). However, it is likely that group III/IV muscle afferents have a broader effect on other muscles of the same limb (2).

AIM: The purpose of the study was to determine if the firing of fatigue-sensitive afferents from elbow extensor muscles, like those of elbow flexors, reduce force production and voluntary activation of the elbow flexors.

METHODS: Transcranial magnetic stimulation (TMS) was used to evoke increments in force from the elbow flexors (superimposed twitch) and provide a measure of voluntary activation. Inflation of a blood pressure cuff about the upper arm was used to block blood flow to the fatigued muscle and maintain firing of group III/IV afferents. In two studies, subjects (n=9) sat with the right arm held in a myograph, which measured flexion and extension torque about the elbow. In study 1, on two days, subjects performed a 2-min maximal voluntary contraction (MVC) of the elbow flexors with or without a subsequent 2-min period of ischaemia. In the 2 min after the sustained MVC, subjects made 4 brief elbow flexion MVCs during which TMS (40-65% stimulator output) was delivered. Design of study 2 was identical except that the 2-min MVCs were done with the elbow extensors rather than flexors. For each brief MVC, the superimposed twitch amplitude was normalised to the mean torque over 100 ms prior to stimulation. Data are reported as the mean of the four brief MVCs.

RESULTS: Study 1. After a fatiguing elbow flexion contraction, maximal flexion torque was significantly less (26.0±4.4% versus 67.9±5.2% of initial maximal torque; $P<0.001$) and superimposed twitches were significantly larger (4.1±1.1% versus 1.8±0.2% ongoing MVC, $P=0.01$) with than without ischaemia. Study 2. After a fatiguing elbow extension contraction, maximal flexion torque was significantly less (82.2±4.9% versus 91.4±2.3% of initial maximal torque; $P=0.007$) and superimposed twitches were significantly larger (2.7±0.7% versus 1.3±0.2% of ongoing MVC; $P=0.02$) with than without ischaemia.

CONCLUSION: Following a fatiguing contraction, voluntary drive to the fatigued muscles is reduced with continued activation of group III/IV muscle afferents. Moreover, fatigue of the antagonist muscle results in decreased torque generation and voluntary drive to the target muscle. Firing of group III/IV muscle afferents from one muscle can affect torque generation and voluntary drive to another muscle in the same limb.

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MFAT_O2.1 ESTIMATION OF INDIVIDUAL MUSCLE FORCE DURING A FATIGUING CONTRACTION USING SUPERSONIC SHEAR IMAGING

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INTRODUCTION: Due to muscle redundancy, the estimation of individual muscle force represents one of the main challenges in biomechanics. Classically, muscle activity level is evaluated by surface electromyography (sEMG), but several limitations inherent to this technique can preclude accurate estimation of individual muscle force. In a recent study, our team reported that the elastography technique called 'Supersonic Shear Imaging' (SSI) is capable of providing a more accurate estimation of muscle force than sEMG during isometric non-fatiguing contractions (Bouillard et al. in press; PlosOne). Neuromuscular fatigue induces a decrease in action potential muscle conduction velocity, an increase in motor units synchronization, and/or force loss, which can be compensated by the recruitment of additional motor units. These phenomena may induce an increase in sEMG amplitude while force remains constant, indicating that sEMG cannot be used to estimate muscle force during a fatiguing contraction.

AIM: The present pilot study aimed to determine whether SSI could be used to estimate muscle force during a fatiguing contraction.

METHODS: For that purpose, it was necessary to investigate a task involving a muscle without synergists (i.e., measured torque produced by only one muscle). Thus, we studied isometric index abduction, mainly involving one synergist (first dorsal interosseous). Six subjects participated in two experimental sessions – one was devoted to SSI measurements and the other was devoted to sEMG recordings. Each session consisted of a maximal isometric fatigue protocol beginning at 50% of maximal voluntary contraction (MVC) and stopped when the force production dropped below 30% of MVC. Before and immediately after this fatiguing contraction, one smooth linear torque ramp from 0 to 80% of MVC was performed. Based on the literature, the relationships between torque and both sEMG activity level and shear elastic modulus were fitted using a linear model. The equations obtained from pre-fatigue ramps were then used to estimate muscle force during the fatiguing exercise.

RESULTS: While the relationships between shear elastic modulus and torque were very similar between pre and post fatigue, the relationships between sEMG activity level and torque were greatly altered by fatigue. SSI provided significant lower RMSerror between measured torque and estimated torque than sEMG activity level for the fatiguing exercise (5,8±1.3 vs. 21.2±9.4% of MVC).

CONCLUSION: SSI provides an estimation of individual muscle force with a satisfactory accuracy during a fatiguing exercise. This elastographic technique will thus provide interesting information regarding alteration in muscle coordination with fatigue.

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MFAT_O2.2 THE HETEROGENEITY OF MULTI-CHANNEL MUSCLE ACTIVITY INCREASES DURING A SUSTAINED SUBMAXIMAL CONTRACTION WITH THE ELBOW FLEXORS

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INTRODUCTION: EMG amplitude increases gradually during sustained contractions when the signal is recorded with conventional bipolar electrodes, which was explained by a monotonic increase in net motor unit activity. Multi-channel surface EMG recordings over a portion of the muscle, however, indicate relative shifts in muscle activity during sustained contractions. By covering the entire muscle with multiple monopolar electrodes and processing the data with principal component analysis (PCA), it is possible to extract the muscle activity more accurately and to observe the extent of variability in surface EMG activity.

AIM: To assess the relative variability in muscle activity for biceps brachii (BB) and brachioradialis (BR) during a fatiguing submaximal contraction.

METHODS: Ten healthy men sustained a target force of 20% MVC (force feedback) with the elbow flexors for 50% of endurance time (3±1 min). We measured flexion force at the wrist and surface EMG with 63±4 electrodes homogeneously distributed over the entire BB and 2×3 electrodes over BR. The monopolar EMG channels were high-pass filtered, PCA-processed (remove common information), rectified and smoothed (over BB five distinct clusters were established using smoothed EMG channels), and averaged over BB and BR separately. Correlation coefficients between BB-BR muscle activities and flexion force were calculated. Analyses were conducted over three 10-s time windows (TW1-3: start, middle, end).

RESULTS: Mean muscle activity of both elbow flexors increased by 35% ($P>0.028$) between TW1-2 with no further increase until the end (TW 2-3; $P>0.118$). Correlations between channels within clusters showed no significant change with TW ($P=0.210$), but correlations between cluster time series decreased by 40% from TW1 to TW2 ($P=0.003$). Correlations between EMG amplitude for the two synergists and between the two muscles with the flexion force showed no effects on TW ($P>0.649$). A substantial increase was found from the low correlations between EMG amplitude for each muscle separately with flexion force ($r_{BB}=0.21\pm0.22$; $r_{BR}=0.10\pm0.49$), to a very high correlation between force and EMG amplitude for BB+BR ($r_{SUM}=0.86\pm0.16$).

CONCLUSION: Most of the change in EMG amplitude during the sustained submaximal contraction occurred in the first interval, as indicated by (i) an increase in the mean EMG amplitude, and (ii) an increase in the heterogeneity of EMG activity within the muscle. The control strategies varied across subjects. There was a strong association between the summed synergist EMG amplitudes, despite low associations for the individual muscles.

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MFAT_O2.3 BICEP FEMORIS VOLUNTARY ACTIVATION DEFICITS CONTRIBUTE TO ECCENTRIC KNEE FLEXOR WEAKNESS FOLLOWING INTERMITTENT RUNNING.

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INTRODUCTION: Hamstring strain injuries (HSI) are the predominant non-contact injury in many sports. Eccentric hamstring muscle weakness following intermittent running has been implicated within the aetiology of HSI. This weakness following intermittent running is often greater eccentrically than concentrically, however the cause of this unique, contraction mode specific phenomenon is unknown.

AIM: To determine if this preferential eccentric decline in strength is caused by declines in voluntary hamstring muscle activation.

METHODS: Fifteen recreationally active males completed 18 × 20m overground sprints. Maximal strength (concentric and eccentric knee flexor and concentric knee extensor) was determined isokinetically at the velocities of ±1800.s-1 and ±600.s- while hamstring muscle activation was assessed using surface electromyography, before and 15 minutes after the running protocol.

RESULTS: Overground intermittent running caused greater eccentric (27.2 Nm; 95% CI = 11.2 to 43.3; p=0.0001) than concentric knee flexor weakness (9.3 Nm; 95% CI = -6.7 to 25.3; P=0.6361). Following the overground running, voluntary activation levels of the lateral hamstrings showed a significant decline (0.08%; 95% CI = 0.045 to 0.120; P<0.0001). In comparison, medial hamstring activation showed no change following intermittent running.

CONCLUSION: Eccentric hamstring strength is decreased significantly following intermittent overground running. Voluntary activation deficits in the biceps femoris muscle are responsible for some portion of this weakness. The implications of this finding are significant because the biceps femoris muscle is the most frequently strained of all the hamstring muscles and because fatigue appears to play an important part in injury occurrence.

MFAT_O2.4 INCREASED INTRACORTICAL INHIBITION DURING 30 MINUTES OF SUSTAINED CYCLING EXERCISE

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INTRODUCTION: We recently showed that, during sustained cycling exercise, the excitability of motor cortical neurons is reduced and the excitability of spinal motoneurons is increased. A possible mechanism for reduced cortical excitability might be increased intracortical inhibition.

AIM: In the current study, we aimed to investigate changes in intracortical inhibition during sustained cycling by measuring the magnitude of EMG suppression induced by subthreshold transcranial magnetic stimulation (TMS).

METHODS: Sixteen participants performed 30 minutes of cycling at 75% of their maximum workload (Wmax), during which subthreshold TMS was applied at a crank angle where right quadriceps electromyography (EMG) was increasing and approximately 50% of its recorded maximum. At the end of steady state cycling, workload was reduced by half and the same subthreshold TMS was used to monitor "recovery" over 5 minutes. Subthreshold TMS was also applied during non-fatiguing control cycling at 75% and 37.5% of Wmax prior to the sustained bout.

RESULTS: Suppression in the rectified EMG was evident in approximately half of the subjects. Although EMG amplitude during control cycling at 37.5% Wmax was approximately half that during 75% Wmax ($P < 0.05$), the amount of suppression was similar in all of the recorded quadriceps muscles ($P > 0.05$) except for vastus medialis, where suppression was significantly greater at the lower workload ($P < 0.05$). Despite a significant increase in rectus femoris EMG amplitude during the sustained cycling ($P > 0.05$), the amount of suppression at the end of the sustained cycling was significantly greater than that at the start in all muscles ($P < 0.05$). At the end of 5 minutes of recovery, background EMG amplitude and the amount of TMS-induced suppression were comparable to control cycling ($P > 0.05$) at the same workload.

CONCLUSION: The results suggest that during sustained cycling, the excitability of intracortical inhibitory interneurons increases. The increase in inhibition is independent of fatigue-induced increases in EMG amplitude, since increased EMG amplitude decreases suppression in the absence of fatigue. Finally, as suppression measured shortly after fatiguing exercise was terminated was similar to that during control exercise at a matched workload, it appears that intracortical inhibitory effects produced by sustained cycling are not long lasting. The observed changes are similar to those seen during a sustained single joint contraction, suggesting that similar mechanisms may regulate the extent of intracortical inhibition during single limb and locomotor exercises.

MFAT_O2.5 FATIGUE-INDUCED CHANGES IN MUSCLE COORDINATION DURING REPEATED CYCLING SPRINTS

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INTRODUCTION: The ability of humans to generate power is progressively lost during repeated cycling sprints. Alteration of muscle coordination during exhaustive exercise also manifests progressively through changes in the level and timing of activation of the different individual muscles involved in the production of mechanical power. Such changes may affect power production through changes in the co-contraction between mono-articular agonist and bi-articular antagonist muscles.

AIM: To quantify changes in muscle coordination during repeated cycling sprints.

METHODS: Fourteen physically-active males performed two sets of five maximal sprints of 4 sec (20 s rest between two sprints and 5min rest between two series) on an air-braked bicycle ergometer instrumented with SRM cranks. Surface electromyography (EMG) signals of four lower-limb muscles: gluteus maximus (GMAX), rectus femoris (RF), vastus lateralis (VL), semi-tendinous (ST) were continuously recorded using DTS Noraxon system. Raw EMG signals were filtered (12-500Hz band-pass filter) and rectified. Average EMG patterns were calculated for each sprint. The amplitude of the EMG signals was normalized in reference to the maximal value obtained during the different maximal sprints. A co-contraction index was then calculated for two pairs of mono-articular agonist and bi-articular antagonist muscles: GMAX-RF and VL-ST. ANOVA with repeated measures were used to evaluate the effect of sprint repetition on the following variables: total mechanical work accumulated (Joules), mean activation level of each muscle (%), and co-contraction index of the two muscle pairs (%).

RESULTS: The total mechanical work decreased significantly during each set of sprints ($p<0.001$, from 3426 ± 160J to 2797 ± 286J during set 1, and from 3326 ± 188J to 3011 ± 123J to during set 2). A decrease in the mean activation level of GMAX was observed ($p<0.05$, from 40 ± 3% to 35 ± 4% in set 1, and from 37 ± 5% to 34 ± 3% during set 2), whereas the mean activation levels of RF ($p=0.052$), ST ($p=0.46$), and VL ($p=0.66$) did not vary. Between the sprints, a decrease of the co-contraction index calculated for GMAX-RF was observed ($p<0.001$, from 43± 4% to 34± 4% in set 1, and from 38± 4% to 35± 4% in set 1) whereas the co-contraction index for VL-ST remained unchanged ($p=0.3$, 21 ± 2% over 10 sprints).

CONCLUSION: Changes in GMAX activation level and co-contraction of GMAX and RF suggest that alterations of the muscle coordination around the hip contribute to the decrease of the mechanical power generated during repeated cycling sprints.

NEUROLOGICAL DISORDERS

NDIS_O1.1 RELATION BETWEEN MUSCLE STRETCH VELOCITY AND SPASTIC CO-CONTRACTION

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INTRODUCTION: Spasticity takes an enormous impact on the quality of life of patients suffering on an upper motor neuron syndrome. Concerned patients might be of all ages with diverse numbers of reasons of spasticity. Thereby strength of the increased muscle tone does often not correlate with the comfort-related situation from the patients' perspective. Additionally, there is a lack of generally accepted definitions and measurement techniques to classify spasticity.

In some patients spasticity is expressed in form of co-contraction of antagonistic muscles. One hypothesis claims that spastic muscular co-contraction is dependent on muscle stretch velocity. Knowledge of the individual muscle stretch velocity dependent co-contraction could become a valuable tool in order to classify different types of spasticity.

AIM: Implementation of a method for measurement of the individual dependency of spastic co-contraction on muscle stretch velocity.

METHODS: The method requires a quantitative measure for co-contraction synchronized to the muscle stretch velocity. In order to quantitatively analyze spastic muscular co-contraction bipolar Surface Electromyography (SEMG) was utilized. Thereby the known problem of crosstalk, influence of electrical activity from muscles, which are not located at the measuring site, is addressed with a Crosstalk Risk Factor (CRF) and a Confidence of Co-Activation (CCA) value. The CCA allows for the discrimination between crosstalk and co-contraction and was implemented by Disselhorst-Klug and Rau [2010].

Muscle stretch velocity correlates with angular velocity. During examination of the individual relation the angular velocity is gradually increased by providing the velocity as a target, which has to be followed by the patient. Thereby compliance of the targeted to measured angular velocity is controlled with the help of a real-time visual feedback.

As a result, the synchronous recording of SEMG and angular velocity led to the assessment of co-contraction at varying muscle stretch velocities.

RESULTS: The method was validated in patients with spasticity of the upper extremity. Thereby elbow flexion and extension was examined, where SEMG was collected from biceps, triceps and brachioradialis. Furthermore, it was evaluated whether the individual and reproducible character of muscle stretch velocity dependent co-contraction is appropriate in order to enable diagnostically classification of spasticity.

CONCLUSION: The inconsistent knowledge and individual features of spasticity face a lack of generally accepted definitions and measurement techniques. Individual determination of muscle stretch velocity dependent co-contraction can be a first step towards the classification of diagnostic- and comfort-related characteristics of spasticity.

NDIS_O1.2 GAIT EMG OF DIABETIC NEUROPATHIC PATIENTS: EFFECT OF DISEASE SEVERITY CLASSIFIED BY A FUZZY EXPERT MODEL

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INTRODUCTION: Diabetic sensorymotor polyneuropathy (DSPN) is related to ulcerations and amputations. Biomechanical alterations during gait, such as changes in lower limb EMG, may be an underlying cause for these tragic events. However, findings are inconsistent and not always related to DSPN, but to diabetes itself, pointing to a lack of defined disease diagnostic and classification methods as a possible reason. Since it´s a continuous process, sickness-health boundaries are unclear and subjective, suggesting the use of Fuzzy Sets Theory, which can quantify disease severity considering diagnosis uncertainty, and allocate patients in degree subsets.

AIM: To analyze the effects of severity degree of DSPN, classified by a fuzzy expert system, on lower limb EMG during gait.

METHODS: 142 people were assessed (55.8±6.8yrs, 76.2±15.1kg, 1.65±0.10m): 30 control subjects (C) and four diabetic groups: 30 without neuropathy (D), 30 with mild (MiN), 28 moderate (MoN), 24 severe DSPN (SN). Input data for the fuzzy system were: symptoms and signs based on Michigan Neuropathy questionnaire and physical assessment, diabetes duration and HbA1c levels. Vastus lateralis (VL), tibialis anterior (TA) and gastrocnemius medialis (GM) were acquired following SENIAM in a single differential mode using bipolar electrodes Ag/AgCl (ϕ=10mm, IED=25mm). EMG signals, sampled at 2kHz, underwent a 10–500 Hz bandwidth filter and were amplified (gain=1000). Linear envelopes were normalized by mean EMG activity and time, by stance time (%stance).

RESULTS: All diabetic groups, except MiN group, had delayed VL peak (D=12.5±2.7; MoN=12.4±5.2; SN=12.2±3.2), when compared to C (10.4±3.5). SN (63.9±5.7) and MoN (62.3±4.9) showed delayed GM peak and earlier TA onset on late stance (MoN=92.0±4.1; SN=91.4±4.0) when compared to others.

CONCLUSION: DSPN has been related to VL delay (Sacco, 2003; Akashi, 2008), and our results confirm those findings, also revealing it starts before neuropathy onset. Delayed GM peak activity was manifested only on the most affected groups, confirming the data on literature (Akashi, 2008; Gomes, 2011), which could be related to lower plantar flexion moments at propulsion phase (Mueller, 1994; Yavuzer, 2006; Sawacha, 2010). Those same groups also presented an early onset of TA during late stance, possibly explaining why there is an increased ankle joint stiffness (Williams, 2007) and decreased ankle extension on the same phase (Giacomozzi, 2008; Sacco, 2009). The fuzzy expert system is a useful tool for clinical practice and research, since it was successful at distinguishing groups with different neuropathy degrees and progressively divergent EMG patterns.

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NDIS_O1.3 CLINICAL AND POSTUROGRAPHIC CORRELATES OF FALLS IN A PARKINSON'S DISEASE COHORT

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INTRODUCTION: Postural instability (PI) and falls are a major source of disability and impaired quality of life in patients with idiopathic Parkinson's disease (IPD). Current PI assessments include clinical protocols and quantitative posturography, but few studies have combined these assessments.

AIM: This study aimed to assess dynamic and static balance in a group of IPD subjects of varying disease duration and severity to determine which posturographic and clinical measures best differentiate patients with a history of falling from non-fallers and age-matched controls.

METHODS: Forty eight individuals with levodopa-responsive IPD and 17 healthy age-matched control subjects without PD completed the following clinical assessments: Hoehn and Yahr Scale, Schwab-England Scale (SES), Berg Balance Scale (BBS), Activities-specific Balance Confidence (ABC) scale, the Unified Parkinson's Disease Rating Scale (UPDRS) motor score, and the 'Timed Up and Go' (TUG). Static body sway and leaning balance in 8 different directions were measured with fixed platform posturography. Twenty-six of the IPD subjects had a history of one or more falls during the previous 2 years.

RESULTS: The IPD subjects with a history of falling were significantly different ($p < 0.05$) from the non-fallers with a longer mean disease duration, poorer scores on scales of functional balance and mobility and lower balance confidence. Sway-path area and sway-path axis length differentiated fallers from normal controls. With dynamic leaning posturography, significant differences were found in the average reaction time, velocity and target hit time of leaning movements to a target, which were slower in fallers than non-fallers and controls. A multiple analysis considering all variables jointly found higher reaction time and higher target achievement time could explain the differences between fallers and all others combined ($p = 0.0025$) and showed a strong correlation between clinical and posturographic data.

CONCLUSION: This study demonstrates that clinical assessments and quantitative posturography can discriminate fallers and non-fallers in a random IPD cohort. Dynamic leaning balance variables closely correlate with a history of falls in IPD.

NDIS_O1.4 EFFECT OF DIABETIC NEUROPATHY ON ELECTROMYOGRAPHY OF THE LOWER LIMBS FROM THE PERSPECTIVE OF DISCRETE WAVELET ANALYSIS (DWA)

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INTRODUCTION: Biomechanical alterations of gait caused by diabetic neuropathy have been extensively discussed in literature, but changes in muscles activity in diabetics are subtle and still not consistent. The wavelet transform allows specific events analysis at different frequency bands within the EMG signal, while maintaining time resolution. The DWA gives a decomposition of the signal that allows a better understanding of the amount of energy in each frequency band.

AIM: Analyze the influence of diabetic neuropathy in muscle recruitment strategies during gait cycle using Discrete Wavelets transform.

METHODS: EMG of vastus lateralis (VL), tibialis anterior (TA) and gastrocnemius medialis (GM) were acquired following SENIAM in a single differential mode using bipolar electrodes Ag/AgCl (f=10mm, IED=25mm). Signals were amplified (gain=1000), sampled at 2kHz and synchronized with 2 foot-switches. 200 subjects equally divided in diabetic neuropathic group (DG) and non-diabetic (CG) performed gait cycles. A filter bank of thirteen non-linearly scaled wavelets that maintain the optimal combination of time and frequency resolution across the frequency range of EMG signals (12–121 Hz) was used for the analysis. Energy in each frequency band (13) was compared between groups (t tests).

RESULTS: The GM of DG showed significantly higher energies at higher frequencies (66Hz, 74Hz, 102Hz), and lower energy at a lower frequency (27Hz). For VL they had higher energies in intermediate frequencies (59Hz and 66Hz), while in lower (27Hz) and in extreme frequencies (102Hz, 109Hz and 121Hz) they presented lower energies. For TA, DG showed significantly reduced proportion of energy at lower frequencies (12Hz, 20Hz and 27Hz).

In the whole gait cycle, DG produced higher energy in VL while they had lower energy of GM. Possibly, VL was compensating the lower energy of GM, because both muscles are part of the extensor triad essential to walk. DG produce lower energy in GM even trying to raise their energy production in higher frequencies. In VL, the higher energy in DG could be due to higher energy proportion in higher frequencies. DG could not produce the same proportion of energy as the CG in many frequencies and for all muscles, demonstrating a different pattern of muscle recruitment.

CONCLUSION: The higher energy in VL observed in DG due to higher frequencies, highlights a different motor strategy that involves different muscle energy production and frequencies to perform successfully their daily activities. This fact shows that diabetics may not keep up with the mechanical demands of walking by changing muscle fibers recruitment strategies, as controls perform.

NDIS_O1.5 SUPRAMAXIMAL VOLITIONAL TORQUE IN HUMANS WITH SPINAL CORD INJURY: ASSOCIATED MOTOR BEHAVIORS

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INTRODUCTION: Individuals with motor incomplete spinal cord injury (SCI) are able to produce volitional torques 20-30% above their one repetition maximum during a fatiguing protocol consisting of repeated maximum volitional effort contractions (MVE) of their knee extensors.

AIM: The goal of this investigation is to understand the motor behaviors which are associated with this supramaximal volitional torque generation in human SCI. This knowledge will allow for the development of effective rehabilitation interventions and allow for further investigations of mechanisms which underlie this behavior.

METHODS: Eleven individuals with chronic SCI (AISA C and D) performed isometric MVE contractions of the knee extensors following various combinations of contraction intensity (% baseline MVE) and duration rest between contractions. Five of these individuals underwent a similar protocol using isokinetic, isotonic and eccentric contractions. Gravity corrected peak torque and surface electromyographic (EMG) activity was assessed. Single motor unit (MU) activity during isometric supramaximal contractions was assessed in a subset of these individuals using either intramuscular or subcutaneous electrodes.

RESULTS: Supramaximal volitional torque was observed when MVE contractions were preceded by high intensity contractions which are separated by brief rest periods – a decay constant of 62% MVE for contraction intensity and 6.5 s for duration between MVEs was observed. This supramaximal torque was associated with increases in agonist EMG and in rate of torque development. Such behaviors were observed to a similar extent during isokinetic and isotonic contractions, but were rarely observed during eccentric contractions. Single MU recordings during repeated MVEs demonstrated increased MU recruitment and rate coding during supramaximal torque generation.

CONCLUSION: Individuals with SCI consistently produce supramaximal torques during high-intensity volitional contractions separated by brief rest periods. This is observed during both static and dynamic contractions. Both surface EMG and single MU recordings suggest central mechanisms contribute to supramaximal torque. These time and intensity parameters are necessary for the clinical implementation of an exercise program in human SCI. Preliminary results from a 4-week training intervention utilizing these parameters demonstrate superior gains in strength and function as compared to conventional resistance training.

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NDIS_O2.1 MYOELECTRIC MANIFESTATIONS OF FATIGUE IN PARKINSON DESEASE

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INTRODUCTION: Parkinson disease (PD) is a neurodegenerative pathology, progressively and chronically invalidating. Along with the classical motor symptoms i.e. spasticity and tremor PD is also characterised by a variegated symptoms classified as “non motor” with a relevant impact on the quality of life and rehabilitation strategies, such as the sensation of fatigue.

AIM: The aim of this work was to study myoelectric manifestations of fatigue in a group of PD and to compare them with a healthy control group (CG) to assess if:

a) in PD group central fatigue is prevalent with respect to its peripheral component and to what extent in comparison with the CG:

b) there are any correlation between myoelectric manifestation of fatigue and the Unified Parkinson’s Disease Rating Scale (UPDRS) and the Parkinson Fatigue Scale (PFS)

METHODS: Twelve males affected by PD, in clinical and therapeutic steady state (Hoehn & Yahr phase II-III), were recruited. CG was formed by 10 healthy males, comparable for age (PD Mean 67 ±6; CG 64±9 years). All the subjects involved in the research performed two voluntary isometric contraction of the right biceps brachii muscle respectively at 30% and 60% of their maximal voluntary contraction (MVC). On the same muscle an electrically supramaximal contraction was also induced for 30 sec at 25 Hz. Voluntary as well as stimulated contractions were separated by 15 minutes of rest and recorded for off line evaluation. Initial values and muscle fibers conduction velocity (CV) rate of change were analysed during both voluntary and stimulated muscle contractions.

RESULTS: CV initial values showed a statistical difference between PD and CG (PD 4,42±0.38 m/s vs CG 4,81±0.53, $p<0.05$ Mann-Whitney U test); no differences in the manifestations of fatigue were observed during electrically elicited contractions. A clear correlation ($r2=0.34$, $p=0.02$) was found between CV and PFS values.

CONCLUSION: Lower CV values observed in PD with respect to CG are in agreement with the well known reduction of type II fiber induced by PD.

Correlation between PFS scale and EMG data confirm the potential clinical role of such an approach since fatigue is the focus of the measure. The lack of correlation with UPDRS scale, confirm the need to introduce in the UPDRS the evaluation of this important non motor symptom. Finally, the lack of difference between the two groups in the electrically elicited contractions underlines that in PD, fatigue plays a “central” rather than a “peripheral” role. This is a pivotal statement for rehabilitation.

NDIS_O2.2 A MULTI-MODALITY APPROACH TO STUDYING THE SHOULDER: EMG, FUNCTIONAL MRI AND MOTION ANALYSIS

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INTRODUCTION: There is a lack of current evidence to inform targeted rehabilitation following common shoulder pathology. This relates to an incomplete understanding of normal shoulder function. Concurrent functional MRI (fMRI) and electromyography (EMG) has the potential to enable a detailed insight into understanding muscle activity and neuromuscular control. However, the size constraints of an MRI scanner, movement artifact and synchronizing multiple data streams presents challenges to study design.

AIM: The aim of this preliminary work is to establish methods for a synchronous fMRI, EMG and motion analysis study of healthy shoulders.

METHODS: EMG was recorded from 10 healthy volunteers with no history of upper extremity complaints or other musculoskeletal problems. One participant underwent fMRI and motion analysis testing. Participants completed 10 cycles of controlled shoulder flexion/extension and adduction/abduction, within each testing modality. EMG and motion analysis testing was performed in a custom made testing jig, which replicated the confines of an MRI scanner, but allowed testing away from the MRI scanner. EMG signals were differentially amplified, digitalized and filtered in accordance with international guidelines. Accepted methods were used to analyze fMRI (BrainVoyeur) and motion analysis data.

RESULTS: The motor task required unimpeded forward flexion of 37 degrees and abduction of 17 degrees, followed by returning the arm to the resting position along the subjects side. Significantly greater activity was evident during shoulder flexion, as compared to extension, for the anterior, middle and posterior deltoid, pectoralis major, latissimus dorsi, teres major, supraspinatus, infraspinatus and subscapularis ($p < 0.001$-0.040). Similarly, with regards to the fMRI data, significant different motor cortex activation (Brodmann Area 4) was seen between flexion/extension and adduction/abduction ($p=0.0009$ to 0.012).

CONCLUSION: The pilot study aims to develop a feasible method for a multidimensional assessment of the shoulder joint in patients with complex pathogenesis and etiology. This work presents a novel approach to studying the shoulder. There is an infant body of EMG data relating to healthy shoulders and no fMRI data has been previously published. Motion analysis was used to accurately define the movement path. A discernible difference in motor cortex activation between flexion and extension was identified; this directly relates to EMG data which showed significant differences in the muscle activation during the task. This work facilitates the development of synchronized EMG and fMRI investigation. This is a critical building block in understanding, for example, complex shoulder instability.

NDIS_O2.3 THE EFFECT OF A SEDATING AND A NON-SEDATING ANTIHISTAMINE ON NEUROMOTOR FUNCTION IN HEALTHY YOUNG ADULTS

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INTRODUCTION: First generation H1 antihistamines act on peripheral and central H1 receptors, and are known to produce feelings of tiredness and impair cognitive skills. In an effort to reduce sedating properties, second generation antihistamines were engineered to have high selectivity for peripheral H1 receptors and therefore minimal effects on the CNS when administered at a therapeutic dose. Although the cognitive effects of sedating and non-sedating antihistamines have been well documented, it is largely unknown if neuromotor function is affected following ingestion of antihisatmines.

AIM: To investigate the action of 10 mg dosages of Promethazine (sedating) and Loratadine (non-sedating) on involuntary and voluntary motor processes using controlled tests of simple reaction time, choice reaction time, and postural tremor.

METHODS: The design was a human double-blind, placebo-controlled, three-way crossover. Eight subjects (5 female, 3 male) were recruited from the university community who were of similar age (21 years). Neuromotor function was assessed 4 times for each of the Promethazine, Loratadine and placebo interventions: pre-ingestion, 1 hour post-ingestion, 2 hours post-ingestion, and the next day.

RESULTS: Simple reaction time was significantly slower 1 hour and 2 hours after the ingestion of Promethazine. Choice reaction time was significantly slower 1 hour and 2 hours after the ingestion of Promethazine, and 2 hours after the ingestion of Loratadine. Finger tremor was greater 1 hour post-ingestion of Promethazine and the day after ingestion of Loratadine.

CONCLUSION: The presence of selective neuromotor deficits following ingestion of Promethazine and Loratadine suggest that antihistamine alters voluntary and involuntary motor processes. Of particular interest is the altered CNS function following ingestion of the non-sedating Loratadine. It is possible that the H1 antagonists used in this study also have antimuscarinic effects, which may impact the central dopaminergic system that plays a role in modulating several CNS processes associated with movement.

NDIS_O2.4 WII-BASED MOVEMENT THERAPY FOR POST-STROKE UPPER-LIMB REHABILITATION

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INTRODUCTION: The biggest impediments to stroke rehabilitation are access, resources and patient compliance. Wii-based Movement Therapy was developed to overcome these by providing a cheap, readily available rehabilitation tool that is motivating and engaging to promote physiological changes that lead to movement recovery after stroke.

AIM: To investigate the efficacy of Wii-based Movement Therapy for post-stroke upper-limb rehabilitation.

METHODS: 34 patients aged 22-83 years, 1 month to 21 years post-stroke, completed the 14 day protocol of 1 hour formal therapy sessions on 10 consecutive weekdays augmented by home practice that progressively built from 15 to 180 min daily, depending on progress and disability. A suite of functional assessments were completed immediately before and after therapy with wireless telemetry recordings during therapy at three time points, early, mid and late therapy.

RESULTS: All patients gained increased functional movement ability. For mild-moderate stroke there was a 21% improvement in timed tasks on the Wolf Motor Function Test ($p=0.002$) but only a 4.0% improvement for severe stroke. When assessed using the Fugl Meyer Assessment, the mild-moderate group improved by 9.5% while patients with severe stroke improved by 39.7% ($p<0.001$). Use of the hand increased in activities of daily living by 29.6% and 10.3% for mild-moderate stroke, respectively; and 13.8% and 5.0% for severe stroke. Grip strength increased but not significantly. Both groups had increased range-of-motion in joints of the upper-limb, albeit with different patterns of improvement. Increases were more prominent in joints of the hand and wrist for severe stroke. Peak heart rate was measured in 25 patients, increasing from early to late therapy by an average of 38% ($p<0.001$). Increased stepping during Wii tennis (56.3%) and boxing (27.2%) contributed to the greater cardiovascular effort (both $p=0.02$). EMG data was characterised by a shift from prolific single motor unit activity to compound muscle activity. This was most pronounced in severe stroke. These changes were matched by increased exercise endurance and stair climbing speeds ($p=0.02$).

CONCLUSION: After a 2 week intensive protocol of Wii-based Movement Therapy patients with mild-moderate stroke more independent, those with severe stroke were less disabled. The pattern of improvements varied with stroke severity. Nevertheless, these results were not only statistically significant and clinically meaningful, but also functionally relevant regardless of the level of disability pre-therapy.

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NDIS_O3.1 A SECONDARY MOTOR TASK EXAGGERATES GAIT DEFICITS IN PARKINSON'S FALLERS

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INTRODUCTION: People with Parkinson's disease (PD) who fall demonstrate alterations in temporospatial, segmental and kinematic parameters of gait. Performance of dual tasks while walking results in decreased performance in people with PD. Given that PD fallers have been shown to have poorer segmental control during controlled walking tasks, their risk of falling could be exacerbated under conditions that challenge postural stability.

AIM: The aim of this study was to determine how gait patterns were altered when performing a secondary motor task.

METHODS: 44 PD patients and 34 healthy age-matched controls were assessed using three-dimensional motion analysis while walking at a self-selected pace during normal walking and while carrying a glass of water. Six trials were recorded for each condition. Falls were recorded prospectively over 12 months using daily falls calendars.

RESULTS: Based on the prospective falls data, participants were divided into four groups; PD Fallers (n=29); PD Non-Fallers (n=15); Control Fallers (n=17); and Control Non-Fallers (n=17). PD fallers and non-fallers had similar disease severity based on the UPDRS and Hoehn &Yahr scores. PD fallers had significantly greater disease duration, Freezing of Gait score and increased fear of falling than non-fallers. Average daily Levodopa dose was not different between the PD fallers and non-fallers.

The secondary task resulted in a decrease in walking velocity, cadence, stride length and toe clearance for both groups. Stance and double support time were increased. Trunk flexion, mediolateral pelvis motion and knee flexion/extension range were increased.

PD fallers were characterised by slower walking velocity, decreased toe clearance, reduced arm swing, increased trunk flexion and mediolateral motion of the head and pelvis, and increased knee flexion. Performance of the secondary task by PD fallers exaggerated differences in mediolateral pelvis motion and knee flexion angle.

CONCLUSION: Postural control deficits in PD fallers may impair their capacity to adapt to different task constraints. In an everyday activity, carrying a glass of water, PD fallers had increased segmental instability and altered kinematics. The risk of falling for people with PD may be increased when performing secondary tasks.

ACKNOWLEDGEMENTS: Parkinson's Queensland Inc, NHMRC Injury Partnership.

NDIS_O3.2 CHANGES IN MUSCLE ACTIVATION AND WORK AREA AFTER ARM SUPPORT TRAINING IN CHRONIC STROKE PATIENTS

Dr Gerdienke Prange, Roessingh Research and Development

Dr Jaap Buurke; Prof Johan Rietman; Mr Thijs Krabben

INTRODUCTION: After stroke many patients have a limited arm function, interfering with daily life activities. This is in part related to involuntary, abnormal coupling between shoulder abduction and elbow flexion. This coupling can be reduced instantaneously by application of arm support, increasing range of motion. Longer-term application of arm support as training intervention is expected to result in improved work area without any support. However, underlying mechanisms are largely unknown.

AIM: To obtain insight into changes in muscle activity underlying changes in work area after arm support training.

METHODS: Eight persons with chronic stroke (with mild to severe hemiparesis; baseline Fugl-Meyer scores ranging from 7 to 61 points) received 6 weeks of 30-minute reach training sessions (3 per week) with arm support (using the Freebal device and a game). Maximal work area without support, using a standardized circle drawing task, was assessed 1 week before and after training. Muscle activity of 8 shoulder and elbow muscles was recorded. Changes in work area, muscle activity (averaged root mean square (RMS) values) and co-contractions (CC-ratio's of RMS antagonist/RMS agonist) were evaluated using paired-samples t-tests.

RESULTS: After training, work area had increased by 3.3% (of maximal area based on arm length) ($p=0.038$), while self-selected movement speed increased by 3.1 cm/s ($p=0.006$). Muscle activity had increased in all muscles, except biceps. The increase in only anterior deltoid and triceps (lateral head) was significant, by 32% and 68% relative to pre-training RMS, respectively ($p\leq0.004$). Most CC-ratio's had decreased after training, except for no change for triceps (lateral head) with anterior deltoid. CC-ratio of biceps with anterior deltoid decreased most substantially (from 1.8 to 1.0), but not significantly ($p=0.092$). Decreases in posterior with anterior deltoid and biceps with triceps were significant ($p\leq0.048$).

CONCLUSION: Reach performance after arm support training improved concerning both work area and speed. Those improvements were related to increases in anterior deltoid activity, accompanied by increases in triceps activity, although biceps activity didn't increase parallel to anterior deltoid. This indicates that both reduced coupling between anterior deltoid and biceps and improved activation of elbow extensors may play a role. Two different processes appear to be related to more selective joint control after arm support training, warranting further research. Either way, arm support training seems a promising application to aid in improvement of work area after stroke.

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NDIS_O3.3 APPLICATION OF AUGMENTED REALITY SYSTEM FOR ASSESSING AND ASSISTING GAIT PERFORMANCE OF PATIENTS WITH PARKINSON'S DISEASE

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INTRODUCTION: Gait disturbances are commonly observed in patients with Parkinson's disease (PD) resulting from a degeneration of dopaminergic neurons in the substantia nigra. The hallmark changes of gait following PD include temporal asymmetry, which manifests as an inability to maintain internal gait rhythm, reducing step/stride length, difficulty turning and slow walking speed. The main feature of augment reality (AR) technology for motor training is the capacity to provide the trainee with immediate performance feedback.

AIM: Thus the main purpose of this study is to use AR system as the external virtual cues to assist gait performance with the real-time visual feedback in PD subjects.

METHODS: 12 idiopathic PD subjects received three walking tests and followed up in one month. By using five inertial sensors combining with multi-axis accelerometer and gyroscopes, the dynamic kinematic data can be measured. Optical flow data can be further generated and displayed in head-mounted displayed for visual feedback during walking. The designed portable (AR) system can be used as gait training as well as assessment system. All subjects were asked to (1) walk along a hallway of 450 cm, (2) perform 45 and 90 degrees of turns and (3) continue to walk for 150 cm for without and with AR-assisted conditions. The gait performance for straight, and 45 and 90 degrees turns were evaluated from the recorded AR system to extract gait parameters including total finish time, turning time, first step of knee flexion angle, cadence, stride length, swing/stance phase ratio of entire gait cycle and actual turning angle.

RESULTS: Our result demonstrated that gait parameters, especially stride length (Non-AR: 46.9+14.1 cm vs. AR: 54.1+13.7 cm), turning time (Non-AR: 3.16+1.2 s vs. AR: 2.40+1.0 s), walking speed (Non-AR: 44.4+8.1 cm/s vs. AR: 50.3+10.7 cm/s) were significantly improved on turning 45 degrees trials. Nevertheless, there were no significant changes in some gait parameters in 90 degrees turning trials. For example, total finish time (Non-AR: 16.04 +2.8 s vs. AR:15.7+3.0 s) and the ratio of swing phase during walking (Non-AR: 29.5 + 5.4% vs. AR: 30.3+4.2%).

CONCLUSION: Our study concluded that the usage of AR system can improve gait performance on walking and turning trials, especially 45 degrees. The future application of portable AR system can be used as a tool for gait training of PD patients without environmental limitation.

NDIS_O3.4 DEVELOPMENT OF SPONTANEOUS MOTOR ACTIVITY WITH AGE IN HEALTHY INFANTS AND INFANTS WITH INFANTILE CEREBRAL PALSY

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INTRODUCTION: Coordination between perception and action is required to interact with the environment successfully. This training is already undertaken by very young infants who perform spontaneous movements to learn how their body interacts with the environment. The strategies used by the infants for this purpose change with age. Therefore, investigations of the development of spontaneous motor activity during the first month of life will give insight into the very early progresses made to control action.

In developmental neurology visual observation of spontaneous motor activity has turned out to be the most important diagnostic criterion. However, objective methods, which allow the evaluation of spontaneous movement development, are not available so far.

AIM: In this paper an objective methodology is presented which allows the quantitative evaluation of the development of spontaneous motor activity in newborns.

METHOD: The introduced methodology is based on the acquisition of spontaneous movement trajectories of the feet by 3D movement analysis. The spontaneous movements of 24 infants, comprising 16 healthy full-term infants (mean gestational age 39.7 weeks, 11 female, 5 male) and eight pre-term infants (mean gestational age 28.6 weeks, 3 female, 5 male) with developing infantile cerebral palsy (ICP), were analysed around the first, the third and the fifth months of life.

To evaluate the spontaneous movements of the newborns, eight movement parameters, which have been shown to be sufficient to discriminate between normal and pathodological movement patterns in infants (Meinecke 2006), were extracted from the recorded 3D trajectories of the babies' feet.

RESULTS: In the healthy group, three of eight parameter values showed significant changes between the first and the third month of life; values of two additional parameters changed significantly between the third and the fifth month of life. In babies suffering from ICP, most changes in the spontaneous movement pattern take place between the first and the third month of life, a trend which was reflected in this study in four of eight parameter values. However, in the ICP group, the parameters changing their values significantly during this period differed from those parameters changing in the healthy group.

CONCLUSION: Using the movement-based parameters, it was possible to provide an objective description of age-dependent developmental steps in healthy newborns. Furthermore, it was shown that pathologies influence development of motor activity significantly. Since the introduced methodology is objective and quantitative, it is suitable to monitor the development of spontaneous motor activity with age.

NEUROPLASTICITY

PLAS_O1.1 MIRROR SYMMETRIC BIMANUAL MOVEMENT PRIMING CAN INCREASE CORTICOMOTOR EXCITABILITY AND ENHANCE MOTOR LEARNING

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INTRODUCTION: After stroke, selective activation of upper limb muscles can be challenging. This is due in part to persistent primary motor cortex inhibition during movement preparation, and contributes to inefficient movement patterns. Mirror-symmetric active-passive bimanual movement (MIR) produces persistent increases in corticomotor excitability of wrist flexor and extensor representations, and has been proposed as a neurophysiological priming mechanism to promote recovery of upper limb function after stroke. However, it is essential that techniques which modulate primary motor cortex (M1) excitability do not impede the release of SICI during movement preparation.

AIM: In healthy subjects we examined corticomotor excitability and short latency intracortical inhibition (SICI) in the context of pre-movement facilitation during a reaction time (RT) task, before and after 20 minutes of MIR.

METHODS: Twelve healthy adults participated (6 males, 6 females, mean age 28.9, age range 20-39). Particpants used a device developed in our laboratory that allows up to 110° rhythmic flexion-extension of one wrist, which in turn drives the passive flexion-extension of the other wrist in a mirror-symmetric pattern. Corticomotor excitability and SICI of left M1 extensor carpi radialis (ECR) and flexor carpi radialis (FCR) representations were investigated before and after a single 20 min session of MIR using single and paired-pulse TMS targeting. Pre-movement facilitation was examined before and after MIR by delivering TMS early or late in the RT period of right wrist extension. Data were collected at baseline, immediately after MIR (Post0) and 30 minutes after MIR (Post30).

RESULTS: Right ECR and FCR MEP area were facilitated after MIR for at least 30 minutes (ECR 127.80 ± 10.41%, $t_{11} = 2.67$ $p = 0.022$; FCR 140.34 ± 16.61%, $t_{11} = 2.428$, $p = 0.034$). Active-Passive movement had no effect on SICI in either ECR or FCR ($p > 0.7$). The absence of interaction between Muscle and Time indicated that SICI was unchanged after MIR. During RT there was an interaction between Muscle and Phase ($F_{1,11} = 5.6$, $p = 0.046$) with increased ECR MEP size during the RT period (early to late) but no increase in FCR MEPs over the RT period. There was no interaction between Time and Muscle ($p > 0.7$), indicating that selective activation of ECR during wrist extension was not degraded by active-passive movement.

CONCLUSION: After 20 minutes of mirror symmetric active-passive bimanual movement there was an increase in corticomotor excitability of the passive M1, with no effect on degradation to selective muscle activation.

ACKNOWLEDGEMENTS: We thank Dr Matt Petoe and Andrew McIntyre-Robinson for their assistance during data collection.

PLAS_O1.2 DIFFERENTIAL MODULATION OF MOTOR CORTEX EXCITABILITY IN BDNF MET ALLELE CARRIERS FOLLOWING EXPERIMENTALLY-INDUCED AND USE-DEPENDENT PLASTICITY

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IINTRODUCTION: Recent evidence indicates that a common polymorphism of the brain-derived neurotrophic factor (BDNF) gene plays a crucial role in synaptic plasticity in the adult brain. In these studies, plasticity in human motor cortex has been induced with either repetitive transcranial magnetic stimulation (TMS) (i.e. experimentally-induced plasticity) or motor training interventions (use-dependent plasticity). However, some studies have shown no effect of the BDNF polymorphism on cortical plasticity, suggesting that the effect may be related to the type of intervention used and how it interacts with BDNF to induce motor cortex plasticity.

AIM: To investigate how people with one of three different BDNF genotypes modulate motor cortex excitability following experimentally-induced and use-dependent plasticity interventions.

METHODS: Electromyographic recordings were obtained from the right first dorsal interosseous (FDI) muscle of 12 Val/Val, 10 Val/Met, and 7 Met/Met BDNF genotypes (aged 18-39 years). TMS of the left hemisphere was used to assess changes in resting FDI motor-evoked potentials (MEPs) before and after three separate interventions consisting of paired associative stimulation (200-paired stimuli, 0.25 Hz, 25 ms interstimulus interval), a simple ballistic task, and complex visuomotor tracking task using the index finger.

RESULTS: Val/Val subjects increased FDI MEPs following all interventions (≥ 25%, $P < 0.01$), whereas the Met allele carriers only showed increased MEPs after the simple ballistic task (≥ 26%, $P < 0.01$). Following complex visuomotor tracking there was no significant change in MEPs for the Val/Met subjects (7%, $P = 0.50$) and a reduction in MEPs for the Met/Met group (-38%, $P < 0.01$). Despite these differences in use-dependent plasticity, the performance of the simple ballistic task ($P = 0.40$) and the complex visuomotor tracking task ($P = 0.68$) was not different between BDNF genotypes.

CONCLUSION: We found that the modulation of motor cortex excitability was strongly influenced by the BDNF polymorphism, but the effect was dependent on the intervention used. These intervention-related differences in use-dependent plasticity were most pronounced in the rare Met/Met subjects, and the largest difference between BDNF genotypes occurred following the complex visuomotor task. Although no effect was observed on motor performance in young healthy subjects, the differences observed in motor cortex plasticity between BDNF genotypes may be more relevant and have a greater impact on motor performance during the recovery of motor function after neurological injury.

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PLAS_O1.3 ANODAL TRANSCRANIAL PULSED CURRENT STIMULATION: A NOVEL TECHNIQUE TO ENNHANCE CORTICOMOTOR EXCITABILITY IN HEALTHY INDIVIDUALS

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INTRODUCTION: Non-invasive electrical stimulation of the human cortex by means of transcranial direct current stimulation (tDCS) has been involved in a number of important discoveries in the field of human cortical function and has become a well-established method for enhancing brain function in healthy human participants. Recently, transcranial alternating current stimulation (tACS) has been introduced to directly modulate human cortical excitability. Transcranial pulsed current stimulation (tPCS) is another variant of non-invasive electrical stimulation which could be used as a novel technique to enhance corticomotor excitability. No direct electrophysiological evidence of tPCS has been reported.

AIM: to compare the effects of tPCS with conventional tDCS on the enhancement of corticomotor excitability in healthy individuals.

METHODS: Eight right handed healthy volunteers were tested in two separate sessions at least 48 hours apart. Corticomotor excitability of the dominant primary motor cortex of the resting right extensor carpi radialis muscle (ECR) was assessed before, immediately, 10, 20 and 30 minutes after application of tDCS or tPCS. In the tDCS session the current was applied for 10 minutes at 1mA current intensity. In tPCS, the pulse duration and inter-pulse interval were set at 500 ms and 50 ms respectively. The current intensity was set at 1.7 mA and the overall length of tPCS application was 5 minutes. The total charges for both applications were kept constant in all experiments. The outcome measure in this study was the amplitude of motor evoked potentials (MEPs) elicited by a single-pulse TMS (Magstim Company Limited, UK). Peak-to-peak amplitude of 15 MEPs were averaged and used for data analysis. All therapeutic and assessment procedures were approved by Monash Ethics Committee.

RESULTS: A three-way ANOVA (SPSS 19) indicates that corticomotor excitability increases significantly following a-tDCS and tPCS application and this increase remains higher than baseline values during all post intervention assessments ($p<0.05$). This test also reveals that the percentages of change is larger in tPCS compared to tDCS ($p<0.05$). Only 30% of the subjects experienced very mild itching and burning sensations during the tPCS or tDCS applications. During application of tPCS, 70% of the volunteers experienced phosphene.

CONCLUSION: Both tDCS and tPCS induce corticomotor excitability and this excitability remains higher than the baseline value at least 30 minutes after the intervention. Compared to tDCS, tPCS induces larger corticomotor excitability of ECR muscles in healthy individuals. More research should be done to explore optimal parameters for this novel therapeutic technique.

PLAS_O1.4 CORTICAL PLASTICITY AFTER THETA BURST STIMULATION IN PARKINSONIAN RATS

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INTRODUCTION: Theta burst stimulation (TBS) is a novel scheme of repetitive transcranial magnetic stimulation (rTMS), which can induce longer lasting effects on the excitability of the motor cortex. From various schemes of TBS approaches, long-term potentiation (LTP)-like or long term depression (LTD)-like plasticity of motor cortex can be evaluated by qualifying the motor evoked potentials (MEPs) to represent the cortical excitability. To further understand the underlying mechanism and refine the therapeutic effects of rTMS in Parkinson's disease (PD), we adapted rTMS methods to PD animal model, which can be obtained by infusion of the neurotoxin 6-hydroxydopamine (6-OHDA) to induce unilateral nigrostriatal dopamine depletion of rats.

AIM: The aim of this study was to examine whether a period of TBS might induce cortical plasticity in PD rats.

METHODS: Twenty-seven normal rats were equally assigned to sham control, intermittent TBS 600 (iTBS) and continuous TBS 600 (cTBS) group for testing immediate effect of TBS. To test the modulation of cortical excitability in PD rats, 12 young (post-lesion one week) and 15 chronic (post-lesion over four weeks) PD rats were chosen to perform the same iTBS protocol to identify LTP-like plasticity in PD progression. The changes of MEPs were measured before and after iTBS every 5 min until 30 min.

RESULTS: The cTBS reduced MEPs for 10 min, whereas the iTBS causing increased MEPs after 5 min intervention and still maintain high level at 30 min in normal rats. However, compared with normal rats, the MEPs show less facilitation pattern in young PD rats and remained unchanged in chronic rats after iTBS, indicating the lack of iTBS-induced long term potentiation (LTP)-like plasticity in motor cortex of PD rats.

CONCLUSION: For the short-term effects of TBS on LTP-like plasticity, we have demonstrated that PD rats have less change in cortical excitability. This lack of LTP-like plasticity could be related to the severity of dopamine depletion. Future studies may detect dopaminergic level in rat brain after rTMS to investigate the cerebro-basal-ganglia network.

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PLAS_O2.1 SPIKE TIMING DEPENDENT PLASTICITY: A NEW TEMPORAL WINDOW IN HUMANS

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INTRODUCTION: Spike-timing dependent plasticity (STDP) is well characterised in human primary motor cortex at short inter-stimulus intervals. However, animal models also demonstrate the induction of STDP at long inter-stimulus intervals. Whether these long inter-stimulus intervals are relevant to the induction of STDPin human primary motor cortex (M1) is unknown.

AIM: To characterise the induction of STDP in M1 facilitatory and inhibitory circuits when the pre-synaptic input arrives at long intervals after the post-synaptic (output) cell is activated.

METHODS: 34 healthy individuals participated. Paired associative stimulation (PAS) involves the temporal coupling of a median nerve stimulus at the wrist with a transcranial magnetic stimulation (TMS) pulse to the primary motor cortex. Single pulse TMS was used to examine motor evoked potential (MEP) amplitude before and after seven PAS protocols PAS25, PAS-100, PAS-200, PAS-250, PAS-300, PAS-350, PAS-450 (note the minus sign indicates that the TMS stimuli preceded the median nerve stimulus). Further, we examined the effect of these PAS protocols on short and long latency intra-cortical inhibition; intra-cortical facilitation and short and long latency afferent inhibition.

RESULTS: MEP amplitude was reduced following PAS-250, PAS-300 and PAS-350, increased with PAS25, and unaltered at the remaining PAS intervals. No change was observed in intra-cortical inhibitory or facilitatory circuits with any protocol.

CONCLUSION: These findings provide evidence of a previously unreported temporal window in which PAS induces a suppression of corticomotor excitability in the human motor cortex.

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PLAS_O2.2 BILATERAL EFFECTS OF EIGHT WEEKS UNILATERAL ACUPUNCTURE ON ANKLE DORSIFLEXION STRENGTH

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INTRODUCTION: Previous studies have shown that acupuncture at acupoints on one limb can improve muscle strength of the treated leg as well as the strength of the contralateral leg.

AIM: The aim of this study was to determine whether manual acupuncture or electroacupuncture at non-acupoints (sham points) could also induce bilateral strength gain.

METHODS: Fifty healthy young men (range 19-27 years) voluntarily participated in the study (5 withdrew) and were randomly allocated into five groups: manual acupuncture (MAcu, n=9) and electroacupuncture (EAcu, n=10) on two acupoints (ST36 and ST39); manual acupuncture (MSham, n=8) and electroacupuncture (ESham, n=8) on two non-acupoints on the tibialis anterior muscle; and control (CON, n=10). The participants (expect the CON) received 15-30 minutes of acupuncture or electroacupuncture on the right leg in each session, three sessions per week for eight weeks, while the CON maintained their normal daily activities. Ankle dorsiflexion strength of both legs was measured in static contractions pre and post the experimental period.

RESULTS: Repeated measures ANOVA with Bonferroni adjustment identified significant and similar strength gains after the treatment ($P<0.05$) in both the right leg (MAcu 15.6%, MSham 19.6%, EAcu 15.8% and ESham 13.6%) and the left leg (MAcu 29.2%, MSham 36.8%, EAcu 23.1% and ESham 17.6%), while the CON showed no significant change (Right -0.1% to Left -2.6%, $P>0.05$).

CONCLUSION: This study demonstrated in a randomised and controlled trial that eight weeks unilateral manual acupuncture or electroacupuncture at sham points could induce similar strength gain as those at the ST-36 and ST-39 acupoints in both limbs. These findings further confirmed the previous reports on the effects of acupuncture on muscle strength and produced new evidence that the strength gain might not require needling at specific acupoints or electric stimulation.

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PLAS_O2.3 INTER-LIMB TRANSFER OF FORCE-FIELD ADAPTATION IS LIMITED EVEN WHEN THE PERTURBATION IS ALIGNED IN EXTRINSIC AND JOINT-BASED COORDINATES

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INTRODUCTION: Humans are able to adapt their motor commands in order to make accurate movements in novel sensorimotor environments, such as when wielding tools that alter limb dynamics. However, it is unclear whether sensorimotor mappings obtained through experience with one limb are available to the opposite (untrained) limb and, if so, in which form they are available. For example, transfer has only been reported from the right to the left limb, and only if the perturbation is introduced abruptly so that large initial errors occur. Moreover, cross-limb generalization of adaptation to novel dynamics has been reported in either extrinsic (world-based) or intrinsic (joint-based) coordinate frames, depending on the nature of the perturbation. However, if adaptation is coded simultaneously in multiple reference frames, previous results may have been confounded by the use of frontal and horizontal plane paradigms, in which sensorimotor perturbations have opposite effects in joint-based and extrinsic coordinates due to the mirror symmetry of the limbs.

AIM: Here we re-assessed cross-limb transfer of adaptation to a velocity-dependent curl field (0.13 N.m-1.s) during reaching in the horizontal plane, and compared the extent of generalization to that observed in a sagittal plane task in which the dynamic perturbation had identical effects in joint and extrinsic coordinates.

METHODS: Subjects made planar reaches in six directions toward targets located 14 cm away, in a virtual reality environment that provided continuous, three-dimensional feedback of hand and target position. Three different groups adapted to the force field with the right arm when the field was introduced either (1) abruptly or (2) gradually, and with the left arm when the field was introduced (3) abruptly. Another three groups (4-6) did the same task but with movement in the sagittal plane. For all groups, performance with the opposite arm was subsequently tested for the same plane of movement and the same field introduced abruptly. Evidence of a learned representation of the new dynamics was obtained by measuring forces applied against the walls of a "virtual channel", from the origin to the target, on random catch trials.

RESULTS: The magnitude of forces exerted against the virtual channel were similar in naïve performance and after opposite limb adaptation for both the left and right hands, after both gradual and abrupt exposure to the field, and in both the sagittal and horizontal planes.

CONCLUSION: Inter-limb transfer of force-field adaptation is limited even when the perturbation is aligned in extrinsic and joint-based coordinates, which suggests that the neural representations of newly encountered dynamics are stored in a network that is not accessible to the opposite limb.

PLAS_O2.4 USE OF NEAR INFRARED SPECTROSCOPY FOR EVALUATING CEREBRAL AND MUSCLE OXYGENATION DURING ISOMETRIC CONTRACTIONS

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INTRODUCTION: Similar to strength training with voluntary contraction, electrical stimulation (ES) modifies the excitability of specific neural paths and such adaptations contribute to the increases in maximum voluntary contraction (MVC) force. There is growing interest in utilizing ES superimposed on volitional muscle contraction, so-called hybrid training. However, the effect of proportional assistive neuromuscular ES training is less clear. Recently, near infrared spectroscopy (NIRS) has been developed as a noninvasive approach to simultaneously quantify cerebral and muscle oxygenation during exercise. For evaluating the neural adaption, the regional oxygenation is used as index to represent metabolic state of muscle and functional activation of brain.

AIM: The purpose of this study is to investigate effect of the proportional assistive neuromuscular ES on changes in cerebral and muscle oxygenation during isometric knee extension.

METHODS: During all exercise sessions, cerebral and muscle oxygenation (Cox, Mox) were recorded simultaneously using NIRS. The single-distance method was used for sensorimotor cortex configured by 2 detectors and 9 paired sources with interoptode distance of 3 cm. To quantify Mox, a multi-distance probe was placed over vastus lateralis muscle. The subject was asked to perform 30 sec isometric knee extension targeted at 40% MVC under three conditions: volitional contraction, ES-induced contraction at 40mA, and hybrid muscle activation by combining ES at 21mA and volitional contraction. We collected NIRS data during 1 min resting baseline, 30 sec isometric knee extension with 3 epochs, and 2 min recovery. Cox and Mox data were analyzed from time and frequency domain.

RESULTS: Our results showed that Cox increased coupled with decreasing Mox in all three contraction conditions. The neuronal activation of brain is more evident in ES-induced contraction than in volitional contraction and hybrid muscle activation. In muscle oxygenation, the hybrid muscle activation induces lower oxygen consumption (25%) than the other two conditions (33%). Compared to the rest condition, exercise-related activation enhanced the power spectral density toward the low frequency band.

CONCLUSION: From the cerebral oxygenation, our findings suggest that the intervention of ES during exercise would induce a high-level cerebral activation. On the peripheral aspect, hybrid muscle activation results in lower oxygen consumption during muscle contraction. Under various isometric contractions, the distribution of power spectral density tends to shift to lower frequency band in cerebral and muscle oxygenation. It is expected that these findings can be applied on stroke patient to establish suitable patient-tailored brain-based rehabilitation program.

ORAL NEUROPHYSIOLOGY

ORAL_O1.1 MASTICATORY EFFICIENCY, EVALUATED BY SEMG, AND ITS RELATION TO THE HEAD AND NECK CANCER TREATMENTS.

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INTRODUCTION: Cancer is one of the most serious problems in global health. In this context, the dentistry community has received in your clinics an increasing number of patients submitted to cancer treatment, mainly to head and neck cancer region. Is so important to understand better what happens with the mastication of patient submitted to head and neck cancer treatment.

AIM: The aim of this clinical study was to evaluate the Masticatory Efficiency of patients submitted to head and neck cancer treatment and compare this data with those persons that had never received this type of treatment.

METHODS: The experimental group consisted of 15 patients (mean age 55 years) with head and neck cancer treatment finalized at least 6 months. This cancer treatment was based on radiotherapy focused on local of different types of head and neck cancer lesions. The control group consisted of 15 subjects paired with experimental group according to age, gender and oral situation. The Masticatory Efficiency, evaluated by the ensemble average of the electromyographic signal (sEMG) of masseter e temporalis muscles, was carried out by Myosystem Br-1 electromyographer at dynamic activities measured during 20 seconds: opening and closing mouth, parafilm clenching and chewing. Data, presented in frequency of the envelope values, were normalized by maximal clenching (SENIAM). Inter-group comparisons were made using independent sample t-test. Significance level was set at $P<0.05$.

RESULTS: There are no statistic differences between groups in all activities tested (opening and closing mounth sig. value = 1.0, parafilm clenching sig. value = 0.683 and parafilm chewing sig. value = 0.292).

CONCLUSION: Radiotherapy treatment finalized at 6 months ago, in cases of head and neck cancer, do not affected the Masticatory Efficiency of patients evaluated, showing that the radiotherapy have not bad residual effect on mastication.

ACKNOWLEDGEMENTS: Financial support from FAPESP (2010/10472-9).

ORAL_O1.2 TOPOGRAPHICAL MOTOR UNIT CHARACTERISTICS OF THE UPPER LIP MUSCULATURE IN HEALTHY AND CLEFT LIP SUBJECTS

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Dr Johannes P. van Dijk; Dr Ales Holobar; Prof Bernd G. Lapatki

INTRODUCTION: Morphogenesis of the upper lip includes the fusion of the median and two lateral segments. This intrauterine process is the precondition for the migration of muscle tissue of the m. orbicularis oris superior to form one muscular entity. Failure of the fusion results in a cleft lip (CL) and/or palate, which is surgically closed within the first year of life.

AIM: To determine motor unit morphology of the m. orbicularis oris superior in CL subjects and healthy controls using high-density surface EMG (HDsEMG).

METHODS: A thin, flexible HDsEMG-array was designed consisting of 256 chlorided silver electrodes distributed over the area of the upper lip. The electrodes were 0.8 mm in diameter and the interelectrode distance was 2.5 mm. So far, we have examined two subjects with unilateral and one subject with a bilateral CL as well as 5 healthy controls. During the measurements the subjects were asked to perform different lip movements with and without force feedback. HDsEMG-signals were decomposed (Holobar 2007), and for each identified motor unit, multichannel motor unit action potentials (MUAPs) were calculated by spike triggered averaging of the HDsEMG. In the interpolated monopolar amplitude map sequences of these MUAPs we topographically identified the initiation and propagation of the potential to determine endplate zones as well as muscle fiber directions and lengths (Lapatki 2006).

RESULTS: Generally, motor units of the m. orbicularis oris superior were found to be organized in a complex manner. In non-CL subjects, we found that most motor units were restricted to small areas, distributed over the upper lip and with an orientation parallel to the oral cavity. Some MUAPs were found to propagate across the philtral ridges representing the borders of the fused lip segments. In the unilateral CL subjects most muscle fibers seem to terminate at the former cleft area. Only a single motor unit seemed to indicate propagation across the surgically closed cleft. In the subject with a bilateral CL no muscle activity could be detected in the median segment.

CONCLUSION: In contrast to non-CL subjects, there seems to be no migration of the muscle fibers through the connection area of the lip segments in CL subjects. This may be explained by the scar tissue forming a barrier. As identification of fiber lengths and orientations was not trivial, we think that model simulations could help to determine these motor unit properties more objectively and thus to characterize alterations in CL subjects more precisely. Our non-invasive technique might be suitable to compare outcomes of, and perhaps optimize, different surgical procedures.

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ORAL_O1.3 TOPOGRAPHICAL CHARACTERISTICS OF MOTOR UNITS OF THE MIDFACIAL MUSCULATURE REVEALED BY MEANS OF HIGH-DENSITY SURFACE EMG

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INTRODUCTION: Despite the great importance of the facial musculature for a variety of functions, such as speech, food intake, and mediation of emotional and affective states, systematic topographical data on this complex muscle system at a single motor unit (MU) level are sparse. In a recent study we determined topographical MU characteristics for the four lower facial muscles using an optimized high-density surface EMG technique (Lapatki 2006).

AIM: To topographically characterize the MUs of the midfacial musculature.

METHODS: Signals were recorded using 0.3mm-thin electrode grids (120 channels, inter-electrode distance 4mm) placed directly at the vermillion border and lateral to the ala of the nose. Thirteen specially trained subjects performed slight to moderate voluntary contractions of seven midfacial muscles. Multichannel motor unit action potentials (MUAPs) were decomposed from the raw EMG signals according to their spatio-temporal amplitude characteristics. For each MUAP, the initiation and propagation of the potential were topographically identified in the time sequence of the interpolated monopolar amplitude maps. Thus, motor endplate zones, muscle fiber directions and lengths as well as bipolar amplitude maxima in fiber direction (i.e. optimal locations for conventional bipolar EMG recordings) could be determined. These data were spatially warped to correct for the different sizes and shapes of individual faces.

RESULTS: The decomposed MUAPs reveal the distinctive topographical characteristics of facial MUs, such as overlapping territories of MUs belonging to different muscles and the occurrence of asymmetrically located endplate zones within single facial muscles. In the orbicularis oris superior and the incisivus labii superioris we found multiple endplate zones belonging to MUs with largely different fiber orientations. In nearly all subjects MUAPs could be assigned to the orbicularis oculi, the zygomaticus major and the levator labii superioris. Results for the other four muscles showed higher inter-individual variability. For some MUAPs with small territories a clear assignment to one of the anatomically defined muscle subcomponents was even impossible.

CONCLUSION: Our findings add substantially to the sparse neurophysiological and anatomical knowledge on the complex facial muscle system on the MU level. Such information is also indispensable for the establishment of objective placement guidelines for conventional (surface and needle) EMG electrodes in the face. The subdivision of the facial musculature seems to be much more variable and less clear than is suggested in anatomical textbooks and studies that are usually based on a very small numbers of specimens.

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ORAL_O1.4 STOMATOGNATHIC SYSTEM ASSESSMENT IN BODYBUILDING PRACTITIONERS

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INTRODUCTION: Bodybuilding gyms have become contemporary health promotion centers, frequented by different audiences and for different purposes. The practice of bodybuilding stems from body movements that require the action of muscle chains. The anatomical rails make the muscular system chains interconnected by means of fascie that integrate and act functionally by vector forces that are distributed along the same, making the muscle system interdependent.

AIM: The objective of this study was to assess the effect of the practice of bodybuilding on the stomatognathic system.

METHODS: We divided 35 male recruits aged 18 to 28 years (22 ± 3 years) into two groups. Group I (GI) consisted of 17 individuals who had been bodybuilders for six to 12 months prior to the start of the study, matched individual to individual (weight, age, respiratory pattern). Group II (GII) consisted of 17 healthy subjects who had undergone no diagnostic changes. This project was previously approved by the Ethics Committee in Research of the Centro Universitário Claretiano de Batatais, process nº 70/2010 CEP. All participants underwent electromyographic (EMG) evaluation in clinical conditions of chewing hard food (8 peanuts), chewing soft food (6 raisins) and non-habitual chewing (Parafilm placed on the molars), with each data collection session lasting ten seconds. Evaluation of bite force in the right and left first permanent molar region was also carried out. Data from the bite force and normalized EMG were tabulated and subjected to statistical analysis using SPSS 17.0 software. The values were compared by t-test analysis ($p < 0.05$).

RESULTS: In the muscle strength analysis, a greater bite force was recorded for GI. While chewing peanuts, there was major activity in the left temporal and right masseter muscles. In chewing raisins, similar activation was found in the right masseter muscle. Unusual chewing (Parafilm) showed an activation pattern wherein the masseter had greater activation in relation to storm surges. Greater muscle activity bilaterally in the sternocleidomastoid muscles during the various clinical conditions for both groups was analysed.

CONCLUSION: The results obtained indicate that bodybuilding practice generates changes in the stomatognathic system, especially in maximum bite force.

PAIN

PAIN_O1.1 NON-INVASIVE DIAGNOSIS OF ANATOMICAL INJURY SITE IN CHRONIC LOW BACK PAIN PATIENTS: A CLINICAL APPLICATION OF MECHANOMYOGRAPHY.

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INTRODUCTION: Evidence shows that even though Chronic Low Back Pain (CLBP) is one of the main contributing factors to rising health-care costs, accurate diagnosis of injury-site remains problematic.

AIM: The primary purpose of this project was to determine whether the non-invasive mechanomyographic technique (MMG) had the potential to accurately identify injury sites in CLBP patients and to provide feedback to assist clinical decision-making during rehabilitation.

METHODS: The contractile properties of back extensor muscle segments surrounding each of the five pairs of lumbar zygapophyseal joints (LZJs), in previously diagnosed CLBP patients (N=6) as well a group of pain-free controls (N=13), were subjected to MMG analysis. Variations in patient contractile properties, from control, were matched with the clinician's clinical diagnosis of anatomical injury site. Where possible, patients were re-tested following rehabilitation to assess patient recovery. Also available were patient MRI scans from which estimates of fat infiltration were determined.

RESULTS: In this case a significant ($p<0.05$) discrepancy in muscle segment contraction time (Tc), between the left and right side of the spine, suggested localised muscle atrophy over the injured joint. Clinical diagnosis confirmed that the localised muscle atrophy, as identified by the MMG technique, was indicative of underlying LZJ pathology. Following a month of injury-specific rehabilitation, in one patient, MMG measures of Tc over the injured LZJ returned to a more "healthy" pattern, which was consistent with improvements in patient back flexibility and pain sensitivity scores. It was also found that the over the injured LZJ had the greatest percentage fat deposition.

CONCLUSION: This study has suggested that the non-invasive MMG technique has the capacity to identify underlying joint pathology based on localised changes in muscle Tc due to injury-related localised muscle atrophy. It also may also provide feedback to assist in clinical decision-making during rehabilitation.

PAIN_O1.2 EFFECT AND EFFECT MECHANISM OF NEUROMAGNETIC TREATMENT FOR THE PAIN OF OSTEOARTHRITIS OF THE KNEE

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Dr Neil Tuttle; Assoc Prof Liisa Laakso

INTRODUCTION: Static quadrapolar magnets have been used for the past twenty years for pain relief with inconclusive research findings of beneficial therapeutic effects.

AIM: The objective of the current pilot study is to examine the field characteristics of two different quadrapolar designs and a placebo, and investigate the efficacy and mechanisms of action for arthritis-associated pain reduction of the knee.

METHODS: Detailed dosimetry was performed on the magnets measuring field strength and field gradients. A placebo device was designed and changes in pain and function scores (using VAS and WOMAC scoring to determine outcomes) were recorded with the active quadrapolar magnet and placebo in a randomised, double-blind, cross-over study methodology. In addition, Sympathetic Nervous System (SNS) outputs (skin temperature, blood flux and skin conductance) were recorded to compare static quadrapolar magnets with placebo.

RESULTS: The placebo device was found to be effective, as participants were unable to detect whether the device was an active or placebo magnet. In measuring the field characteristics of the magnets, we found that the single bodied quadrapolar magnets had steeper field gradients perpendicular to the local field vector compared to an alternating quadrapolar array magnet. The single bodied quadrapolar magnets were used in the clinical study of seven participants.

There was an upward trend in pain scores during the washout period and improved pain scores were greater with the active magnets than for placebo. Analysis was by a one way Anova with trial effect of $p=0.602$ and treatment effect $p=0.591$. There was no statistically significant effect on the WOMAC functional knee scores and there was no effect on the SNS measures from either the active or placebo interventions (VAS scores $p= 0.113$; skin temperature on hairless skin $p =0.098$; skin temperature on hairy skin $p= 0.890$; skin conductance on toes 2 and 3 (hairless skin) $p=0.981$; skin conductance on toes 4 and 5 (hairless skin) $p= 0.073$; and blood flux $p=0.370$; functional squat $p=0.178$; WOMAC pain $p= 0.238$; WOMAC stiffness $p= 0.129$ and WOMAC function $p=0.429$). Qualitative pain diary reports recorded a decreasing trend in pain scores for both the active and placebo periods. There was a perceptible 'placebo effect' of the placebo magnet.

CONCLUSION: A new design of a single body quadrapolar magnet of similar thickness and strength was found to have a steeper field gradient than a competing device with four separate bipolar magnets arranged into a quadrapolar array.

The lack of significance of efficacy may be due to the homogeneity of device application, the neurogenic manifestation of central segmental sensitization and/or the small sample size. The inability to detect change in SNS measures may have been due to a number of reasons including the placement of monitoring devices, or that the effect mechanism of the magnets does not occur through the SNS.

PAIN_O1.3 THE RELATIONSHIP BETWEEN MUSCLE ACTIVITY AND CLINICAL FEATURES IN PATIENTS WITH CHRONIC NECK PAIN

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Prof Gwendolen Jull; A/Prof Deborah Falla

INTRODUCTION: While changes in activation of the cervical flexors are a known feature of chronic mechanical neck pain disorders the strength of the relationship between altered muscle activity and clinical symptoms is largely unknown.

AIM: To report findings from three related studies investigating the relationship between reported clinical symptoms and electromyographic (EMG) amplitude recorded from the cervical flexor muscles during a test of flexor muscle performance.

METHODS: In separate studies, the relationship between levels of clinical symptoms (pain intensity, disability, symptom duration), and EMG amplitude of the superficial (sternocleidomastoid and anterior scalene) (Study 1, n=84) and deep (longus colli/longus capitis) (Study 2, n=32) cervical flexor muscles during the performance of the cranio-cervical flexion muscle test, was evaluated in patients with chronic mechanical neck pain. The relationship between changes in clinical symptoms and deep cervical flexor muscle activity were also evaluated in 14 of the 32 participants from Study 2 following a 6 week program of specific deep cervical flexor training (Study 3).

RESULTS: A significant association was observed between reported pain intensity and the EMG amplitude of both the superficial (positive association, $P<0.003$, $R^2=0.16$) and deep (negative association, $P<0.05$, $R^2=0.13$) cervical muscles during the test. No association was observed between the level of flexor muscle activity and symptom duration ($P>0.5$), or perceived disability ($P>0.2$). Following training, there was a significant relationship between the reduction in neck pain intensity obtained from training and the percent increase in EMG amplitude of the deep cervical flexors during the cranio-cervical flexion test ($R^2=0.34$, $P<0.05$).

CONCLUSION: These studies show a relationship between reported levels of neck pain and the function of the deep and superficial cervical flexor muscles in patients with persistent neck pain. Although this relationship is relatively modest (13-34% explained variance) indicating the complex nature of chronic pain, the findings do support clinical recommendations to address motor function in patients with chronic neck pain disorders.

PAIN_O1.4 EFFECTS OF STIMULI LOCATION AND TEST STIMULUS MODE ON DIFFUSE NOXIOUS INHIBITORY CONTROL-EFFECTS

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INTRODUCTION: The ability of a painful stimulus to reduce perception of pain in another area of the body, referred to as diffuse noxious inhibitory controls (DNIC), has been studied extensively to understand central mechanisms of pain modulation in various patient groups and experimental conditions. Assessment of this phenomenon has traditionally involved the effect of a test stimulus (TS; e.g. measurement of pressure pain threshold on a forearm) and conditioning stimulus (CS; e.g. cold pressor pain applied to the arm contralateral to the TS). However, the effect of the TS type (e.g. pressure or thermal pain) and location (e.g. application of TS and CS to: homonymous or heteronymous body parts; on the same or opposite sides of the body) on the DNIC effect is poorly understood.

AIM: This study aimed to evaluate the effect of different TS types (thermal and pressure), and TS and CS locations on the DNIC-like effect.

METHODS: Twenty-six healthy subjects participated in the study. Pressure pain thresholds (PPT) and numerical pain scale intensities (NPS, 0 – 100) in response to a predetermined painful heat stimulus were assessed at baseline, and during exposure to a concurrently applied painful heat stimulus (CS). CS intensity was set at 1 °C above pain threshold. In an additional trial CS was set at skin temperature to act as a sham control. Heat pain was delivered via a contact thermode and a pressure algometer was used to assess PPT. In separate trials, spaced by 30 min, trials were conducted with the TS and CS applied to opposite or same sides of the body, on anatomically different or identical regions, using four different locations: (1) right forearm, (2) left forearm, (3) right side of the lower back, and (4) left side of the lower back. DNIC was evaluated as the change in TS between baseline and application of the CS.

RESULTS: PPT increased during exposure to the CS only when the stimuli were applied to opposite sides of the body: CS – left back, TS – right back; CS – right back, TS – left forearm; CS – left forearm, TS – right back; CS – right forearm, TS – left forearm. PPT values did not differ from baseline during the sham CS trial ($p = 0.467$). Conversely, pain reported during the thermal TS was lower (consistent with activation of a DNIC-like process) during the CS (including sham CS), regardless of the arrangement of the stimuli.

CONCLUSION: In this study PPT provided data that were consistent with activation of a DNIC-like mechanism. This effect was only found to be significant when PPT was assessed at an anatomical site on the contralateral side of the body to the CS, regardless of whether the trunk or limb was tested. These findings have implications for the underlying mechanisms that underpin the DNIC-like effect.

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PAIN_O2.1 STRUCTURE OF VARIABILITY OF VASTUS LATERALIS DURING STAIR DESCENT IS HIGHER AMONG ADOLESCENTS WITH PATELLOFEMORAL PAIN COMPARED TO HEALTHY ADOLESCENTS

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INTRODUCTION: Patellofemoral Pain Syndrome (PFPS) is a highly prevalent knee condition among adolescents. Treatment aims at restoring neuromuscular control of the quadriceps. So far the assessment of the neuromuscular control of the quadriceps has been quantified as the difference in muscle onset of m. vastus medialis (VM) and m. vastus lateralis (VL) measured by surface EMG (sEMG) during e.g. stair walking. However the results have been inconsistent underlining a demand for new methods. Sample Entropy (SaEn) quantifies the complexity of the signal investigated. Changes in the structure of variability of motor patterns such as sEMG may be related to changes in motor strategies due to pathology.

AIM: to compare muscle onset and the structure of variability of the VM and VL during stair decent between adolescents with PFPS and healthy adolescents.

METHODS: 57 adolescents with PFPS between 15 and 19 years of age were recruited (mean age 17.3, mean symptom duration 34.5 months, worst pain last week, 53.4mm on a visual analogue scale). The control group consisted of 29 healthy adolescents between 15 and 19 years of age (mean age 17.5). Bipolar surface electrodes were placed on VM and VL using the same methodology as Cowan et al[1]. Subjects walked down a stairway with 22 steps. Subjects were given one practice trial and were told to walk at their normal pace. sEMG from the stance phase of each stride was divided into five identical time cycles representing (0–25–50–75–100%). SaEn was used to quantify the structure of variability of the time series from the sEMG recordings for each cycle during stance phase. Muscle onset was based on automatic detection [2]. Repeated measures ANOVA was applied for SaEn values introducing group (healthy, PFPS) as a between-subject factor and cycle as a within-subject factor. Muscle onset was compared analysed using t-test.

RESULTS: Subject group had a significant effect on SaEn for VL ($F=6.53$, $p=0.01$), but no significant effect for VM ($F=2.01$, $p=0.16$). Adolescents with PFPS were characterized by a higher structural variability of sEMG from VL. No difference was found in onset of VM compared to VL (PFPS: 1.2ms vs. healthy: 1.5ms, $p=0.75$).

CONCLUSION: Adolescents with PFPS have a higher structural variability from VL than healthy adolescents, which is in line with previous findings in patients with Medial Tibial Stress Syndrome [3]. No difference in muscle onset was found which suggest that muscle onset of VM and VL may not be of crucial importance in adolescent PFPS. This study warrants future research on the effect of rehabilitation on SaEn derived from sEMG of the VL.

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PAIN_O2.2 EFFECT OF PAIN LOCATION ON REORGANISATION OF MOTOR UNIT DISCHARGE AND DIRECTION OF FORCE PRODUCTION

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INTRODUCTION: Redistribution of drive to motoneurones within painful muscles and their synergists is associated with a change in the direction of external force. This is thought to redistribute stress within the muscle to unload the painful structures.

AIM: To determine if the redistribution of motor unit activity and angle of external force during pain are spatially organized with respect to pain location.

METHOD: Gross and single motor unit electromyography (EMG) from four quadrants of soleus and both gastrocnemii heads, and kinetic data, were collected from nine participants (age: 27.4 ± 7.8 years; 5 males). Data were recorded during matched isometric plantarflexion in 4-conditions: 2 control conditions without pain (no pain) that each preceded contractions with either pain induced (induced by a single bolus injection of hypertonic saline) in the lateral ($Pain_L$) or medial ($Pain_M$) side of soleus. For each condition, three 10 s contractions were performed, with 20 s rest between.

RESULTS: Group data (n=196 motor units) show that approximately 76% of the motor units discharged during both the control and respective pain contractions. Of the remaining motor units approximately half discharged only during the control and half discharged only during pain. This redistribution of motor unit activity occurred throughout the four quadrants of soleus, irrespective of pain location. Neither the quadrant of the soleus (p=0.43), nor the pain location (p=0.98) affected the significant decrease of motor unit discharge rate during pain ($p<0.0001$; $Pain_L$: 7.3±0.9 to 6.9±1.1 Hz, $Pain_M$: 7.0±1.1 to 6.6±1.1 Hz). There was large inter-participant variation in altered MU discharge with pain. The direction of force during pain (relative to the horizontal and coronal planes) was significantly different (outside the 95% CI) to that produced during the non-painful contractions for 7/8 and 6/8 participants during $Pain_L$ and $Pain_{M,}$ respectively. A similar location of pain between participants did not induce a systematic change in force direction.

CONCLUSION: Pain in the medial/lateral compartments of soleus did not induce a systematic change in the redistribution of motor unit activity or force direction. Our results provide evidence of complex adaptations, i.e., various solutions to adapt to pain.

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PAIN_O2.3 EXPERIMENTAL MUSCLE PAIN INFLUENCES THE COMMON SYNAPTIC INPUT TO THE MOTONEURON POOL

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INTRODUCTION: Spinal and supraspinal synaptic inputs are largely spread across the motoneuron (MN) pool [1]. This results in a significant level of correlation between their output spike trains [2]. Frequency domain measures of correlation between spike trains, such as coherence, allow the estimation of the frequency content of common inputs [3].

AIM: In this study we investigated the influence of experimental muscle pain on the common inputs to MNs by coherence analysis. We hypothesized that the activity of small diameter muscle afferents, that are elicited during muscle pain [4], would decorrelate the activity of the other pathways [5] and influence the strength of correlation in selected frequency bandwidths.

METHODS: Single motor unit (MU) potentials were recorded from the tibialis anterior (TA) and abductor digiti minimi (ADM) muscles in two experimental sessions [3,6]. Preliminary results on four subjects (two for each muscle) are reported. Intramuscular EMG was measured and decomposed with EMGLAB [7]. The recorded signals were analyzed before and after an injection of 0.5 ml sterile hypertonic saline (5.8%) into the belly of the target muscle. Coherence analysis was performed using the composite spike train (CST) of two MUs [8] and averaged across all combinations of the decomposed MUs. The z-transformation was performed on coherence values to compare across different subjects and the confidence level (CL) was computed to detect significant coherence values (i.e., values above CL).

RESULTS: In the TA muscle, the coherence function in the frequency band 3 - 10 Hz (alpha-band) decreased from 1.69 to 1.29 (both levels significant as above CL = 0.6) in one subject and from 1.45 to 1.31 (CL = 0.6) in the other. For the ADM muscle, the coherence in the alpha band also decreased from 1.49 to 0.89 (CL = 0.57) and from 1.55 to 1.00 (CL = 0.58) in the two subjects, respectively. Conversely, there was no consistent trend of change in coherence in the beta band (10 – 30 Hz).

CONCLUSION: These preliminary results show that experimental muscle pain influences the alpha band of the common synaptic input to the MN pool.

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PAIN_O2.4 EARLY CESSATION OF MUSCLE ACTIVITY DURING A MOTOR CONTROL TEST OF THE SCAPULA IN PEOPLE WITH SHOULDER IMPINGEMENT

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INTRODUCTION: People with shoulder impingement can have altered scapulothoracic muscle recruitment during arm movement. These scapulothoracic muscles are crucial in providing control of scapular position relative to the thorax and humerus. A motor control test has been devised to clinically assess the dynamic control of the scapula during arm movement. It is not yet known whether impingement patients differ from healthy individuals in their control of the scapula and if retraining scapulothoracic muscles restores normal muscle activity during the novel test.

AIM: To assess muscle activation during a motor control test in healthy individuals and people with shoulder impingement pre- to post-intervention.

METHODS: Sixteen healthy and 16 participants with shoulder pain and impingement signs were recruited from the local community. Participants were assessed using a motor control test, which involved maintaining control of scapular orientation/alignment during arm elevation to 90° and lowering back to rest. Healthy participants were assessed once and pain participants before and after a 10 week intervention aimed at retraining scapulothoracic muscles and improving the alignment/orientation of the scapula. Activation of the scapulothoracic muscles (Upper Trapezius, Middle trapezius, Lower trapezius, Serratus anterior) in relation to glenohumeral angle were determined using surface electromyography. Duration of activation was compared between healthy, pre- and post-intervention results using independent samples and paired samples t-tests.

RESULTS: Premature termination of lower trapezius (LT) ($p<0.05$) and serratus anterior (SA) ($p>0.05$) activity were shown pre-intervention during the arm lowering phase of the test, at an arm angle of 27° ± 15 and 28° ± 15 compared to healthy individuals (mean arm angle 17° ± 8 and 22° ± 10). Duration of activity in LT and SA muscles was increased significantly ($p<0.05$) post-intervention, with muscle activity terminating at an arm angle of 19° ± 7 and 17° ± 8 respectively, to match that of the healthy participants.

CONCLUSION: The findings demonstrated that shoulder impingement patients have reduced duration of important scapulothoracic muscles compared to healthy subjects during the motor control test. After a 10 week tailored motor control intervention, duration of scapulothoracic muscle activation was significantly improved to match the healthy subjects. The demonstrated motor control change in scapular impingement patients suggests a tailored intervention may improve function in shoulder impingement patients.

PHYSICAL MEDICINE & REHABILITATION

PMRE_O1.1 THE EFFECT OF MANUAL TREATMENT OF PECTORALIS MINOR MUSCLE ON ADOLESCENT ELITE HANDBALL PLAYERS. A RANDOMIZED CONTROLLED TRIAL.

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INTRODUCTION: Handball includes a great portion of repetitive overhead movement patterns in the shoulder girdle. The scapula with its surrounding muscles plays a vital role in making these movement patterns optimal. Recent studies have reported sport related adaptations in the shoulder girdle in adolescent elite tennis and baseball players that have been associated with shoulder injuries. No study has analyzed whether these adaptations are present in adolescent elite handball players.

AIM: The aim of the first part of the study was to investigate whether adolescent elite handball player have a shorter pectoralis minor muscle (PM) and decreased internal rotation in the gleno-humeral joint on their dominant side compared with the non-dominant side. The aim of the second part is to study if massage and stretching has an effect on the length of PM and the shoulder posture on players with a shorten PM.

METHODS: Two-hundred and fifty-one adolescent Swedish elite handball players, 160 boys, aged 15.5 (± 0.9) and 92 girls aged 15.3 (± 0.9), were screened for PM length, shoulder posture and gleno-humeral joint rotation mobility using a digital caliper and a goniometer. Players with a shorten PM will be randomized to massage/stretching of the PM or a placebo treatment of the PM in a randomized controlled trial (RCT).

RESULTS: The players showed significantly greater decrease of internal rotation in their dominant arm compared with their non-dominant side ($p=<0.0001$) and a shorter PM on the dominant side ($p=<0.0001$). Approximately 85% of the players had a shorter PM on their dominant side. There were no difference between the boys and the girls. The result of the ongoing RCT will also be presented.

CONCLUSIONS: Adolescent elite handball players have shoulder adaptations in form of shorter PM, more rounded shoulder posture and decreased internal rotation in their dominant side compared with the non-dominant. No differences were found between boys and girls. To evaluate the clinically relevance of these findings, further studies is needed.

PMRE_O1.2 WHAT IS THE OPTIMAL MANUAL MUSCLE TEST FOR SUBSCAPULARIS?

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Dr Mark Halaki, University of Sydney; Dr Ian Cathers, University of Sydney; Mr Anthony Downes

INTRODUCTION: The optimal manual test for an individual muscle is one that generates maximal activation of the target muscle with minimal activation of other synergistic muscles. EMG studies have identified five manual muscle tests that generate high activity levels in subscapularis. However, no single study has compared subscapularis activity levels during these five tests and no study has compared subscapularis activity levels with all other shoulder internal rotator muscles during these tests.

AIM: The aim of this study was to compare subscapularis, pectoralis major, latissimus dorsi and teres major activity levels during five isometric tests to determine which of these commonly-used manual muscle test positions is optimal for subscapularis i.e. which recruits subscapularis at the highest levels in the presence of low activity in other shoulder internal rotator muscles.

METHODS: The dominant arm of 15 asymptomatic subjects was tested. Activity was recorded from subscapularis, latissimus dorsi and teres major using intramuscular electrodes and from pectoralis major using surface electrodes. Three repetitions of 5 isometric shoulder tests were performed in random order: internal rotation at 0° and 90° abduction with the subject seated, internal rotation at 90° abduction in supine lying, lift off test and belly press test. Mean (± SD) normalized EMG activity was calculated. A two factor repeated measures ANOVA was performed to compare mean activity levels across the 4 muscles and 5 tests. Tukey post hoc analysis was used to identify specific differences when significant ANOVA results were obtained.

RESULTS: Subscapularis activity levels were not significantly different between the 5 isometric tests. During the belly press test and the internal rotation tests in sitting and supine subscapularis activity levels did not differ significantly from all other shoulder internal rotators tested. During the lift off test subscapularis activity was significantly greater than pectoralis major activity and significantly less than latissimus dorsi and teres major activity levels.

CONCLUSION: None of the isometric tests examined satisfies both criteria for an optimal manual muscle test for subscapularis. All 5 tests recruit subscapularis at moderately high levels but none of the tests recruits subscapularis at significantly higher levels than other shoulder internal rotator muscles.

PMRE_O1.3 DOES SUPRASPINATUS INITIATE SHOULDER ABDUCTION?

Mr Darren Reed, The University of Sydney

Dr Ian Cathers, Faculty of Health Sciences, The University of Sydney; Dr Mark Halaki, Faculty of Health Sciences, The University of Sydney; A/Prof Karen Ginn, Discipline of Biomedical Science, The University of Sydney

INTRODUCTION: Understanding normal muscle function is crucial to the prescription of exercises in gym-based and rehabilitation programs that aim to promote and/or restore normal muscle function. Although it is universally reported in anatomy textbooks that supraspinatus initiates shoulder abduction there is no direct electromyographic (EMG) evidence to support this claim.

AIM: To determine if supraspinatus activates prior to other shoulder muscles and thereby initiates shoulder abduction.

METHODS: Fourteen asymptomatic subjects (6 female, 8 male), with no history of shoulder pain volunteered for this study. Dynamic scapular plane abduction was performed using the dominant arm at 25%, 50% and 75% maximum abduction load. Muscle activity was recorded from supraspinatus, infraspinatus, subscapularis, lower trapezius, serratus anterior using intramuscular electrodes and from upper trapezius and deltoid using surface electrodes. Initial activation time for each muscle was determined as the time from the start of movement to when the EMG activation level exceeded three standard deviations above baseline measures. A two factor repeated measures ANOVA was performed to compare the initial activation timing across the seven muscles and three loads. Tukey post hoc analysis was used to identify specific differences when significant ANOVA results were obtained.

RESULTS: Initial activation of all muscles tested was prior to movement onset. Significant differences existed in the initial activation timing of different muscles across all loads ($F_{6,78}=3.47$, $p<0.01$). Supraspinatus, infraspinatus and deltoid were activated significantly earlier than subscapularis. However, supraspinatus, infraspinatus, upper trapezius, lower trapezius, serratus anterior and deltoid all had similar initial activation times. The effect of load was not significant ($F_{2,26}=1.88$, $p=0.17$).

CONCLUSION: Supraspinatus does not initiate shoulder abduction. Although it activates prior to movement, it does not activate earlier than any of the other shoulder muscles tested except subscpularis. Simultaneous activation of shoulder abductors, rotator cuff and axioscapular muscles is required to initiate abduction. Anatomy textbooks, clinical tests and exercises should reflect the fact that supraspinatus does not initiate abduction.

PMRE_O1.4 ACTIVATION OF HIP MUSCLES DETECTED WITH FINE-WIRE ELECTRODES DURING FOUR COMMON THERAPEUTIC EXERCISES IN PERSONS WITH PATELLOFEMORAL PAIN

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Dr George Beneck, California State University at Long Beach; Dr Christopher Powers, University of Southern California

INTRODUCTION: Weakness of gluteal muscles has been linked to excessive hip internal rotation and adduction, which contribute to patellofemoral pain (PFP). TFL is a hip internal rotator with potential to exert a lateral force on the patella. It is not known which exercises preferentially activate gluteal muscles while limiting TFL activity, or how relative activation of these muscles compares between persons with and without PFP.

AIM: The purpose of this study was to compare electromyographic (EMG) activity of gluteal muscles and TFL between persons with and without PFP while performing four exercises. We used a novel method to assess relative EMG activity of gluteal muscles and TFL (the Gluteal-TFL Activation Index or GTA). The higher the index value (due to lower TFL and/or higher gluteal EMG), the better the exercise is at emphasizing gluteal activity while minimizing TFL activity.

METHODS: Nine pain-free persons and nine with a diagnosis of PFP, ages 18-50, participated. Fine-wire electrodes were inserted into TFL, gluteus medius (GMED), and superior gluteus maximus (SUP-GMAX). Subjects performed maximum voluntary isometric contractions (MVICs) for each muscle. Raw EMG signals were sampled at 1,560 Hz with a bandwidth of 35-750 Hz. Subjects performed sidelying abduction (ABD), sidelying clam (CLAM), hip hike (HIKE), and unilateral bridging (UniBRIDGE) exercises. The mean root-mean-square (RMS) of the EMG signal in each exercise was normalized to MVIC, for each muscle. Two-way ANOVAs and independent t-tests compared the two groups for each muscle in each exercise (alpha = .05). One-way ANOVAs and simple-type contrast tests compared each gluteal muscle to the TFL for each exercise within each group. The GTA Index was calculated for each exercise in each group as follows:

{[(GMED/TFL) x GMED] + [(SUP-GMAX/TFL) x SUP-GMAX]} _____ 2

RESULTS: Between-groups comparisons showed that the PFP group had significantly lower SUP-GMAX EMG than controls in both UniBRIDGE and CLAM. Within-groups comparisons showed that for PFPs, SUP-GMAX was significantly lower than TFL in all exercises except CLAM. In controls, one or both gluteal muscles was significantly higher than TFL in all exercises except HIKE. The PFP group had lower GTA index values for all exercises compared to the pain-free group. Both groups demonstrated their highest values in the CLAM.

CONCLUSION: Persons with PFP may over-activate TFL and under-activate SUP-GMAX compared to pain-free subjects, warranting corrective exercise retraining. Pain-free group findings showed CLAM and UniBRIDGE were best and HIKE was worst for activating gluteals while minimizing TFL activity.

PMRE_O2.1 A COMPREHENSIVE ANALYSIS OF MUSCLE RECRUITMENT PATTERNS DURING ABDUCTION IN DIFFERENT PLANES AND AT DIFFERENT LOADS

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Dr Mark Halaki, University of Sydney; Dr Ian Cathers, University of Sydney; A/Prof Karen Ginn, University of Sydney

INTRODUCTION: Abduction in the scapular and coronal planes is widely recommended in exercise and rehabilitation programs. There is some evidence to suggest that muscle recruitment patterns may be different in different abduction planes and affect exercise prescription but it has not been comprehensively investigated using EMG.

AIM: To determine how changing the abduction plane and load affects the activation levels in muscles around the shoulder.

METHODS: Fourteen asymptomatic subjects, with no history of shoulder pain volunteered for this study. Dynamic abduction was performed using the dominant arm in the coronal, scapular, and midway between the scapular and sagittal planes (scap-sag) and at each of 25, 50 and 75% maximum load. Indwelling electrodes recorded muscle activation levels from supraspinatus, infraspinatus, subscapularis, lower trapezius and serratus anterior, while surface electrodes recorded from upper trapezius, pectoralis major and middle deltoid. The average EMG levels were calculated for each muscle. A three factor repeated measures ANOVA (7 muscles x 3 planes x 3 loads) was performed to compare activation levels, followed by Tukey post hoc analysis.

RESULTS: The different muscles were activated at different levels ($F_{6,78}=2.2$, $p<0.05$) and the activity in all muscles increased as load increased ($F_{2,26}=65.2$, $p<0.01$). There was also a difference in the pattern of muscle activation with plane ($F_{12,156}=4.3$, $p<0.01$) but post hoc tests showed that this was only true for middle deltoid which was significantly less in the scap-sag plane compared to the coronal plane ($p<0.05$), while all other muscles were activated at a similar level across all planes ($p>0.09$). In the coronal plane, infraspinatus was activated higher than subscapularis ($p<0.05$) but both were similar to supraspinatus ($p\geq0.23$). Upper trapezius was activated higher than lower trapezius ($p<0.05$) and both were similar to serratus anterior ($p\geq0.67$). In both scapular and scap-sag planes, infraspinatus was activated higher than supraspinatus ($p<0.05$) and both were activated higher than subscapularis ($p<0.05$). Upper trapezius and serratus anterior were activated at similar levels ($p\geq0.99$) and both were higher than lower trapezius ($p<0.05$).

CONCLUSION: When considering exercise prescription, abduction performed in any of the three abduction planes will activate all muscles tested at similar levels, except middle deltoid. However, the relative contribution of individual rotator cuff muscles and axioscapular muscles change between the coronal plane and both the scapular and scap-sag planes. Increasing load systematically increases the activation of all muscles.

PMRE_O2.2 GENDER DIFFERENCES IN METABOLIC RESPONSE TO PERCUTANEOUS ELECTRICAL MUSCLE STIMULATION IN TYPE 2 DIABETES

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Mr Kohei Watanabe; Dr Kazuhito Fukuda; Prof Toshio Moritani

INTRODUCTION: Electrical muscle stimulation (EMS) is expected to be a candidate for new exercise method in patients with type 2 diabetes, who have a difficulty in performing voluntary exercise as a consequence of excessive obesity, osteoarthritis and/or diabetic complications. We provided the first evidence indicating that EMS could effectively attenuate postprandial hyperglycemia in type 2 diabetes. Determining gender differences in the effects of EMS on glucose metabolism is an important step in the delineation of biological factors that may impact the physiological benefits of EMS.

AIM: The purpose of this study is to assess the effect of gender on metabolic response to percutaneous EMS in type 2 diabetes.

METHODS: Eleven men (57.0±2.7 years) and eight women (63.9±4.2 years) outpatients with type 2 diabetes volunteered to participate in this investigation. Written informed consent was obtained from all patients. All patients participated in two experimental sessions; one was a 30-min EMS 30 min after breakfast (EMS trial) and the other was a complete rest after breakfast (Control trial). In each trial, blood was sampled before and at 30, 60, 90, and 120 min after the meal. Also, respiratory gas exchange and lactate concentration were measured before and during EMS. The time course of the change in glucose concentration was analyzed with two-way repeated measures ANOVA for time, trial in each sex. Furthermore, ANOVA was used for VO2, RQ and lactate concentration during EMS to assess gender differences.

RESULTS: It was found that EMS significantly attenuated postprandial glucose level at the time point of 60, 90 and 120 min after meal in men ($P<0.05$), whereas there was not a significant difference between trials in women. Also, men had significantly higher RQ and lactate concentration than women during EMS ($P<0.05$) while VO2 during EMS was similar between men and women.

CONCLUSION: The glucose metabolism during and post EMS period were found to be significantly lower in women than in men. It is well known that EMS preferentially activates type II fibers that have a larger capacity for glycogen utilization. Thus, gender difference is most likely due to smaller anaerobic glycolysis in women whose type II fibers are smaller. This study would provide fundamental evidence regarding the potential application of EMS for treating glucose homeostasis in patients with type 2 diabetes.

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PMRE_O2.3 KNEE FLEXOR STRENGTH AND BICEP FEMORIS ACTIVATION DEFICITS FOLLOWING HAMSTRING STRAIN INJURY.

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INTRODUCTION: Hamstring strain injuries (HSI) are prevalent in sport and re-injury rates have been high for many years. Maladaptation following HSI are implicated in injury recurrence however nervous system function following HSI has received little attention.

AIM: To determine if recreational athletes with a history of unilateral HSI, who have returned to training and competition, will exhibit lower levels of voluntary activation (VA) and median power frequency (MPF) in the previously injured limb compared to the uninjured limb at long muscle lengths.

METHODS: Twenty-eight recreational athletes were recruited. Of these, 13 athletes had a history of unilateral HSI and 15 had no history of HSI. Following familiarisation, all athletes undertook isokinetic dynamometry testing and surface electromyography assessment of the biceps femoris long head and medial hamstrings during concentric and eccentric contractions at ± 180 and ± 60deg/s.

RESULTS: The previously injured limb was weaker at all contraction speeds compared to the uninjured limb (+180deg/s mean difference(MD) = 9.3Nm, $p = 0.0036$; +60deg/s MD = 14.0Nm, $p = 0.0013$; -60deg/s MD = 18.3Nm, $p = 0.0007$; -180deg/s MD = 20.5Nm, $p = 0.0007$) whilst VA was only lower in the biceps femoris long head during eccentric contractions (-60deg/s MD = 0.13, $p = 0.0025$; -180deg/s MD = 0.13, $p = 0.0003$). There were no between limb differences in medial hamstring VA or MPF from either biceps femoris long head or medial hamstrings in the injured group. The uninjured group showed no between limb differences with any of the tested variables.

CONCLUSION: Previously injured hamstrings were weaker than the contralateral uninjured hamstring at all tested speeds and contraction modes. During eccentric contractions biceps femoris long head VA was lower in the previously injured limb suggesting neural control of biceps femoris long head may be altered following HSI. Current rehabilitation practices have been unsuccessful in restoring strength and VA following HSI. Restoration of these markers should be considered when determining the success of rehabilitation from HSI. Further investigations are required to elucidate the full impact of lower levels of biceps femoris long head VA following HSI on rehabilitation outcomes and re-injury risk.

PMRE_O2.4 DISTAL PATELLAR TAPE PLACEMENT AND REMOVAL AFFECTS ELECTRICAL MUSCLE ACTIVITY AND LIMB FLEXION AT WALK

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INTRODUCTION: Placement of a tension tape to the skin over the distal patellar ligament is commonly used in the management of habitual locking of the patella in horses, which is caused by an inadequate tension of the quadriceps on the patella and indirectly on the distal patellar ligaments. The effect of treatment is incompletely understood. An increase in muscle tension caused by changed input of the mechanoreceptors in the ligament is hypothesised.

AIM: To identify hindlimb muscle and kinematic response to tape placement and removal over the distal patellar ligaments

METHODS: Kinematics and surface electromyography were measured in five horses without clinical neurological impairments, with electrodes placed over the muscle bodies of left and right M. extensor digitorum longus, M. vastus lateralis, and M. biceps femoris (Mbf). Measurements were taken with an EMG telemetric system with a sample frequency 1.2 kHz. Twelve markers were placed on left and right side on the femur and tibia, additional markers were placed on the sacrum and on the hooves. Kinematic data were collected using ten digital infrared cameras recording at 120 Hz.

On the right femorotibial joint a nonrigid textile adhesive tape was placed under manual tension on the skin in a transversal direction from the site of insertion of the medial distal patellar ligament over the tibial tuberosity and across the popliteal area until the end was taped on itself. For placement of the tape, horses were standing square. Care was taken to create the maximum tension that the horse accepted without kicking out and breaking the tape. The tests were carried out on three consecutive days with the horses walking on a treadmill at individual standardised speed. On each day synchronous EMG and kinematic data collection comprised 3 trials (each 10 seconds), before placement of the tape (PRE), 1 minute after placement of the tape (TAPE) and 1 minute after removal of the tape (POST).

The parameters studied were the maximum flexion of the limb during the swing phase represented by the maximum height of the hoof, the stride length and the muscle activity distribution within a stride cycle at walk, with EMG values normalised to the first quartile to account for noise.

RESULTS: In Horse 1, movement asymmetry was significantly reduced at POST, and maximum limb flexion and stride length were significantly increased in both hindlimbs at POST. While the basic EMG activity (normalised second quartile values) throughout the motion cycles did not change, the Mbf maximum activity (normalised fourth quartile values) showed an increase in the non-taped limb at TAPE.

CONCLUSION: Taping affects muscle activity both in the taped and in the non-taped limb, and changes kinematics after tape removal.

PMRE_O2.5 THE BIOMECHANICAL DETERMINANTS OF ADDUCTOR RELATED GROIN PAIN

Dr Dylan Morrissey, QMUL

Ms Claire Small; Miss Paulina Kloskowska; Prof Roger Woledge; Dr Richard Twycross-Lewis

INTRODUCTION: Adductor related groin pain (ARGP) is common amongst football code athletes and can result in significant time lost from sporting participation. The associated motor control deficits are not well understood.

AIM: The aim of this series of studies has been to better understand the muscle activation patterns and kinematics associated with ARGP.

METHODS: After obtaining informed consent, 9 male recreational football code athletes with chronic ARGP, and 9 activity-matched controls: and also 10 professional footballers with ARGP and 10 matched controls were measured. Bilateral muscle activation of the gluteus medius, gluteus maximus, external oblique, rectus femoris, adductor longus and hamstring muscles were made with telemetric sEMG. A full lower limb kinematic analysis was made with an active motion capture system. Onset of movement was identified with a force plate. The data was time-normalised to quantify muscle activation parameters at the onset, middle and end of the standing hip flexion and straight leg raise manoeuvres.

RESULTS: The guteus medius to adductor longus activation ratio was significantly reduced in recreational footballers with groin pain when the injured leg was either moving ($F = 64.3$, $p < 0.001$) or in stance phase ($F = 32.4$, $p < 0.001$) when compared to activity-matched uninjured subjects in both manoeuvres, equating to a difference varying between 20 and 40% depending on phase and type of movement. These differences were particularly due to decreased abductor muscle activation. Similar findings of lesser magnitude have been found in the professional group. We are now analysing the sagittal plane muscle activation findings and associated kinematics.

CONCLUSION: Football code athletes with groin pain exhibit significantly altered coronal plane muscle activation with comparison to activity matched uninjured subjects. These findings help explain the presentation of resistant groin pain need to be taken into account when planning rehabilitation for these athletes.

PMRE_O2.6 FOOT ORTHOSES AND FLAT INSOLES PRODUCE IMMEDIATE REDUCTIONS IN PAIN ASSOCIATED WITH PATELLOFEMORAL JOINT OSTEOARTHRITIS DURING PROVOCATIVE FUNCTIONAL TASKS

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INTRODUCTION: Patellofemoral joint (PFJ) osteoarthritis (OA) is a distinct and common clinical entity associated with considerable pain, morbidity and impaired quality of life. Similarities in symptoms, biomechanics and muscle dysfunction between PFJ OA and patellofemoral pain (PFP) in younger adults suggest that PFJ OA may be responsive to interventions known to be efficacious for PFP, such as foot orthoses. However, this simple intervention has not been investigated for PFJ OA.

AIMS: To determine i) which functional tasks are most pain-provocative for individuals with PFJ OA; and ii) the immediate effects of foot orthoses and flat insoles on pain associated with PFJ OA during the most provocative functional tasks.

METHODS: A within-subjects, repeated measures, randomised cross-over trial recruited individuals with PFJ OA (age ≥ 40 years; PFJ osteophytes on skyline radiographs; anterior knee pain during PFJ-loading activities e.g. steps, squatting). Participants wore running sandals (Nike Straprunner) and rated their pain (11-point numerical rating scale, 0-10) during level walking, five small squats, walking up and down four steps, and five step-downs. They repeated each task wearing i) sandals with prefabricated foot orthoses (Vasyli International), and ii) sandals with flat EVA inserts, in a random order. Repeated measures analysis of variance and post hoc tests of simple effects examined differences in pain between the three shoe insert conditions for functional tasks rated ≥ 3/10 ($p < 0.05$).

RESULTS: 18 participants (9 females; age 59±10) reported most pain during the step down task (5.3±2.2), followed by squatting (3±2.3), stair ambulation (2.7±1.9) and walking (1.6±1.7). There were significant main effects for orthoses for the step down task ($p < 0.000$), but not for squatting. Post hoc tests revealed that participants experienced significantly less pain during step down with foot orthoses than with shoes alone (mean difference -1.81, 95% confidence interval -2.83 to -0.79), and with flat insoles compared to shoes (-2.25, -3.03 to -1.47). However, there were no significant differences between foot orthoses and flat insoles (0.44, 0.26 to 1.15).

CONCLUSIONS: Shoe inserts, be it prefabricated foot orthoses or flat insoles, can produce immediate and significant reductions in pain during provocative activities in those with PFJ OA. Importantly, the magnitude of pain improvement is greater than the minimal clinically important difference. This indicates that shoe inserts are likely to be an effective intervention for PFJ OA, and warrant further investigation using randomised clinical trials to determine longer-term effects.

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PMRE_O2.7 SHOULDER FLEXOR ECCENTRIC TRAINING IS EFFECTIVE TO REDUCE PAIN AND IMPROVE FUNCTION ON ATHLETES WITH OVERUSE SHOULDER DYSFUNCTION

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INTRODUCTION: A high number of throwing movements performed regularly is related to the development of acquired shoulder instability, which may lead to pain and rotator cuff tendons dysfunction, being the most common cause of pain among pitchers. Since eccentric training has been proved effective in treating overuse tendinopathies, it was hypothesized that eccentric exercises could improve function and reduce pain of throwing related shoulder pain.

AIM: The present study aimed to verify the effect of shoulder flexors eccentric training on pitchers presenting shoulder pain during the eccentric phase of throwing.

METHODS: Four volleyball and two handball players (22.6±2.3 years old, 72.3±14.2 kg and 1.75±0.09m), five presenting dominant and one both shoulder pain at eccentric phase of pitch took part of this experiment (n=7 shoulders). Initial and final evaluation included pain measurement by visual analogical scale during functional tests, being shoulder diagnostic tests, maximal effort pitch and one repetition maximum test (1RM) of abduction, flexion and external rotation of shoulder. Electromyographic root mean square (RMS) was calculated for biceps brachii and upper trapezius muscles during isometric, concentric and eccentric phases of the 1 RM test. Eight sessions of eccentric training, consisted of 3 bouts of 15 repetitions from maximal abduction, flexion and external rotation (free of load) controlling eccentrically 80% 1 RM during extension, adduction and internal rotation until the hand touched the contralateral hip, after each bout subjects referred pain. A repeated measure ANOVA (3 bouts X 8 sessions) was performed to compare referred pain. A student t-test was performed to compare 1 RM maximal load, RMS pre and post training.

RESULTS: Although the third bout presented higher referred pain when compared to the first, there was a significant decrease of pain along the sessions. All subjects improved significantly pain-free range of motion (22%, $p<0.01$), 1RM load (13%, $p<0.01$) and decreased up to 100% referred pain ($p<0.05$) for all functional diagnostic tests, maximal effort pitch and 1 RM test. Also, greater biceps brachii RMS was found after training (16%, $p<0.05$), during eccentric phase of 1 RM test, whereas no changes were found for upper trapezius. Eccentric training may have improved tendon vascularization, which is effective to reduce pain and so interfere on reflex inhibition, allowing higher biceps brachii recruitment during eccentric phase.

CONCLUSION: Therefore, it can be concluded that eccentric training reduces pain and improves function for pitchers, which may contribute to prevent and treat athletes with throwing related shoulder.

PMRE_O2.8 FUNCTIONAL DIFFERENCES BETWEEN ANATOMICAL REGIONS OF THE ANCONEUS MUSCLE IN HUMANS

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INTRODUCTION: Despite several early electromyography (EMG) investigations of activity of anconeus, there remains considerable doubt regarding its function. As expected, these studies show greater anconeus EMG during elbow extension than elbow flexion. However, there is debate regarding its contribution to other functions, including a role in abduction of the ulna during forearm pronation or a contribution to stabilisation of the elbow joint. Conflicting data may be explained by recent anatomical work, which suggests that anconeus has two distinct fibre orientations: transverse (AT) and longitudinal (AL). Potential differential function of these two segments has not been evaluated.

AIM: To compare the activation of the two regions of anconeus in a range of voluntary tasks.

METHOD: Muscle activity was recorded from two regions of anconeus identified from recent anatomical studies and from typical elbow flexion and extension muscles with intramuscular and surface EMG electrodes. Eleven participants performed: (i) pronation-supination around the medial and lateral axes of the forearm, (ii) elbow flexion-extension in pronation, supination and neutral positions of the forearm, and (iii) gripping. Maximal voluntary contractions (MVC) and submaximal (10% MVC) force-matching tasks were completed.

RESULTS: Activity varied between the two segments of anconeus. AL was more active during pronation than supination, AT was not. During pronation, activity of AL and AT was greatest during supination-pronation about the lateral axis. AT was more active during elbow extension with the forearm in pronation, whereas AL did not differ between pronation and neutral forearm alignment. AL was more active than AT during the maximal gripping task; however, there was no difference in activity during the submaximal task.

CONCLUSION: These findings are consistent with the proposal that AL controls abduction of the ulna during forearm pronation. Different effects of forearm position on AL and AT activity during elbow extension may be explained by the anatomical differences between the regions.

These data suggest anconeus is involved in multiple functions at the elbow and forearm and this varies between anatomically distinct regions of the muscle.

ACKNOWLEDGEMENT: Funding was provided by the National Health and Medical Research Council (NHMRC) of Australia.

PMRE_O3.1 PEOPLE WITH CHONDROPATHY HAVE GREATER PHYSICAL IMPAIRMENTS COMPARED TO THOSE WITHOUT OR CONTROLS FOLLOWING HIP ARTHROSCOPY

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INTRODUCTION: Hip arthroscopy is increasingly being used to diagnose and treat intra-articular hip joint pathology. While post-operative rehabilitation aims to reduce symptoms and enhance physical function, there is minimal knowledge of the physical impairments (hip range of motion (ROM) or strength, functional performance) following hip arthroscopy. Importantly, since people with chondropathy at the time of surgery may represent a population with early onset hip osteoarthritis, knowledge of specific impairments in this subgroup may assist in the implementation of targeted interventions post operatively.

AIM: To compare the physical impairments between people post hip arthroscopy with and without chondropathy and a group of age matched healthy controls.

METHODS: 70 patients (35 female; age=35±10yr; height=1.75±0.10m; weight=79±12kg) were recruited 12-24 months post hip arthroscopy performed for intra-articular hip pathology by a single surgeon; and 60 healthy controls (41 female; age=36±9.6yr; height=1.71±0.94m; weight=68±12kg) were recruited. Participants were tested for hip ROM, normalised hip joint peak torque and functional performance (hop for distance). The intra-rater reliability of physical tests was established (ICC and SEM). Hip arthroscopy patients were grouped into those with chondropathy (CHA) and those without (0HA). Between-group differences of physical impairments were tested using Univariate Analysis of Co-Variance (ANCOVA) tests. Post hoc analysis was then performed on all impairments where a significant between group difference was observed (p<0.01).

RESULTS: All tests of physical impairment demonstrate good reliability (ICC>0.80). No differences exist between groups for patient characteristics. ANCOVA tests revealed differences for hip internal rotation (IR) ROM at both 0° hip flexion (p=0.039) and 90° hip flexion (p=0.001), hop for distance (p<0.001); and for all strength measures (abduction(AB) p<0.001 adduction(AD) p<0.001; extension(EX) p<0.001; flexion(FL) p<0.001; external rotation(ER) p=0.001; IR p=0.003). Post hoc analysis revealed no difference between controls and 0HA for the hip IR ROM measures. However, CHA had lower range of hip IR at 90° hip FL compared to controls and 0HA (p=0.001). Hip muscle strength was reduced in all measures between the controls and CHA (FL p <0.001; EX p <0.001; AB p<0.001; AD p<0.001; ER p<0.001; IR p=0.001). Furthermore, 0HA also exhibited lower AB (p=0.006) and AD (p=0.004) strength, compared with controls. A difference in functional tests was only seen between CHA and controls (p<0.001).

CONCLUSION: Physical impairments exist in people who are 12-24 months post hip arthroscopy compared to controls. People with chondropathy at the time of hip arthroscopy have greater impairments in hip IR ROM, all hip muscle strength and functional performance compared to both those without chondropathy, and healthy age-matched controls. This study is important as it is the first to describe physical impairments in this patient population. It may enable therapists to provide rehabilitation programs which are targeted to address specific deficits, thus potentially enhancing post-operative outcomes in this population.

ACKNOWLEDGEMENTS: Physiotherapy Research Foundation Beryl Haines Memorial Grant

PMRE_O3.2 ANODAL TRANSCRANIAL DIRECT CURRENT STIMULATION: THE EFFECTS OF ELECTRODE SIZE ON CORTICOMOTOR EXCITABILITY IN HEALTHY INDIVIDUALS

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Dr Shapour Jaberzadeh

INTRODUCTION: Transcranial direct current stimulation (tDCS) is a simple, safe and non-invasive neuromodulatory technique that uses low intensity direct current delivered directly to the area of interest over the cerebral cortex via two surface electrodes. Cathodal stimulation (cathode over target area, c-tDCS) results in decreased cerebral excitability and anodal stimulation (anode over target area, a-tDCS) results in increased excitability. The extent of modulatory effects and safety of a-tDCS is determined by the current density which is the product of current intensity and surface area of the stimulating electrode (cm2). There are several cross-sectional studies that have used tDCS to induce corticomotor excitability (CME); however, no studies to date have compared the effects of different electrode sizes on a-tDCS-induced corticomotor excitability of an upper limb muscle in healthy individuals.

AIM: to investigate the effects of electrode sizes on a-tDCS-induced CME of the right extensor carpi radialis muscle (ECR).

METHODS: Eight right handed healthy volunteers were tested in three separate sessions at least 48 hours apart. CME of dominant primary motor cortex (M1) of resting ECR was assessed before, immediately, 10, 20 and 30 minutes after a 10 minute application of 1 mA a-tDCS. Three different electrode sizes, small (12cm2), medium (24 cm2) and large (35 cm2) were compared. The outcome measure in this study was the amplitude of motor evoked potentials (MEPs) elicited by a single-pulse transcranial magnetic stimulation device (Magstim Company Limited, UK). The current density in all experiments was kept constant at 0.029 mA/cm2. All therapeutic and assessment procedures were approved by the Monash Ethics Committee.

RESULTS: Repeated-measure ANOVA indicates that in all different electrode sizes, CME increases significantly following a-tDCS application (12 cm2: $F_{4,28} = 15.39$, $p < 0.001$, 24 cm2: $F_{4,28} = 15.39$, $p < 0.001$, 35 cm2: $F_{4,28} = 15.39$, $p < 0.001$). The maximum increase in cortical excitability (122%) was induced by the smallest electrodes (12cm2). These increases were 65% and 55% for 24cm2 and 35 cm2 electrode sizes, respectively.

CONCLUSION: The fact that smaller electrodes produce larger ECR M1 excitability indicates that the stimulation is local and primarily affects the ECR M1, while the bigger electrodes may not only affect the ECR M1 but also affect the nearby sensory or motor areas. These sensory and motor areas may have some cortico-cortical projections. Some of these projections are inhibitory and using larger electrodes enhances these inhibitions. On the other hand, using smaller electrodes produces more local effects and minimises these inhibitions.

PMRE_O3.3 IMPACT OF ADDITIONAL STANDARDIZED RESISTIVE TRAINING ON RECOVERY OF MUSCULAR CO-ORDINATION AFTER KNEE ENDOPROSTHESIS

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INTRODUCTION: Due to the growing number of people requiring orthopedic intervention, individualized physiotherapeutic rehabilitation and adequate postoperative care becomes increasingly relevant whereby the costs of the health system must be considered. In this paper an intelligent, cost-effective and easy-to-use training system for home rehabilitation, based on resistive elements, is introduced.

AIM: The aim of this study is to examine the effectiveness of an additional self-operating training of patients using an intelligent training system.

METHODS: 40 patients with knee endoprosthesis were investigated. During their time of rehabilitation 20 patients received an additional training program with a self-operating training system, which intensifies and to a possible extent controls the rehabilitation effort by the help of a visual feedback. The other subjects represent the control collective. The training system is based on resistive elements like elastic tubes and bands, which are commonly used in physiotherapy. A force sensor, connected to the resistive materials, offers real-time information on the performed motion, namely the range of motion and the performed velocity. In the beginning of the rehabilitation, exercises with the resistive materials are trained and recorded with the guidance of a physiotherapist. The system then provided a real-time feedback, which visualized the targeted and the performed movement and thus was motivating and guiding the patients to move in the intended manner.

RESULTS: To evaluate the functional situation of the lower extremity joint chain, the kinematics and sEMG were recorded. During gait analysis patients walked in their individual gait rhythm and velocity. The data of the patients gait were captured by an opto-electronic ten-camera system (VICON MX+T20) Joint angles were calculated by Plug-In Gait from VICON, synchronized to the gait cycle and averaged over 15 steps. In addition to kinematics, surface-EMG (sEMG) was derived from 8 leg muscles to detect the muscular coordination pattern. SEMG electrodes were placed on the muscles according to SENIAM recommendations.

The muscular co-ordination as well as the gait pattern of patients show post-rehabilitative significant differences compared to the patients from the control collective. Both gait kinematics as well as muscular co-ordination was improved when using the intelligent self-training system.

CONCLUSION: By clinical gait analysis it has been shown, that additional training with the Feedback System improves the rehabilitation outcome significantly.

PMRE_O3.4 GAIT KINEMATICS AND KINETICS IN PATIENTS AFTER ENDOPROSTHETIC KNEE REPLACEMENT FOR BONE TUMOR RESECTION: A COMPARISON WITH HEALTHY CONTROL.

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Mr Koutatsu Nagai; Dr Takeshi Okamoto; Prof Junya Toguchida; Prof Noriaki Ichihashi; Dr Takeharu Nakamata; Prof Tadao Tsuboyama; Mr Noriatsu Tatematsu; Dr Tomitaka Nakayama

INTRODUCTION: Endoprosthetic knee replacement is often used to preserve joint function in patients with bone tumor around the knee. However, the reconstructed knee that cannot maintain sufficient strength will cause compensatory motion during walking, which might impair lower limb joints and compromise the long-term functional outcome of patients after the knee replacement. The paucity of knowledge about their gait characteristics hinders the achievement of the optimal gait pattern for these patients.

AIM: The aim of this study was to define the kinematic and kinetic differences in patients after endoprosthetic knee replacement compared with healthy controls.

METHODS: Five patients after endoprosthetic knee replacement for bone tumor resection (men:women = 3:2, age (mean(SD)): 25 (5.5) years, height: 1.68 (0.07) m, body weight 63 (25) kg) and five healthy controls (men:women = 3:2, age: 25 (3.4) years, height: 1.69 (0.05) m, body weight 66 (11) kg) participated in this study with written informed consent. We captured the gait of the subjects walking along a 6m walkway five times using a three-dimensional motion analysis system with two force plates. We calculated walking speeds, ground reaction forces, internal joint moments, joint reaction forces, and joint power from one gait cycle of each trial and averaged them for each subject. We compared the specific gait variables of the operated and contralateral limbs of the patients with those of the right side of the controls using Dunnett's test. Significance was set at $p<0.05$. The ethics committee of Kyoto University approved this study.

RESULTS: Walking speeds were 1.25 (0.14) m/s in the patients and 1.16 (0.12) m/s in the controls. Four of five patients kept their operated knee extended and one kept it flexed in stance phase. In early stance, the average angular velocity from foot-flat to the end of midstance and the time integral of negative ankle joint power were greater on the operated side than in controls ($p=0.046$, $p=0.02$, respectively), while hip moments and power did not differ significantly. In the latter half of stance, the second peak of the vertical ground reaction force on the contralateral side was higher than in controls ($p=0.001$) and those on the operated side were lower than in the controls ($p<0.001$). The maximal ankle extension moment in the terminal stance phase was lower on the operated side than in the controls ($p=0.03$), and joint reaction force in the contralateral knee was greater than in the controls ($p=0.03$).

CONCLUSION: Our results suggested that after endoprosthetic knee replacement for bone tumor resection, patients intensify their contralateral push-off regardless of their gait pattern. This strong push-off might increase joint reaction force at the contralateral knee.

POSTURE, BALANCE & GAIT

POBG_O1.1 THE EFFECT OF TAI CHI EXERCISE ON STRENGTH, STRENGTH RATIOS, AND POSTURAL CONTROL IN OLDER ADULTS.

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INTRODUCTION: Tai Chi (TC) is a traditional Chinese exercise that has become popular among many older populations as a form of exercise to improve health and physical wellbeing. The simple, soft, and fluid movements of TC are performed in a semi-squat posture that can place large loads on the muscles of the lower extremities which has been demonstrated to cause significant improvements in the neuromuscular and somatosensory systems. This has led to TC being declared an important exercise in the development of postural control and hence, become important in the areas of falls prevention and healthy ageing.

AIM: To investigate the efficacy of 12 weeks of Tai Chi practice on the lower limb muscular strength, strength ratios, and postural control in an older population.

METHODS: Twenty four older adults (72.0 ± 4.2 years) underwent 12 weeks of Tai Chi exercise (TCG) and fifteen were allocated into a control group (73.9 ± 4.1 years) (CG). Maximal isometric muscular strength (MVC) assessment of knee extensors (KE), knee flexors (KF), ankle plantarflexors (AP), and ankle dorsiflexors (AD) was conducted while surface electromyography (sEMG) was simultaneously recorded during each trail. Maximal sEMG amplitudes were measured along with antagonist coactivation levels. The Hamstring to Quadriceps Ratio (HQR) and Dorsiflexor to Plantarflexor Ratio (DPR) were calculated from these MVC values. Static stabilometry tests were conducted with Center of Pressure (COP) displacements recorded in the anterior-posterior (AP) and medial-lateral (ML) directions plus calculations of resultant distance (RD). Both Traditional and Diffusion analyses were calculated for all postural data.

RESULTS: All muscle groups of the TCG were significantly stronger post exercise [$p<0.05$], while there were no changes in strength within the CG [$p>0.05$]. Only the KE and AP muscle activation significantly increased within the TC group [$p<0.05$] with no changes in any of the muscle groups of the CG [$p>0.05$]. Only the KF of both groups showed significant changes in activation level when acting as an antagonist (coactivation).There were no significant changes in either the HQR or DPR for either the TCG or CG [$p>0.05$]. Of the eight postural measures, only mean velocity and sway area exhibited significant reductions post TC [$p>0.05$].

CONCLUSION: The TC exercise did not effectively attenuate or reverse the age related decline in postural control in this group of older adults. This might however be a product of exercise specificity as TC is a dynamic exercise and the postural control assessment was static. TC was found to be effective in improving muscular strength of the lower extremities of older adults which is often link to greater mobility and improved quality of living.

POBG_O1.2 RESPONSE TO PERTURBED STANDING IS ASSOCIATED WITH PROSPECTIVE INCIDENCE OF FALLS IN THE ELDERLY

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INTRODUCTION: Compromised postural control is argued to contribute to the risk for falling. Although balance measures in quiet standing rarely predict incidence of falls, the quality of postural response to a perturbation might be able to distinguish better between people who are going to fall and those who are not.

AIM: To assess whether the postural response to a perturbation in standing is affected differently in a group of elderly who report one or more falls (fallers) in the subsequent 12 months compared people who do not go on to experience a fall (non-fallers).

METHODS: Participants (n=106; age - 75.3±5.5 years; height - 169.1±9.1 cm; weight - 77.7±15.5 kg) stood on a force plate for 3 periods of ~135s, blindfolded, with headphones that played white noise (to prevent distraction). In separate trials, mechanical vibration (60 Hz) was applied to the achilles tendons, lower back or neck to perturb balance for 15 s at 15 and 75 s after the start of recording. Centre of pressure data (COP) were analysed in anterior-posterior (AP), medio-lateral (ML) directions and were divided into 9x15-s epochs. In each epoch, mean COP displacement, SD, sway path length, normalised sway path length, COP area, mean absolute COP velocity, and SD of COP velocity were calculated. Data were compared between individuals who reported 1 or more falls (n=44)(data collected monthly for 12 months) and those who reported none (n=62).

RESULTS: Statistics include comparisons with a younger group of participants; results are focussed between fallers and non-fallers.

Both groups displaced COP equally by vibration conditions ($P>0.273$). Fallers had greater AP and AP/ML sway path length during vibration of achilles tendons (first vibration only) and lower back ($P<0.035$), COP velocity and SD COP velocity were greater during achilles and lower back vibration ($P<0.036$), AP COP SD was greater during lower back vibrations ($P<0.017$), COP area was greater during/after first lower back vibration compared to non-fallers ($P<0.033$). Neck vibrations did not affect balance.

CONCLUSION: A range of measures of compromised balance was prospectively related to falls when balance was perturbed by vibration of Achilles and lower back. In general, the measures showed that balance of fallers was more disturbed during vibration of the back and Achilles tendon than that of the non-fallers. Vibration provides an illusion of muscle lengthening via stimulation of muscle spindles. The greater disturbance to balance may either be explained by a greater effect of the illusion due to compromised sensory integration (e.g. compromised vestibular function would limit the alternative information available for the nervous system to judge the effect of the perturbation), or a reduced capacity of the neuromuscular system to respond (e.g. increased lower limb stiffness or muscle weakness).

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POBG_O1.3 EFFECT OF TYPE OF SURGICAL APPROACH OF TOTAL HIP ARTHROPLASTY ON BALANCING CAPACITY AFTER SUDDEN PERTURBATION

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INTRODUCTION: The recovery of balancing capacity after total hip arthroplasty (THA) is an important question, because falls are one of the most common problems at elderly subjects. Most studies concerning balance control have focused mainly on measuring postural balance during quiet standing on a stable or a sinusoidally moving platform. However, a high level of complex coordination is required to regain balance after a sudden impulse of change in direction, which could be modeled by a provocation test.

AIM: The goal of this research was to analyze the effect of the surgical approach of total hip arthroplasty (THA) on balancing ability.

METHODS: The control group included 23 males and 22 females; the AL patient group included 11 male and 11 female patients operated on by a conventional anterior-posterior approach; and the posterior patient group included 13 male and 12 female patients operated by a posterior approach during the early postoperative period. Balancing ability after sudden perturbation was modeled by a provocation test during double leg and single leg stance. Balancing ability was characterized by the Lehr's damping ratio. A two-sample t-test was used to analyze the influence of the surgical approach.

RESULTS: The Lehr's damping ratio calculated from testing while standing on the affected leg was significantly smaller than the results of testing during stance on the unaffected leg or on both legs prior to THA and after THA in both patient groups. The Lehr's damping ratio was significantly smaller prior to THA compared to the control group. In the AL patient group the Lehr's damping ratio of the affected side recovered to normal values 6 months after THA; however in the posterior patient group the Lehr's damping ratio of the affected side recovered to normal values earlier, namely 3 months after THA. Gender affected the Lehr's damping ratio in the control group, at AL patients 6 months after THA and at posterior patients 3 months after THA; in those cases the Lehr's damping ratio at females was higher compared to the results of males.

CONCLUSION: The type of approach significantly influenced balancing ability after sudden perturbation. Balancing ability recovers earlier to normal at patients operated on by the posterior approach. Deterioration in balancing ability after sudden perturbation can increase the risk of falling in the early postoperative period.

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POBG_O1.4 POSTURAL STABILITY COMBINED WITH DOMINANCE AND VISUAL INPUT IN INDIVIDUALS WITH RECURRENT LOW BACK PAIN.

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INTRODUCTION: This study examined stability in three regions of the spine based on dominance side and visual feedback. Subjects with (n=26; 9 men, 17 women) and without (n=28; 11 men, 17 women) recurrent low back pain (LBP) participated in this study.

METHODS: All subjects were asked to maintain single leg standing balance with the contralateral hip flexed 90 degrees for 25 seconds. The outcome measures included the duration of standing balance and the combined stability based on the rotation (Rxyz) with and without visual input. The spine regions included the upper and lower thorax and lumbar axes relative to the core spine axis which represent spine root. The combined rotation and holding duration were compared between subjects with and without recurrent LBP during the single leg holding test. Anthropometric factors were also considered between groups.

RESULTS: The subjects without recurrent LBP demonstrated longer hold durations than the subjects with recurrent LBP ($F=12.81$, $p=0.001$). The combined stability was significantly different based on dominance side ($F=4.37$, $p=0.04$), visual input ($F=11.33$, $p=0.001$), and spinal region ($F=101.72$, $p=0.002$). In addition, the combined stability of the spinal region had an interaction with visual input between groups ($F=4.50$, $p=0.03$). The combined stability of the spine root (0.52 ± 0.03) was lowest compared to the other regions of the spine in subjects with recurrent LBP.

CONCLUSION: Therefore, the kinematic changes of postural stability are different based on dominance side and visual feedback between subjects with and without recurrent LBP. Possible kinematic rehabilitation training of the core spinal axis could be used in the prevention of falls. Follow-up, randomized controlled trials are needed to investigate the characteristics of postural adjustability in order to enhance both biomechanical and neuromuscular function in subjects with recurrent LBP.

POBG_O2.1 CHANGE IN EVENT-RELATED POTENTIAL ASSOCIATED WITH FINGER REACTION TO AUDITORY SIGNAL JUST BEFORE POSTURAL DISTURBANCE WITH BACKWARD FLOOR TRANSLATION

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INTRODUCTION: For postural control with floor disturbance after finger flexion, attentional switch from sensory information and/or performing the task just before the disturbance is an important function.

AIM: To investigate relationships between attentional switch to postural disturbance and postural control using event-related brain potentials (ERP) associated with finger flexion just before backward floor translation.

METHODS: Thirteen subjects maintaining quiet standing posture, were perturbed by a backward floor translation (S2) 2s after an auditory warning stimulus (S1) (S1-S2 condition). The experiment was divided into conditions with auditory response signal (RS) or without it. RS was presented 500 ms before S2. Condition with RS was presented in the following three tasks: 1) left or right fingers were selectively flexed in response to a high or low tone signal (Choice-reaction); 2) fingers in the dominant side were flexed to every tone signal (Simple-reaction); and 3) no fingers were flexed (No-reaction). ERP from a Cz electrode, activity of postural muscles and the center of foot pressure in the anteroposterior direction (CoPy) were analyzed.

RESULTS: In the three conditions with RS, ERP negatively increased toward RS and N1 was found about 100 ms after RS, with no significant differences among conditions. Additionally, P3 was found about 300ms after RS. P3 latency was longer than both simple and choice reaction times and showed no significant differences among three conditions with RS. P3 amplitude was larger in Choice-reaction than in Simple- and No-reaction. ERP was then negatively increased toward S2. There was no significant difference in mean potential for 100ms before S2 among three conditions with RS and S1-S2 condition. Forward displacement of CoPy in response to S2 was smaller in the conditions with RS than S1-S2. Preparatory activity of postural muscles just before S2 and burst activation of triceps surae in response to S2 started earlier in the conditions with RS than S1-S2.

CONCLUSION: Attention directed to RS was considered to be adequately switched until postural disturbance, especially in Choice-reaction larger attention would be required for the switching. With effective attentional switching and RS as a cue signal for disturbance, postural control was successfully performed.

POBG_O2.2 ANTAGONISTIC CO-ACTIVATION OF NECK MUSCLES DURING FLEXION AND EXTENSION

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INTRODUCTION: Co-activation of antagonistic muscles is a well-known concept has been documented for limb muscles in several species. For the trunk musculature co-activation of muscles responsible for spinal stabilization has also been documented.

AIM: To describe the relationship between the activity of neck flexors and extensors reaching flexed and extended head and neck positions.

METHODS: Surface electromyography were measured in ten horses without signs of neck pain and clinical neurological impairments, with electrodes placed over the muscle bodies of left and right extensors: M. splenius (SPL), M. omotransversarius (OMO); and over flexors: M. cleidomastoideus (CM) and M. cleidobrachialis (CB). Measurements were taken with an EMG telemetric system with a sample frequency 1.2 kHz. In vivo measurements were taken in ten horses; they were trained to reach the extended (head high, neck long) and flexed (head low, neck short) positions. The EMG signal was rectified and sampling rate reduced to 120 Hz. A Butterworth low-pass filter was applied (fifth order; cut-off frequency, 10 Hz).Values of left and right muscle were analysed together as the movements were restricted to the vertical plane. Co-activation was quantified as follows: sum of the muscle activities throughout the movements were normalized to 100 % and the contribution each muscle was calculated from it. Movement values has compared to neutral head and neck position at stance.

RESULTS: All muscles measured showed obvious peak activities just prior to reaching the required head and neck positions. Extensor muscles showed 57 % (SPL) and 20 % (OMO) of the overall muscle activity during extension. During flexion they showed 42 % (SPL) and 15 % (OMO) of the overall muscle activity. There was no significant difference between flexion and extension in SPL and OMO activity. Flexor muscles showed 11 % (CM) and 12 % (CB) of the overall muscle activity during extension. During flexion they showed 23% (CM) and 20 % (CB) of the overall muscle activity. There was significant difference between flexion and extension in CB activity. Muscle activity during neutral position was not significantly different from either flexion or extension in all four muscles investigated.

CONCLUSION: In this study only the muscles available for surface EMG were measured, therefore overall muscle activity needed to reach certain head and neck positions is expected to be considerably larger than the activities reported here. The SPL has mainly a postural role and anatomical description as a head and neck extensor does not reflect this function. The flexor activities reflect their smaller volume compared to the extensors, which is explained by flexion being in the direction of the gravitational force.

POBG_O2.3 DUAL TASKING WHEN WALKING IN PEOPLE WITH PARKINSON'S DISEASE: A SINGLE BLIND RANDOMISED CLINICAL TRIAL

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INTRODUCTION: People with Parkinson's disease (PD) have difficulty walking whilst performing added tasks and can improve immediately after 1-3 training sessions, but the effects of a training program have not yet been determined. This study compared the efficacy of a 4 week, 12hr program of dual vs. single task walking training in people with PD to improve their ability to walk whilst performing added tasks.

METHODS: Sixty-three people with PD were recruited into a parallel group randomised trial with concealed allocation, assessor blinding and intention to treat analysis. Of these, 32 were randomly allocated to dual and 31 to single task walking training. The primary outcome measure was step length recorded with an 8m GAITrite system under dual task conditions at 4 time points – baseline 1, 2, post and at 6mths follow up. Secondary outcome measures included spatiotemporal gait parameters under single and dual task conditions, executive function, clinical gait performance and community mobility. Both groups undertook one-on-one progressive gait training. The dual task training group performed these gait tasks whilst also undertaking progressively difficult added tasks. Generalised linear models were performed to determine the effect of group and time on outcomes.

RESULTS: The groups were not different at baseline and there was no difference in measures between baseline 1 vs. 2. Both training groups improved their step length when performing dual tasks post training. At follow up, step length was shorter than post ($p < 0.019$), but greater than baseline ($p < 0.01$). The dual task training group showed greater improvements pre to post training in step length than the single task training group (9.7 vs. 4.2 cm). Six-minute walk distance improved in both groups and was maintained at follow up. Distance covered in 3mins when having a conversation improved in both groups post treatment ($p < 0.001$), but only maintained this level at follow up in the dual task group ($p = 0.279$).

CONCLUSIONS: This is the first study to report the effect of a dual task walking training program compared to a single task program. A one-on-one, individualised training program of single or dual task walking training improved step length under dual task conditions in people with PD and gait did not return to pre-training levels in either group. Dual task training effected greater changes in some measures of dual tasking when walking.

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POBG_O2.4 NORMALIZING STANCE WIDTH

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INTRODUCTION: In previous studies, stance widths are most often determined as a percentage of shoulder width, where 70% of shoulder width is considered a narrow stance width and 140% of shoulder width is considered a wide stance width. A few studies have also normalized stance width to the width of the hips (distance between trochanters). However, there are also a possibility to normalize stance width in relation to the length of the lower extremities, since this variable might not change as much in dynamic situations and may correlate higher to the angle of the lower extremity in a frontal plane.

AIM: This study aims to compare measurements of stance width when normalized to shoulder width, hip width and leg length for three different stance widths with feet attached to a board.

METHODS: Motion capture (Qualisys, 16 Oqus-cameras) was used to measure 7 active male kitesurfers with their feet attached to a kiteboard (1.36 m). They were 20-28 years old, in average 180 cm (SD=7 cm) and 78 kg (SD=7 kg). The subjects were standing with three different stance widths, using the same external rotation (20° bilaterally). Markers were attached to shoulders (acromion processes), knee joint lines, hips (trochanter major), heels (mid-posterior of calcaneus) and ankles (lateral and medial malleoli). Stance width was measured as the distance between the two medial ankle markers and normalized towards the distances between (1) the shoulder markers, (2) the hip markers and knee marker plus knee marker and lateral ankle marker and (3) the right and left hip marker. Furthermore, the angle of an extended lower extremity towards a vertical line in the frontal plane was measured. All measurements were done twice, and SPSS 20 was used for data analysis of correlation (Pearson's r).

RESULTS: The measured stance widths between ankles were 39.9 cm, 43.6 cm, and 48 cm (SD=1.2-1.4) for all subjects. The correlations (r) between the angle of the leg towards a vertical line and normalized stance width for the three normalization variables were: (1) 0.79, (2) 0.96 and (3) 0.93. All of the correlations were significant at a level of $p>0.01$.

CONCLUSION: The results show that the variables hip or leg length would be preferred to use when normalizing stance width for young male athletes, standing in wide stance widths. Further studies using a greater number of subjects, more stance widths and a more heterogeneous group are suggested for the future.

POBG_O3.1 QUANTIFYING THE FUNCTIONAL STATE OF MUSCLES STABILISING THE KNEE JOINT WHILE WALKING USING PRINCIPAL COMPONENT ANALYSIS

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INTRODUCTION: For a safe landing well pepared and coordinated muscle activity is important because at initial contact the knee joint is anatomically instable and gets only stable when the limb is loaded [1]. A high degree of agonist-antagonist co-activation between thigh muscles maintains active knee joint stability [2], and protects the joint from injuries [3].

AIM: To measure how individuals prepare and coordinate muscles around the knee which actively absorb the impact at heel strike.

METHODS: Surface electromyograms (EMG) of the quadriceps (vastus medialis, vastus lateralis, rectus femoris) and the hamstring (biceps femoris, semitendinosus) muscle group were collected from 10 healthy females walking at self-selected speed. A total of 180 steps from the left leg (18 steps/subject) were analysed. Principal Component Analysis was performed on the normalised EMG power (200 ms before to 200 ms after heel strike) extracted by a wavelet-based time-frequency analysis (92-395 Hz) [4]. The Pearson correlation coefficient was used to determine the coordination between muscle pairs for the first two principal component scores (PC-scores) with a significance level of $p<0.05$.

RESULTS:

CONCLUSION: The inter-subject variability of EMG patterns observed while walking represent differences in the neuromuscular control mechanism to motor output, but nevertheless the knee joint is stabilised by highly coordinated muscle activation within a muscle, within a muscle group as well as between both thigh muscles located medially and muscles located laterally.

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POBG_O3.2 MUSCLE ACTIVATION IN VALGUS ANKLE OSTEOARTHRITIS PATIENTS DURING WALKING — THE EFFECT OF REALIGNMENT SURGERY

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INTRODUCTION: In valgus ankle osteoarthritis (OA) the medial part of the joint cartilage is preserved. Therefore realignment surgery is a possible treatment option [1]. To date, little is known about muscle activation in valgus ankle OA and the effect of joint preserving surgery. Studies on knee OA showed that principal component analysis (PCA) allowed the investigation of temporal muscle activation during gait [2].

AIM: To compare pre- and post-surgery lower limb muscle activation patterns of OA patients while walking.

METHODS: Surface electromyography (EMG) of Mm. gastrocnemius medialis (GM), gastrocnemius lateralis (GL), soleus (SO), peroneus longus (PL), and tibialis anterior (TA) was measured (sampling rate: 2400 Hz) during walking in three subject groups: 5 valgus ankle OA patients before (PRE), 5 valgus ankle OA patients 7-9 years after realignment surgery (POST) and 12 healthy controls without hindfoot malalignment.

EMG signals of 6 gait cycles from the affected leg of the patients and the right leg of the controls were further analyzed using a wavelet transformation with time normalization [3]. The total intensity was calculated by summing the intensities over wavelets ranging from 19 to 395 Hz and dividing them by the sum of the intensities over all time points. Total intensities were filtered (4th order, zero-lag Butterworth, cut-off 10 Hz) and submitted individually for each muscle to a PCA. Principal component (PC) scores were compared between controls and PRE, as well as between controls and POST using a Wilcoxon ranksum test ($\alpha=0.05$).

RESULTS: Significant differences in the first two PC scores were found between PRE and controls in GM, GL, SO and PL, while there were no significant differences between POST and controls. GM, SO, and PL were active in PRE patients during both early and late stance, whereas in POST patients and controls these muscles were mainly active in late stance. This was reflected in the first PC (relationship between early and late activation) of these three muscles with significantly higher scores in PRE than in controls. Additional significant differences were seen in the second PC of GM which resulted in a lower amplitude in PRE, and of GL which led to an earlier peak in PRE patients.

CONCLUSION: This study showed that, several years after realignment surgery, the temporal activation of the lower leg muscles while walking, returned to a normal activation pattern, similar to the one observed for control subjects.

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POBG_O3.3 PREMATURE ANKLE PLANTARFLEXOR ACTIVITY DURING GAIT IN 716 PATIENTS WITH DIFFERENT PATHOLOGIES

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INTRODUCTION: Premature plantarflexor activity (PPF) during loading response of walking can be observed in patients with multiple pathologies. It is a common abnormality in clinical gait analysis and often associated with an initial forefoot contact (IFC) [1].

AIM: The aim of this study was to analyse the clinical significance for PPF and to gain understanding about etiological factors.

METHODS: The 3D gait analysis data of 716 patients (268 orthopaedic, 461 neurologic patients) and 103 healthy subjects were investigated retrospectively. These were all available data in our gait laboratory (1999-2012) that included surface electromyograms (SEMG) of the medial gastrocnemius muscle and kinematics. SEMGs were recorded according to the SENIAM guidelines during gait at a self selected speed. The raw SEMG signal was bandpass filtered with a 4th order butterworth filter of 20-500Hz and full wave rectified. All data were time-normalised to a gait cycle and each envelop SEMG was amplitude-normalised to the average value over each cycle. PPF was defined, according to non-dimensional walking speeds [2] of <0.227, 0.228-0.363 and >0.363, as constant activity above 28%, 23% and 31% of the maximum activity over the first 10% of the gait cycle. Association of PPF with IFC were calculated by means of phi coefficient.

RESULTS: PPF was present in 277/716 patients (38.7%) and in only 1/103 healthy subject (1.0%). In orthopaedic patients with uni-/bilateral involvement PPF was present in 15.0/13.5%. Neurological patients with hypotonic muscles showed PPF in 50.0/39.8% (uni-/bilateral involved). The prevalence in patients with hemi-/di-/tetraplegic spasticity was 51.7/66.2/56.1%. In 122/277 patients (44.0%) with PPF this was accompanied by an IFC. PPF and IFC were positively associated for the uni- and bilateral orthopaedic, and for the bilateral cerebral palsy patient groups with phi=.388/.262/.227.

CONCLUSION: The high prevalence of PPF in patients and the negligible number of healthy subjects with PPF underline the clinical significance of this abnormality. A solely neurological component can be excluded, since PPF was present in a considerable number of orthopaedic patients. Altered biomechanics through IFC with multiple etiologies is surely a factor for PPF, but rather low phi coefficients imply that other factors, such as muscle weakness, contracture or spasticity, have an impact as well. PPF is a complex abnormality with clinical significance, due to high incidence rates across different patient groups.

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POBG_O3.4 GAIT PARAMETERS ASSOCIATED WITH HALLUX VALGUS: A SYSTEMATIC REVIEW

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INTRODUCTION: Hallux valgus (HV) has been linked to functional disability and increased falls risk in older adults. However, it is unclear how HV affects gait parameters that may underpin functional disability.

AIM: This systematic review investigated gait parameters associated with HV in otherwise healthy adults.

METHODS: Electronic databases (Medline, Embase, CINAHL) were searched from inception to October 2011, including cross-sectional studies of healthy individuals, with a clear definition of HV and a non-HV comparison group. Two independent investigators rated included papers for methodological quality. Effect sizes with 95% confidence intervals (CI) were calculated as standardized mean differences (SMD) for continuous data, and risk ratios (RR) for dichotomous data.

RESULTS: Nine papers included a total of 589 participants. Three plantar pressure studies reported increased hallux loading (SMDs 0.56 to 1.78) and medial forefoot loading (SMDs 0.62 to 1.21) in HV participants, while one study found reduced first metatarsal loading (SMD -0.61, CI: -1.19 to -0.03). HV participants demonstrated less ankle and rearfoot motion during terminal stance (SMDs -0.81 to -0.63) and intrinsic muscle overactivity (RR 1.6, CI: 1.1 to 2.2). Most studies reported no differences in temporospatial parameters; however, one study reported reduced speed (SMD -0.73, CI: -1.25 to -0.20), step length (SMDs -0.66 to -0.59) and less stable gait patterns (SMDs -0.86 to -0.78) in older adults with HV.

CONCLUSION: Individuals with HV appear to have altered gait patterns compared to controls. Limitations in study design mean that cause and effect relationships cannot be inferred. Prospective studies are warranted to enhance understanding of the relationship between HV and functional disability.

POBG_O3.5 RELATIONSHIP BETWEEN THE EMG CHARACTERISTICS AND CENTER OF PRESSURE OF THE FOOT DURING STAIR DESCENT WEARING SHOES WITH DIFFERENT HEEL HEIGHTS

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INTRODUCTION: Young women prefer wearing high-heeled shoes because such shoes make them look taller and fashionable. However, wearing such shoes might have an effect on important and frequently performed tasks of daily living, such as stair descent.

AIM: The aim of this study was to investigate the EMG characteristics, kinetics of the lower extremity, and center of pressure (COP) of the foot of women performing a stair descent task while wearing high-heeled shoes with varying heel heights.

METHODS: Eight young healthy women, aged 19–21 years, without any history of orthopedic disease participated in this study. A three-dimensional motion analyzer (Vicon Nexus) with 8 infrared camera units was used to measure the kinematic parameters during walking. Kinetic parameters such as the floor reaction force were measured using AMTI force plates. EMG data were recorded using the Noraxon system while the participants performed a stair descent task. The stair steps used had a tread width of 30 cm and a height of 16 cm, which were similar to those of stairs found in public places in Japan. The participants wore high-heeled shoes with different heel heights (0, 3, 6, and 9 cm) while performing the stair descent task. For each participant, data were recorded at a constant walking speed.

RESULTS: Data obtained during the stair decent task revealed significant differences in the anteroposterior (AP) displacement of COP of the shoes with different heel heights. Statistical analysis showed that the AP displacements of COP were significantly lower for the shoes with 9-cm heel height than for the shoes with 0- and 3-cm heel height ($p < 0.01$). The maximum length of moment arm of the knee joint at the terminal stance did not differ among the shoes with different heel heights. Furthermore, EMG measurements of the rectus femoris muscle were significantly larger for the shoes with heel heights 6 and 9 cm than for the shoes with heel heights 0 and 3 cm ($p < 0.01$). Similar to the AP displacements, the peak value of extension moment of the knee joint and the peak knee joint flexion angle were significantly larger for the shoes with 9-cm heel height than for those with 0-, 3-, and 6-cm heel heights.

CONCLUSION: The AP displacements of COP during stair descent are associated with significant changes, mainly in rectus femoris activity. A lower COP ensures greater stability while performing various activities.
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POBG_O3.6 A SYNERGY PERSPECTIVE ON GAIT – OVER-GROUND VS. TREADMILL WALKING

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INTRODUCTION: Increased stride-to-stride time variability is reported among elderly fallers and various patient groups [1]. Variability is therefore often regarded as an indicator of gait deficits. However, movement variability is also a general and natural phenomenon. A synergy perspective on movements has proposed that elemental and performance variables may represent good and bad components of variability [2].

We suggest that the gait pattern can be regarded as a movement synergy in which medio-lateral deviation in one stride can be corrected during the next stride (the elemental variables). Such corrections ensure a straight gait path (the performance variable).

AIM: The aim of this study was to apply a synergy approach to gait analysis by comparing over-ground and treadmill walking. The treadmill was hypothesized to demand a less variable walking path resulting in a larger good/bad variability ratio.

METHODS: Eight young subjects participated in the study. They walked over-ground down a 200 meter hallway and on a treadmill at preferred gait speed. A tri-axial accelerometer (Xsens) was fixed at the lower back of the participant by a belt around the pelvis. The gyro-corrected medio-lateral acceleration signal was summed up for each stride. Each acceleration stride sum was plotted against the subsequent stride sum in a coordinate system. Variability was evaluated in diagonal directions in the plot. Good variance was evaluated with respect to a straight line with a positive slope going through the mean of the strides, and bad variance with respect to a similar line with a negative slope. The good/bad variance ratio was calculated and the difference between treadmill and over-ground walking was finally evaluated.

RESULTS: The good/bad variance ratio for over-ground walking was 1.7 (CI95%: 1.5-2.0). When walking on the treadmill the ratio increased significantly to 2.4 (CI95%: 2.3-2.5); ($p<0.01$). The normal variance did not change significantly during the treadmill walking ($p=0.46$).

CONCLUSION: The good/bad ratio for stride-to-stride variability was larger than 1.0. This indicates the pattern of a synergy. The pattern was emphasized during treadmill walking reflecting construct validity of the measure. The synergy approach to gait variability may provide a new way to assess gait variability.

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POBG_O3.7 PERTURBATIONS TO WALKING IN THE FRONTAL AND SAGITTAL PLANE INFLUENCE SPECIFIC MUSCLE SYNERGIES

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INTRODUCTION: Human locomotion can be described by a set of muscle synergies or motor modules, which are not influenced by walking speed, loading or voluntary actions executed during walking. However, studies on balance control of walking over slippery surfaces indicated that the gait pattern is altered due to sensory inputs.

AIM: To investigate the effects of perturbations in the frontal and sagittal plane on the modular organization of human walking.

METHODS: Eight healthy men (age range, 23-38 years) were asked to walk through a 7-m pathway, stepping on a moveable platform with the right foot. Initially, no perturbation was delivered (BASES), followed by perturbations provided in four directions and repeated 10 times randomly (10-cm translations at 65.7cm.s-1) in the following directions: forward (FW), backward (BK), leftward (LF) and rightward (RI). Surface electromyography (EMG) was measured from the right lower limb, trunk and neck, beginning from the right foot strike on the force platform until the next right foot strike. Motor modules (muscle synergies) were extracted from the EMG signal envelopes by means of non-negative matrix factorization. The quality of reconstruction was evaluated as the amount of variance accounted for (VAF) the description of the muscle patterns with weighing coefficients (WEC) and activation coefficients (ACC).

RESULTS: Four motor modules were sufficient to reconstruct BASES walking pattern with VAF=0.86±0.10, as well as the perturbed walking with VAF=0.86±0.18 (min 0.82, max 98). The modulation of BK perturbations showed no difference in relation to normal walking. For the other directions three out of four WECs of normal gait were maintained during the perturbed gait (similarity = 0.92±0.1) and only one module for each perturbation was changed. The different WEC for FW was related to load acceptance, whereas LF and RI showed different swing phase WECs. On the other hand, ACC were only similar in case of motor modules for load acceptance and propulsion. The inter-subjects analysis revealed high similarity among modules for both unperturbed and also perturbed walking (mean similarity=0.93, min =0.55, max=0.99), which indicated that both the normal walking strategies and those for recovering balance after perturbations were a consisted pattern throughout the tested subjects.

CONCLUSION: Perturbations elicited in different directions during walking showed a low dimensional modular organization, for which additional modules were not required in order to control the slipping leg. Rather the kinematic changes provoked by perturbations were compensated by muscular activations with a similar modular organization as normal walking with only one module influenced by the sensory input associated to the perturbation.

POBG_O3.8 HOW DOES RUNNING WITH REDUCED BODY WEIGHT ON A LOWER BODY POSITIVE PRESSURE TREADMILL AFFECT MUSCLE ACTIVATION PATTERN AND IMPACT ACCELERATION?

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INTRODUCTION: Ambulation with reduced body weight (BW) in a lower body positive pressure treadmill (LBPPT) allows training with reduced vertical ground reaction forces while the aerobic stimuli can be maintained (1). Therefore, running on the LBPPT constitutes a potential training tool for e.g. patients with knee osteoarthritis. However, it is not known to which extent the temporal muscle activation pattern are influenced by the reduced BW.

METHODS: Nine healthy males (age 60.9 yrs, BMI 29.8 kg/m2) ran (8 km/h) on the LBPPT (G-trainer, AlterG, USA) at 100, 80, 60, 40 and 20 %BW. EMG was recorded (sampling frequency 1000 Hz) from the left and right vastus lateralis, vastus medialis, biceps femoris and semitentinosus muscles. RMS filtered values (21 ms values moved in 1 ms steps) of pre-activity (50 ms before heel strike), braking phase and propulsion phase were calculated and expressed relative to %EMGmax. Vertical ground reaction force was measured and stance phases were identified. Peak ground reaction force was calculated. Acceleration (distal end of femur) was measured and impact acceleration along the longitudinal axis of femur was calculated. Data from 100 stride cycles were averaged.

RESULTS: Timing of EMG across the relative stride cycle was largely unaffected by BW reduction. However, for the extensor muscles pre-activation (e.g. VL: 20.7%EMGmax at 100%BW and 13.5%EMGmax at 20%BW) and activation in the braking phase (e.g. VL: 48.2%EMGmax at 100%BW and 20.9%EMGmax at 20%BW) decreased significantly with BW reduction, while extensor muscle activation in the propulsion phase only decreased to a minor degree (e.g. VL: 6.0%EMGmax at 100%BW and 4.3%EMGmax at 20%BWEMGmax). In contrast pre-activation for the knee flexor muscles did not change with BW reduction and during the stance phase knee flexor muscle activity increased significantly with BW reduction. Impact acceleration just after heel strike decreased from 0.628 m/s2xkg to 0.322 m/s2xkg and peak ground reaction force was reduced from 19.8 N/kgBW to 8.0 N/kgBW, when BW was reduced from 100%BW to 20%BW.

CONCLUSION: Body weight reduction with lower body positive pressure did not change the timing of the EMG activity across the relative stride cycle. However, the relative activation pattern between knee extensor and knee flexor muscles just before heel-strike and in the stance phase were highly influenced by the BW. Reduced impact acceleration indicated reduced joint impact load during running with reduced BW.

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POBG_O3.9 THE BIOMECHANICAL EFFECTS OF SHOE HEEL HEIGHT — THE JOINT MOMENT OF HIP EXTERNAL ROTATION

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INTRODUCTION: High-heeled shoes have become fashionable in recent years and are used by young girls and women. However, users are often unaware of the detrimental influence of high heels on knees, hips, and other joints. High heels reportedly pose several risks; for example, wearing them increases the risk of stair falls and traffic accidents.

AIM: In this study, we recorded data on the centre of pressure, centre of gravity, and joint moment of the lower limbs throughout the mid stance, from the time of heel contact to the completion of the walking cycle, and analyzed this data to clarify the effects of high heels.

METHODS:

Subjects: Eight healthy female students participated in this study. Their mean (standard deviation) age, height, and weight were 19.8 (1.2) years, 158.1 (4.5) cm, and 50.6 (4.3) kg, respectively. Before the measurements, the purpose and procedure of this study were explained in detail to all the subjects, and informed written consent was obtained from them.High heels: We used shoe heel heights that were representative of the various heel heights available in the market: 0, 30, 60 and 90 mm.

Materials: A VICON system was used to capture three-dimensional movements. The sampling frequency was 100 Hz. The system was equipped with six infrared cameras and four force plates, and 35 plug-in-gait markers were used for each subject. The VICON data were recorded throughout the mid stance of the walking subjects, from the time of heel contact to the completion of the walking cycle. Statistical analysis was conducted using one-factor ANOVA and Tukey–Kramer tests. Subjects wore shoes with different heel heights. Before the measurements, the subjects were allowed to practice walking with each shoe pair in order to achieve a comfortable gait.

RESULTS: There were significant differences among the joint moments of hip external rotation in the horizontal plane for different heel heights. The ANOVA test results indicated that the joint moment of hip external rotation significantly increases with the heel height. This observation was also corroborated by the Tukey–Kramer test results when the joint moments for 0 and 90 mm were compared.

CONCLUSION: Thus, it becomes necessary for the heel wearer to increase the joint moment of hip external rotation with an increase in heel height.

POBG_O3.10 LONG-TERM NEUROMUSCULAR ADAPTATIONS DURING WALKING POST-ACL RECONSTRUCTION

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INTRODUCTION: Individuals with anterior cruciate ligament (ACL) reconstruction are at increased risk to develop knee osteoarthritis (OA). Furthermore, neuromuscular impairments have been observed in persons with ACL reconstruction.

AIM: To compare the lower extremity neuromuscular strategies of 1) those with unilateral ACL reconstruction (>1yr post-surgery) to controls and 2) the injured to the non-injured leg during walking.

METHODS: Eleven individuals with ACL reconstruction (7 female/4 male; age 25±6yrs; BMI 23.5±3.9kg/m2; Tegner 7.1±1.6) and 16 healthy controls (10 female/6 male; 25±4yrs; BMI 25.05±2.7kg/m2; Tegner 6.1±1.0) are represented. Participants performed six walking trials at their self-selected pace and bilateral muscle activity was recorded during the stance phase. Electromyography (EMG) data were collected from the vastus lateralis [VL], vastus medialis [VM], biceps femoris [BF], semimembranosus [SM], and gluteus maximus [GMax]. Muscles were analyzed individually and combined based on function: knee extensors included VL and VM; knee flexors included BF and SM; hip extensors included GMax, BF and SM. EMG amplitudes for muscle groups were calculated using a weighted average based on the maximum isometric force of individual muscles. Co-contraction intensities were determined for knee flexors:extensors, lateral knee muscles, and medial knee muscles. Participants performed three isometric hip extensor, knee extensor and knee flexor contractions for EMG normalization. Group differences were statistically tested using ANOVA and injured versus non-injured leg differences were determined using paired student t-tests ($p<0.05$).

RESULTS: No differences in individual muscle EMG amplitudes were observed between the ACL reconstruction and the control group or between the injured and non-injured leg. For muscle groups, knee extensor EMG amplitude was significantly increased when comparing the injured to non-injured leg ($p = 0.041$). There were no significant differences in co-contraction intensities when comparing the injured to non-injured leg. However, increases in knee flexor:extensor co-contraction intensity ($p=0.035$) and lateral knee muscle co-contraction intensity ($p =0.010$) were observed in the ACL group as compared to controls.

CONCLUSION: Individuals post-ACL reconstruction displayed long-term changes in neuromuscular control during walking. The adaptations observed may act to control anterior tibial translation, prevent excessive ACL strain, and increase overall joint stability. Increased lateral knee muscle co-contraction may act to reduce medial knee compression, which is associated with knee OA. However, increases in knee flexor:extensor co-contraction likely increases joint compression and perhaps contributes to early knee OA onset.

ROBOTS IN REHABILITATION

ROBO_O1.1 EVALUATION FOR AN ASSISTIVE DEVICE USING A PNEUMATIC ACTUATOR

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INTRODUCTION: Sit-to-Stand movement (STS) is one of the most important movements in the activity of daily life. However there are some elderly people who cannot stand up satisfactorily, because of aging. These days a lot of assistive device (AD) has been developed for those people. When we develop an AD, we must know three important points: which muscle, when, and how strong does work. We also have to evaluate quantitatively how the STS differs with or without AD.

AIM: We propose the evaluation of AD based on IEMG and a joint angle.

METHODS: A subject stood up freely from his chair with or without an AD. The AD which we developed was using a pneumatic actuator. Tension caused by the expansion of the actuator to which we give a pressure. The vertical component force of the tension against a knee causes on the knee extension. We measured surface-EMG of Vastus Lateralis (VL), Hamstring (HA), Tibialis Anterior (TA) and Gastrocnemius (GA), a joint angle and a vertical floor reaction force (Fz) during STS. IEMG was calculated from the measured surface-EMG. In this study, the STS was separated to five phases by a hip joint angle and a knee joint angle, and was evaluated by IEMG and Fz of each phase.

RESULTS: VL IEMG decreased between phase 3 and phase 5. Also HA IEMG decreased in phase 4. But TA IEMG increased between phase 1 and phase 4, and GA IEMG increased in phase 5. We also found the difference of timing when the hip joint started to extend. In the case of STS without AD, the hip joint started to extend when the body weight moved to a base of support. On the other hand, in the case of STS with AD, the hip joint started to extend when about 50% of body weight moved to a base of support.

CONCLUSION: From the result of IEMG, it was indicated that the AD gave VL and HA an assistive effect, but gave TA and GA an inhibitive effect. From the relationship between the hip joint extension timing and the body weight movement, we could find the difference of STS strategy. It was supposed that the STS with AD seemed to be a momentum strategy, and without AD seemed to be a force control strategy.

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ROBO_O1.2 VALIDATION OF THE PERTURBERATOR ROBOT AND MODULATION OF ANKLE IMPEDANCE BY CO-CONTRACTION WHILE STANDING

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INTRODUCTION: Ankle impedance has been studied extensively during passive tasks but not during dynamic activities, such as walking. To provide natural, biomimetic control to recently developed robotic ankle prostheses, we must understand how ankle impedance is modulated during stance phase. To this end, we developed a robotic platform, termed the Perturberator, to perturb the ankle during walking.

AIM: In this study we validated the Perturberator using Trulife® Seattle Light prosthetic feet which have known stiffnesses. Additionally, investigated changes in ankle impedance caused by muscle co-contraction.

METHODS: The stiffnesses of two Seattle Light Feet were determined using an ISO standards prosthetic foot testing machine. Subsequently, an able-bodied subject wore both prosthetic feet under custom ankle-foot casts. The subject stood on the Perturberator and was perturbed 30 times using a 0.5° ramp with a time constant of approximately 30 ms. Data acquired included force platform data and ankle angle from a Delsys electrogoniometer. The impedance of the prosthetic feet in parallel was determined by least-squares systems identification techniques relating ankle angle to ankle torque. To investigate the effect of co-contraction on ankle impedance while standing, five subjects stood on the Perturberator and the same perturbation paradigm was used. Subjects were shown feedback of their tibialis anterior (TA) and soleus (SOL) muscle activity levels from surface EMG measured with a Delsys Bagnoli-16 amplifier and were randomly instructed to stand quietly or co-contract to 50-75% of their maximum voluntary contraction. Similarly, systems identification techniques were used to determine the impedance of the ankle with and without co-contraction.

RESULTS: When measured using the testing machine, the left and right prosthetic feet had stiffnesses of 16.6±0.06 and 18.8±0.6 Nm/° (parallel stiffness: 35.5±0.6 Nm/°). The parallel stiffness of the prosthetic feet estimated by the Perturberator was 38.5±4.0 Nm/°, a statistically significant ($p < 0.01$) difference of 9%. The average combined ankle stiffness of the subjects while quiet standing was 6.0 ±2.2 Nm/°. While co-contracting, subjects had a significantly greater ($p = 0.04$) average impedance of 11.2±3.9 Nm/°.

CONCLUSION: The stiffness component of impedance measured by the Perturberator was within 9% of independently measured prosthetic feet. This error is considered acceptable, and sources of error include the attachment to the casts and sway of the subject. Subjects could significantly alter their ankle impedance during standing by co-contracting their TA and SOL muscles. Additionally, this provides evidence that the Perturberator is capable of discriminating changes in impedance due to muscle activity.

ROBO_O1.3 EFFECT OF ARM POSITION FOR SIMULTANEOUS AND PROPORTIONAL MYOELECTRIC CONTROL: A COMPARISON BETWEEN AMPUTEE AND INTACT-LIMBED INDIVIDUALS

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INTRODUCTION: It has been shown that changes of arm position can affect the efficacy of myo-control for intact-limbed subjects. However, it is not clear if such an effect also applies to amputees.

AIM: The current study investigated if the change of arm position influences the efficacy of myo-control differently in intact-limbed (IL) and trans-radial amputee (TRA) individuals. The investigation was based on the simultaneous and proportional control with a bi-lateral mirror training paradigm.

METHODS: Three TRA and 5 IL subjects participated in the study. The subject was instructed to perform bi-lateral mirrored movements of the wrist, selectively activating 2 of the 3 degree-of-freedom (DOF) of the wrist: flexion/extension (DOF1), radial/ulnar deviation (DOF2), and pronation/supination (DOF3). The same movements were repeated with three arm positions: neutral position with the arms at the side of the body (POS1); with the elbows flexed and the upper arm vertical to the Sagittal plane (POS2); and with the arms fully extended forward (POS3). During the movements, HD-EMG was recorded from the amputated side (for TRA) or the dominant side (for IL), concurrently with wrist kinematics of the contra-lateral limb. The envelops of the EMG signals from one of the arm positions were used to train 3 MLP networks, each of which was used to estimate one joint angle at the one of the DOFs from the same arm position. The trained MLP was subsequently used to estimate the same joint angle at the other two arm positions. The accuracy of the estimation was measured using the multivariate r2 index. The statistical significances of Subject Type (ST) and Arm Position (AP) was investigated by 2-way ANOVA.

RESULTS: When the MLP was trained in one position and tested with unseen data from the same position, the performance was always better than when it was tested on data from a different position. When only the latter scenario was considered (implying arm position change) the factor ST was always significant ($p<0.05$ for all cases), while AP was never significant ($p>0.05$ for all cases).

CONCLUSION: The change in arm position did have an effect on the efficacy of myo-control in the simultaneous and proportional paradigm, for both TRA and IL. However, such an effect was shown to be less pronounced in TRA than in IL, indicated by a significant smaller decrease in r2 in TRA than in IL.

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ROBO_O1.4 EFFECTS OF A NEW ROBOT-ASSISTED GAIT DEVICE ON ELECTROMYOGRAPHIC PARAMETERS DURING FLOOR WALKING IN INDIVIDUALS AFTER A STROKE

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INTRODUCTION: The success of gait rehabilitation after stroke depends on active walking exercises. However, the motor impairments of hemiplegia often make such effective exercises impossible. To facilitate gait training for patients after stroke, many robot-assisted gait devise have been developed. “Rhythm assist system (RAS: Honda R & D Co. Ltd, Japan)” is an automated stride assistance system which applied robotic engineering to controlling walk ratios (stride length/cadence) and adding supporting power to the thigh during walking. In our previous study, the RAS significantly improved swing phase asymmetry ratio which is related to gait speed in individuals after stroke. However, the change of a muscle activities and co-activation pattern during walking by using RAS was still unclear.

AIM: To identify the effects of the RAS on ankle muscle activities and co-activation during walking in individuals after stroke.

METHODS: Twenty five individuals (13 male, 11 female, mean age: 58.3 years, range: 38 - 91) with hemiplegia after stroke were participated in this study. The RAS assists both flexion and extension of the hip joints in a ballistic manner by means of electrical actuators. All participants walked twice on a 5-m walkway at a self-selected comfortable speed with RAS. Electromyography (EMG) was used to assess gait with the RAS. In this study, the EMG measurements during gait were performed in four conditions depending on the intensity of assisting torque (0, 1, 2 and 3Nm). Five to ten gait cycles were used to determine the EMG parameters. EMG signals were bilaterally obtained from the tibialis anterior (TA), gastrocnemius (GAS) and soleus (SOL) muscles. EMG amplitudes were normalized using that of maximal isometric voluntary contractions and were expressed as percentage of MVC. Mean amplitudes during gait cycle were used as the EMG parameter in all muscles. In addition, co-activation index (CCI) was calculated during gait cycle between TA and GAS or SOL. Two-way repeated measurement analysis of variance and multiple comparisons (Bonferroni) were used to determine the differences of EMG parameters among assisting conditions (0-3Nm) and side (affected and nonaffected) in all muscles.

RESULTS: Significant decrease of muscle activity among assisting conditions was shown in SOL ($p<0.05$) without significant interaction. The TA muscle activity and the CCI between TA and SOL showed significant interactions. In these parameters, significant decreases depending on the intensity of assisting torque were shown only on affected side ($p<0.05$).

CONCLUSION: The RAS can reduce the muscle activation and co-activation through improving efficient walking due to adding supporting power.

SENSORIMOTOR

SENS_O1.1 THE INTENSITY-DEPENDENT RELEASE OF TRIGGERED REACTIONS CONTRIBUTES TO MODULATION OF THE LONG-LATENCY STRETCH REFLEX

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INTRODUCTION: The long-latency stretch reflex (LLR) is adaptable like voluntary movements, yet occurs at reflex latencies. It contains at least two components that can modulate in a task-appropriate manner: one opposing muscle stretch and another associated with rapid release of planned movements. The component of the LLR related to rapid release of planned movements has been described as a "triggered reaction," which should remain invariant with respect to perturbation amplitude. However, it was recently shown that this component can scale with perturbation intensity, arguing against triggered reactions, and the proposed mechanisms for their release. A possible explanation for resolving the existence of triggered reactions with the observed amplitude scaling is that the probability of releasing a triggered reaction varies with perturbation intensity, as is the case for auditory-triggered reactions.

AIM: Our objective was to evaluate two hypotheses regarding the amplitude scaling of the LLR: 1) amplitude scaling arises from a feedback response to the imposed muscle stretch; and 2) amplitude scaling arises from an intensity-dependent probability of releasing a triggered reaction, appearing as amplitude scaling when multiple responses are averaged.

METHODS: Data were collected from 8 subjects instructed to make ballistic elbow extension movements. Flexion perturbations ranging from 0.5-120°/s were applied with the cue to initiate movement. Activation of the sternocleidomastoid (SCM) neck muscles was used to indicate the presence of a startle-like response, which we have shown corresponds to the release of a triggered reaction. Ten repetitions were collected for each perturbation, presented in a block-randomized order. LLRs from the lateral head of the triceps were quantified as the average EMG amplitude between 75-105 ms after the perturbation.

RESULTS: The probability of releasing a triggered reaction increased with perturbation intensity. LLR amplitude was larger for reflexes elicited in the presence of a SCM activity for all perturbation velocities. These results accounted for most of the amplitude scaling observed when considering average responses. However, there was still a small but significant scaling of the LLR when considering trials without SCM activity. This is likely attributed to the known amplitude dependence of the LLR elicited in the absence of a planned movement.

CONCLUSION: In support of both hypotheses, scaling of the LLR with perturbation intensity appears to result from an intensity-dependent probability of releasing a triggered reaction when a motor action has been planned, and a smaller intensity-dependent feedback response to the perturbation.

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SENS_O1.2 DOES SENSORY DEAFFERENTATION IMPROVE HAND DEXTERITY? INTERACTIONS BETWEEN SOMATOSENSORY AND MOTOR CORTICES FOLLOWING TEMPORARY DEAFFERENTATION.

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INTRODUCTION: Cortical inhibitory systems play an important role in motor function. The motor cortex can be inhibited by peripheral sensory inputs and by intracortical mechanisms. Recent studies in stroke patients (with impaired hand function) have proposed that pharmacologically induced temporary functional deafferentation (TFD) of the forearm might result in beneficial effects on the somatosensory sensibility and motor capacity of the stroke-affected hand.

AIM: In this study we examined whether cortical inhibition from peripheral sensory input is altered by TFD and how this affects the excitability of cortical inhibitory circuits and MEP amplitudes.

METHODS: Healthy right-handed subjects, aged 18 to 55 years, participated in this double-blind, randomised study across two separate sessions. During one session they received a topical anaesthesia cream (EMLA) applied to their left forearm, during the other session they received a placebo (aqueous cream). Behavioural measures of sensory and motor functions, administered to the non-dominant hand before and after TFD, included the Von-Frey Hair Test (VFHT), Grooved Orientation Task (GOT), and four post-treatment repeats of the Grooved Pegboard Task (GPT). Two types of intracortical inhibition were assessed by paired-pulse transcranial magnetic stimulation (TMS). Short-interval intracortical inhibition (SICI) was determined with a subthreshold conditioning stimulus (CS) followed by a test stimulus 2 ms later. Cortical inhibition from peripheral sensory input was induced by stimulation of index finger digital nerves of the left hand and followed 25 ms later by a suprathreshold TMS pulse over the right motor cortex.

RESULTS: In those participants with confirmed anaesthesia of the forearm, we observed an increase in Von-Frey sensitivity at the site of biceps brachii. Time to complete the grooved pegboard task decreased over four repeat measures, and the rate of this observed decrease was significantly greater for the TFD sessions. In the TMS measures, we observed an increase in short-interval intracortical inhibition in the TFD sessions, but no change in cortical inhibition from peripheral nerve stimulation.

CONCLUSION: In this study of the effect of TFD we observed an increase in hand dexterity as measured by the grooved pegboard task. This is consistent with previous studies in which changes in peripheral feed-back have been shown to influence motor cortical excitability. The results from our TMS measures suggest that the neural circuits involved in SICI are sensitive to afferent inputs, but that topical anaesthesia, at a site proximal to nerve stimulation, has no significant effect on short latency afferent inhibition.

SENS_O1.3 ADAPTATION TO NOVEL VIRTUAL AND REAL BIOMECHANICS CHALLENGES OPTIMAL FEEDBACK CONTROL

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Prof Gerald Loeb, University of Southern California; Dr Timothy Carroll

INTRODUCTION: Computational models based on the principles of optimal control accurately predict the relative activation of muscles during goal directed actions in redundant systems such as the wrist.

AIM: It is unclear, however, whether the central nervous system (CNS) achieves behaviour that appears to be optimal through online, top-down optimisation, or because the architecture of distributed sensorimotor networks has evolved to favour near-optimal behaviour. To resolve this issue, we exposed human subjects to a range of real and virtual modifications of their biomechanics.

METHODS: We developed a technique based on the empirical determination of the “pulling vectors” of the five major wrist muscles, which enabled online reconstruction of wrist force from EMG recordings. In 4 experiments, we modified muscle pulling vectors, either virtually or actually, while subjects were reaching for targets in various directions with a cursor representing either the reconstructed force or the real force.

RESULTS: In exp 1 (n=6), an extensor muscle was virtually cut, such that activation of the muscle had no effect on the cursor. An optimisation of muscle effort predicts a reduction in the activity of that muscle, but we observed instead a massive increase which scaled with the required increase of its neighbour muscles. In exp 2 (n=6), the signal-dependant noise associated with activation of one muscle was virtually amplified to increase cursor variability towards targets normally requiring that muscle. An optimisation of motor variability predicts a reduction in the activity of that muscle, but we did not observed any change in the pattern of muscle activity. In exp 3 (n=7), the force generating capacity of a single muscle was reduced by muscle damage. Results were similar to exp 1, despite congruent sensory information in this condition of an actual reduction in muscle force. When asked to control a simulation whose muscle pulling actions represented a posture different from their actual posture in exp 4 (n=5), subjects persisted in using the coordination patterns associated with their actual posture.

CONCLUSION: Solutions to muscle redundancy are not continuously optimized for biomechanical changes. Subjects used previously learned muscle activity patterns even when they already had better strategies in their repertoire. Results from exp 4 suggest a hierarchical control scheme in which muscle activity is partly determined by low-level regulatory functions shaped by sensory feedback from the current posture.

SENS_O1.4 NEW VISUOMOTOR MAPPINGS ARE ENCODED IN DIFFERENT COORDINATE FRAMES FOR PERTURBATIONS OF GAIN AND ROTATION

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Dr Timothy Carroll, The University of Queensland; Dr Aymar de Rugy, The University of Queensland

INTRODUCTION: The nervous system has the ability to adapt to novel environments that pose a discordance between motor commands and perceived movement outcomes. For example, when exposed to a novel visuomotor gain or rotated visual feedback, a new sensorimotor mapping is acquired to restore movement accuracy. Previous work suggests different neural substrates for adaptation to these two types of perturbation, with broad generalization to untrained areas of the workspace for gain and narrow generalization for rotation. However, it is not clear whether adaptation to these two perturbations operate in the same or different coordinate frames.

AIM: Here we investigated the coordinate frames of adaptation to altered visuomotor gain and rotation by training on an isometric wrist force aiming task in one arm posture, and testing for generalization in a different posture. A pattern of perturbation comprising opposite orientations for different areas of the workspace allowed the intrinsic (muscle) coordinates of the perturbation to be set in direct conflict, or in accordance, with the extrinsic (visual) coordinates, depending on the posture adopted during generalisation testing.

METHODS: Experiment 1 examined adaptation to visuomotor gain (1.2 and 0.8 times baseline) or rotation (±30˚) with the right forearm in a pronated position and generalization was assessed with the forearm rotated by 90˚ clockwise (i.e. in a neutral position). Due to the pattern of perturbation used (i.e. opposite orientations separated by 90 degrees), this posture shift caused the orientation of the perturbation to conflict in extrinsic versus intrinsic coordinates. In experiment 2, subjects adapted to visuomotor gain in a supinated position and generalisation was assessed in a pronated position such that the perturbation was aligned in intrinsic and extrinsic coordinates.

RESULTS: In experiment 1, there was strong generalisation of visuomotor rotation to the untrained posture according to an extrinsic frame of reference. By contrast, for visuomotor gain there was significantly less adaptation to the untrained hand posture. Experiment 2 revealed that the adaptation to gain fully generalized to an untrained posture when the two coordinate frames were aligned.

CONCLUSION: These results indicate that adaptation of visuomotor rotation is represented in an extrinsic reference frame. In comparison, the fact that a change in posture resulted in weak generalisation for a gain perturbation only when the perturbation conflicted in intrinsic and extrinsic coordinates suggests that adaptation to visuomotor gain involves encoding in both intrinsic and extrinsic coordinate frames.

SENS_O2.1 THE EFFECTS OF NECK MUSCLE FATIGUE ON THE CERVICAL FLEXION RELAXATION RESPONSE AND ON CERVICAL JOINT POSITION SENSE

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INTRODUCTION: Previous research of the flexion relaxation Ratio (FRR) in the low back has postulated that muscles during a state of fatigue are unable to provide sufficient stability of the spine, and fatigue is also know to impair lumbar spine proprioception, but little work has been done in the cervical spine.

AIM: The first aim of the study was to determine whether neck muscular fatigue affects upper limp joint position sense (JPS), specifically, accuracy of angle recreation at the elbow joint. The second aim was to determine if muscular fatigue alters the timing of the phases of the cervical FRR, in particular, the onset and cessation of the myoelectric silence during a FRR task.

METHODS: 9 healthy subjects participated in the FRR study examining altered timing of FRR phases. This study consisted of 3 cervical neck FRR tasks under 2 different conditions: neutral head position no fatigue, and fatigued. Fatigue was induced by a 30 second maximal isometric contraction resisting against a wall mounted force transducer. Cervical neck flexion angle was monitored throughout FRR task. The cervical neck flexion angle corresponding to the onset and cessation of myoelectrical silence was compared using a repeated measures ANOVA. 17 healthy subjects participated in the JPS study consisting of two conditions: neutral head position no fatigue, and fatigued. Fatigue was induced by the same method as above. Constant error (CE), variable error (VE), and absolute error (AE) were used to determine the accuracy of movements.

RESULTS: A significant effect of muscular fatigue was found for both FRR onset and cessation angle changes ($P=0.035$) ($P=.004$), respectively. There were no significant changes in CE, VE, AE between neutral JPS and neutral fatigued JPS.

CONCLUSION: This study suggests that muscular fatigue is a modulator of the FRR which may play a large role in the insufficient stabilizing of the spine and surrounding structures when injured or fatigued.

SENS_O2.2 LOWER LIMB CORTICAL EXCITABILITY CHANGES AND ALTERATIONS TO EARLY BEREITSCHAFTS POTENTIAL FOLLOWING SPINAL MANIPULATION

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INTRODUCTION: Previous studies have shown neuroplastic changes to corticospinal excitability following spinal manipulation. The level(s) of the central nervous system where these changes take place are not yet clear.

AIM: This study sought to explore whether such neuroplastic changes in motor control observed following spinal manipulation at least in part occur at the cortical level.

METHODS: 16 subjects (23.25±2.56 yrs., 10 male and 6 females) participated in a two group, cross study design (8 in each group). In one group motor evoked potentials (MEPs) were recorded from the right tibialis anterior (TA) following single pulse TMS before and after a spinal manipulation intervention. Recruitment curves were compiled from the averages of ten MEP amplitudes recorded at each of five different stimulus intensities (90%, 100%, 110%, 120% and 130% of rest threshold;RTh). To investigate the effect of spinal manipulation on the amplitude of the MEPs a two-way repeated measures ANOVA with factors time (pre vs post), and stimulus intensity (90%, 100%, 110%, 120% and 130% RTh) was carried out. To assess for changes in parameters of the recruitment curve the maximum value or plateau (MEPmax), the stimulus intensity required to obtain a 50% response (S50) and the slope parameter k of the Boltzmann fitted data were assessed with paired t-tests. In another group movement related cortical potential (MRCP) were recorded for morphological analysis prior to and following a spinal manipulation intervention. The amplitude of the early bereitschafts potential (BP), the amplitude of the late BP, latency of peak negativity with respect to onset of task and rebound rate of movement monitoring potential were analyzed with paired t-tests. Participants were randomly allocated to groups.

RESULTS: The analysis of the MEP amplitudes revealed a significant effect for factors time ($F=7.88$, $p=0.006$) and intensities ($F=17.8$, $p<0.0001$). Paired t-tests revealed that TA MEPmax increased significantly by 53±46% ($P=0.012$). No changes were observed in the S50variable or the slope parameter k of the Boltzmann fitted data. Morphological analysis of the individual components of the MRCP showed significant 73±56% increase in amplitude of the early BP ($P<0.05$). No significant changes were observed for any of the other measures.

CONCLUSION: These preliminary results suggest that spinal manipulation has lead to neuroplastic changes that at least in part occur at the cortical level, as the amplitude of early BP is known to reflect processing in supplementary motor cortex (SMA).

SENS_O2.3 THE INFLUENCE OF CORTICOSPINAL AND RETICULOSPINAL INNERVATION ON STARTLE EVOKED MOVEMENT OF THE HAND

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INTRODUCTION: A startling acoustic stimulus involuntarily releases planned ballistic movements, referred to as startReact. StartReact movements are readily elicited at the wrist and elbow. Recent evidence indicates that distal musculature of the hand, specifically the first dorsal interosseous (FDI) muscle, is not susceptible to startReact (Carlsen 09). As startReact is mediated through the reticulospinal tract, the lack of startReact in FDI was explained by relatively few reticulospinal projections to this muscle. Still, reticulospinal projections exist in the hand but recent work suggests these projections mediate different tasks than the corticospinal tract (Baker 07).

AIM: Therefore, we hypothesize that startReact will be present in FDI during tasks shown to be mediated by the reticulospinal tract (e.g. grasp). This would indicate that the ability to elicit startReact is pathway dependent and not related to a proximal-distal gradient.

METHODS: Data were collected in 5 subjects performing two finger tasks. The first was index finger abduction – identical to that performed in Carlsen 09. The second was a grasp task. Electromyography was recorded in the FDI muscle - activated during both tasks. Subjects performed each of these tasks following two non-startling acoustic stimuli of 80dB. The first sound represented “get ready,” the second represented “go.” Randomly, the second “go” was replaced with a startling acoustic stimulus of 128dB. Sternocleidomastoid (SCM) activation indicated a startle occurred. Trials were split into SCM+ (startle) and SCM- (no startle) and the latency of muscle activity in the FDI quantified. If our hypothesis is supported, there will be minimal difference between SCM+ and – trials during finger abduction (confirming Carlsen 09) but significant difference between SCM+ and – trials during grasp.

RESULTS: We found results that supported our hypothesis. The average SCM+ and – latencies across subjects during finger abduction were 108 and 112ms respectively. The same latencies during grasp were 101 and 120ms. This result was consistent across subjects with all subjects showing a two-fold increase in difference between SCM+ and – latencies during grasp as opposed to finger abduction task.

CONCLUSION: These results suggest that movements mediated through reticulospinal projections can be elicited even in the distal musculature of the hand. This is potentially significant for rehabilitation as we have shown startReact movements following stroke to be similar to unimpaired movements suggesting that therapies that utilize alternative methods for movement execution, like startReact, may be appropriate therapeutic targets.

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SENS_O2.4 THE ROLE OF QUARICEPS, TRICEPS SURAE AND TIBIALIS ANTERIOR MUSCLE SPINDLES IN POSTURAL CONTROL IN INDIVIDUALS WITH KNEE OSTEOARTHRITIS

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INTRODUCTION: Knee osteoarthritis (OA) is a painful musculoskeletal condition of uncertain aetiology. Proprioceptive impairments are often reported amongst the broad neuromotor symptoms of knee OA. Although evidence of proprioceptive impairments associated with knee OA is somewhat equivocal, many studies indicate impaired proprioceptive acuity at the knee and at other joints in individuals with knee OA. However, there has been little investigation of the underlying causes of the proprioceptive impairments. Muscle spindle activity provides one of the most important contributions to perception of joint position and movement, and the central processing of muscle spindle afferent input is integral to optimal proprioception. Muscle spindle function may be compromised in individuals with knee OA given issues such as changes to quadriceps muscle mass. It is possible to probe muscle spindle function in OA by evaluating the effect of perturbing their function. Vibration (60 Hz) over muscle provides a potent perturbation and generates illusions of movement. Assessing the postural response to muscle spindle perturbation during quiet standing provides an indication of muscle spindle function.

AIM: This study aimed to investigate whether muscle spindle function in the quadriceps, triceps surae and tibialis anterior muscle spindle is altered in individuals with knee OA.

METHODS: Thirty individuals with moderate/severe right knee OA and thirty healthy asymptomatic controls (HC) participated. Participants stood comfortably and blindfolded on a force plate (sampled at 120Hz) for 45s. Each trial included three 15s epochs: Baseline, Vibration and Recovery. Mechanical vibration (60Hz) was applied bilaterally over the quadriceps, triceps surae or tibialis anterior muscles, in randomised order, throughout the 15s Vibration epoch. There were two consecutive runs for each muscle. Mean displacement (normalised to the Baseline epoch) of CoP in the sagittal (AP) plane was analysed for each second of of each run. Three separate RM-ANOVAs (Group x Time x Run) were conducted to determine if there were differences between the groups and between the runs in displacement of CoP.

RESULTS: There was a significant Group x Time x Run interaction for the triceps surae muscles $p = 0.03$ and no significant interaction or main effects for the quadriceps or the tibialis anterior. Examination of the triceps surae data revealed during Run 1 both groups had a larger and sustained response to vibration while in Run 2 there was an attenuation of the response to vibration that was more pronounced in the HC than the OA group.

CONCLUSION: Individuals with knee OA have less adaptation in the displacement of their centre of pressure in response to repeated perturbation of the tricep surae muscle spindles than healthy controls. Our findings suggest proprioceptive impairments associated with knee OA may be mediated by deficits in muscle spindle function.

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SENS_O3.1 NEURAOPLASTIC CHANGES IN UPPER LIMB CORTICAL EXCITABILITY FOLLOWING SPINAL MANIPULATION

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INTRODUCTION: Utilizing specific transcranial magnetic stimulation (TMS) protocols prior to and after spinal manipulation, alterations in the activity within specific intracortical facilitatory and intracortical inhibitory pathways have been observed to an upper limb muscle (abductor pollicis brevis; APB).

AIM: This study sought to investigate whether the previously shown motor control changes could be due to alterations in recruitment patterns of the APB motor neuron pool following spinal manipulation.

METHODS: Motor evoked potentials (MEPs) were recorded from APB of the dominant limb following single pulse TMS of the contra-lateral motor cortex in eight subjects (24.12±2.85 yrs, 4 male and 4 females) before and after either a spinal manipulation intervention or a control intervention. Recruitment curves were compiled from the averages of ten MEP amplitudes recorded at each of five different stimulus intensities (90%, 100%, 110%, 120% and 130% of rest threshold). To investigate the effect of spinal manipulation on the amplitude of the MEPs a two-way repeated measures ANOVA with factors time (pre vs post), and stimulus intensity (90%, 100%, 110%, 120% and 130% RTh) was carried out separately for the manipulation and control intervention data. To assess for changes in parameters of the recruitment curve the maximum value or plateau (MEPmax), the stimulus intensity required to obtain a 50% response (S50) and the slope parameter k of the Boltzmann-fitted data were assessed with paired t-tests. To assess spinal excitability changes F wave persistence and amplitudes were recorded following median nerve stimulation at the wrist.

RESULTS: The analysis of the spinal manipulation data revealed a significant effect for the MEP amplitudes for factors time ($F=9.88$, $p=0.0024$) and intensities ($F=18.13$, $p<0.0001$). Paired t-tests revealed that MEPmax following spinal manipulation had increased significantly by 89±95% ($P=0.012$). The S50-variable and the slope parameter k of the Boltzmann-fitted data remained unchanged. No changes were observed following the control intervention. No changes in F-wave parameters were observed for either intervention.

CONCLUSION: The preliminary results of this study add to the growing body of evidence that suggests spinal manipulation leads to neuroplastic changes in cortical excitability of upper limb muscles. As MEPmax reflects the plateau of the recruitment curve, which is thought to represent the balance of complex excitatory and inhibitory components of the corticospinal volley, the preliminary results support previous research showing changes in intracortical excitatory and inhibitory pathways following spinal manipulation.

SENS_O3.2 THREE-DIMENSIONAL ANALYSIS OF SMALL MUSCLE VIBRATIONS DURING VOLUNTARY ISOMETRIC CONTRACTION

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INTRODUCTION: The motion of skeletal muscles during voluntary contractions is naturally three-dimensional (3D) due to muscle architecture. However common techniques for recording small muscle vibrations during contractions, known as mechanomyogram (MMG), only measure a single component of the muscle motion.

AIM: The purpose of the study was to investigate the frequency dependence of the 3D features of MMG of the biceps brachii during voluntary isometric contraction.

METHODS: MMGs were recorded with 5 skin-mounted miniature 3D accelerometers aligned along the biceps axis of 15 healthy young men. Each subject was situated laying on his back with the right arm attached to the dynamometer at the wrist. The elbow was flexed at 90 degrees, and the wrist was oriented in the neutral position. The right upper arm was placed horizontally with its posterior part not touching the bed surface. Subjects performed voluntary isometric contraction at 20%, 40% and 60% of their maximum contraction force (MVC) for 10 seconds. Mean power frequency and power spectral density was computed for all 3 acceleration components. The variations of the 3D angular orientation of the acceleration vector (in spherical coordinates) were computed across frequencies. The data were averaged across sensor locations.

RESULTS: The mean power frequency in the vertical direction (28.0 ± 5.1 Hz) was significantly ($P < 0.01$) greater compared with the longitudinal (20.5 ± 2.7 Hz) and transverse direction (21.5 ± 2.8 Hz) across contraction levels. The angle of vibration was not influenced by contraction level in horizontal or vertical plane. The horizontal angle was 42.3 ± 6.4 deg and 36.2 ± 5.0 deg ($P < 0.01$) from the transverse direction of the muscle at low and high frequencies relative to the mean power frequency, respectively, across contraction levels. The vertical angle of vibration was 21.3 ± 2.7 deg and 48.9 ± 4.8 deg ($P < 0.01$) from the horizontal plane at low and high frequencies, respectively.

CONCLUSION: The 3D analysis of MMG revealed the differences in the vibration angle of the biceps brachii during voluntary isometric contraction. These frequency-dependent differences in vibration angle may reflect the synchronous muscle activity (tremor or whole limb motion) at lower frequencies and asynchronous muscle activity at higher frequencies.

SENS_O3.3 INVESTIGATION OF SENSORIMOTOR REFERENCE FRAMES FOR ADAPTATION TO A NON-LINEAR VISUOMOTOR ROTATION

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Dr Aymar De Rugy, School of Human Movement Studies, University of Queensland; Dr Timothy Carroll, School of Human Movement Studies, University of Queensland

INTRODUCTION: If visual feedback is distorted during goal-orientated movement, the performer is required to readjust their motor output to the demands of the novel visual-motor ('visuomotor') conditions. This recalibration has been demonstrated to occur predominantly in extrinsic spatial coordinates, as the generalisation of prior learning proceeds towards the spatial targets that were encountered in training even with the use of muscles that were not trained. However, when a dynamic disturbance is encountered that alters the association and mapping between force and directional motion, adaptation seems to proceed through an intrinsic reference frame; potentially demonstrating that this type of learning and generalisation requires an alteration in neural associations at a more‘motor' stage of the sensorimotor transformation.

AIM: In this study, subjects adapted to a non-linear visuomotor perturbation that required altered muscle activation for a given cursor trajectory to re-assess whether aspects of visuomotor adaptation are coded in an intrinsic reference frame.

METHODS: Subjects (n=22) adapted to an anti-clockwise visual rotation, which was either abrupt (n=8) or gradual (n=8) in onset, or performed movements with undistorted visual feedback as a control (n=6). The task was to reach a virtual visual target through the application of isometric wrist force. The magnitude of the perturbation was proportional to the instantaneous resultant force, resulting in a curved cursor trajectory for a linear force trajectory. Following adaptation, the subjects’ performing forearm was rotated by 90deg and generalisation was assessed in the new posture to targets that represented the prior training direction in both extrinsic and muscle space.

RESULTS: Subjects adapted to the perturbation by making curved movements, for both abrupt ($p<0.01$) and gradual ($p<0.01$) rotation conditions. Significant ($p<0.01$) generalisation was found towards the adapted target defined in extrinsic, but not muscle space.

CONCLUSION: Visuomotor adaptation occurs predominantly in an extrinsic coordinate frame, even when altered muscle activation is required for a given movement trajectory.

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SENS_O3.4 THE ACUTE EFFECT OF WHOLE BODY VIBRATION EXERCISE ON THE SOLEUS SENSORIMOTOR PATHWAY

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INTRODUCTION: Whole body vibration (WBV) has become an increasingly popular exercise modality, particularly in the elderly. In an earlier study we identified that 10-min of WBV, of two different forms, resulted in an acute reduction in standing balance performance in healthy, middle-aged, women. Mechanisms leading to their poorer balance were, however, not investigated at the time, although vertical vibration resulted in worse balance performance than rocking vibration.

AIM: To examine the acute effect of two types of WBV on the responsiveness of the soleus Ia-afferent pathway.

METHODS: Twenty young, healthy subjects were exposed to 10-mins of either vertical or pivotal WBV while standing. Pre and post WBV measurements of soleus Ia-afferent pathway responsiveness were made via an electrically elicited Hoffmann reflex (H-reflex). All measurements were made while standing supported, to eliminate changes in soleus motoneurone pool excitability via postural sway. Direct muscle responses (M-waves) of soleus and background muscle activity (EMG) of soleus and other lower limb muscles were also measured.

RESULTS: Both forms of WBV exposure resulted in a significant decrease in the maximum soleus H-reflex (Hmax). When Hmax was normalised to the maximum M-wave (Mmax), Hmax:Mmax was reduced by 25.6% and 15.6% following vertical and pivotal vibration, respectively. There was no significant WBV effect on soleus Mmax or any other lower limb EMG measure.

CONCLUSION: The reduction in soleus Hmax:Mmax post WBV is indicative of a reduction in the efficacy of the Ia-afferent pathway. The reduction is most likely due to pre-synaptic inhibition at the Ia-terminals via pad-interneurones, although homosynaptic post activation depression may also contribute to the depression. Vertical vibration, compared to pivotal vibration, appears to produce the largest reflex depression and has the greatest negative effect on balance. The reduction in soleus Ia-afferent responsiveness may help explain the previously observed decrement in balance performance in middle-aged women after WBV. Care should be taken in prescribing WBV exercise in the elderly and patients with balance impairments.

SPINE

SPIN_O1.1 ATTENTIONAL FOCUS INFLUENCES SPACE-BACED SPINAL REPOSITION PERFORMANCE: IMPLICATIONS FOR THE ROLE OF POSTURAL CONTROL

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INTRODUCTION: There is conflicting evidence within the literature if individuals with low back pain (LBP) have poor spinal proprioception. A common method to assess spinal joint position sense (JPS) is having participants replicate a target spinal position. One factor contributing to the conflicting literature may be the negligence of cognitive variables in spinal reposition performance. One cognitive variable that may be important to reposition performance is an individual's focus of attention. An internal focus (i.e., focus of body regions) reduces motor task accuracy and postural control compared to an external focus (i.e., focus on movement intent). Secondly, existing studies have assessed reposition performance using either a space-based or a body-centered frame of reference to measure reposition performance. The latter precludes the contribution of postural control which may influence reposition performance.

AIM: To elucidate the role of different attentional focus on spinal reposition performance using a space-based frame of reference.

METHODS: A block randomised repeated measures study was conducted with 17 controls and 17 LBP participants. Spinal position sense was assessed using 7 “target – matching" pairs of trials over 1 external (auditory cue), 2 internal (sensory stimulus to the back and leg) focus of attention, and 1 control (self-paced) conditions.

RESULTS: An internal focus to the leg resulted in poorer accuracy compared to an external focus (P = 0.014) and control conditions (P = 0.032). The control condition resulted in greater precision compared to an external focus (P = 0.008) and internal focus to the back (P = 0.001).

CONCLUSION: The focus of attention had a significant impact on space-based reposition accuracy and precision. In contrast, from our previous findings, we did not find a significant impact of attentional focus on body-centred reposition performance. This suggests that any effect of different attentional focus on spinal reposition performance may lie in postural control. When adopting an internal or external focus, there may be an increased in neuromuscular co-contraction, in an attempt to increase postural control. This may have resulted in greater "noise" within the motor control system accounting for worsening of space-based spinal reposition precision.

Reposition performance may be due to a combination of spinal JPS and postural control. When interpreting current research on spinal proprioception, there needs to be a consideration as to whether a body-centred or a space-based centred frame of reference was used.

SPIN_O1.2 ALTERED ACTIVITY OF THE EXTENSOR MUSCLES IN CHRONIC MECHANICAL NECK PAIN

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Dr Barbara Cagnie; Mr Ashton Reeve; Prof Gwendolen Jull; Prof James Elliott

INTRODUCTION: Impairment in muscle function is a feature of chronic mechanical neck pain (MNP). While many studies have investigated the function of the cervical flexor muscles in neck disorders, in comparison, the extensor muscles of the neck have not been comprehensively evaluated.

AIM: To compare the pattern of neck extensor muscle use in participants with MNP to that of healthy controls during two different extension exercises by use of muscle functional magnetic resonance imaging (mfMRI).

METHODS: Data recorded from 12 subjects with chronic MNP (10 women, 2 men) were compared to that from 11 healthy subjects (7 men, 4 women). mfMRI measures of shifts in T2-relaxation were made for the multifidus/semispinalis cervicis, semispinalis capitis and splenius capitis muscles, at the C2-3, C5-6 and C7-T1 levels, prior to and immediately following two different exercises; cervical extension in cranio-cervical neutral and cervical extension in cranio-cervical extension. T2 shift values (difference between pre and post exercise T2-relaxation values) for each muscle and exercise condition were used for analysis.

RESULTS: For the splenius capitus muscle there was a significant main effect for group at the C7-T1 level ($p=0.03$) but not for the C2-3 or C5-6 levels ($p>0.08$). Tests of simple effects revealed that the MNP group had significantly lower splenius capitus muscle T2 shift values than the healthy controls at the C7-T1 level ($p=0.03$) in response to the cervical extension in cranio-cervical neutral exercise. For the multifidus/semispinalis cervicis muscles there was no significant main effect for group ($p>0.11$) although the group x exercise interaction approached significance ($p>0.08$). Tests of simple effects demonstrated that T2 shift values for multifidus/semispinalis cervicis were significantly lower for the MNP group at both the C5-C6 ($p=0.03$) and C7-T1 level ($p=0.04$) compared to the control group during the cervical extension in cranio-cervical neutral exercise.

CONCLUSION: Results of this study suggest that altered differential activation of the cervical extensor muscles may be a feature in some patients with MNP and should be considered in the clinical assessment of patients with these disorders.

SPIN_O1.3 OCCUPATIONAL LOW-BACK EXPOSURE AND DISC-RELATED DISEASES — BIOMECHANICAL ANALYSES ON CUMULATIVE LUMBAR LOAD WITHIN THE GERMAN SPINE STUDY 'EPILIFT'

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INTRODUCTION: With the political re-unification of the two parts of Germany in 1990, possibilities for workers compensation regarding severe diseases in the lower back through materials handling and awkward postures were discussed.

AIM: To enhance the scientific basis, a comprehensive multidisciplinary population-based case-control study, the so-called German Spine study 'EPILIFT' was conducted to analyse the hypothesised association between long-term physical work and the risk for developing degenerative lumbar-spine diseases.

METHODS: In 4 regions of Germany, in total 915 patients with lumbar-disc herniation or severe narrowing and 901 control subjects were prospectively recruited. In comprehensive interviews, trained occupational hygienists gathered external-load data such as postures, object masses, action frequency and duration and exposure periods. Subsequently, "situational lumbar load", indicated by peak lumbosacral compressive force, was determined for all relevant activities during the occupational life of 1,199 persons by 3-D dynamic biomechanical-model calculations. "Cumulative lumbar load" was summarized individually by applying several dose models comprising various properties like thresholds for disc compression, trunk inclination and shift dose.

RESULTS: In EPILIFT, positive dose-response relationships were found for symptomatic disc herniation and for disc-space narrowing, among males and females. Higher odds ratios in relation to controls were statistically verified for the majority of exposure categories, characterised by the occupationally induced lumbar-load total-lifespan dose. Further analyses focussed on the reasons for the increased lifetime doses of diseased subjects; this effect can neither be attributed solely to higher disc-compressive forces nor solely to longer durations of the performed handling-or-posture actions. However, the combination of both was verified statistically, i.e. the work profiles are signified by higher doses through, in mean, higher disc forces and longer task durations. Furthermore, on average, severe symptomatic disc-space narrowing was developed considerably later than disc herniation, and the level of working intensity like the dose per year codetermines the type of disease.

CONCLUSION: Statistically significant positive associations were identified between cumulative lumbar load and lumbar-disc herniation and narrowing, in men as well as in women.

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SPIN_O1.4 CONTROL OF TRUNK OBLIQUE MUSCLES IN CART PUSHING IS AFFECTED BY ANTICIPATION OF CHANGES IN TRUNK TWISTING MOMENTS

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INTRODUCTION: Specific anticipatory activation of trunk muscles has been observed in preparation of the trunk to perturbations based on prior knowledge of the forthcoming perturbation. This perturbation could be a voluntary arm movement or the lifting of a box with known inertial properties. In contrast, when the mechanics of a forthcoming perturbation are unknown, co-contraction of trunk muscles occurs. In cart pushing, perturbing moments on the trunk frequently occur in the transverse plane, i.e. twisting moments, which are actively modulated by the oblique abdominal muscles.

AIM: The present study was designed to study the effects of twisting moments on oblique abdominal muscle activity when performing expected and unexpected turns in cart pushing.

METHODS: Twelve healthy subjects were instructed to push a 200 kg cart with handles at shoulder height and hip height and to perform turns to the left into a 1 m wide path. Subjects performed a gradual turn, a sharp turn and an unexpected sharp turn initiated as fast as possible after an auditory cue. The normalized EMG amplitudes of left (right) external oblique and right (left) internal oblique muscles were averaged to represent left (right) rotator muscle activity. For studying the state of anticipatory activation, the average rotator muscle activity over 200 ms prior to the onset of a change in hand forces was compared to straight pushing (without turning). For studying effects of expectation, the peak values of twisting moment, twisting motion and EMG amplitudes of bilateral rotators after initiating a turn were determined.

RESULTS: Prior to making a turn, the baseline value of rotator muscle activity was only significantly higher in the expected gradual and sharp turn compared to straight pushing. The type of turn significantly affected the peak of the rotator muscle activity. After initiating a turn, clockwise twisting motion was associated with a clockwise twisting moment. In the unexpected sharp turn, the low muscle activity before the turn in combination with high but late muscle activity after the turn reflected that an uncontrolled trunk twisting motion occurred, due to the moment caused by the interaction with the cart.

CONCLUSION: Anticipatory activation was initially absent when preforming an unexpected turn, while bilateral trunk rotator muscle activity increased after the turn, indicating co-contraction in response to the unexpected perturbation. When unexpectedly having to change the direction of a cart, an uncontrolled twisting motion with delayed muscle activation may put the lumbar spine at risk of injury.

SPIN_O1.5 ASSESSMENT OF SYMMETRY IN KINETIC AND KINEMATIC PARAMETERS IN ASYMPTOMATIC SUBJECTS AND PATIENTS WITH LBP DURING SIT-TO-STAND AND STAND-TO-SIT

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INTRODUCTION: Low back pain (LBP) is a major public health issue throughout the entire world, generating major societal and economic burdens, and it has been the focus of extensive research. Nevertheless, while many studies have examined gait in both LBP and asymptomatic (AS) subjects, evaluations of other everyday activities such as sit-to-stand (SitTS) and stand-to-sit (StandTS) are limited, particularly among AS subjects.

AIM: Determine if differences in biomechanical symmetry exist between LBP patients and asymptomatic subjects while performing common daily living activities such as SitTS and StandTS.

METHODS: 11 patients with LBP (63.1+/-7.3 years) and 35 AS subjects (23.0+/-2.9 years) performed 30 sec SitTS and StandTS trials. Five biomechanical variables measured bilaterally were used make comparisons between limbs and groups: peak vertical ground reaction force (VGRF), peak hip and knee flexion moment, hip and knee flexion range of motion (ROM), and lateral trunk tilt. A symmetry index (SI) was calculated by dividing the values for the non-dominant (ND) side by dominant (D) side values, with a value of 1 indicating perfect symmetry. Statistical differences between bilateral parameters were determined with t-tests (alpha=0.05).

RESULTS: There were no differences in VGRF between the ND and D limbs in LBP patients or AS subjects during SitTS (SI=1.061 & 1.019, respectively) or StandTS (SI=1.036 & 1.029, respectively). AS and LBP subjects also displayed small differences in lateral trunk tilt either away from or toward the D limb during SitTS trials. Subjects in both groups exhibited less than 2% difference in lateral trunk tilt during StandTS trials. Subjects with LBP were found to have larger variations from perfect symmetry than healthy subjects, although these differences were not significant. AS subjects surprisingly displayed significant bilateral differences in peak hip flexion moments during SitTS and StandTS. AS subjects also had considerably larger peak hip flexion moments in their ND limb compared to their D limb during SitTS (SI = 1.137) while these differences were somewhat reduced, yet still significant during StandTS (SI = 1.088). Patients with LBP displayed significant ($p<0.05$) bilateral differences in peak hip flexion moments during SitTS (SI = 0.862) and StandTS (SI = 0.884). Subjects in both groups exhibited less than 3% differences in hip flexion ROM and 4.1% or less difference in knee flexion ROM between the ND and D limbs during both SitTS and StandTS.

CONCLUSION: The study is the first to investigate biomechanical symmetry measures bilaterally during SitTS and StandTS between AS and LBP subjects and provides a baseline for comparison.

SPIN_O1.6 SUBOPTIMAL POSTURAL STRATEGY AND BACK MUSCLE OXYGENATION DURING INSPIRATORY RESISTIVE LOADING

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INTRODUCTION: Proprioceptive weighting changes may explain differences in postural control performance. In addition, the respiratory movement has a disturbing effect on postural balance. Postural balance seems to be impaired in individuals with respiratory disorders. It remains unclear which underlying mechanisms may explain the decreased postural control when the inspiratory muscles are loaded.

AIM: To determine whether inspiratory resistive loading (IRL) has a negative effect on proprioceptive postural control due to a metaboreflex.

METHODS: Center of pressure displacement was determined in 12 healthy individuals in upright standing on foam without vision while breathing against an IRL (60%PImax). Concurrent ankle-back muscles vibration was used to evaluate the dominance of proprioceptive signals used in postural control. Muscle oxygenation of the back muscles was assessed using near-infrared spectroscopy. The Tissue Oxygenation Index (TOI) and the combined hemoglobin value (cHb) were calculated, which indicates the balance between oxygen supply and extraction and the change in blood volume, respectively.

RESULTS: Two subgroups were defined based on the individuals' relative proprioceptive weighting (ratio). The cut-off was set on 0.57 (group mean) placing those with a higher value in the ankle-steered group and those with a lower ratio in the back-steered (multi-segmental) group (0.68±0.07 and 0.45±0.09, respectively, $p < 0.05$). During IRL combined with concurrent ankle-back muscles vibration, the ankle-steered group showed a significantly larger posterior sway compared to the multi-segmental group (-0.065±0.044m and -0.005±0.011m, respectively, $p < 0.05$). The back muscles TOI and cHb showed no decline in the multi-segmental group, but showed a slight increase (less than 2% and 0.34µM) during the full IRL. In contrast, the ankle-steered group showed a significantly progressive decline in TOI and cHb till -5% and -2.36µM, respectively ($p < 0.05$). A significant difference between the two groups was observed after 6 minutes for TOI and 30 seconds for cHb of the IRL protocol.

CONCLUSION: Individuals who showed an increased reliance on ankle proprioceptive signals during postural control maintained this suboptimal postural strategy during IRL. The lower back muscle oxygenation and blood volume observed during IRL may be due to a metaboreflex. This may decrease back muscle spindle sensitivity and may further downweight back proprioceptive signals for postural control. Further research may reveal whether unloading of the inspiratory muscles (e.g., training) may have a positive effect on postural control by reweighting the proprioceptive signals in favor of the back muscles.

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SPIN_O1.7 CHANGES IN DIRECTION-SPECIFIC ACTIVITY OF PSOAS MAJOR AND QUADRATUS LUMBORUM IN PEOPLE WITH BACK PAIN ARE SPECIFIC TO MUSCLE REGION AND PATIENT GROUP

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INTRODUCTION: Psoas major (PM) and quadratus lumborum (QL) muscles have anatomically discrete regions that are activated differentially in a manner that is predicted from their biomechanics. Recent work suggests a redistribution of activity between trunk muscles that have a potential extensor moment during sitting in people with low back pain (LBP) such that those LBP individuals with low erector spinae (ES) activity appear to rely more on activity of the more posterior regions of QL than those with high ES activity. These data imply activity of PM and QL is tuned towards or away from preferential activation during trunk extension based on whether the LBP individual had a tendency to use less or more activation of the ES to maintain their extended/upright lumbar posture. These data may imply changes in preferred direction for activation of regions of PM and QL in a subgroup of people with LBP, but this has not been formally investigated.

AIM: To investigate the tuning curves for activation of discrete regions of PM and QL in people with LBP, sub-grouped into those with low and high activation of ES in upright sitting.

METHODS: Ten volunteers with recurring episodes of LBP and nine pain-free controls performed isometric trunk efforts against a horizontal cable in eight directions in upright sitting. LBP patients were sub-classified into those with low and high ES electromyographic activity (EMG) when sitting with a lumbar lordosis. Fine-wire electrodes were inserted using ultrasound guidance into fascicles of PM arising from the transverse process (PM-t) and vertebral body (PM-v) and anterior (QL-a) and posterior layers (QL-p) of QL.

RESULTS: LBP patients with low ES activity showed changes in the preferential direction of PM-t, PM-v and QL-p, biased towards greater activation during trunk extension. LBP patients with low ES activity activated PM-v and QL-p to a greater percentage of their maximal voluntary activity (>45% and 65%, respectively) than the other muscles in both pain-free and LBP groups with high ES activity during trunk right lateral-flexion efforts, biased towards extension. In the LBP group with high ES activity, there was a lack of a discrete activation pattern of PM-t and PM-v towards pure extension or flexion trunk efforts, respectively, as observed in the pain-free group.

CONCLUSION: These findings show changes in directional preference in regions of PM and QL based on ES activity levels in LBP individuals when maintaining an upright lumbar posture.

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SPIN_O1.8 IS ACTIVATION OF TRANSVERSUS ABDOMINIS AND OBLIQUUS INTERNUS ABDOMINIS ASSOCIATED WITH LONG-TERM CHANGES IN CHRONIC LOW BACK PAIN?

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INTRODUCTION: Changes in activation of transversus abdominis, including contraction thickness changes and delayed onset, have been observed in persons with low back pain. Motor control exercises can improve activation, but whether increased activation of transversus abdominis is related to clinically significant reduction of low back pain in the long-term is not known.

AIM: To investigate associations between activation of transversus abdominis and obliquus internus abdominis and pain intensity one year after exercise for chronic nonspecific low back pain.

METHODS: Recruitment of mm. transversus abdominis and obliquus internus abdominis during the abdominal drawing in maneuver was registered by B-mode ultrasound and first onset of abdominals relative to prime mover with M-mode ultrasound. Registration was done before and after 8 weeks with guided exercises for 109 patients with chronic non-specific LBP. Pain was assessed with a numeric rating scale (0-10) before and one year after intervention. The association between deep abdominal muscle activation before and after intervention and long-term pain was examined by multiple linear and logistic regression methods.

RESULTS: Participants with small baseline transversus abdominis lateral slide and increased transversus abdominis slide after intervention had significantly better odds for long-term clinically significant improvement compared to participants with small baseline slide and no improvement in slide (OR = 14.70, 95% CI 2.41 to 89.56). There were no associations between contraction thickness ratios and long-term pain. Clinically significant pain improvement (≥ 2 points on the numeric rating scale) one year after intervention was marginally related to baseline transversus abdominis recruitment measured by lateral slide (OR = 0.76, 95% CI 0.62 to 0.93). Linear regression indicated that faster first onset of abdominals was marginally related to long-term pain improvement (β 0.02, 95% CI 0.00 to 0.05).

CONCLUSION: Improved transversus abdominis lateral slide among participants with low baseline slide was associated with clinically important long-term pain reduction. High baseline slide and delayed onset of the abdominal muscles after the intervention period were weakly associated with higher pain at one year follow-up.

SPIN_O2.1 THE EFFECT OF SPECIFIC OR GENERAL EXERCISE ON ANTICIPATORY POSTURAL ADJUSTMENTS IN PATIENTS WITH CHRONIC LOW BACK PAIN

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Mrs Cristy Brooks

INTRODUCTION: Specific trunk focussed exercise programs are often advocated for rehabilitation programs in patients with chronic low back pain (LBP) based on observations for delayed anticipatory postural adjustments (APAs). However, there is a lack of clinical trials evaluating changes in APAs following any form of exercise program for LBP.

AIM: The aim of this study was to measure self-rated pain, disability, and the onsets of various trunks muscles as a measure of APAs, before and after an 8-week supervised exercise program.

METHODS: This was a double-blind randomized controlled trial. 64 patients with chronic low back pain were assigned to either a specific trunk exercise group or a general (cycling only) exercise group. Surface electromyography was used to evaluate the onsets of various trunk muscles in response to a rapid upper limb task. Self report data was analysed by intention to treat.

RESULTS: Self rated disability was significantly reduced in the specific exercise group only, with a clinically meaningful reduction ($p<0.001$, $d=-0.85$, 37.7% decrease). Pain scores significantly reduced in both exercise groups ($p<0.05$). Significant time effects were observed for all muscle onsets ($p<0.05$), with no between group effect observed. Muscle onset times tended to become more coordinated with the onset of the deltoid prime mover.

CONCLUSION: To elicit clinically meaningful improvements in disability, specific trunk exercise should be used. With similar improvements in both pain and APAs between groups, other behavioural mechanisms probably best explain the disability improvement following specific trunk exercise (i.e. fear avoidance). Similar between group changes in APAs suggest an underlying neuromuscular adaptation common to any exercise program that is adhered to over a period of time that includes some form of postural control with repeated limb movement (such as the static cycling with individualized postures and repeated leg movements).

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SPIN_O2.2 MOMENT DIFFERENCES BETWEEN LUMBAR SPINAL SEGMENTS: ACTIVE OR PASSIVE CONTROL

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INTRODUCTION: During daily life, the trunk has to withstand forces in various directions. Functional tasks like pushing shopping carts, walking the dog, and pulling suitcases involve forces that are unpredictable and varying in magnitude, point of application, and direction. These external forces require different internal moments at the different levels of the spinal column and moment differences between adjacent spinal segments may vary widely. At present, it is not known whether the central nervous system accurately controls moments at all spinal levels by means of trunk muscle activity (active strategy) or whether it uses passive tissue strains by allowing segmental rotations to produce moments required for equilibrium (passive strategy).

AIM: To determine whether the moments at lumbar spinal segments are controlled by changes in activation of trunk muscles and/or by changes in the curvature of the lumbar spine.

METHODS: In a custom rig, 10 healthy male subjects resisted external forces applied to the trunk to cause 50Nm moments with respect to L5/S1. Trunk exertions ranged from pure extension, via left lateral flexion to pure flexion efforts, in steps of 30°. Two series of trunk exertions were performed, with external force application at T5-level and T9-level. During exertions, bilateral surface-emg was recorded for abdominal muscles (5 sites) and back muscles (3 sites). Simultaneously, lumbar curvature was assessed by means of an Optotrak-system. Analysis of variance was performed in PASW with a 2*7 repeated measures ANOVA ($p<.05$).

RESULTS: All abdominal muscles and back muscles changed activity as a function of the moment direction ($p<.01$). Of the back-muscles, left iliocostalis lumbalis was activated less in the T9 than in the T5 condition ($p=.006$). For the abdominal muscles, the anterior part of left external oblique and the lateral aspect of left internal oblique were activated less in the T9 condition ($p=.038$ and .03). Lateral flexion angle changed as a function of force direction ($p=0.013$). Lordosis angle decreased by 3 to 4 degrees in the T9 condition compared with T5 ($p=.004$).

CONCLUSION: When faced with bigger moment differences between adjacent movement segments (T9 condition), it seems that the central nervous system allows alterations to the curvature of the lumbar spine to cause passive moments in addition to adapting activation of back-muscles and abdominal muscles. During upright trunk exertions, the intersegmental moment differences of the lumbar spine seem to be controlled in part passively.

SPIN_O2.3 INCREASED RISK OF SEGMENTAL INSTABILITY FOLLOWING LUMBAR DISC HERNIATION SURGERY

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INTRODUCTION: Following lumbar disc surgery, both disc degeneration and a surgery induced compromise of the neuromuscular segmental stabilization mechanisms may lead to the development of mainly translational segmental instabilities in the operated segments. Such instabilities may give rise to pain and impaired function and may considerably contribute for bad long term outcomes following disk surgery. Hitherto no study seem to exist that has ever considered the relative risk of segmental instability estimated from „hard data“, like those from functional X rays following such procedures. Furthermore, it remains unclear whether or not segmental instability following lumbar disc surgery would be related to a poor clinical long term outcome in these patients.

AIM: To assess the relative risk of segmental instability in the operated segment 12 years following lumbar disc surgery. To investigate whether or not the occurrence of postoperative segmental instability was related with pain or impaired function in these patients.

METHODS: 120 subjects who had undergone first time lumbar disc herniation surgery and had participated in a rigorous RCT that evaluated the short and intermediate term effects of comprehensive physiotherapy were invited for a follow-up examination 12 years after study assignment. Clinical outcomes comprised of assessment of pain and health related functioning (LBP rating scale, German version). Standard and dynamic digital radiographs in both full flexion and extension of the lumbar spine served to proof instability. Two independent radiologists who were unaware of both the results from the clinical evaluation and the operated lumbar disc segment, performed the radiolographical evaluation using the method by Stokes & Frymoyer. Translational motion had to exceed 3mm. Differences were resolved in agreement with a third independent radiologist.

RESULTS: 69 patients (32 females; mean age 55.7 ± 9.9 yrs) completed both functional X-rays of the spine and a clinical assessment after a mean follow up of 12.16 ± 0.63 years. 18 instable segments (14 exceeding 5 mm) were identified; 14 occurred in operated segments (1 instability occurred in a re-operated segment). The relative risk for a segmental instability following lumbar disk surgery was 3.6 times increased. Neither the occurrence nor the size of segmental instability was related to pain or impaired health related functioning.

CONCLUSION: As lumbar disc surgery is associated with an increased risk of segmental instability, surgical interventions necessary to remove the slipped disk may compromise the neuromuscular segmental stabilization mechanisms of the operated vertebral segments. Such structural impairment, however, seems without clinical significance.

SPIN_O2.4 THE INFLUENCE OF TASK COMPLEXITY ON BACK MUSCLE COORDINATION IN PEOPLE WITH RECURRENT LOW BACK PAIN

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INTRODUCTION: A stable system is one that maintains its intended behavior despite perturbation. In order for the spine to be stable, the coordination of trunk muscle activity must be sufficient to control the internally and externally generated forces applied to it. Furthermore, stability must be maintained under conditions with varying amounts of complexity and associated cognitive demand. In healthy people, back muscle control is altered under conditions of increased cognitive demand, with earlier activation of the deep back muscles in preparation for a perturbation during a rapid arm movement. Earlier activity of the back muscles may be an attempt to maintain spinal stability in this more demanding condition. Although back muscle control is changed in people with a history of recurrent low back pain (LBP), it is unclear whether coordination of back muscle activity is modified by increased cognitive demand in this group and, if so, whether this occurs in a manner similar to controls.

AIM: To investigate the influence of increased cognitive demand on the coordination of back muscle activity in painfree controls and people with a history of recurrent LBP during symptom remission.

METHODS: Intramuscular and surface electrodes recorded electromyographic activity (EMG) of deep (DM) and superficial fibres (SM) of the lumbar multifidus and deltoid muscles, as participants performed single rapid arm movements in response to an audio cue. Cognitive demand was increased by asking participants to simultaneously perform a modified Stroop task (cognitive demand condition). DM and SM EMG amplitude was calculated as root mean square (RMS) during 10 ms epochs before and after onset of deltoid EMG, normalized to the peak EMG amplitude in the control condition for each muscle, and log-transformed.

RESULTS: Although both groups took longer to initiate arm movements ($p<0.01$) during the cognitive demand condition than the control condition, no differences in the temporal or spatial features of DM or SM RMS EMG (DM: $p=0.69$; SM: $p=0.44$) were present between conditions in either group.

CONCLUSION: These findings suggest that people with a history of recurrent LBP adapt the coordination of the back muscles in a similar manner to painfree controls when cognitive demand is increased.

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SPIN_O3.1 SPINAL KINEMATICS AND MOVEMENT COORDINATION OF THE CERVICAL AND THORACIC SPINE OF PEOPLE WITH CHRONIC NECK PAIN

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INTRODUCTION: Neck pain is one of the common musculoskeletal problems managed by clinicians. With the close anatomical and biomechanical interaction between the cervical and thoracic spine, knowledge on movement kinematics and coordination between these spinal regions would help to optimise clinical evaluation and to develop more effective intervention for neck pain condition.

AIM: To examine the spinal kinematics and the movement coordination of the cervical and thoracic spine of people with chronic neck pain, and to examine, if difference exists, when compared to healthy controls during physiological movements of the neck and functional activities.

METHODS: 15 participants with chronic mechanical neck pain and 15 age and gender matched healthy controls were recruited in this study. Kinematics of three spinal regions (cervical, upper thoracic and lower thoracic spine) was measured with the three dimensional electromagnetic motion tracking system while participants performed active neck movements in three anatomical planes and two functional tasks which involved a light load transferring task of 1 or 2 kg. Spinal kinematics (range of motion, angular velocity and angular acceleration) of the corresponding spinal regions was compared between two groups. Cross Correlation analysis was used to further examine the coordination of spinal movement took place at the respective regions. Analysis of variance (ANOVA) was applied to compare the difference between groups.

RESULTS: Significant reductions of the angular acceleration at both the cervical and upper thoracic spine regions were found in chronic neck pain when compared to the healthy controls ($F_{1,28}=4.754$, $p=0.04$). Cross Correlation analysis revealed a significantly lower degree of coordination of the cervical and upper thoracic spine acceleration in the chronic neck pain participants, when performing the physiological neck movements and functional activities.

CONCLUSION: The difference of the spinal kinematics and the significantly reduced coordination of the cervical and upper thoracic acceleration were found in the chronic neck pain participants when compared to the healthy controls. These findings suggested the possible adaptation or compensation of the movements in the cervical and thoracic spine with the presence of chronic pain condition. The findings are useful to clinicians in analysing the movement coordination of chronic neck pain sufferers.

SPIN_O3.2 MOTOR CONTROL OF THE BACK DURING FRONTAL PLANE PERTURBATIONS WITH AND WITHOUT PAIN

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INTRODUCTION: Spine stability is challenged during perturbations and has been suggested to be affected in low back pain and potentially affected by muscle fatigue and soreness.

AIM: The aim of this study was to investigate the consequence of experimental low back muscle pain with and without fatigue or muscle soreness, on the lower back muscle activity during standing with standardized surface perturbations.

METHODS: Nineteen participants (3 females and 16 males, mean age 26.5 years) initially fulfilled a questionnaire to ensure that they were healthy without low back or gait disorders. Participants were examined on 4 different days: baseline, without and with post-exercise fatigue, and delayed onset muscle soreness; in all sessions with and without bilateral and unilateral experimental low back pain. Pain was induced by unilateral or bilateral injections of hypertonic saline into m. longissimus at L2 level. Subjects scored the pain intensity on an electronic Visual Analogue Scale (VAS). The subjects were standing on a moveable platform that could generate unexpected perturbations. Twenty perturbations were conducted randomly in 6 different directions, but only responses to the lateral tilts to left and right were analyzed. Bilateral surface electromyography (EMG) was recorded from 16 muscles (m. iliocostalis, longissimus, multifidus lumbalis, rectus abdominalis, obl. int. and ext. abdominalis, gluteus medius and biceps femoris) following each perturbation. The muscle amplitude quantified as the root-mean-square (RMS) in an epochs of 500 ms after the perturbation was extracted from the EMG recordings. Repeated measurement ANOVA was performed but only left and right m. longissimus with and without perturbation were analyzed.

RESULTS: The VAS scores were higher after bilateral injection of hypertonic saline (2.8 ± 1.8 cm) when compared with all other conditions ($P < 0.01$). The pain intensity during unilateral (1.6 ± 1.2 cm) injection of hypertonic saline was higher than the two baseline conditions ($P < 0.01$). Further data analysis is needed but preliminary inspection showed no significant changes in the RMS EMG between any of the examined conditions in left and right m. longissimus.

CONCLUSIONS: This preliminary data analysis illustrates that the motor control of the lumbar back during frontal plane perturbation is not markedly affected by muscle pain or soreness. Further analyses of the motor control patterns during perturbations in different conditions with and without pain are required.

ACKNOWLEDGEMENT: The study was supported by Aalborg University, Department of Health Science and Technology and University College North Denmark and the department of Physiotherapy at University College North Denmark.

SPIN_O3.3 QUANTIFICATION OF RIB MOTION DURING TRUNK MOVEMENT WITH A NOVEL ULTRASOUND TECHNIQUE

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INTRODUCTION: Clinical theories of rib and thoracic vertebral motion have been developed based on anatomical and biomechanical predictions, and clinical observations. A limitation for validation of clinical theories and techniques has been lack of in vivo measurement techniques. Static rib position has been measured in scoliosis and rib motion measured during respiration, but rib motion during trunk movement has not been studied in vivo.

AIM: 1) To develop a method to quantify rib motion with ultrasound (US) imaging, 2) quantify inter-rib motion during trunk side bending (SB) in painfree individuals, and 3) determine if rib motion differs between thoracic levels during SB.

METHODS: US images were used to measure movement between consecutive ribs (3-9) bilaterally during trunk SB to the left and right. Inclinometers and visual feedback during task performance were used to standardize the range of SB motion and limit movement to the thorax. Two methods of image analysis were performed, a computer template matching method and a visual analysis method. A subset of data was used to determine inter-tester reliability. A mixed effect model was used to investigate differences in range of motion (ROM) (inter-rib motion) between participants, between levels, and between directions of movement.

RESULTS: US measures of inter-rib motion were reliable when averaged over at least two trials (ICC for 2 measures 0.759, for 3 measures ICC 0.879). The new US technique measured the predicted decrease in inter-rib distance with ipsilateral SB, and increase with contralateral SB. Amplitude of motion was similar between thoracic levels (all $p > 0.109$) although there was a tendency for greater movement between ribs at lower levels (rib 7-8, rib 8-9).

CONCLUSION: These data confirm the viability of US imaging to measure rib motion and provide initial observations to validate clinical findings. Further development of the technique is required to improve reproducibility, examine criterion validity, and determine responsiveness to change before implementation in clinical studies.

ACKNOWLEDGEMENT: Funding was provided by the National Health and Medical Research Council (NHMRC) of Australia.

SPIN_O3.4 NEUROMUSCULAR STABILISATION OF THE LUMBAR SPINE - COMBINED IDENTIFICATION OF REFLEXES AND ANTAGONISTIC CO-CONTRACTION

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INTRODUCTION: A-specific low back pain (LBP) and its recurrent behaviour are often attributed to motor control deficits (e.g. delayed 'reflex' response, increased antagonistic co-contraction) as potential cause and/or effect. Neuromuscular identification will be applied to investigate these deficits.

AIM: Combined identification of reflexes and co-contraction during lumbar spine stabilization in the sagittal plane within healthy subjects. In subsequent studies this method will be applied to investigate lumbar stabilization in LBP patients.

METHODS: Fifteen healthy subjects, restrained at the pelvis, were perturbed in ventral direction with a multisine force disturbance (0.2-15 Hz) at the T10-level of the spine. Both relax and resist task conditions were studied. Kinematics (low back and thorax motion), contact force and muscle activity (sEMG of abdominal and back muscles) were recorded. Closed loop identification techniques were applied, resulting in frequency response functions (FRFs) of the human low back admittance (relation between motion and contact force) and the reflexive muscle activity (motion and sEMG). Coherence was evaluated for linearity (starting at one, being reduced due to noise and other non-linearities). For physiological representation, a linear neuromuscular control (NMC) model including passive (co-contractive) and reflexive elements was constructed and fitted onto the FRFs.

RESULTS: Coherence of the admittance was high (> 0.75) up to 3.5 Hz (higher frequencies had coherence > 0.5). Coherence of the reflexive activity of the back muscles was high up to 3.5 Hz (> 0.5), while coherence for abdominal muscles was insignificant. Task dependency was found at low frequencies for both admittance and reflexive back muscle activity (the resist task had lower admittance and stronger reflexes). The NMC model including reflexive contribution of muscle spindle (position and velocity) and golgi tendon organ (force) feedback and passive viscoelasticity resulted in a good fit to the data for both tasks, while the estimated physiological parameters had high estimation accuracy.

CONCLUSION: Combined identification of the reflexive and passive components in the low back was successfully performed. The methodology developed has the potential to investigate the motor control deficits in LBP patients in detail.

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ULTRASOUND: MUSCLE & TENDON

USMT_O1.1 ANALYSIS OF MUSCLE THICKNESS IN SUBJECTS WITH ANTERIOR CRUCIATE LIGAMENTPLASTY

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INTRODUCTION: Ultrasound is characterized as a dynamic assessment that evaluates the cross section of the muscles. The thickness of the masseter and temporal muscles has been related to occlusal factors, temporomandibular disorders, facial growth and morphology, being an important aspect to be considered in the study of the stomatognathic system.

AIM: This paper aims to demonstrate the muscle thickness and its compensations in individuals with anterior cruciate ligament.

METHODS: A total of forty (40) male subjects with age mean 25.58 ± 2.47 years, selected from two groups. Group 1 (G1) consisting of twenty (20) healthy individuals (control group) and group 2 (G2) consists of twenty (20) patients after anterior cruciate ligament. The study was approved by research ethics committee of the Centro Universitário Claretiano de Batatais (Case: 14 / 2010). After the selection of samples, an assessment of muscle thickness was performed with an ultrasound machine brand model SonoSite Titan, nationalized with 56 mm linear transducer in 10 MHz of the research institute USP - Ribeirão Preto. They give up ultrasound images of the right masseter (RM) and Left (LM), right temporal (RT) and left (LT) during the clinical condition of teeth clenching at maximal habitual intercuspal (MHI). The values were statistically analyzed using SPSS 17.0 for Windows (SPSS Inc., Chicago, IL, USA) by Student 't test for independent samples. Adopted as a significance level of 5% ($p \leq 0.05$).

RESULTS: The result obtained during the clinical condition of MHI in G1 was: RT: 1.50 ± 0.21cm, LT: 0.75 ± 0.08cm, RM: 1.47 ± 0.13cm and LM: 0.77 ± 0,13cm. The G2 values were: RT: 1.48 ± 0.21cm, LT: 0.77 ± 0.09cm, RM: 1.46 ± 0.15cm and LM: 0.76 ± 0.13.

CONCLUSION: Were concluded that subjects with anterior cruciate ligament to have a lower muscle thickness in the stomatognathic system, this factor is associated with decreased proprioception of the knee muscles and compensation in other musculoskeletal systems.

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USMT_O1.2 MECHANICAL NECK MUSCLE ACTIVATION DURING REPEATED ARM FLEXION REGISTERED WITH ULTRASOUND: A COMPARISON OF PATIENTS AND HEALTHY CONTROLS

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INTRODUCTION: Impaired motor function is a known feature of chronic mechanical neck pain yet cervical muscle function during repetitive upper limb tasks has not been well investigated. Such investigations are of potential clinical relevance as many patients with neck disorders report that repetitive upper limb activities aggravate their symptoms.

AIM: To investigate the mechanical activity of ventral and dorsal neck muscles during a repetitive 90° loaded arm flexion task in individuals with and without chronic neck pain.

METHODS: Ten individuals with chronic mechanical neck pain (mean age 60 years; SD 7.1) (10-13 years after surgery for cervical disc disease; pain intensity of 36 mm on the visual analogue scale and 31% function on the Neck Disability Index) and 10 age and sex matched healthy controls participated in the study. Ultrasonography and post-process speckle tracking analysis were used to measure the degree of deformation (%) and deformation rate (m/s) of the dorsal (trapezius, splenius, semispinalis, multifidus) and ventral (sternocleidomastoid, longus capitis, longus colli) muscles at the C4-segmental level during the ninth and tenth repetition (of 10 repetitions) of loaded arm flexion to 90° (barbell men 1 Kg, women 0.5 Kg). Ultrasound measurements of muscle deformation and deformation rate were compared between groups and between muscles (significance set at $p < 0.05$).

RESULTS: For the ventral and dorsal neck muscles no group ($p>0.05$ and $p>0.14$, respectively) or group by muscle interactions ($p>0.45$ and >0.35, respectively) were observed for either deformation or deformation rate measures. Although no group differences were observed, tests of simple effects revealed some general tendencies for elevated values of muscle deformation and deformation rate in the ventral neck muscles of the patient group; deformation of the longus colli, ($p=0.10$) and sternocleidomastoid ($p=0.08$), and in deformation rate of the longus colli ($p=0.07$) and longus capitis ($p=0.13$).

CONCLUSION: Although differences between group measures fell short of statistical significance (large variability in data and small sample size) there was a general tendency for larger deformation and higher deformation rates in the patient group particularly for the ventral muscles These findings may be indicative of an altered motor strategy in the patient group in response to the repetitive upper limb task. Further investigation is warranted with larger sample size.

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USMT_O1.3 NOVEL INSIGHT INTO THE DYNAMICS OF MALE PELVIC FLOOR CONTRACTIONS THROUGH TRANSPERINEAL ULTRASOUND IMAGING

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INTRODUCTION: Transperineal ultrasound imaging (US) enables minimally invasive assessment of pelvic floor muscle function. Although commonly used in females, the approach has had limited use in males. This approach has advantages because the mid-sagittal view visualises a bony landmark and the entire urethral length. This allows investigation of displacement of multiple points along the urethra and the unique mechanical actions of multiple muscles that could influence continence.

AIM: To use a new transperineal US technique to compare relative displacement of urethra-vesical junction, ano-rectal junction, and distal urethra during voluntary pelvic floor muscle contractions in continent men.

METHODS: Measurement and comparison of urethral displacement at specific urethral regions in ten continent males (28-41 years). Measures made on 2D mid-sagittal plane ultrasound images included the displacements of specific points along the urethra. Anatomic considerations suggest that these are caused by contraction of the levator ani, striated urethral sphincter and bulbocavernosus muscles. Pearson’s correlation coefficient was used in investigate the relationship between displacements of pairs of points.

RESULTS: Data show individual variation in displacement of the distal urethra (striated urethral sphincter contraction) and urethra-vesical junction (levator ani contraction). A strong inverse linear relationship (0.723) between displacements of these points indicates two alternative strategies of urethral movement.

CONCLUSIONS: Transperineal US imaging allows simultaneous investigation of multiple mechanisms with potential to influence urinary through measurement of urethral displacement. Data provide evidence of different but coordinated strategies to maintain urinary continence in males.

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USMT_O1.4 EFFECTS OF THE LONG-TERM USE OF HIGH HEELED SHOES ON THE NEUROMECHANICS OF HUMAN WALKING

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INTRODUCTION: Human movement involves an ongoing interaction between muscular and tendinous tissues, and the manner in which these tissues interact may be substantially altered by changes in their properties. Numerous interventions have been shown to alter muscle and/or tendon properties. One common but poorly understood intervention is the long-term use of high heeled shoes, which force the foot into a plantar flexed position and thus alter joint mechanics during gait.

AIM: Long-term high heel use is known to shorten medial gastrocnemius muscle fascicles and increase Achilles tendon stiffness, but the consequences of these changes for muscle and tendon function during movement have not been explored. The aim of this study was to examine the effects of habitual high heel use on the neural and mechanical behaviour of the human calf muscles during walking.

METHODS: A group of 9 habitual high heel wearers (age 25 ± 7 years; height 168 ± 7 cm; mass 65 ± 17 kg) were tested. To satisfy inclusion criteria, these subjects had to have worn shoes with a minimum heel height of 5cm for at least 40 hours per week and a minimum of 2 years. Ten control subjects (age 25 ± 4 years; height 166 ± 5 cm; mass 60 ± 7 kg) who habitually wore heels for less than 10 hours per week were also tested. Subjects walked at a self-selected speed over level ground while ground reaction forces, ankle and knee joint kinematics, lower limb muscle activity and gastrocnemius fascicle length data were acquired.

RESULTS: The muscle fascicles of habitual high heel wearers exhibited substantially larger strains when walking in heels than when walking barefoot (~13% versus ~4%), despite the smaller range of ankle rotation when walking in high heels. This finding is consistent with the notion of increased Achilles tendon stiffness after long-term high heel use. In barefoot walking, habitual heel wearers exhibited higher MG muscle activation but similar fascicle strains and joint kinematics relative to controls, which may be a response to the ‘unfamiliar’ strains imposed on the muscle-tendon unit during barefoot walking, resulting in muscle stiffening.

CONCLUSION: Long term use of high heeled shoes appears to be related to changes in muscle fascicle length trajectories and neural activation strategies during walking. The results may partly explain why high heel wearers often experience discomfort and muscle fatigue in daily life, and may have important implications for muscle-tendon efficiency and injury risk during common movements like walking.

USMT_O2.1 MEDIAL GASTROCNEMIUS MUSCLE FASCICLE ACTIVE TORQUE-LENGTH AND ACHILLES TENDON PROPERTIES IN YOUNG ADULTS WITH SPASTIC CEREBRAL PALSY

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INTRODUCTION: Individuals with spastic cerebral palsy (CP) typically experience muscle weakness. The mechanisms responsible for muscle weakness in spastic CP are complex and may be influenced by the intrinsic mechanical properties of the muscle and tendon.

AIM: To investigate the medial gastrocnemius (MG) muscle fascicle active torque-length and Achilles tendon properties in young adults with spastic (CP).

METHODS: In nine young adults with spastic CP (17±2yrs) and ten typically developing individuals (18±2) yrs) participated in the study. Active MG torque-length and Achilles tendon properties were assessed under controlled conditions on a dynamometer. EMG was recorded from leg muscles and ultrasound was used to measure MG fascicle length and Achilles tendon length during maximal isometric contractions at five ankle angles throughout the available range of motion and during passive rotations imposed by the dynamometer.

RESULTS: Compared to the typically developing group, the spastic CP group had significantly lower active ankle plantarflexion torque across the available range of ankle joint motion, greater levels of antagonistic co-contraction and longer Achilles tendon slack length.

CONCLUSION: This study confirms young adults with mild spastic CP are weak and have altered muscle-tendon mechanical properties, most notably an increased Achilles tendon slack length. This adaptation may facilitate a greater storage and recovery of elastic energy and partially compensate for decreased force and work production by the muscles of the triceps surae during activities such as locomotion.

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USMT_O2.2 RELIABILITY AND VALIDITY OF ULTRASOUND MEASUREMENTS OF MUSCLE FASCICLE LENGTH AND PENNATION IN HUMANS: A SYSTEMATIC REVIEW

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INTRODUCTION: Ultrasound imaging is widely used to measure architectural features of human skeletal muscles in vivo. Many studies have examined the intra- and inter-tester reliability of ultrasound measures and a few studies have examined the validity of ultrasound measures by comparing ultrasound measures with direct measures on cadaveric muscle.

AIM: To systematically review studies of the reliability and validity of 2D ultrasound measurement of muscle fascicle lengths or pennation angles in human skeletal muscles.

METHODS: A comprehensive search was conducted. Data were independently extracted by two researchers. Study quality was assessed with a modification of existing scales used to assess studies of reliability and validity.

RESULTS: Thirty-six reliability studies and six validity studies met the inclusion criteria. The studies examined intra- and inter-rater reliability on 14 skeletal muscles in healthy and diseased subjects under passive and active conditions. Most studies used a stationary ultrasound probe but 5 studies used extended field of view (panorama) methods that involved movement of the probe. Study quality was generally moderate. These studies consistently reported that ultrasound measurements of muscle fascicle lengths have at least acceptable reliability (ICC and r values were always > 0.6 and CV values were always < 10%). The reliability of measurements of pennation angles is broadly similar (ICC and r values were always > 0.5 and CV values were always < 14%). Data on validity are less extensive and probably less robust, but suggest that measurement of fascicle lengths and pennation angles have an acceptable accuracy (ICC > 0.7) under certain conditions, such as when large limb muscles are imaged in a relaxed state and the limb or joint remains stationary.

CONCLUSION: The available data suggest ultrasound imaging can be used to obtain reliable and valid measures of muscle fascicle length and pennation. More studies are needed to determine validity in small muscles and under dynamic conditions, and to compare the validity of measures obtained using different strategies to align the ultrasound probes.

USMT_O2.3 DIFFERENCES IN MUSCLE FASCICLE BEHAVIOUR BETWEEN FORWARD AND BACKWARD WALKING

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INTRODUCTION: Exercise-induced muscle damage (EIMD) transpires following unaccustomed exercise. A common protocol for inducing EIMD in the lower limbs is backward downhill walking.

AIM: To compare medial gastrocnemius muscle fascicle and muscle-tendon unit length changes during backward downhill walking and forward walking on the flat in order to better understand the potential mechanical causes of EIMD. We hypothesised, in accordance with the popping sarcomere theory, that to incur damage the MG muscle fascicles would consistently operate at longer lengths during backwards downhill walking compared to forwards walking.

METHODS: 10 healthy male participants (age 21.5 ± 1.5 years) performed a backward walking protocol that required participants to walk backwards downhill on a 13% grade for 1hr on a motorised treadmill. Participants walked at a speed of 6km/hr while wearing a backpack containing an additional load (10% of their body mass). Ultrasonography and 3-D motion analysis were used to assess the changes in muscle fascicle length and muscle-tendon unit length at 0min, 30min and 60min. Data was also collected during 1min of forwards walking and 1min of backward walking on a 0% grade immediately before and after the backward walking protocol.

RESULTS: Fascicles operated at a shorter length during backwards downhill walking (45.76 ± 6.23mm to 56.40 ± 4.01mm) than during forwards walking (53.28 ± 7.51mm to 64.25 ± 5.50mm). Backwards downhill walking resulted in rapid, active lengthening of muscle fascicles during loading in early stance at a similar time to rapid muscle-tendon lengthening. In contrast, during forwards walking the fascicle and muscle-tendon unit shortened during early stance and remained relatively isometric during muscle loading in mid-stance. All participants exhibited signs of EIMD as a result of the backward walking protocol as indicated by a reduction in isometric force 2 hours after completion of the exercise.

CONCLUSION: Contrary to our initial hypothesis, EIMD was induced at shorter muscle lengths than were exhibited in forwards walking and hence absolute strain of muscle fascicles is unlikely to be the mechanical stimulus for EIMD in this activity. The rapid stretch of fascicles during force development is a more likely mechanism leading to EIMD.

USMT_O2.4 SUBJECT-SPECIFIC SERIES ELASTIC ELEMENT INTO EMG DRIVEN MUSCLE INCREASES MUSCLE FORCES ESTIMATION DURING HIGHLY DYNAMIC TASKS

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Dr Guillaume Rao, Institute of Movement Sciences EJ Marrey; Dr Eric Berton, Institute of Movement Sciences EJ Marrey

INTRODUCTION: Neuromusculoskeletal (NMS) models are developed to estimate muscle forces allowing to investigate musculoskeletal disorders. Developing accurate models is challenging because of the NMS system complexity and the presence of high inter-subject variability. The estimation of muscles forces is based on the mechanical properties of tendon-aponeurosis (T-A) complex. A generic definition based on in vitro test of tendon is generally used into NMS models to estimate muscle forces. The ultrasonography allows to estimate subject-specific T-A mechanical properties.

AIM: The aim of this study was to investigate the influence of more subject-specific tendon-aponeurosis mechanical properties on NMS model and more specially on muscle forces estimation during highly dynamic tasks.

METHODS: Seven subjects performed isometric contraction in order to estimate the T-A force-strain relationship. Two ultrasound probes were positioned over the muscle-tendon junction and the mid-belly of the medial gastrocnemius muscle. The combination of ultrasonography and motion capture was used to estimate the in vivo tendon strain on custom ergometer. A geometric model was used to estimate aponeurosis strain at each time based on the muscle-tendon length, the tendon length, the fibre length and the pennation angle. The muscle-tendon length was computed from Opensim (SimTK) and the muscle fibre parameters were estimated simultaneously by the second ultrasound probe. The T-A force-strain relationship was estimated for the medial gastrocnemius and scaled for others ankle muscles based on tendon and aponeurosis length for each muscle measured by ultrasonography. Subjects performed running and one-leg hopping tasks. The EMG-driven model was calibrated separately with the generic tendon definition based on in vitro test, and the subject-specific T-A force-strain relationship. Then, the model was used to predict muscle forces during dynamic tasks.

RESULTS: The use of subject-specific tendon-aponeurosis definition leads to higher muscle force estimation for the plantar-flexor group (4988±1602N vs. 4246±992N) and the soleus (3444±1136N vs. 2870 ±803N), respectively for subject-specific definition and generic definition. Previous experimentations using ultrasonography have shown an important decoupling between fibre and muscle-tendon behaviour close to our finding with subject-specific T-A definition.

CONCLUSION: The use of more subject-specific tendon-aponeurosis into NMS model leads to higher muscle forces estimation and closer fibre behaviour compared to previous experimentations. This method could be used to take into account the alteration of tendon-aponeurosis mechanical properties with neuromusculoskeletal disorders.

POSTER PRESENTATIONS

BIOMECHANICS

BIOM_P1.1 COMPARISON OF TRUNK AND SHOULDER MUSCLES EMG DURING PULL-UP EXERCISE OF THE PILATES METHOD IN TWO DIFFERENT POSITIONS OF SPRINGS

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INTRODUCTION: One of the proposals of Pilates method, at an advanced exercise level, like the pull-up, is to work intensively trunk muscles through exercises with low number of repetitions and that can challenge the ability to control body movement. The pull-up exercise is performed on the “chair” apparatus, with the trunk in a flexed position, with hands on the top of the “chair” and feet resting on a pedal with springs, where one has to elevate the trunk and the lower limbs mainly through trunk muscles activities instead of shoulder girdle muscles. It is commonly proposed by Pilates that the lesser the spring’s assistance the more trunk muscle activity is required.

AIM: To compare trunk and shoulder girdle muscle activity during the Pull-up performed at two difficulty levels modified by changing springs position.

METHODS: nine healthy individuals (5 men, 28±5yrs; 1.72±0.07cm; 68±12kg) who had been practicing Pilates for at least six months were assessed. Surface EMG of rectus abdominis (RA), internal oblique (IO), iliocostalis (ILIOC), multifidus (MU), anterior deltoid (AD) and posterior deltoid (PD) were acquired following SENIAM in a single differential mode using bar bipolar electrodes Ag/AgCl (IED=20mm), while individuals performed 4 repetitions of 3 exercise cycles for both spring levels (high and low). The spring constant was 280 N/m. EMG signals were passed through a 20–450 Hz bandwidth filter, amplified (gain=2000), sampled at 1kHz. RMS values were normalized by the MVIC. At the beginning of the movement, the spring at the lower level (positioned at 25º from horizontal plane) offered a vertical assistant push of 150 N and the higher level spring (35º from horizontal plane) of 209 N.

RESULTS: During the ascent phase, the low spring showed significantly higher RMS values than the high spring for all muscles, except for the PD and during the descent phase, AD, IO, RA and ILIOC muscles presented higher RMS. Mean RMS values during whole exercise cycle at high spring were: AD 60%, IO 67.5%, RA 57%, MU 68%. At low spring: AD 63.5%, IO 78.5%, RA 77.5%, MU 70%.

CONCLUSION: Considering the MVIC values, the pull-up is effective in both spring levels as an exercise for strengthening flexors (RA and IO) and extensors (MU) trunk muscles, as well as the shoulder muscle (AD), but not ILIOC muscle that did not achieve RMS values of at least 60%. The low spring level provided lesser vertical assistant to pull and produced a higher EMG activity for most muscles in the whole pull up exercise cycle. The results confirm that changing the position of the springs to a lower tension level is a useful procedure in the Pilates method in order to increase trunk muscles activities.

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BIOM_P1.2 RECRUITMENT PATTERNS OF THE CERVICAL AND THORACIC SPINE MUSCLES OF PEOPLE WITH CHRONIC NECK PAIN

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INTRODUCTION: Muscle plays a very important role in maintaining spinal stability and allowing pain free movement of the spine to be carried out efficiently with optimal motor control. With the complexity of the muscle system of the cervical and thoracic spine, knowledge on the differential roles of muscles of this spinal region would offer more accurate evaluation and more effective intervention for people with chronic mechanical neck pain.

AIM: To examine the contribution of individual muscles and the recruitment patterns of the cervical and thoracic spine muscles of the chronic neck pain sufferers and to examine differences in muscle activity , when compared to the healthy controls during active physiological movements of the neck and two functional tasks that simulate daily activities.

METHODS: 15 participants with chronic mechanical neck pain and 15 age and gender matched healthy controls were recruited in this study. Synchronised measurements of the spinal kinematics of three spinal regions (namely the cervical, upper thoracic and lower thoracic region) and surface electromyography (EMG) of five pairs of spinal muscles (Cervical Erector Spinae (CES), Upper Trapezius (UT), Sternocleidomastoid (SCM), Thoracic Erector Spinae at 4th (TES 4) and 9th thoracic spines (TES 9)), were carried out while participants performed1) active physiological neck movements in sitting and 2) two functional tasks involved light load transfer with their upper limbs (1or 2 kg). EMG threshold method was used to detect the onset and cessation of each muscle in order to reveal its contribution in various phases of the spinal movement or task performed. Cross Correlation analysis was applied to further examine the recruitment pattern of these muscles with reference to the spinal kinematics. Analysis of variance (ANOVA) was used to compare the differences between groups.

RESULTS: The CES and SCM of the neck region and TES 4 and TES 9 of the thoracic region were found to be playing a very different role between the neck pain group and the healthy group when performing active neck movements and light load transferring tasks as significant differences of Coefficient of Cross Correlation of the cervical and upper thoracic acceleration with these four pairs of muscles between groups (P values varied from 0.01- 0.03).

CONCLUSION: Differences were found between chronic neck pain participants and healthy controls on 1) individual muscle contribution to spinal movements of the cervical and thoracic spine and on 2) the muscle recruitment patterns. These findings enhance the understanding and interpretation of the physical examination of chronic neck pain sufferers and provide insight for the more specific muscle re-education and training for the clinical management of chronic mechanical neck dysfunction.

BIOM_P1.3 LINE ACTIVITIES OF ANTERIOR SERRATUS MUSCLE (ASM) AND EXTERNAL OBLIQUE MUSCLE (EOM) MEASURED BY EMG

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INTRODUCTION: Coordination of multiple trunk muscles may determine some daily activities of people. ASM and EOM in the lateral trunk link each other and probably affect the evaluation of trunk movements in clinical settings. Imbalance in activities between left and right ASMs might lead to the extremity ataxia.

AIM: The link between ASM and EOM in the healthy subjects was investigated with the prescribed motion at super limb girdle, by EMG. Difference in activities between left and right laterals was also analyzed.

METHODS: Subjects were 11 healthy men (25.3±3.8 yo) having no orthopedics diseases, 10 men right-handed and 1 left-handed. Subjects lay at supine position. Initially, shoulder joints bent to 90º, limb joints extended, and wrist joints in middle position, with keeping all muscle activities as weak as possible. Then, the prescribed motion was commenced shortly as follows: from the supine position above, subjects actively abducted and upwardly rotated both shoulder blades in a prompt manner. Using the multi-channel telemeter system (WEB7000, Nippon Kohden Co., Japan), To assess coordination between muscles, EMG activities were taken from skin surfaces over ASM and EOM and the 300-500 Hz components were analyzed through a software (BIMUTAS-VIDEO FOR WEB, Kissei Comtec Inc., Japan). To measure the difference in periods between left and right shoulder motion prescribed, foot switches to detect the sessaton activities were placed on shoulder blade prickle triangles of both sides. Using SPSSver13, statistical analyses, some paired *t*-test when necessary, were performed with the significance $P<0.05$.

RESULTS: Concerning with line activities between ASM and EOM, starting times in EMG were significantly different between two muscles in the left half, but not in the right half. Starting time of the left ASM delayed when compared to the right ASM. Also, stating time of the left abdominal EOM delayed in comparison to the right. The total periods of prescribed motions in left and right shoulders were not different significantly.

CONCLUSION: Line activity between ASM and EOM may be stronger in the right half than in the left half, since the difference in EMG starting time between ASM and EOM was observed only in the left half. Early occurrence in EMG may be due to the dominance in right-handed subjects. Coordination of trunk muscles may be dependent on the hand dominance. These results suggest that coordination of trunk muscles can be evaluated by the assessment of synchronization between responsible muscles in the trunk.

BIOM_P1.4 ASSESSMENT OF NEUROMUSCULAR COMPARTMENTS FIBULARIS LONGUS MUSCLE BY ELECTRICAL STIMULATION AND ACCELEROMETRY

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INTRODUCTION: In recent decades it has been postulated the existence of subdivisions within the muscles, called neuromuscular compartments (CNMs), which provide anatomical, physiological and biomechanical features. Examples of neuromuscular compartmentalization are the tibialis anterior, biceps brachi, medial gastrocnemius and fibularis longus, which have shown a complex organization of motor nuclei, innervation and compartmentalization. Currently, research has confirmed the existence of CNMs in animal models and humans through anatomical studies, but they have not ratified the muscular organization through studies involving biomechanical and neurophysiological variables.

AIM: Compare neuromuscular compartments fibularis longus muscle through the motor threshold (UM) and acceleration of the foot.

METHODS: This was a cross-sectional study conducted in the Biomechanics Laboratory of the School of Kinesiology, Universidad de Talca, Chile. Thirty-seven healthy young volunteers (range 18 to 24 years of age) were selected to participate in the study after taking a written informed consent approved by the bioethics committee of the Universidad de Talca. In all participants was located superior neuromuscular compartment (CNM-S), anterior (CNM-AI) and posterior (CNM-PI), and also the motor points of each of these according to data from previous research. Later, a triaxial accelerometer installed on the back foot and each compartment of fibularis longus was stimulated electrically. The variables studied were the UM and the acceleration of the foot (x, y, z) of each CNM. We used ANOVA and Bonferroni post-hoc test was considered significant at $p < 0.05$.

RESULTS: There is a greater mean acceleration of the X axis relative to the axes Z and Y in all CNMs ($P = 0.000$). There are significant differences in mean X axis acceleration between the CNM-S and CNM-PI ($P = 0.037$), where the mean acceleration of the CNM-PI is higher (0.61 m/s2). No significant difference between the motor threshold CNMs ($P = 0.928$).

CONCLUSION: The fibularis longus muscle presents neuromuscular compartmentalization that influences the biomechanical characteristics of the foot, showing a predominance of acceleration in the X axis corresponding to the plane of abduction of the foot. The CNM-PI has the greatest acceleration of the foot on the X axis.

BIOM_P1.5 UNIQUE NEUROMUSCULAR ACTIVATION IN THE VASTUS INTERMEDIUS DURING DYNAMIC KNEE EXTENSIONS

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INTRODUCTION: Neuromuscular activation patterns of the vastus intermedius (VI) muscle during knee extensions remain poorly understood because of technical difficulty recording them using surface electromyography (EMG). However, an innovative technique has been developed to acquire neuromuscular activity of the VI with a negligible amount of cross-talk from the adjacent vastus lateralis (VL) muscle during isometric contraction by surface EMG (Watanabe & Akima 2009, 2010, 2011).

AIM: This study aimed to determine the neuromuscular activation patterns of the quadriceps synergists including the VI during dynamic knee extension exercises at different loads.

METHODS: Nine healthy men (mean age, 24.6 ± 7.3 years) performed dynamic knee extensions at 20%, 40%, 60%, 80% and 100% one-repetition maximum (1RM). Neuromuscular activation of the VI, VL, vastus medialis (VM) and rectus femoris (RF) was acquired using surface EMG (sampling rate, 2000 Hz; band pass width, 20 to 450 Hz) and the root mean square (RMS) was calculated as performed previously (Watanabe & Akima 2009, 2010). Dynamic knee extension exercises consisted of the concentric phase for 3 s and the eccentric phase for 3 s, and each phase was divided into three sub-divisions, the acceleration phase, constant velocity phase, and deceleration phase. The RMS of each subdivision was normalized to the RMS at 100% 1RM for each concentric phase or eccentric phase.

RESULTS: The EMG activity of the VL, VM and RF slightly increased from the acceleration phase to the deceleration phase during concentric contraction. However, the EMG activity of the VI was significantly higher than those of the VL, VM and RF at the acceleration phase and quickly decreased in the constant velocity phase; as a result, it was significant lower than those of the VL, VM, and RF in the deceleration phase. This activation pattern diminished at lower loads. The EMG activities during eccentric contraction at all intensities looked like mirror images of the concentric contraction.

CONCLUSION: These results clearly demonstrated that the VI plays a key role during dynamic knee extensions in the flexed knee position and this evidence greatly enhances the understanding of the neuromuscular activation patterns of the individual muscles of the QF during knee joint actions.

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BIOM_P1.6 ASSOCIATION BETWEEN CHANGES IN CERVICAL POSTURE AND MUSCLE ACTIVITY DURING EXPOSURE TO AN ACUTE PSYCHOSOCIAL STRESSOR

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INTRODUCTION: Overuse injury of the cervicoscapular musculature among office workers has been attributed to forward head postures and to elevated muscle activity caused by occupational stress. The upper trapezius(UT) and cervical extensor(CE) muscles assist with stabilizing the position of the head and neck, and it is unclear whether changes in cervical posture during stressful computer work can explain previously observed increases in muscle activity during exposure to simulated occupational stressors.

AIM: The purpose of this study was to examine the relationship between changes in cervical muscle activity and changes in cervical posture during exposure to an acute psychosocial stressor in healthy office workers.

METHODS: Twenty seven office workers with no history of neck pain(23 females, 4 males; mean(SD) age = 30(8.7)) performed a computer mousing task under 3 experimental conditions; a baseline(BL) condition required subjects to perform only the physical demands of the mousing task, the low stress(LS) condition required subjects to perform the mousing task with additional cognitive demands of the OpSpan working memory task, and a high stress(HS) condition required subjects to perform the OpSpan mousing task in the presence of psychosocial stress. Cervical posture was quantified as the angle between the horizontal and a line from the seventh cervical vertebrae to the tragus of the ear as assessed by digital photography. Surface electromyography (EMG) was recorded from the dominant UT and CE muscles during a 5-second window corresponding to the time of the postural assessment. Cervical angle and EMG were compared across conditions using repeated measures ANOVA, and the relationship between absolute changes in these variables across LS and HS conditions was assessed using Pearson's correlation.

RESULTS: There was a significant increase in UT EMG across stress conditions (BL=14.8(14.5)µV, LS=23.8(20.0)µV , HS=27.6(27.3)µV; p=0.003), but no corresponding increase in CE EMG (p=0.29). There were no significant changes in cervical angle across stress conditions (p=0.13). Furthermore, there was no significant association between changes in cervical angle and EMG from BL to the HS condition for either muscle (UT: r=0.18, p=0.39; CE: r=0.37, p=0.11).

CONCLUSION: The cognitive challenge imposed by the OpSpan task selectively increases activation of the UT, but not the CE muscle group. This increase in UT muscle activity cannot be explained by changes in cervical posture during exposure to the stressor, and may instead be attributed to increased psychological demands of the task. These findings have potential implications for the prevention and treatment of stress-related trapezius myalgia.

BIOM_P1.7 THE ONSET TIME OF QUADRICEPS IN ATHLETES WITH CHRONIC KNEE PAIN DURING BADMINTON FOREHAND LUNGES

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Ms Hsing-Hsan Lee; Dr Ming-Tung Huang

INTRODUCTION: To compare the onset time of vastus medialis (VM) and vastus lateralis (VL) between athletes with knee pain and healthy athletes during the forehand forward and backward lunges.

AIM: To evaluate the role of quadriceps muscle in badminton forehand lunges.

METHODS: Seventeen subjects with chronic knee pain (injured group) and 17 healthy subjects (control group) were recruited. Their age was between 16 to 27 years. Surface electrodes (Delsys Incorporated, USA) were used to record electromyographic (EMG) activity of VM and VL on the dominant (racket-hand) side. The injured group and control group were asked to perform the tasks of forehand forward lunge and forehand backward lunge within three seconds in a simulated badminton court. The EMG data were full-wave rectified and low-pass filtered. A computer algorithm was used to identify the onset of EMG activity. The algorithm identified the point at which the mean value of a moving window of 50 ms exceeded the baseline (obtained in 50 ms before the EMG signal started to activate) by more than three standard deviations of the baseline. The mid-point of the moving window was determined as the onset time. Independent t-test was used to compare the onset timing differences of VM and VL in two tasks between two groups. The level of significance was determined at $p < .05$.

RESULTS: No significant group difference was found in the onset time of VM and VL during the forehand forward lunge (control: -20.71 ± 73.62 ms; injured: -19.49 ± 58.29 ms; $p = .928$) and during the forehand backward lunge (control: -29.69 ± 59.78 ms; injured: -26.51 ± 76.75 ms; $p = .818$).

CONCLUSION: VM and VL are the two principle muscles that work synergistically to stabilize the patella during dynamic knee movement. Current literature suggested that onset time difference does exist in the VM and VL between those with and without anterior knee pain; however, our findings did not support this. This result gives us a thought that looking at onset time difference between VM and VL may not be as indicative as it is assumed during these two specific tasks.

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BIOM_P1.8 A TRAINING SHIRT FOR STIMULATING UPPER BODY MUSCLES DURING WALKING EMG EVALUATION OF TRAINING EFFECTS

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Mr Keio Ishiguro; Mr Fujiyasu Kakizaki; Mr Tomokazu Muto; Mr Takashi Nakayama; Mr Yukisato Ishida

INTRODUCTION: Rubber band training is available for strengthening the weak muscles in physical therapy. Exercise with holding a rubber band from the scapula to both hands provides appropriate muscle activity to strengthen the upper body muscles. Thus, we have made a training shirt specially designed for stimulating upper body muscles in the ADL.

AIM: To test the efficiency of the training shirt, EMG of the responsible muscles were evaluated.

METHODS: A prototype of the training shirt was made as a rubber band was inweaved from hand to hand over both scapula into a long sleeve shirt with the aid of Addidas Japan KK Reebok Japan. This band area in the shirt is called as a power net. We measured EMG activities of the upper body muscles of 10 male subjects during walking with or without the power net shirt. Subjects walked on a treadmill at 4 km/h with 3 min walk before 10 gate cycle-measurements of EMG (Biomonitor ME6000, Mega Electronics, Finnland) with s sampling frequency of 1000Hz. Electrodes were placed on the midpoint along the fiber line of triceps brachii, biceps brachii, latissimus dorsi and erector spinae. The mean RMS of EMG during 10 gate cycles was calculated and the obtained values with or without the power net shirt were compared. Statistical significance was performed with t test ($p<0.05$).

RESULTS: Compared to the shirt without power net, wearing the power net shirt elevated EMG activities by 44% and 12% in triceps brachii and latissimus dorsi, respectively ($p<0.05$).

CONCLUSION: The power net shirt for upper body muscle is effective to stimulate responsible muscles to improve the posture control of upper body. This shirt may provide benefits for busy people lacking time for exercise, since it activates responsible muscles unconsciously during achieving the ordinal ADL such as walking.

ACKNOWLEDGEMENTS: We are extremely grateful to members of Addidas Japan KK Reebok Japan for developing the prototype long sleeve shits with the power net at the upper body.

BIOM_P1.9 ANTHROPOMETRICS AND ELECTROMYOGRAPHY AS PREDICTORS FOR MAXIMAL VOLUNTARY ISOMETRIC LEG STRENGTH

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INTRODUCTION: Force production depends on neural drive from the CNS and muscle cross-sectional area. Neural drive to the muscle may be assessed by measuring EMG activity. Kroll et al. (1990) used anthropometric measures to determine optimal predictor variables of maximal force. Results showed that limb length, girth, and volume, and body mass were all strong predictors of force. Green et al. (2011) followed Kroll's approach with the addition of EMG to observe its relative impact on the prediction of maximal elbow flexion force.

AIM: The purpose of this study was to evaluate the relative contribution of both anthropometry and EMG to the prediction of lower leg force.

METHODS: Male (N = 37) and female (N = 44) participants performed six, five second isometric dorsiflexion MVCs with three minutes rest in between. Ag/AgCl recording electrodes were placed in a bipolar configuration one cm distal to the electrically identified motor point on the tibialis anterior. Body mass (kg), lower leg length (cm), calf circumference (cm), and foot length (cm) were recorded. Root mean square (RMS) amplitude of surface EMG (sEMG) activity and mean force were averaged across six trials from a one second sample window located in the middle of the contraction. Multiple linear regression analysis was performed.

RESULTS: Males were 26.6% stronger than females as measured by force; however, females displayed a 4.8% greater sEMG amplitude during maximal effort based on average RMS values. In males, force had the highest correlation with body mass ($r = .41$, $p < .05$) while the greatest correlation for females was between force and leg length ($r = .53$, $p < .01$). For males the initial prediction equation included body mass as a predictor of force ($R^2 = .17$, $F = 6.85$, $p < .05$). The addition of a secondary anthropometric measure (leg length) resulted in an R^2 of less than 4% ($F = 1.22$, $p > .05$). The addition of the neural component as a second predictor was non-significant ($R^2 = 0.002$, $p > .05$). For females the initial predictor was leg length ($R^2 = .28$, $F = 15.42$, $p < .01$). Adding a secondary anthropometric measure to this equation had an R^2 of less than 2% ($F = 0.53$, $p > .05$). The R^2 when neural drive was added to the equation was 5.35% ($F = 2.21$, $p > .05$).

CONCLUSION: Consistent with previous work by Green et al. (2011) for the upper limb, body mass was still the stronger predictor of dorsiflexion strength for males, while it was limb length for females. Additional anthropometric measures and EMG did not significantly improve the prediction equation in the lower leg. These findings are important for simple and easy strength prediction in the work place.

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BIOM_P2.1 NEUROMECHANICAL PROPERTIES OF PLANTAR FLEXORS IN OLDER VERSUS YOUNGER HEALTHY WOMEN

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Mr Hae Dong Lee, Yonsei University; Mr Jin Young Jung, Yonsei University; Mr Dae Yeon Lee, Yonsei University; Mr Sung Cheol Lee, Yonsei University

INTRODUCTION: With aging, degradation of muscular function appears to be natural, resulting in physical health ailments and furthermore loss of independence. Loss in muscle function can be attributed to decreases in muscular mass (senile sarcopenia) along with neuromuscular interaction.

AIM: The purpose of this study was to compare the differences of neuromechanical properties between older and younger healthy women.

METHODS: Fifteen younger females (age; 20.4±0.6 yrs, height: 164.8±4.3 cm, weight: 55.3±5.8 kg) and fifteen older females (age; 63.7±3.3 yrs, height: 153.2±4.5 cm, weight: 57.5±8.7 kg) participated in this study. In order to assess strength and neuromuscular function of the triceps surae muscles, a custom-built dynamometer, electrical stimulator (GRASS-88, GRASS Technology, USA), and electromyography (Trigono Wireless 8chanel, Delsys, Boston, MA) were used. Subjects performed maximal voluntary ramp isometric ankle plantarflexion at systematically different ankle joint angles (0 and 10 degrees dorsiflexion (DF) and 10 and 30 degrees plantarflexion (PF)). The maximal voluntary torque, twitch torque during resting, and interpolated twitch torque during maximal voluntary plantarflexion torque, were examined. Torque –angle relationship and muscle inhibition of the triceps surae muscles were compared between younger and older females. Two-way repeated-measure ANOVA was used to test statistical significance.

RESULTS: Torque-angle relationship during isometric ankle plantarflexion was found to be significantly different between younger and older females (group, angle, and group*angle $P<0.001$), 10 degrees DF at (119.34±17.08 Nm and 62.37±34.17 Nm), zero degrees (110.53±19.41 Nm and 59.89±27.59 Nm), 10 degrees PF 10 (95.47±19.72 Nm and 51.64±21.08 Nm), and at 30 degrees PF (64.63±17.08 Nm and 39.44±11.31 Nm), respectively. Muscle inhibition was found to be significantly different between younger and older females (group, $p<0.001$; angle, $p<0.17$; group*angle, $p<0.084$), at 10 degrees DF (17.52±6.61 % and 47.48±24.11 %), zero degrees (18.11±10.39 % and 45.55±27.91 %) and 10 degrees DF (18.71±5.68 % and 45.22±25.50 %), and 30 degrees PF (31.84±17.59 % and 48.03±15.06 %), respectively.

CONCLUSION: Older females were found to show significantly smaller ankle plantarflexion torque values which seemed to be largely due to greater muscle inhibition, suggesting regular exposure to strength training for maintenance of muscle strength and function for independent life.

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BIOM_P2.2 THE EFFECT MEASUREMENT OF THE ORTHOSIS BY ACCELEROMETER

Mr Takahiko Fukumoto, Kio University

INTRODUCTION: It is very effective to use an accelerometer for motion analysis. We reported on gait analysis using an accelerometer at ISEK 2010. This tool can measure force in parts of the body that would otherwise be impossible to measure. For example, the accelerometer can measure the lateral thrust of the knee. However, is a quantitative evaluation possible only with an accelerometer? Whether or not effective measurements of orthoses can only be taken with an accelerometer has not been reported.

AIM: To determine whether: (a) quantitative evaluation of the lateral thrust of the knee is possible with an accelerometer; and (b) if lateral acceleration of the knee is altered in people with osteoarthritis when using an orthosis compared to barefoot walking.

METHODS: The study population comprised eight women (age: 70.9±6.8yrs; height: 150.0±5.9cm; weight: 53.3±4.9kg), all of whom had osteoarthritis of the knee (grade 3-4). Written informed consent was obtained from all participants before initiating the study.

A triaxial accelerometer was attached to subjects' skin over the center of the lateral condyle of the diseased side. Participants were tested in two conditions: barefoot; and wearing a lateral wedge insole orthosis. Participants walked at their preferred but constant speed (2.9km/h±11%) for about 10 meters. The same experiment was performed three times. Peak acceleration was calculated, and the mean value for each parameter determined. The sampling frequency of the accelerometer was 100 Hz. Lateral acceleration in the two conditions was compared using a t-test.

RESULTS: Putting on an orthosis did not cause pain for any participant. Lateral acceleration reached its maximal value in the heel contact phase. Lateral acceleration levels during walking were recorded as: 16.6±5.2m/s^2 (barefoot); and 13.8±4.9m/s^2 (wearing orthosis) ($p < 0.01$).

CONCLUSION: According to Newton's equation of motion, acceleration occurs in proportion to an ipsilateral force. Because lateral acceleration decreased in this study, lateral thrust also decreased. However, we are unable to effectively identify significant acceleration because the standard deviations in acceleration vary. Therefore, we can use an accelerometer as a simple tool for clinical evaluations; however, it cannot serve to effectively compare acceleration values between one person and another.

BIOM_P2.3 A COMPARISON OF THREE-DIMENSIONAL KINEMATICS AND GROUND REACTION FORCE BETWEEN INSTEP AND OUT-FRONT SOCCER KICKS

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INTRODUCTION: The out-front kick (OFK) is both important to shooting success and game excitement. The research to describe the characteristics of OFK is needed.

AIM: The aim of this study was to compare three-dimensional kinematics and ground reaction forces (GRF) of the lower extremities between the instep kick (ISK) and OFK kick in collegiate soccer players.

METHODS: Eight male collegiate soccer players (age: 20.4±0.7 years, height: 183.1±6.1 cm, weight: 75±4.4 kg) randomly performed the ISK and OFK. Three-dimensional data and GRFs were measured during all kicking trials. The motions of both kicks were captured using a three-dimensional motion analysis system (Vicon MX-F20, Oxford, UK). Support foot kinetic data were also collected using force platform (ORG-6, AMTI, Watertown, MA, USA). Support foot to ball distance, support foot angle of direction, peak ball velocity, segment angles, maximal angular velocity, and GRF were calculated for each trial. Paired t-tests were performed at the significant level of .05 to test differences between measures.

RESULTS: No significant ($P > .05$) differences in peak ISK ball velocity (22.25+3.42 m.s-1) compared to OFK ball velocity (21.41+3.42 m.s-1). The OFK was found to have a greater anterior-posterior distance (mid-foot center of support foot to ball center = -17.96+8.29 cm) and closer medial-lateral distance (mid-foot center of support foot to ball center = 21.90+3.21 cm) from the ball in comparison to the ISK (AP distance= -5.29+4.35 cm, ML distance= 29.35+2.77 cm) ($P < .05$). Angle direction of the support foot during the OFK was not in agreement with the ball direction. The OFKs displayed higher knee flexion (64.74+5.83 deg) and internal rotation (9.13+6.78 deg), ankle inversion (-3.10+2.66 deg) and adduction (15.45+13.14 deg) angles in the kicking leg than the ISK ($P < .05$). Also, the OFK displayed lower hip adduction (-5.40+3.63 deg), and ankle plantar-flexion (-13.45+11.38 deg) in the kicking leg than the ISK (hip adduction = -15.37+3.07 deg, ankle plantar flexion = -32.37+6.28 deg) ($P < .05$). The ISKs displayed higher peak lateral GRF (0.39+0.13 BW) than the OKF (-0.15+0.19 BW) ($P < .05$).

CONCLUSION: Our results suggest it to be difficult for goalkeepers to predict the direction of the ball when soccer players perform the OFK. When performing OFK, Soccer players should be careful to prevent high vertical projectile height. In addition, Different types of kicks require different types of skill training.

BIOM_P2.4 THE INFLUENCE OF WHEELCHAIR TILT-IN-SPACE ON PRESSURE FORCE AND SHEAR FORCE ON THE BUTTOCK

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Mr Takahiko Fukumoto, Kio University; Mr Shu Morioka, Kio University; Mr Yohei Okada, Kio University

INTRODUCTION: Wheelchairs are commonly used to prevent the bedridden in elderly and disabled people. Prolonged sitting is one of the causes of decubitus ulcers. Decubitus ulcers occur from sustained pressure force and shear force on the buttock–seat interface. We need to decrease pressure force and shear force on the buttock to prevent the decubitus ulcers. Reclining function in the wheelchairs decrease the pressure force, but adversely increase the shear force. Tilting function in the wheelchairs also decrease the pressure force. There have been little studies to investigate the effects of tilting function in the wheelchairs on the shear force.

AIM: The purpose of this study was to investigate the influence of wheelchair tilt-in-space on pressure force and shear force on the buttock.

METHODS: Twelve healthy subjects aged 24.3±2.2 years participated in this study. Protocols of three wheelchair tilt-in-space, including (1) 0° tilt-in-space (2) 10° tilt-in-space, (3) 20° tilt-in-space, were randomly assigned to participants. Participants sat in five minutes in each condition. To measure the amount of force applied to the gluteal region while sitting, a force plate (FORCE PLATE Ktsmp, Anima Crop., Japan) was used to measure the floor reaction force in the vertical and the anteroposterior direction on the wheelchair . The vertical component of the floor reaction force express as pressure force and the anteroposterior component of the floor reaction force express as shear force in the anteroposterior direction. The sampling frequency was 20 Hz. The average value during 5 minutes measurement was calculated. One-way analysis of variance with repeated-measures design was used to examine the effect of wheelchair tilt-in-space on vertical and anterior components of the floor reaction force. Bonferroni correction was used for post hoc analysis. All statistical tests were performed at an alpha level of .05.

RESULTS: The vertical and the anteroposterior components of the floor reaction force were significantly different among three conditions. The vertical component of the floor reaction force in 10° tilt-in-space and 20° tilt-in-space significantly decrease as compared with that in 0° tilt-in-space. The anterior component of the floor reaction force in 10° tilt-in-space significantly decrease and the posterior component of the floor reaction force in 20° tilt-in-space significantly increase in comparison with that in 0° tilt-in-space.

CONCLUSION: The results in the present study indicated that 10°tilt-in-space decrease the pressure force and shear force in the buttock during sitting on the wheelchair. 10° tilt-in-space might be possibly an effective intervention for preventing the decubitus ulcers in elderly and severely disabled people.

BIOM_P2.5 A COMPARISON AMONG SPORT TASK CHARACTERIZED BY EXTERNAL GRAVITY CONTROL. PRELIMINARY SPECULATION BASED ON AUTOMATIC VISUAL ANALYSIS

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Mr Donato Formicola, Motor Science Research Center, Turin

INTRODUCTION: Muscle activity is strictly dependent by external constraints (e.g. the force of gravity, among others). The effectiveness in motor control is influenced by internal and external force interactions and by co-contraction strategies. Co-contractions, induced in response of external forces, can drive the harmonious evolutions of the gestures in élite athletes.

AIM: The aim of this research was to show that a basic motor task (BMT) performed in terrestrial dynamic situations is organized in terms of number and duration of actions in response to the contribute of the gravity with respect to the whole set of constraints.

METHODS: Four BMTs belonging respectively to four sport disciplines were considered: 1) the free throw in basketball (BB), 2) the ride of an obstacle in the Trial, a sport motorcycle speciality (TR), 3) the Snatch in Olympic Weightlifting (SN) and, 4) the dive, in the short-distance swimming competitions (DV). Gravity was managed in different manner to accomplish each BMT. The sequence BB, TR, SN, and DV, ordered BMTs with respect to the importance of gravity in the athlete movement. Ten top-level athletes were recruited for each BMT. Biomechanical models of the BMTs were obtained by the first component of a PCA (PC1) of the inverse dynamic data (radial and tangential) recorded with a stereoscopic motion-capture system (for BB, TR and SN) and a comparative analysis of the last ten-year specific literature (for DV). PC1s were normalized in timeline and magnitude to allow the comparison among the four BMTs.

RESULTS: When the athletes were prone to move on the ground, the PC1 showed positive variations of the trends. When the athletes utilized the gravity to execute a number of flying movements, the PC1 trend dropped down. This findings were consistent with the ballistic laws. Friedman Test highlighted statistically significant difference ($p<0.001$) among PC1s. A Dunn-Sidak Post Hoc Test showed significant differences between BB and the other BMTs. Cross-correlations were found statistically significant different ($p<0.05$) in time delays between BB and TR, TR and SN, TR and DV, and SN and DV. In the other cases, R^2 was found always lower than 0.1, that is those BMT were aligned in time but showed different time course.

CONCLUSION: This work try to describe and visually depict differences in time course of different BMT, using a single automatic approach PCA-based. Two clear clusters (BB versus the others) were identified due to the importance of the gravity force constraint.

BIOM_P2.6 A RANDOMIZED CROSS-OVER STUDY OF THE PRESSURE DISTRIBUTION MAP OF EXTERNAL CHEST COMPRESSION AMONG SUBJECTS PERFORMING 30:2 AND CONTINUOUS CARDIOPULMONARY RESUSCITATION

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INTRODUCTION: The major injuries in external chest compression during cardiopulmonary resuscitation are the rib, sternum and xiphoid process fractures [1,2]. The main cause of the fractures may due to the non-balanced pressure distribution of the palm when performing the external chest compression. The goal of external chest compression is to increase the inter-thoracic pressure and press onto the heart directly to provide oxygen-rich blood to the brain and the heart. Teaching and retention of the CPR skill is an important issue of the curriculum, including how and what the nest strategy of hands placement during CPR.

AIM: The purpose of this study was to develop the pressure distribution map when performing 30:2 and continuous external chest compression of CPR.

METHODS: 14 male and 32 female subjects with CPR license performed 30:2 (30:2-CPR) and continuous (C-CPR) three-minute external chest compression with dominant hand under 100 and 120 compressions per minute, respectively, while the pressure sensor- MatScan– Pressure Measurement System Evolution Based (Tekscan Inc, South Boston, USA) was recorded. The sampling rate of the pressure sensor was 300 Hz. The pressure distribution map of the palm and the maximum pressure value were analyzed for each minute.

RESULTS: Our study showed that the pressure distribution map of female focus on the ulnar side of the palm, but the pressure map became a line shape parallel to the sternum. In contrast, the male subjects have the pressure more shifed onto the radial side of the palm. And no matter the gender are, the pressure map of 30:2-CPR shift to left side compared to C-CPR. The shift of the pressure to either radial or ulnar side might cause xiphoid fractures or rib and sternum fractures.

CONCLUSION: Because the unbalanced pressure distribution might be the main cause of the fractures during external chest compression, our results support that there are a gender effect on pressure distribution map under different CPR skills. In female, the results indicate the pressure shift to the ulnar side under C-CPR and to the left side and become a horizontal line shape as pressure time increased under 30:2-CPR. This factor might result in sternum or rib fractures of the patients while receiving CPR. But the pressure shift to radial side in male means the pressure shift onto the abdominal region. That indicated the non-efficiency CPR skill. Thus it is important to learn the skills to keep the pressure balanced distribution over the chest region during external chest compression of CPR.

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BIOM_P2.7 THE EFFECT OF THE MOVEMENT DIRECTIONAL DIFFERENCES ON ELECTROMYOGRAMS RECORDED FROM THE SHOULDER JOINT MUSCLES IN THE SAME POSITION

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INTRODUCTION: Understanding the contribution of the rotator cuff and other shoulder muscles to complex movements of the upper limbs is necessary for clarifying the roles of these muscles during various activities. The functional activities of the shoulder muscles in a single movement direction have been shown by previous studies. However, these studies have not clarified whether shoulder muscle activity differs for different movement directions when the upper limbs are in the same position.

AIM: The purpose of this study was to compare electromyograms recorded from the shoulder joint muscles in the same position for different movement directions.

METHODS: The study included 15 healthy subjects. The subjects performed shoulder elevation from 0° to 120° (EV), shoulder depression from 120° to 0° (DR), shoulder horizontal adduction from -15° to 105° (HD), and shoulder horizontal abduction from 105° to -15° (HB). The subjects completed raised and lowered the shoulder across 4 movement planes. The horizontal abduction angles were 0° (0° plane), 30° (30° plane), 60° (60° plane), and 90° (90° plane). Electromyographic (EMG) signals were recorded from the supraspinatus (SSP) by using fine wire electrodes. EMG signals from the infraspinatus (ISP), anterior deltoid (AD), middle deltoid (MD), posterior deltoid (PD), pectoralis major (PM), biceps brachii (BB), and upper trapezius muscles (UT) were recorded using active surface electrodes. The shoulder joint angle was recorded using an 8-camera motion capture system. The angular velocity was set at 10°/sec. The average rectified EMG values were calculated as a percentage of the maximal voluntary contraction (%ARV). The differences in the muscle activity in the 4 movement directions (EV, DR, AD, and AB) were compared using one-way analysis of variance.

RESULTS: During EV and HB, the SSP showed significantly higher activity than that shown during DR, and HD in the 0°, 30°, and 60° planes. The EMG activity did not significantly differ among the movement directions in the 90° plane. During EV, the ISP showed significant higher activity than DR, and HD in the 90° plane. And during HB, the ISP showed significant higher activity than DR in the 90° plane. The EMG activity did not significantly differ among the movement directions in the 0°, 30°, and 60° planes. The EMG activities of the other muscles significantly differ among the movement directions.

CONCLUSION: The current results indicated that the EMG activity of the SSP changed depending on the movement direction. The EMG activity of the ISP didn't clearly changed depending on the movement direction. All the muscles showed different EMG activity depending on the movement direction.

BIOM_P2.8 SURFACE ELECTROMYOGRAPHIC ACTIVITY OF POSTERIOR MUSCULAR CHAIN DURING SELECTED NECK-TRAINING EXERCISES

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Author in absentia

INTRODUCTION: Despite the importance of neck muscle strengthening in contact sport like rugby or wrestling, the impact of neck conditioning exercises on cervical muscle recruitment has not been fully investigated.

AIM: To compare activation level of posterior cervical (C), thoracic (TH) and lumbar (L) muscles across different common neck-training modalities.

METHODS: 15 amateur rugby players unaccustomed to neck strengthening participated to the study. Surface electromyographic (SEMG) activity was recorded bilaterally over the cervical (C4), thoracic (TH9, TH12) and lumbar (L3, L5) extensor muscles during 1/ head bridging on a stable Swiss-ball maintained by one experimenter (HBSW-S), 2/ head bridging on an unstable Swiss-ball self-maintained by the subject (HBSW-U), 3/ head bridging on the ground (HBG) and 4/ maximal isometric cervical extension in a quadruped position against external manual resistance (CE-4PK). SEMG activity was normalized to that obtained during appropriate maximal isometric voluntary contraction (MVIC) and averaged across sides. Then, SEMG amplitude ratio (C/THL) was computed to determine the degree of specificity of selected neck exercises in recruiting preferentially the cervical muscles compared to the thoraco-lumbar muscles (THL).

RESULTS: During all exercises, cervical extensors were relatively more recruited than trunk muscles (C: 87+/-25% vs. TH: 47+/-13% and L: 38+/-9% MVC; $P<0.001$). In addition, cervical activation level was lower during HBSW-S (66+/-15%MVIC, $P<0.001$) while HBSW-U and HBG exhibited the highest SEMG values (95-97%MVIC, $P<0.001$). However, C/THL SEMG ratios during head-bridging exercises (1.5+/-0.1 to 1.9+/-0.2) were lower than during CE-4PK (3.4+/-0.4, $P<0.001$).

CONCLUSIONS: Our findings indicate that all exercises may be useful for neck muscle strengthening. In addition, they suggest that neck extension performed in quadruped position is more suitable for selective cervical extensor muscles than maintaining head-bridging postures on and off a Swiss-ball. This may help clinicians and coaches to select the appropriate exercise depending on whether or not high recruitment of cervical muscles is needed alone or in combination with thoraco-lumbar muscles. Overall, even though additional research is warranted to further substantiate the biomechanical and clinical significance of SEMG ratios, exercise prescription should be undertaken with care as the mechanical loading on the passive structures of the cervical spine is unknown in these neck-training modalities.

CLINICAL NEUROPHYSIOLOGY

CLNE_P1.1 ATLAS OF THE MUSCLE INNERVATION ZONES FOR PROPER SURFACE EMG ELECTRODES PLACEMENT: TRUNK AND UPPER QUADRANT MUSCLES

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INTRODUCTION: Electrode positioning for surface EMG detection is important to obtain accurate estimation of signal variables. Literature recommendations suggest that surface EMG electrodes should be placed between the innervation zone (IZ) and the proximal/distal tendon. Nevertheless, complete information about IZ location for skeletal muscles is neither standardized, nor available. We conducted a multicenter study to investigate the most relevant superficial muscles and provide details for ensuring a proper positioning of bipolar electrodes for both clinical and research applications.

AIM: The purpose of this work is to highlight the IZ location in muscles of the trunk and upper quadrant

METHODS: Forty healthy subjects (20 males and 20 females) aged between 20 and 30 years were enrolled after giving written consent. IZs were investigated by visual analysis of single differential multichannel surface EMG signals. Location of IZs was identified where signals showed minimal amplitude and/or phase reversal. Surface EMG signals were acquired during submaximal isometric contractions using a linear array of 16 electrodes, with an interelectrode distance equal to 2.5 or 5 mm (according to the muscle length), applied on standard anatomical landmark frames.

Surface EMG signals were recorded from 15 muscles: Rectus abdominis, Infraspinatus, Latissimus dorsi, Serratus anterior, Erector spinae, Sternocleidomastoid caput sternalis, Brachioradialis, Extensor carpi ulnaris, Extensor carpi radialis, Flexor carpi radialis, Pronator teres, Palmaris longus, Flexor pollicis brevis, Abductor pollicis brevis and Abductor digiti minimi.

RESULTS: Except for Brachioradialis, only one innervation zone was found in all the analysed muscles. No significant differences in IZ location were found between males and females.

Extensor carpi ulnaris, Serratus anterior and Erector spinae did not show any IZ, probably due to their segmented structure. Rectus abdominis showed three different IZ, confirming its anatomy of a segmented muscle.

CONCLUSION: On the basis of anatomical landmarks, optimal electrode sites for 12 muscles out of 15 was identified. Hence suggestions for a proper electrode placement are provided in order to increase standardisation and reliability of surface EMG investigation.

CLNE_P1.2 ATLAS OF MUSCLE INNERVATION ZONES FOR PROPER SURFACE EMG ELECTRODES PLACEMENT: LOWER LIMB MUSCLES

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INTRODUCTION: Electrode positioning for surface EMG detection is important to obtain accurate estimation of signal variables. Literature recommendations suggest that, for fusiform muscles parallel to the skin, surface EMG electrodes should be placed between the innervation zone (IZ) and the proximal/distal tendon. Nevertheless, complete information about IZ location for skeletal muscles is neither standardized, nor available. We conducted a multicenter study to investigate the most relevant superficial muscles and provide details for ensuring a proper positioning of bipolar electrodes for both clinical and research applications.

AIM: The purpose of this work is to highlight the IZ location in superficial muscles of the lower limb.

METHODS: Forty healthy subjects (20 males and 20 females) aged between 20 and 30 years were enrolled after giving written consent. IZs were investigated by visual analysis of multichannel single differential sEMG signals. Location of IZs was identified where signals showed minimal amplitude and/or phase reversal. Surface EMG signals were acquired during submaximal isometric contractions using a linear array of 16 electrodes, with an interelectrode distance equal to 2.5 or 5 mm (according to the muscle length), applied on standard anatomical landmark frames.

Surface EMG signals were recorded from 13 muscles: Gluteus maximus, Gluteus medius, Vastus lateralis, Vastus medialis, Rectus femoris, Semitendinosus, Peroneus longus, Tensor fascie latae, Soleus, Gastrocnemius lateralis, Gastrocnemius medialis, Biceps femoris and Tibialis anterior.

RESULTS: The location of the IZ was not recognised across all subjects in some lower limb muscles due to the poor quality of surface EMG signals or high pennation angle. In 4 out of 13 muscles the IZ was identified in less than twenty subjects. As previously reported in literature Gluteus medius and Soleus showed an IZ only exceptionally. Only Vastus medialis and Vastus lateralis showed clear surface EMG signals and always detectable IZ. No significant differences in IZ location were found between males and females.

CONCLUSION: On the basis of anatomical landmarks, optimal electrode site for 7 muscles out of 13 has been identified. In 6 out of 13 muscles we strongly suggest to determine the IZ location before placing the electrodes. Therefore suggestions for a proper electrode placement are provided in order to increase standardisation and reliability of surface EMG investigation.

CLNE_P1.3 USING NON INVASIVE BRAIN STIMULATION TO MODULATE ANTICIPATORY POSTURAL ADJUSTMENTS AFTER STROKE

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INTRODUCTION: The physical and behavioral consequences of stroke can include motor disabilities such as asymmetric gait and increased fall rate. Abnormal anticipatory postural adjustments (APAs) immediately before step initiation may contribute to these deficits. Step initiation APAs are the muscle activations and inhibitions occurring prior to voluntary stepping that help maintain the body's equilibrium in preparation for the forthcoming movement.

AIM: The principal aim of this study was to investigate between-limb step initiation APA asymmetries in stroke patients and healthy controls, and to transiently modify this asymmetry in stroke patients using anodal transcranial direct current stimulation (aTDCS). We hypothesized that stroke patients would show asymmetric step initiation APAs, with longer muscle activation onset times (MAOTs) for their paretic leg than their non-paretic leg, and that upregulation of lesioned motor cortex (M1) would transiently improve MAOTs in stroke patients.

METHODS: Step initiation task – We recorded bilateral electromyography (EMG) from the tibialis anterior (TA) and soleus (SOL) muscles as subjects stepped forward with a designated foot in response to an auditory cue. Ten trials were conducted for each leg as the stepping limb. A foot switch reported the precise time of heel-off to verify that all APAs were made before movement onset. Seated task – Subjects were seated comfortably and TA EMG was collected as they dorsiflexed the designated foot as quickly as possible in response to an auditory cue (simple reaction time). Stimulation – Subjects performed the same step initiation task and seated task after application of anodal transcranial direct current stimulation (aTDCS) over M1 of the affected hemisphere (stroke) or the left hemisphere (controls).

RESULTS: Delayed MAOTs were revealed for the paretic limb of stroke patients when it was the stepping limb and the stance limb compared with the non-paretic limb. MAOTs during the seated task were longer then in the step initiation task for healthy and stroke subjects. aTDCS transiently shortened MAOTs in both subject groups with a greater change for stroke subjects.

CONCLUSION: We conclude that M1 is integral to the generation of step initiation APAs. Data help inform the use of aTDCS as a therapeutic tool after stroke. We plan to investigate associations between other measures of step initiation APAs including center of pressure variability and measures of corticospinal tract integrity.

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CLNE_P1.4 CHANGES IN SURFACE EMG INTERFERENCE PATTERN WITH MUSCLE FORCE DURING VOLUNTARY CONTRACTION

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INTRODUCTION: The interference pattern of the surface electromyographic signal (surface EMG) is produced by the summation of individual action potentials from active motor units in a muscle. Interference pattern analysis of EMG has been used to describe the physiological and pathological conditions of skeletal muscles. One of the commonly used methods is Turns-Amplitude Analysis (TAA). A turn in the EMG signal is defined as an independent of the baseline potential reversal that exceeds an established threshold (100µV is commonly used). Turn amplitude is defined as the electric potential change between two turns. Because muscle force is modulated by two neural mechanisms - motor unit rate-coding and recruitment, it could be expected that the interference pattern of EMG changes with muscle force output. Typically, TAA is used to analyze EMG signals obtained at a given force level, however, it is unclear how TAA parameters (turns/second & turn amplitude) change with different levels of motor unit rate-coding and recruitment (i.e. different muscle force levels).

AIM: Determine values of TAA parameters at different force levels during voluntary muscle contraction

METHODS: Subjects were seated comfortably on a chair with their dominant arm (45-degree shoulder flexion, 90-degree elbow flexion) secured on a custom device for elbow flexion force measurement. Fixed-disc electrodes were attached on the skin above biceps brachii muscle to record EMG signals. MVC was first determined and then subjects were asked to perform 3-second isometric elbow flexion at four force levels (20, 40, 60, and 80% MVC). Visual feedback on a computer screen and verbal cue were provided to encourage the subjects to maintain steady the force output.

RESULTS: Our preliminary results show that although both parameters (turns per second and mean amplitude) increase with the force levels, mean amplitude increased linearly with force levels but turns per second and force levels has a sigmoidal relationship with a rapid rising portion from 20 to 60% MVC and plateaued after 80% MVC.

CONCLUSION: It has been reported that all the motor units in biceps brachii are recruited at force level around 88%. It appears that the value of turn amplitude is mainly influenced by motor unit rate-coding as its relationship with force was linear throughout the full force range. On the other hand, turns per second appears to be influenced by motor unit recruitment as its value plateaued when recruitment is completed. Understanding how EMG interference pattern change as a function of force could potentially expand its clinical application and help clinicians and researchers better understand the neuromuscular system.

CLNE_P1.5 A COMPARISON OF TWO METHODS IN ACQUIRING STIMULUS-RESPONSE CURVES WITH TRANSCRANIAL MAGNETIC STIMULATION

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INTRODUCTION: Transcranial magnetic stimulation (TMS) Stimulus-response (S-R) curves are constructed by plotting the motor evoked potential (MEP) output against the stimulus intensity. S-R curves allow investigators to determine parameters in participants such as motor threshold (MT) and maximal MEP amplitude (MEPmax). S-R curves are used ubiquitously in many different TMS study protocols, however few studies have investigated the methodology of the S-R curve itself; in particular whether properties of the S-R curve differ when investigators use either a "ramped" method starting from a low stimulus intensity and increasing intensity of 5% steps of stimulator output (i.e. 35%, 40%, 45% etc) or a "randomised" method with no particular order in the delivery of stimuli intensity (i.e. 55%, 40%, 85% etc).

AIM: This study compared S-R MEP and SP duration response curves to TMS, using to either a ramped or randomised methodology in a hand and arm muscle of both limbs.

METHODS: Ten healthy males and females (mean ± SD, age 29.6 ± 6.4 years, 3 female), free of neurological condition, completed two separate testing sessions for the first dorsal interosseous (FDI) and biceps brachii (BB) muscles of both limbs. In one session participants completed, in randomised order, a ramped S-R curve and a randomised curve in left and right FDI muscles. In the other session, participants returned and completed S-R curves, in randomised order, for the BB muscle. Testing between hands and arms were randomised between participants. Both MEP amplitudes and SP durations were plotted against TMS intensity and calculated via a fitted non-linear Boltzman sigmoid equation. MEP amplitude and SP duration were also correlated between S-R curve methods for homologous muscles.

RESULTS: No differences were observed in MEP MT or MEPmax amplitude, and SP duration thresholds and maximal durations between ramped or randomised S-R curves of homologous muscles ($P>0.05$). Statistically significant correlations were observed between MEP amplitudes and SP durations at similar stimulus intensities between ramped or randomised S-R curves for homologous muscles ($r=0.78$ to 0.97; $P<0.01$).

CONCLUSION: This study has demonstrated that investigators can use either a ramped or randomised S-R curve protocol without the concern of creating “serial order” effects that may affect MEP amplitude or SP duration.

CLNE_P1.6 A CLINICALLY APPLICABLE TIME-FREQUENCY CHARACTERIZATION OF SPASTIC MUSCLE ACTIVITY

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INTRODUCTION: Cerebral Palsy (CP) may cause permanent loss of movement coordination and impaired locomotion mainly due to tone abnormalities. Previous studies have been dedicated to the characterization of an electromyographic (EMG) signal of a spastic muscle and showed differences in the frequency content of the EMG relative to the unimpaired muscle. However, these studies are based on advanced signal processing and statistical techniques that may threaten their daily use in a clinical environment.

AIM: The aim of this study was to develop a time-frequency analysis to be used in a daily clinical environment to characterize the electromyographic signal of spastic muscles.

METHODS: A single blinded analysis was conducted. Only physicians who recorded the data knew the patients' impairment side. This information was confronted to the results of the time-frequency analysis to validate the proposed characterization. Ten unilateral spastic CP subjects were asked to walk at their self-selected speed. Dynamic electromyographic (EMG), ground reaction, and foot switches data were collected at 2000 Hz. The most reproducible gait cycles were selected based on the reproducibility of the foot switch pattern and further used for the time-frequency analysis. Bilateral EMG data of the medial gastrocnemius muscles were first bandpass filtered (Butterworth, zero time-lag, 4th order, cut-off 10-400 Hz) then subjected to a Discrete Wavelet Transform using a Morlet mother wavelet. From each time-frequency map, the mean value of the frequencies corresponding to the maximal amplitude at each time was further used to characterize the frequency content of the EMG signal.

RESULTS: The unimpaired side showed a statistically lower maximal frequency content than the impaired side (66.83 ± 19.23 Hz vs. 96.21 ± 17.39 Hz). The detection of the impaired side from the EMG data was proven successful for all subjects (100% success in the blind analysis).

CONCLUSION: Based on a time-frequency analysis, the proposed methodology allows characterization of the spastic muscle EMG signal that can be used on a daily basis in a clinical environment. Studies about the frequency content evolution after botulinum toxine injections may be further considered.

CLNE_P1.7 3D SPATIAL CHARACTERISTICS OF MASSETER MOTOR UNITS OBTAINED BY SCANNING EMG AND HIGH-DENSITY SURFACE EMG

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INTRODUCTION: The human masseter muscle has a complex multipennate structure and consists of several deep and superficial parts separated by 3-5 tendon sheets running parallel to the surface of the cheek. Localized motor unit (MU) territories and task specific MU activity enables this muscle to control specific and separated muscle portions independently. Previous studies found most masseter MU territories to occupy only a small portion of the muscle's cross sectional area, and only ca. 10% of them extend across the tendon sheets. It is as yet unknown how MUs of the different subdivisions of the masseter are represented at the skin surface.

AIM: To determine 3D spatial MU characteristics of the masseter muscle by means of adapted scanning EMG and high-density surface EMG (HDsEMG) techniques.

METHODS: HDsEMG of the masseter muscle was obtained using a specifically designed electrode grid consisting of 256 electrodes (1 mm in diameter, inter-electrode distance 3 mm). Two pairs of fine wire electrodes were inserted into the muscle through holes in the grid at a distance of 6mm and at depths of ca. 7mm and 15mm, respectively. An additional monopolar needle was inserted for the scanning EMG recording in between the two fine wires electrode pairs. While the subject kept a constant contraction level (with ca. 8-12 MUs visible in the superficial wire pair), the needle was retracted from its initial (deep) position at the lateral mandibular ramus using a stepper motor with a feed of 150µm per second. Since we used the decomposed fine wire EMG for triggering the scanning signal, multiple MUs could be scanned in one run. Also HDsEMG MU action potentials were obtained by spike triggered averaging.

RESULTS: So far, we have obtained signals from one healthy subject in which we performed two scans at different positions. In a first attempt, 15 MUs were decomposed from the fine wire electrodes. However, none of these MUs were visible in the scanning needle and surface EMG signals, respectively. In the second attempt 7 distinct MUs could be identified in the scanning needle. These MUs varied in territory and depth to a great extent although they were triggered by a single bipolar wire signal. All of these 7 MUs showed also spatial amplitude profiles at the skin surface.

CONCLUSION: In this preliminary study, we successfully implemented an adapted approach for simultaneously scanning multiple MUs territories in one run. With HDsEMG we can simultaneously determine the spatio-temporal surface profile of these MUs. From recordings in more subjects we expect to add substantial basic knowledge on this highly complex and important masticatory muscle. This information is indispensable for correct interpretation of both invasive and surface EMG recordings.

CLNE_P1.8 NON-INVASIVE DIAGNOSIS OF NEUROMUSCULAR DISORDERS BY HIGH-SPATIAL-RESOLUTION-EMG

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INTRODUCTION: The diagnosis of neuromuscular disorders, especially during childhood, is of major interest for task-orientated therapy. The changes in the skeletal muscles are mostly related to changes in the electrical activity of single motor units (MUs). Therefore, information about the single MU activity is essential for the diagnosis of neuromuscular disorders. However, in clinical practice this information is gained with invasive methodologies. High-Spatial-Resolution EMG (HSR-EMG) detects the single MU activity non-invasively. This methodology is based on the use of a multi-electrode array in combination with a spatial filter processing. Initial clinical investigations have shown that the HSR-EMG signal is changed in a characteristic way in patients with muscular and neuronal disorders. This might allow a reliable distinction to be drawn between healthy volunteers and patients with neuromuscular disorders, as well as between patients with muscular disorders and patients with neuronal disorders.

METHODS: To quantify the typical changes in the HSR-EMG pattern in each patient group, a set of seven parameters was introduced. The parameters can be divided into three groups, regarding (a) the excitation spread, (b) the entire signal course in time, and (c) the shape of isolated peaks within the signal. A classification procedure was developed by means of a fuzzy approach, which makes distinctions based on the parameter set between patients and healthy volunteers as well as between the three groups.

For clinical validation, HSR-EMG recordings were taken at isometric, maximum voluntary contraction of the abductor pollicis brevis muscle of healthy volunteers and patients suffering from Duchenne Muscle Dystrophy (muscular disorder) and Spinal Muscle Atrophy (neuronal disorder). After determination of the parameter values, the HSR-EMG signal of each patient was assigned to one of the three groups by fuzzy classification.

RESULTS: By means of the classification procedure, 100% of all investigated healthy children, 100% of all investigated patients with muscular disorders, and 87% of all investigated patients with neuronal disorders were correctly identified. This means that, on average, in 97% of all investigated subjects the diagnosis identified by means of non-invasive HSR-EMG was correct.

CONCLUSION: HSR-EMG provides information about the single MU activity non-invasively. Typical changes in HSR-EMG patterns can be evaluated using seven parameters, which allow for differentiation between different neuromuscular disorders. Therefore, the HSR-EMG promises to be a suitable tool for non-invasive diagnosis of neuromuscular disorders in the clinical setting.

CLNE_P1.9 EFFECT OF JOINT ANGLE ON MUSCLE STIFFNESS ASSESSED WITH ULTRASOUND SHEAR-WAVE ELASTOGRAPHY

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INTRODUCTION: Recently, it was demonstrated that muscle stiffness could be determined by ultrasound elastography based on the velocity of shear-wave propagation within soft tissues (Shinohara et al., 2010). It is unknown whether muscle stiffness measurement using ultrasound shear-wave elastography is influenced by muscle length.

AIM: The purpose of this study was to determine the effect of joint angle on muscle shear modulus at rest and during muscle contraction.

METHODS: Nine healthy young men (n = 6) and women (n = 3) performed a maximal voluntary contraction (MVC) task and a submaximal contraction task of elbow flexion with their right arm. These tasks were performed at 3 elbow joint angles (70, 90, 110 deg; full extension = 180 deg). For the submaximal contraction task, subjects matched elbow flexion torque with target torque (15, 30, 45, and 60% of MVC at the corresponding joint angle) for 6 s. As a measure of muscle stiffness, Young's modulus of the short head of the biceps brachii was measured at rest and during submaximal contraction task using an ultrasonic scanner capable of shear-wave elastography. Young's modulus was calculated as [3 x tissue density (1000 kgm-3) x propagation velocity suared] and expressed in kPa. Amplitude of surface electromyogram (AEMG) was measured in the short head of biceps brachii muscle.

RESULTS: There was no significant influence of joint angle on exerted torque or AEMG during MVC and submaximal contraction tasks. Young's modulus at rest increased with the joint angle. It was 11.3 ± 1.0 kPa at 70 deg, 15.5 ± 2.3 kPa at 90 deg, and 24.2 ± 3.9 kPa with significant differences between all joint angle combinations ($P < 0.05$ for all). During submaximal contraction, Young's modulus at 70 deg was significantly lower compared with 90 deg and 110 deg ($P < 0.05$ for both) across contraction levels. Young's modulus at 90 deg was lower, on average, compared with 110 deg although the difference did not reach a statistical significance ($P = 0.058$). Young's modulus increased linearly with increases in the contraction level with significant differences ($P < 0.05$) from the adjacent contraction in each joint angle. There was no significant interaction of joint angle and contraction level on Young's modulus.

CONCLUSION: Young's modulus of the resting and contracting biceps brachii muscle was lower with the elbow joint angle of 70 deg (shorter muscle length) compared with 90 and 110 deg (longer muscle length).

ERGONOMICS

ERGO_P1.1 PREVENTION OF OCCUPATIONAL MUSCULOSKELETAL OVERLOAD BY SELF-ADJUSTMENT

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INTRODUCTION: The overload of muscular or skeletal structures during occupational work represents an important cause for the development of musculoskeletal complaints and diseases and for illness-related absence from work, i.e. the requirements of work surpass the performance capacity of the working person. In this investigation two principles of prevention striving for the mutual adaptation between the occupational load and the abilities of the working person are compared, namely (a) design of work and working conditions and (b) self-adjustment of workload by the working person.

AIM: On the basis of shop-floor studies the question was examined whether mechanisms of self-adjustment exist which reduce the actual load on the muscular and skeletal system to the current performance capacity and can in this way prevent overload.

METHODS: The analysis of muscular load is based on total-day EMG recordings from 13 office workers employed in the German tax authority and subsequent evaluations of temporal changes in the EMG amplitude and frequency spectrum. Skeletal load was determined for 8 persons working in various occupations with a relevant amount of object-handling activities (surface construction, metal work at a drop hammer, industrial meat processing, dustbin removal); for these persons posture and action forces where estimated for total working shifts on the basis of video recordings and object-mass determination. Based on the posture and action-force data, 3-D biomechanical simulation calculations were performed for all relevant working situations of the working days using a previously developed computer model.

RESULTS: The study among office workers reveals that persons with a decrease in myoelectrical activity of the shoulder muscles claimed less frequently of shoulder complaints than persons with an increasing or constant muscular activity. In the study among persons with object-handling jobs, lumbar load values were cumulated for all 1-hour sections of the working days and a decrease in the cumulative lumbar load in the course of the day was observed. It is assumed that the decrease in the muscular and skeletal load, respectively, is induced by the working person itself and is interpreted as an adaptation of the workload to the current performance capacity which presumably decreases in the course of the working day.

CONCLUSION: It is concluded that mechanisms of self-adjustment exist adapting the workload to the actual performance capacity. In total, self-adjustment is assumed to represent an effective strategy to prevent musculoskeletal overload and complaints.

ERGO_P1.2 ACUTE HYPOBARIC CONDITIONS DURING FLIGHT DOES NOT AFFECT MUSCLE ACTIVATION BUT REDUCES LOCAL MUSCLE TISSUE OXYGENATION.

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INTRODUCTION: Cabin attendants are subjected to acute moderate hypobaric conditions during flight as the air pressure corresponds to approximately 2440 m above sea level. Knowledge regarding the effect of the hypobaric conditions on the work load is lacking. Cabin attendants are exposed to local static contractions (e.g. carry and serve food) as well as whole body loads (e.g. walk, push/pull).

AIM: To study if the hypobaric conditions during flight influence the local and the systemic physiological responses in the cabin attendants during work.

METHODS: 14 cabin attendants (7m and 7f) and 13 (6m and 7 f) matched controls performed isometric wrist extensions at 20 %MVC for 2x2 min (local model) and bicycling at 50 and 100 W (systemic model). Measurements were performed in a pressure chamber at normobaric and hypobaric pressures equivalent to sea level and cabin pressure during flight (2440 m.a.s.l). Forearm EMG (m. extensor carpi radialis) and forearm muscle tissue oxygenation (StO2) (NIRS) were measured during wrist extensions. VO2, heart rate and ventilation were measured during steady state bicycling. On a separate day, resting venous blood samples were taken.

RESULTS: Forearm EMG was not affected by the hypobaric condition (18.2 %EMGmax at sea level vs. 17.9 %EMGmax at 2440 m.a.s.l.). However, the hypobaric condition decreased muscle StO2 by 6.5 % both at rest and during exercise. No between group differences were found.

The hypobaric condition did not affect the majority of the systemic parameters. The exception was a small but significant increase in heart rate from 131 bpm to 135 bpm at 100 W.

The cabin crews tended to have higher haemoglobin ($p=0.1$) and hematocrit ($p=0.09$) values than controls.

CONCLUSION: The hypobaric condition, as during flight, did not influence muscle activation during the submaximal isometric contractions, whereas the local forearm muscle StO2 was decreased. The reduced tissue oxygenation quite possibly affects the development of fatigue as the reduced tissue oxygenation corresponds to oxygenation levels during higher contraction levels in normobaric conditions. The hypobaric condition did not affect the systemic response at light to moderate exercise levels.

Generally, no differences in the acute response were found between cabin attendants and the control group, indicating lack of long term adaptation to work in the hypoxic environment in the cabin attendants, although a trend was seen in the blood samples.

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ERGO_P1.3 TIME COURSE CHANGES OF TRUNK MUSCLE ACTIVITIES DURING SITTING IN A STABLE OR UNSTABLE POSITION

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INTRODUCTION: When people sit in an unstable position, for example on an exercise ball, their back muscle activity levels are higher than when sitting in a stable position such as on an office chair. We therefore developed a new tool, not to be used in exchange for a stable chair but to be placed upon it, in order to manufacture instability during sitting.

AIM: The aim of this study was to clarify characteristic changes in trunk muscle activities and trunk angle in subjects maintaining a sitting posture on the new tool.

METHODS: Fourteen subjects participated in the experiment. The experiment was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Sapporo Medical University. Trunk muscles activities were recorded with surface electromyography (sEMG) from the lumbar erector spinae (ES), rectus abdominis (RA), and external oblique (EO) muscles. Two acceleration sensors were set up on the L3 and T5 levels of the spine to calculate trunk angle. All data were A/D converted with 1-kHz sampling frequency and stored in a computer. To examine the effects of unstable sitting positions by means of the new tool, subjects were asked to sit on a padded chair without a backrest as a control condition. Subjects were instructed to maintain their seated posture for 15 minutes in both the new tool and padded chair conditions. All raw sEMG signals were band-pass filtered (Butterworth, 10-450Hz), and the average rectified value (ARV) and median power frequency (MDF) calculated. ARV was calculated as a relative value for ARV of the subject's maximum voluntary contraction (ARVmax) in each muscle (%ARVmax). Data were calculated every one minute. Calculated data were then compared between the two sitting conditions, and over the time course of the experiment.

RESULTS: In the padded chair condition, %ARVmax of the ES was gradually reduced until eight minutes. The %ARVmax of the ES from eight to 12 minutes appeared significantly lower than at the beginning of sitting. The trunk angle was also gradually bent forward in the padded chair condition. By contrast, there were no significant changes to %ARVmax in the new tool condition. MDF in each muscle was not changed in either sitting condition or over any time course.

CONCLUSION: The reduced %ARVmax of the ES in the padded chair condition suggests that the reduction of the ES activity is not caused by fatigue. Therefore, it is thought that the new tool proposed in this study could maintain ES muscle activity and trunk angle.

ERGO_P1.4 ERGONOMIC PROBLEMS WITH SURGICAL INSTRUMENTS: MECHANICAL ANALYSIS OF THE AUTOMATIC CIRCULAR STAPLER

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INTRODUCTION: Laparoscopic surgery has many advantages for patients and surgeon, whereas musculoskeletal problems such as hand or upper limb pain, discomfort and numbness among surgeon are reported. Automatic suturing instrument is commonly used in laparoscopic surgery; however, using this instrument is not easy for some surgeon because the handle design may not be appropriate for surgeons with small hands, especially for female surgeons. Although appropriate ergonomics evaluation is crucial for the safety use and preventing medical accident, objective kinetics and ergonomic data is still scarce.

AIM: The purpose of this study was to examine the mechanical force and the physical workload of the automated suturing instrument.

METHODS: Two experiments were conducted. The first one was to assess the mechanical characteristics of the automatic suturing instrument. The automatic circular stapler (EEA: 0.5Kg, handle size: 11cm) was tested. Cattle's colon, thickness of the tissue (3-4mm) is similar to human's large intestine, was chosen as the suturing sample. Load test was conducted by the tensile testing machine (Autograph-AGS-J, Shimadzu Cooperation) to measure the force to suture the sample. Specific jig was made to fix EEA and the wire of the tensile testing machine was hung on the distal end of EEA handle. Loading range was set to 150N, 200N and 250N and each load was tested three times. The relation between each load and the suturing condition was examined.

The second experiment was to quantify the physical exertion when human performed grasping task with EEA. The subjects were 11 healthy females with a mean age of 27.4±10.7 years. The performance parameters were grasping force and forearm muscle work. Each subjects grasped EEA with their maximum force and surface EMG response of forearm flexor muscles were measured. Strain gage was also attached to EEA to measure force. Each subject's gripping force measured by grip-dynamometer and integrated EMG of forearm muscles were compared to those performed with EEA grasping task.

RESULTS: The results of this study demonstrated 250N was needed to suture the sample completely. When exerting 200N, some staplers were not engaged with the sample. Suturing was not completed with 150N. The subject's mean grip force was 270N ±68N whereas the mean EEA grasping force was 147N±41N. However, the mean integrated EMG of the gripping force was almost equivalent to the EEA grasping task.

CONCLUSION: This study demonstrated the force to operate EEA is almost equivalent to the adult female grip force. This suggests the mechanical inefficiency of the instrument and ergonomic consideration is necessary.

ERGO_P1.5 ADVANCED MUSCULOSKELETAL SIMULATION AS AN ERGONOMIC DESIGN METHOD

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INTRODUCTION: In recent years, the advent of new tools for musculoskeletal simulation has increased the potential for significantly improving the ergonomic design process and ergonomic assessment of design. In this paper we investigate the use of one such tool, 'The AnyBody Modeling System', applied to solve a one-parameter and yet, complex ergonomic design problem. The aim of this paper is to investigate the potential of computer-aided musculoskeletal modelling in the ergonomic design process, in the same way as CAE technology has been applied to engineering design.

AIM: To demonstrate how advanced computer musculoskeletal modelling can nowadays be used to assist in the design process, a simulation of a sawing task involving the fish saw was performed using the AnyBody musculoskeletal modelling system. This simulation involved a simple sawing task in which the effects on muscular effort arising from small changes in the placement of the handle were investigated.

METHODS: A musculoskeletal model of a human operator using a hand saw was constructed in the AnyBody Modeling System (ver. 4.1, AnyBody Technology A/S, Denmark). The AnyBody Modeling System uses recorded motion as input into the model. Inverse dynamics and a muscle recruitment algorithm, based on optimization, are then used to predict redundant muscle actions, and/or joint moments responsible for the motion. This entails solving a series of dynamic equilibrium equations within the biomechanical model which leads to the calculation of joint reaction forces, mechanical work and other properties that are useful to the assessment of human performance.

RESULTS: Analyses were performed with variable handle offsets of -50, 0, 50, 100, 150, 200, 250 and 300 mm, where positive values designate handle positions above the blade. It becomes easier for the operator to advance the saw as the blade moves forward over the work piece. It can also be seen that the muscles are overloaded (i.e. above 100% relative muscle activity) at the beginning of the stroke for all handle positions. Under normal circumstances, the operator is likely to manage this situation by reducing the normal force acting on the saw in order to advance the saw. The analysis also reveals that the effort required to drive the movement forward depends on the height of the handle above or below the blade, and that an increase or reduction in relative muscle activity with handle displacement occurs across the entire movement. This means that the effort of driving the saw can be represented by the effort at a single point in the movement. This effect can be clearly seen by plotting the muscle activity envelope at the beginning of the stroke against the offset position of the handle. It appears that an optimum offset exists at a handle position of approximately 200 mm, and also that this optimum is rather flat in the sense that handle offsets between 150 mm and 250 mm result in almost similar levels of muscle activation.

CONCLUSION: The musculoskeletal modelling example of the sawing task suggests that it is advantageous from an ergonomic perspective to move the handle position of the saw upwards with respect to the blade, such that the blade is not directly extending the forearm, but located somewhat below it. Musculoskeletal simulation appears to offer the potential to substantially improve the field of ergonomic design and assessment in the same way that, for instance, finite element analysis has fundamentally changed the engineering design process.

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FUNCTIONAL ELECTRICAL STIMULATION

FEST_P1.1 PROBABILISTIC CONTROL OF FUNCTIONAL ELECTRICAL STIMULATION

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INTRODUCTION: Functional electrical stimulation (FES) has improved upper limb motor function in a segment of tetraplegics paralyzed as a result of spinal cord injury. The repertoire of motor behaviors that can be elicited by FES, however, is presently limited to a relatively small set of preprogrammed movements. Probabilistic modeling may provide a means to overcome this limitation and enable straightforward predictions of stimulus patterns needed to evoke an extensive range of movements.

AIM: The first goal of this project was to use probabilistic methods to predict EMG patterns in multiple muscles controlling the upper limb in a monkey subject during unrestrained movement. The second goal was to transform predicted patterns of muscle activity into trains of stimulus pulses in an attempt to evoke desired movements in the anesthetized monkey.

METHODS: Intramuscular mono-polar electrodes were chronically implanted in 28 scapular, shoulder, elbow, and wrist muscles in an adult male Rhesus macaque monkey. Following recovery from surgery, EMG signals and limb kinematics were recorded while the monkey made a wide-range of free movements of the upper limb. A subset of these data was used to characterize the probabilistic relationship between EMG and kinematics using a dynamic neural network (Johnson & Fuglevand J Neural Eng 2009). The trained neural network was then used to predict EMG signals for all 28 muscles based on hand trajectory information from a new set of movement trials. Predicted EMG signals were then converted into patterns of current pulses that varied both in amplitude and frequency (Johnson & Fuglevand J Neural Eng 2011). In one session, the monkey was anesthetized with propofol, seated upright while stimulus pulses were delivered to the 28 muscles and evoked movements recorded.

RESULTS: For most muscles, root-mean squared errors between actual and predicted EMG signals were low, indicating overall good prediction using the neural network. Crosstalk, however, caused contamination among some of the EMG signals. The movements evoked with electrical stimulation, therefore, did not correspond well to the desired movements.

CONCLUSION: Probabilistic modeling offers a means to predict muscle stimulation patterns needed to produce a large repertoire of movements. Refinements, including bipolar electrode configurations to reduce crosstalk, however, are required to effectively predict FES patterns needed to produce desired movements with good fidelity.

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FEST_P1.2 TORQUE, M-WAVES AND H-REFLEXES DURING NMES OVER THE FEMORAL NERVE TRUNK VERSUS THE QUADRICEPS MUSCLE BELLY

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INTRODUCTION: Neuromuscular electrical stimulation (NMES) can be delivered over a nerve trunk or muscle belly and can both generate contractions through peripheral (by depolarising motor axons) and central (by depolarising sensory axons) pathways. Generating contractions through peripheral pathways is associated with a non-physiological motor unit recruitment order which may limit the efficacy of NMES for rehabilitation. In contrast, recruitment through central pathways follows Henneman's size principle.

AIM: Compare recruitment through peripheral and central pathways for contractions of similar amplitude evoked by NMES applied over the femoral nerve trunk versus the quadriceps muscle belly.

METHODS: NMES was delivered to evoke 10 or 20% of maximum voluntary isometric contraction (MVIC) torque 2-3s into the stimulation (Time1). Two patterns of stimulation were delivered; 1) Constant frequency: 15Hz for 8s and 2) Step frequency: 15-100-15Hz and/or 25-100-25Hz for 3-2-3s, respectively. Torque and electromyographic activity recorded from vastus lateralis were quantified at the beginning (Time1) and end (Time2; 6-7s into the stimulation) of each stimulation train. M-waves (peripheral pathway) and H-reflexes (central pathway) evoked during NMES were quantified. The coefficient of variation (CV) was also quantified to determine the consistency of each dependant measure between 3 consecutive contractions.

RESULTS: Torque generated by stimulation over the nerve and muscle did not differ in mean amplitude for either contraction amplitude. In contrast, M-waves were ~7-10 times smaller and H-reflexes ~8-9 times larger during NMES over the nerve compared to over the muscle. To generate 10% MVIC, M-waves and H-reflexes were 3.3±2.3% (mean±SD) and 4.7±1.7% of the maximal M-wave (Mmax), respectively, during NMES over the nerve and 33.4±25.1% and 0.5±0.4% Mmax, respectively, during NMES over the muscle. To generate 20% MVIC, M-waves and H-reflexes were 7.0±5.3% and 8.6±6.5% Mmax, respectively, during NMES over the nerve and 52.9±26.2% and 1.0±0.8% Mmax, respectively, during NMES over the muscle. The CV for each dependant measure was ~2 times larger during NMES over the nerve compared to NMES over the muscle.

CONCLUSION: NMES over the muscle produced contractions primarily through peripheral pathways. NMES over the nerve produced contractions with greater recruitment through central pathways, which may help reduce muscle atrophy and fatigue for NMES rehabilitation. However, the inconsistency in the torque produced during NMES over the femoral nerve may limit its applications for producing functional movements.

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FEST_P1.3 COMBINATION OF MOTOR IMAGERY AND PERIPHERAL NERVE ELECTRICAL STIMULATION FACILITATES CORTICOMOTOR EXCITABILITY.

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INTRODUCTION: Motor imagery has been reported to activate the motor cortex that is involved in normal voluntary movements. However, motor imagery may be insufficient to activate the motor cortex than voluntary movement, because motor imagery is absence of an afferent input from muscle or nerve. Peripheral nerve electrical stimulation (ES) can induce an afferent input to the cortical cortex. We hypothesized that the activation of the motor cortex is facilitated by the combination of motor imagery and ES or an increase in the amount of afferent input as compared to motor imagery alone.

AIM: We investigated how a combination of manipulations influenced activation of the motor cortex and the effect of ES intensity on its activation during motor imagery.

METHODS: Six healthy persons (average age, 24.7 ± 3.7 years; range, 21–33 years) participated in this study. The effect of a combination of two manipulations was studied: (i) combination of motor imagery and ES (above motor threshold), (ii) combination of motor imagery and ES (above sensory threshold), (iii) motor imagery alone, (iv) ES alone (above motor threshold), and (v) ES alone (above sensory threshold). For the imagery condition, the subjects observed a video animation of the movement of the opposing thumb to the little finger, and then they imagined the same movement. For the ES condition, ES was applied to the right ulnar nerve at the wrist. Two different ES intensity was set; (i)1.05-1.1 motor threshold (MT) and 1.1 sensory threshold (ST). The stimulation was delivered for 20 s at 10Hz using a 1 ms pulse width. Corticomotor facilitation was assessed by the amplitude of motor-evoked potentials (MEPs) elicited by transcranial magnetic stimulation (TMS), which were recorded from the thenar and abductor digiti minimi muscles. TMS intensity was set to 1.2 motor threshold. TMS was applied when the thumb was in touch with the little finger in the video animation.

RESULTS: The results showed that motor imagery combined with ES enhanced corticomotor excitability in the thenar muscle compared to either manipulation performed alone. Concerning the ES effects on corticomotor excitability during motor imagery, increasing the intensity of stimulation facilitated excitability in the thenar muscle.

CONCLUSION: Combination of Motor imagery and ES enhanced corticomotor excitability compared with either manipulation performed alone. Moreover, a higher stimulation intensity resulted in increase in afferent input might be enhanced corticomotor excitability during motor imagery.

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FEST_P1.4 EFFECTIVE COUGH EVOKED BY SURFACE ELECTRICAL STIMULATION OF ABDOMINAL MUSCLES AFTER HIGH LEVEL SPINAL CORD INJURY

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INTRODUCTION: Respiratory complications are the major cause of death of people with high-level spinal cord injury (SCI, impairment level ≥T5) because they have a reduced ability to cough due to expiratory muscle paralysis. We have recently shown that cough can be significantly improved using surface electrical stimulation of the abdominal muscles using a novel positioning of stimulating electrodes postero-laterally on the trunk (Lim et al., 2007, Butler et al., 2011). The stimulus intensity produced an abdominal expiratory pressure of ~40 cmH2O.

AIM: Here we investigated the effect of increasing the stimulus intensity on the cough using postero-lateral surface electrical stimulation of the abdominal muscles.

METHODS: 6 subjects with SCI (C4-T5) were tested. Subjects coughed voluntarily at the same time as a train of electrical stimulation was delivered (50 Hz, 1s) with stimulus intensities increasing in 40 mA increments from 0-280 mA until either the expired cough flow or thoracic pressure was maximal. A gastro-oesophageal catheter was used to measure expiratory abdominal and thoracic pressures and peak expiratory flow during the coughs.

RESULTS: Increases in stimulus intensity resulted in increased abdominal and thoracic pressures up to 70-80 cmH2O. Peak expiratory cough flows reach a maximum of ~4.7 L/s at 160 mA with abdominal and thoracic pressures of ~50 cm H2O. Further increases in pressures up to ~80 cmH2O were not associated with increased peak expiratory flow. This is likely to be due to dynamic compression of the airways by the high intrathoracic pressure.

CONCLUSION: Increases in stimulus intensity can produce effective coughs in SCI subjects using surface electrical stimulation of abdominal muscles timed to coincide with a voluntary coughs. The expiratory pressures and flows are comparable to those in a voluntary cough in able-bodied subjects

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MODELLING & SIGNAL PROCESSING

MOSP_P1.1 RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND TENDENCY TO CHOOSE VERTICAL TRANSFER MOVEMENTS

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INTRODUCTION: It has been reported that an increase in physical activity reduces the risk of obesity and heart disease. The choice of movement methods in daily life, such as walking or the stair climbing, causes variations in physical activity levels, and it has been thought that this variation affects improvement and maintenance of health.

AIM: The aim of this study was to measure and examine the relationship between physical activity and the tendency to choose vertical transfer movements.

METHODS: Subjects were 7 healthy females (age, 19－22 years). We measured their anaerobic threshold (AT) [ml/kg/min] using the bicycle ergometer test. We fitted a pedometer (Intelligent Calorie Counter, ICC) on them and recorded their daily life activity for 2 days. The ICC was equipped with 3 axis acceleration sensors, a gyroscope sensor, and a barometer and was able to distinguish a movement method and movement time in the vertical direction. The following data was calculated: total activity time in a day [min], total time of vertical transfer [min], total energy consumption [kcal/day], and stair utilization in the vertical direction [%]. Pearson correlation analysis was performed using IBM SPSS ver. 19, with $p < 0.05$ being considered significant.

RESULTS: The mean (SD) values were as follows: AT, 15.8 (1.5) ml/kg/min; total activity time, 75.5 (25.3) min/day; total energy consumption, 1482.5 (283.1) kcal/day; and stair utilization in ascending and descending direction transfers, 38.9 (20.4) % and 39.6 (16.7) %, respectively. The coefficients of correlation between the total energy consumption and stair utilization (ascent/descent) were −0.97/−0.93.

CONCLUSION: The total energy consumption was negatively correlated to stair utilization. Naito et al. (1994, 2000) examined various kinds of everyday activity that affected total energy consumption, and they concluded that using stairs more frequently, less sitting, and less hard labor would increase total energy consumption. The study subjects were university students; they did little hard labor and sat longer attending lectures. Furthermore, their stair utilization was high, but total energy consumption was low because total time of vertical transfer was short. Because the physical activity levels of the subjects did not vary significantly between each other, we were unable to find the relationship between physical activity and the tendency to choose movements using the vertical direction transfer method.

MOSP_P1.2 DETERMINATION OF INDIVIDUAL SUBJECT-SPECIFIC SEMG-FORCE RELATIONSHIPS

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INTRODUCTION: Musculoskeletal models are an important basis for gaining better understanding of physiological as well as patho-physiological motion patterns. These models are commonly driven by forces generated by the contribution of different muscles. However, direct measurement of muscle forces is beyond the current state of research capability. Muscular activation can be measured via sEMG, but there is no general relationship between sEMG-signals and the resulting muscle force. The present task is to address the subject-specific differences that occur along with the technical limitations of sEMG and the determination of the resulting muscle forces.

AIM: To present a method for a subject-specific calibration strategy, leading to individual sEMG-force relationships.

METHODS: In isometric contractions, the joint torques generated by the muscles and external forces must be in equilibrium in different joint angle positions. Based on this demand, the theoretical required muscular forces at different joint angles were calculated. Additionally, the RMS-values of sEMG- signals of the contributing muscles were gathered from isometric measurements in different joint positions, resulting in a sEMG-angle relationship. Finally, the sEMG-angle relationship was combined with the calculated muscle forces from the equilibrium equations, to define a subject-specific-sEMG–force relationship.

VALIDATION: The calibration method was validated in a musculoskeletal model of the elbow joint. sEMG-signals were taken from the biceps brachii and transformed into muscle forces via the developed calibration strategy. These forces were used as an input to a musculoskeletal model, causing the desired elbow flexion movements.

CONCLUSION: In conclusion it is possible to define a subject-specific sEMG-force relationship by means of an easy-to-use calibration setup, and so drive musculoskeletal models.

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MOSP_P1.3 SEARCHING FOR OPTIMAL ELECTRODE NUMBER AND CONFIGURATION IN MULTICHANNEL MYOELECTRIC PROSTHESIS CONTROL

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INTRODUCTION: Despite recent advances in myoelectric prostheses, user acceptance stays low, among others due to a limited number of intuitively controllable functions. Using pattern recognition and multiple electrodes, a better control might be obtained, but it is unknown what electrode configuration is optimal. Often, muscle specific electrode configurations are used, but as the muscle anatomy in acquired or congenital amputees is altered, such a configuration is not straightforward. Placing many electrodes in a fixed grid and using a smart configuration-calibration procedure, could overcome this problem.

AIM: To test performance dependency on electrode number and configuration, starting from a 40-electrode grid while reducing the number of electrodes in three ways.

METHODS: EMG signals of 8 natural isometric wrist and hand contractions (6s for training and 3s for the test set) from 10 able-bodied subjects were collected using a grid of 4x10 monopolar gel electrodes. The first of the three approaches was creating electrode-subsets based on muscle specific locations. With two electrodes on both flexor and extensor muscles as a basis, multiple combinations of subsets (with 4, 6, 8, 10 and 12 electrodes) were made selecting electrode pairs on radial, ulnar, pronator, or supinator aspect of the forearm. The second approach was a sequential forward selection (SFS) method, which starts with an empty set and sequentially adds the electrode that yields a maximum increase of the classification performance, until the performance does not improve anymore. From these sequences of selected electrodes, the first 4, 6 and 8 electrodes and the entire sequence were used as subsets. The third approach involved selecting one of the four “bracelets” of electrodes on the contour of the forearm (1x10). Nearest neighbor classifiers were trained with training sets (RMS values of the selected electrode signals, calculated over periods of 150ms with 50ms-sliding window) and then tested with the test sets. Classifier performances were calculated for both average reference derivation and bipolar derivation for all three approaches.

RESULTS: For the muscle specific configuration, optimal result of 95.2% accuracy was obtained with 10 electrodes on the flexor, extensor, radial, ulnar and pronation aspect of the forearm. For the SFS approach, optimal result was obtained with 8 electrodes: 97.4% accuracy. The best “bracelet” configuration was the most distal one, reaching 97.4% accuracy with 10 electrodes. An average reference derivation performed better than a bipolar one for all approaches.

CONCLUSION: For this set of contractions, an 8-electrode SFS and a 10-electrode “bracelet” configuration give the best results. The last is the most practical way of positioning electrodes.

MOSP_P1.4 MODELING ACTIVATION OF SMALL CUTANEOUS AFFERENTS BY ELECTRICAL STIMULATION

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INTRODUCTION: Although the peripheral axons of sensory and motor neurons show great similarities, a number of important differences exist. For example, sensory and motor neurons differ in conduction velocity (CV) and strength-duration (SD) properties. Morphological differences exist between sensory and motor fibers, and different ion channel densities in the node of Ranvier have also been suggested. Accurate models of motor axons, such as the MRG (McIntyre, Richardson, and Grill) model, have been developed, but less focus have been committed to development of models of sensory axons.

AIM: 1) Develop a valid model of the activation of small cutaneous afferent axons by electrical stimulation and 2) investigate the origin of differences between excitation properties of sensory and motor axons.

METHODS: The sensory axon model was developed in the NEURON simulation software using an approach similar to the MRG model, i.e., a double cable model to describe the myelin layer as a non-perfect insulator. Morphological parameters were modeled according to literature for sensory Aδ fibers. The diameters of the entire fiber, axon, node, myelin attachment segment, and main paranodal segment were 4.5, 4.3, 1.7, 2.1 and 3.19 µm, respectively. The length of the node, myelin attachment segment and main paranodal segment were 1, 3.19 and 6 µm, respectively. The internodal length was 100 µm. CV and SD properties were measured from the model and compared to literature. The SD time constant was estimated by fitting the Weiss-Lapicque equation to the SD data.

RESULTS: The model exhibited excitation properties comparable to those reported for in vivo recordings in literature. The rheobase was 0.33 mA while the strength duration time constant was 410 µs. The CV was 9.9 m/s.

CONCLUSION: These results show that by altering the morphological parameters in accordance with those observed in small cutaneous fibers, a model of peripheral motor axons exhibited properties resembling observations on peripheral sensory axons. The activation threshold was higher for shorter pulses but lower for longer pulses. Moreover, the CV was slower compared with the motor neuron model. This is in accordance with the literature for sensory fibers. The results indicate that morphology is the primary factor determining the observed differences between sensory and motor fibers.

MOTOR CONTROL

MOTC_P1.1 CHANGES IN LOAD SHARING BETWEEN WRIST MUSCLES ARE CONSISTENT WITH MINIMIZATION OF MUSCLE ENERGY

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INTRODUCTION: In order to generate a specific force required to produce movement, we typically face a redundancy problem when selecting a unique pattern of muscle activity from a countless set of viable activation combinations. How the central nervous system (CNS) solves this redundancy problem has challenged researchers for decades, and is critical to the development of robotic and prosthetic systems that attempt to effectively mimic human movements. Recent optimal control theories propose that motor commands are established in order to optimise biologically relevant task goals while minimising costs such as effort and motor noise. In the context of wrist movements, optimal control models that minimise the summed squared muscle activations can produce muscle activations that are consistent with experimental results.

AIM: Here, we test predictions from optimal control during isometric contractions performed at different force levels, and consider the total energy cost of movements via a model of muscle energetics.

METHODS: We measured changes in the electromyographic (EMG) activity of wrist muscles over a range of forces from 5% to 70% of a maximal voluntary contraction (MVC) for 16 equally spaced target directions. Subjects were instructed to direct a visual cursor three consecutive times to each target, and to remain at the target for 1.5s. Intramuscular fine-wire electrodes were used to record activity from the five main forearm muscles (extensor carpi radialis [ECR] brevis, ECR longus, flexor carpi radialis, flexor carpi ulnaris, extensor carpi ulnaris) during the task. The energy use associated with each movement was estimated via a model of muscle energetics for the isometric condition according to an anatomically realistic wrist model developed in MSMS software.

RESULTS: Muscle tuning curves, with normalised muscle EMG presented as a function of target direction, indicated that muscle activity increased in different proportions with force levels for different target directions. Specifically, the increase in activity for the direction at which muscles are preferentially used (i.e., the muscle preferred direction) was less than for the other non-preferred directions. This reflects an increase in muscle load sharing with increasing force level, such that muscles with mechanical actions less favourable to produce force in a particular direction are increasingly used in combination with the more favourable muscles at higher force levels.

CONCLUSION: This result is at odds with simulations from optimal control based on muscle activation, whose muscle redundancy solution scaled linearly with force level in all target directions. Further exploration on energetic costs associated with this pattern of load sharing between muscles is on-going.

MOTC_P1.2 LATERALITY OF INTERHEMISPHERIC INHIBITION FROM ACTIVE TO RESTING MOTOR CORTEX DURING A FINE-MOTOR MANIPULATION TASK

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Mr Kazumasa Uehara; Prof Kozo Funase

INTRODUCTION: Our previous study has shown that ipsilateral primary motor cortex (M1) excitability was markedly increased during the fine-motor manipulation (FM) task. In addition, ipsilateral short-interval intracortical inhibition (ipsi-SICI) was significantly decreased during the FM task. These effects were evident during the performance of the task using the non-dominant left hand, but not the dominant right hand. We hypothesized that the enhanced ipsilateral M1 excitability produced during the FM task is mediated by transcallosal inputs.

AIM: In order to explore this hypothesis, we examined the changes in interhemispheric inhibition (IHI) from the active to the resting M1 during the performance of the FM task and compared them with those produced during a simple voluntary contraction task.

METHODS: Transcranial magnetic stimulation (TMS) was delivered to evoke a motor evoked potential (MEP) from the first dorsal interosseous (FDI) muscles of both hands. When the subjects performed the instructed task using their non-dominant left hand, the test stimulus (TS) was applied to the ipsilateral left M1 and the conditioning stimulus (CS) was applied to the contralateral right M1 and vice versa. The TS intensity was adjusted to generate a control MEP of approximately 1~1.5mV. The 3 CS intensities were tested, 1.0, 1.2, and 1.4 rMT. The interstimulus interval (ISI) was fixed at 10ms. As a sensorimotor task, an FM task (using chopsticks to pick up, transport, and release glass balls) was adopted. In addition, index finger abduction (IA) task was also performed as a control task. These tasks were carried out using both hands separately, and the test order for each hand was randomized between subjects.

RESULTS: Increased IHI induced from the active to the resting M1 was observed during the FM task. This effect was evident during the performance of the task using the non-dominant left hand, but not the dominant right hand. In addition, although almost the same MEP amplitude was generated in the active FDI at a particular CS intensity during the FM task and the IA task, increased IHI was observed during the FM task using non-dominant left hand.

CONCLUSION: The present findings suggest that the increased IHI may be linked to reduction of ipsi-SICI. Additionally, our present results support the assertion that the projections from the transcallosal and the corticospinal pathways are distinct.

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MOTC_P1.3 FACTORS AFFECTING THE ABILITY OF STEERING WHEEL IN PATIENTS WITH PARKINSON'S DISEASE

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INTRODUCTION: It is very important to evaluate the ability of driving car in order to rehabilitate Parkinson's disease (PD) patients into society. There is no easy and useful tool to evaluate ability of driving car in PD patients.

AIM: The aim of this study is to clarify factors affecting steering ability in PD patients from a physiological and neuropsychological perspective, using a simulation task involving wave-tracking trajectory of varying predictability.

METHODS: Subjects comprised 15 PD patients on drug control (mean age = 74 ± 8 years old; Hoehn and Yahr stage 2 = 10, stage 3 = 5), 15 age-matched elderly people (mean age = 72 ± 4 years old) and 15 young adults (mean age = 21 ±1 years old). Wave-tracking trajectory involved 3 tasks: Sin waves for predictable trajectory; Chaos waves for short-term predictable trajectory; and Random waves for unpredictable trajectory. Wave-tracking performance was assessed by trajectory deflection and the phase lag between the target and tracked trajectories. Motor function in upper limbs was evaluated using the Simple Test for Evaluating hand Function (STEF). Comprehensive Trail Making Test (CTMT) was used for evaluating the ability of visual attention. Electroencephalogram (EEG) and plethysmogram (PG) were recorded during tracking trajectory to detect physiological responses. The frequency of frontal midline theta (Fmθ) occurred in EEG was determined using wavelet analysis. Power values of low frequency component (low frequency, 0.04 – 0.15 Hz; LF value) and high frequency one (high frequency, 0.15 – 0.40 Hz; HF value) were calculated by spectral analysis of PG variability. HF and LF/HF values were evaluated as indices of parasympathetic and sympathetic nervous activities, respectively. One way ANOVA was used to compare the difference of group and task. Statistical significance was set at $p<0.05$.

RESULTS: The performance on the CTMT and STEF in PD patients was significantly lower than that in young and elderly subjects. In the chaos wave-tracking task, the differences in trajectory and the phase were significantly larger in PD patients than those in young and elderly subjects. These differences were significantly correlated with the CTMT and STEF. In all of the tasks, the HF values reflecting parasympathetic nervous activity were significantly lower in PD patients than in young subjects. No significant difference was given between subjects, with respect to the occurrence of Fmθ reflecting the degree of attention.

CONCLUSION: The chaos-based trajectory tracking task is useful in the evaluation of steering ability in PD patients. Factors affecting the ability of steering wheel in PD patients are three functions of visual attention, autonomic nervous system, and motor coordination in upper limbs.

MOTC_P1.4 EFFECT OF EXERCISE-INDUCED FATIGUE ON POSTURAL CONTROL OF THE KNEE

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Mr Lars Arendt-Nielsen

INTRODUCTION: Muscle fatigue is associated with reduced power output and work capacity of the skeletal muscle. Fatigue-induced impairments in muscle function are believed to be a potential cause of increased injury rates during the latter stages of athletic competition and often occur during unexpected perturbations. However the effect of fatigue on functionally relevant, full body destabilizing perturbations has not been investigated.

AIM: This study examines the effect of muscle fatigue on the activation of the quadriceps and hamstrings to fast, full body perturbations evoked by a moveable platform.

METHODS: Fatigue was induced using dynamic exercise which was performed on a bicycle ergometer. The subject's maximal heart rate was calculated using the Carvonen equation. After the warm up the workload was increased until each subject reached 80 - 90% of their maximal heart rate and, thereafter, was kept constant until exhaustion. Surface electromyographic (EMG) signals were recorded from the knee extensor (vastus medialis, rectus femoris, and vastus lateralis) and flexor muscles (biceps femoris and semitendinosus) of the right leg in 9 healthy men during full body perturbations performed at baseline and immediately following the high intensity exercise. In each condition, participants stood on a moveable platform during which 16 randomized postural perturbations (8 repetitions of 2 perturbation types: 8 cm forward slides, 8 cm backward slides) with varying inter-perturbation time intervals were performed over a period of 2 - 3 min. Maximal voluntary knee extension and flexion force was measured before and after the high intensity exercise protocol to confirm the presence of fatigue.

RESULTS: Immediately after exercise, the maximal force decreased by 63% and 66% for knee extensors and flexors respectively ($P<0.0001$). During the post-exercise postural perturbations, the EMG average rectified value (ARV) was significantly lower than the baseline condition for both the knee extensors (average across all muscles; baseline: 19.7±25.4 µV, post exercise: 16.2±19.4 µV) and flexors (baseline: 24.3±20.9 µV, post exercise: 13.8±11.0 µV) (both $P<0.05$). Moreover the EMG onset was significantly delayed for both the knee extensors (baseline: 132.7± 32.9 ms, post exercise: 170.8±22.9 ms) and flexors (baseline: 139.1±38.8 ms, post exercise: 179.3±50.9ms) (both $P<0.05$). A significant correlation ($R^2=0.53$; $P<0.05$) was identified between the percent reduction of knee extension MVC and the percent change in onset time of the knee extensors post exercise.

CONCLUSION: Muscle fatigue induces a reduction in the activation of both the quadriceps and hamstring muscles in response to rapid destabilizing perturbations potentially reducing the stability around the knee.

MOTC_P1.5 ONLINE DECOMPOSTION OF SINGLE-CHANNEL INTRA-MUSCULAR EMG TO CONTROL EMG-POWERED PROSTHESIS

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INTRODUCTION: The motor unit spike trains, which can be extracted by decomposition of intramuscular EMG signals (iEMG), provide information on the force exerted by the muscle, which makes them suitable for prosthesis control. Using iEMG as a source of control has advantages in comparison with surface EMG (sEMG) since: (1) iEMG can be recorded also from deep muscles, (2) electrodes can be chronically implanted, (3) cross talk is absent and thus different detection sites are independent which may allow control of multiple degrees of freedom. Using motor unit spike trains as input for the control of prostheses requires a method for the online decomposition of iEMG.

AIM: We have recently developed an iEMG decomposition program (H.R. Marateb, et al;J. Neural Eng. 8 (2011) 066015 (13pp)). Data-dependent thresholds used for outlier detection and pattern recognition, and its efficient density-based classification cores, with O(n) computational complexity, enabled us to implement this decomposition program online.

METHODS: The online version of the iEMG decomposition program was implemented in Visual C++. Using incomplete decomposition, it is possible to estimate the number of active Motor Units (MUs), and MU robust firing statistics.Thus, resolving superimposed MUAPs was not implemented. The OptiVec Vectorized programming package (http://www.optivec.com) was used to efficiently implement vector and matrix operations and loops in an object-oriented framework. Several strategies, such as Superscalar scheduling, Loop-unrolling, Simplified addressing, and Functional and Data Parallelism,were used to increase the efficiency of the program and, finally, a Fuzzy system that incorporates expert human knowledge was re-written in C++.

RESULTS: In the Matlab implementation, the decomposition of 1s of low-to-moderate iEMG signals took 350 ms on an Intel dual-core 1.83-GHz CPU with 2 GB of RAM. For the online Visual C++ implementation, the required time was reduced to 50 ms. Using the new implementation, the processing time was reduced by a factor of 7 which is closer to online methodology in practice. However, due to the optimal delay of 100 ms-125 ms for myoelectric prosthesis, the input iEMG clustering buffer must be reduced for online applications in comparison with that of offline programs.

CONCLUSION: Direct control of powered prosthesis using implanted electrodes has been demonstrated in the literature. In previous studies, however, global features of intramuscular signals have been used for the control. In this study, we provide a method for the online decomposition of iEMG into the constituent MU spike trains. This would allow a completely new approach to prosthesis control based on the direct decoding of the neural drive to muscle through iEMG decomposition.

MOTC_P1.6 EFFECTS OF TRAINING ON CENTRAL AND PERIPHERAL FATIGUE INDUCED BY HIGH INTENSITY DYNAMIC EXERCISE

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INTRODUCTION: Muscle fatigue is an exercise-related decrease in the maximal voluntary force or power of a muscle or muscle group. Training is known to reduce fatigue and increase endurance however the mechanisms underlying this effect are not fully clear.

AIM: To investigate the effect of training on central and peripheral fatigue during high intensity exercise.

METHODS: Twenty healthy volunteers participated in the study and were randomly assigned to either a 6-week endurance training program or a control group. For the training group, exercise was performed on a bicycle ergometer 3 times per week. The load intensity ranged between 50 to 70% of the heart rate reserve and the duration of the sessions were between 20 and 45 min. At baseline and on week 7, dynamic exercise was performed on a SRM bicycle and consisted of light cycling followed by a ramping protocol starting at 100 W with the workload increased by 15 W. min -1 until exhaustion. The exercise test was terminated either: (1) voluntarily by the subject, or (2) when pedaling cadence could not be maintained at 75 rev. min-1. Maximal voluntary knee extension isometric contractions (MVC) and knee extension MVCs with superimposed electrical stimulation of the femoral nerve were measured before and after the exercise. To quantify central activation failure during each MVC, the central activation ratio (CAR) was calculated as the MVC divided by the total force (stimulated + voluntary force) and to quantify peripheral fatigue, electrical stimulation was applied to the femoral nerve at rest. Moreover muscle fiber conduction velocity of the vasti muscles (measured during sustained isometric knee extension at 30% MVC) was measured before and immediately following the fatiguing exercise.

RESULTS: Preliminary results indicate a significant increase in the baseline knee extension MVC (pre: 541.5 ± 123.8 N.m, post: 712.1 ± 119.6; $P<0.05$) and power output (pre: 286.6 ± 35.1 W, post: 335 ± 49.2; $P<0.05$) post training for the training group. Moreover the percent reduction in MFCV during the sustained contraction was lower post training (-4.19±0.4%) compared to baseline (-11.1±1.6%; $P<0.05$) for the training group. Furthermore, the percent reduction in the resting twitch (RT) was lower (-12 ± 3.9%; $P<0.05$). in the post training condition compared to baseline (-29.15 ± 7.64%).

CONCLUSION: Six weeks of endurance training improves the ability to resist high intensity fatiguing exercise. This may be partly explained by reduced peripheral fatigue as demonstrated by the results for MFCV and RT in post training condition.

MOTC_P1.7 AGE-RELATED VISUAL FUNCTIONS AFFECTING POSTURAL CONTROL: A COMPARATIVE STUDY OF YOUNG ADULTS AND THE ELDERLY

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INTRODUCTION: Several studies have shown that visual system function deteriorates with age. Such deterioration results in a limited ability to adopt movements required to maintain postural balance in response to changing tasks and environmental demands.

AIM: The purpose of this study was to identify which changes in visual system function, important for posture and balance control, contribute to the decline in stability that is observed with age.

METHODS: This study was composed of an elderly group (mean age: 67.75±6.11 years) and a young adult group (mean age: 19.14±0.53 years) with 14 participants in each group. Participants were fitted with an EMR-8B head mounted eye tracker (EMR), which consisted of a field lens (NAC Image Technology) and set up with a cap, mirror arm, and image binarization. After visual parameters were calibrated, participants were instructed to stand upright on a computerized dynamic posturography (CDP) platform (Equi-test, NeuroCom International, Clackamas, Oregon, USA) while adjustments for foot width were made. To control for gaze during posturography testing, a plain white screen was fitted onto the moveable visual surround (i.e., the “front tilting wall”). Elderly and young adult groups were compared using a one-tailed t-test with SPSS for Windows (ver. 15).

RESULTS: After gathering and analyzing Equi-test and vision data, a significant difference between groups was found for postural sway, fixation point duration, pupil diameter, convergence angle, and percent eye movement velocity.

CONCLUSION: Our study demonstrates that age-related changes in visual function influence postural control. We observed that elderly participants changed their visual line more frequently compared to young participants. Furthermore, the onset of moving velocity was delayed in the elderly adult group, reflecting a loss in the time needed to collect appropriate information required for postural control (i.e., their visual information tended to provide temporally incorrect information to the central nervous system). In addition, convergence functions necessary for binocular cues of depth or distance perception decreased in the elderly adult group. In general, peripheral inputs coming from visual, somatosensory, and vestibular systems help detect the body’s spatial position and movement with respect to gravity and the environment. Further studies are needed to clarify the relationship between visual and physical functions.

MOTC_P1.8 EFFECT OF KNEE JOINT ANGLE ON EMG-FORCE RELATIONSHIP OF QUADRICEPS FEMORIS INVOLVING VASTUS INTERMEDIUS MUSCLE

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INTRODUCTION: Many investigators have examined the relationship between surface EMG amplitude and generated force (EMG-force relationship) to clarify the neuromuscular properties of individual synergists (vastus lateralis, VL; vastus medialis, VM; rectus femoris, RF) in the quadriceps femoris (QF) muscle group. We previously showed that the EMG-force relationship of the vastus intermedius (VI) muscle shifts downward compared with the identity line and with the other three synergists in the QF, at 90˚ of knee joint angle (Watanabe & Akima 2009). However, whether the EMG-force relationship of an individual QF muscle varies with changing knee joint angles is unclear.

AIM: The present study investigates the effect of knee joint angle on the EMG-force relationship of individual muscle of the QF.

METHODS: Ten healthy men (age, 21.3 ± 1.1 years; height, 174.1 ± 5.6 cm; weight, 67.6 ± 11.7 kg) performed 20%, 40%, 60%, 80% and 100% of maximal voluntary contraction (MVC) during isometric knee extension at 90˚, 120˚ and 150˚ of knee joint angles (180˚ = fully extended). A surface EMG electrode was attached to the superficial region of the VI identified by ultrasonography and then surface EMG data from individual muscles of the QF were recorded as described (Watanabe& Akima 2009, 2010, 2011). The electrode of the VI was placed on the common superficial region at each knee joint angle. The root mean square (RMS) of the individual muscle of the QF at each knee joint angle was normalized by the RMS of the MVC during isometric knee extension.

RESULTS: Normalized EMG in the VL was significantly higher than that of the VM and/or RF at 20% and 40%MVC at knee joint angles of 90˚, 120˚ and 150˚ and at 60%MVC at knee joint angle of 150˚. Normalized EMG was significantly lower for the VM than for the RF at 80%MVC at knee joint angle of 90˚ and 20%MVC at knee joint angle of 150˚. Overall, the EMG-force relationship in all four muscles at knee joint angle of 150˚ shifted downward compared with that of 90˚ and 120˚ (all $P < 0.05$).

CONCLUSION: The EMG-force relationship of each of the three muscles at the surface of the QF as well as that of the deep VI significantly influence knee joint angle from a low to a high level of muscle contraction. Knee extension action at 150˚ achieves the relatively same force using less motor unit activity. We conclude that motor unit activation strategies in individual QF muscles differ between extended and flexed positions of the knee joint.

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MOTC_P1.9 MUSCLE RECRUITMENT AND REGULATION OF THE REACTION FORCES DURING A TURN TASK

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Dr Jill McNitt-Gray

INTRODUCTION: During the initiation of a pirouette, both legs contribute to angular impulse generation about a vertical axis passing through the total body center of mass (TBCM). During the pirouette, the mechanical objective is to maintain the TBCM position over the base of support. Maintenance of balance during the turn is regulated by redirecting the reaction force (RF) relative to the TBCM. We expected that if the pirouette is performed with the stance leg's knee and hip flexed (LF) there would be a greater ability to redirect the RF during the turn than if the pirouette was performed with the stance leg's knee and hip extended (LE).

AIM: To determine if turn initiation and balance during the turn is regulated differently between a LE and a LF.

METHODS: One collegiate dancer performed each pirouette condition 9 times with each foot on a different forceplate (Kistler, 1200Hz) while monitoring the activation of 10 muscles of the stance leg using EMG surface electrodes (Konigsberg, 1200Hz). The EMG data were filtered using a 4^{th} order zero-phase butterworth filter at 10-400Hz and quantified using root mean squared values in 20ms average bins. EMG data were normalized to the maximum binned values during isometric manual muscle tests (Kendall).

RESULTS: During turn preparation, there were comparable EMG recruitment strategies, however, in the LF condition, there was less recruitment of the gastrocnemius than observed in the LE condition. The reduction in gastrocnemius EMG corresponds with a reduction in the muscle tendon unit length of the gastrocnemius. During the turn, when the horizontal RF was large, RF redirection during the LE condition was associated with activation of hip muscles, whereas during the LF condition RF redirection was associated with the activation of hip and knee muscles.

CONCLUSION: Muscle recruitment strategies and RF regulation during the preparation and turn phases of the pirouette for both the LE and LF conditions were found to be specific to the kinematic context of the stance leg.

MOTC_P2.1 EFFECT OF SHOULDER ELEVATION SPEED ON THE TIMING OF SCAPULAR MUSCLE ACTIVITY

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INTRODUCTION: Scapular upward rotation during shoulder elevation is caused by the coordinated activity of the trapezius and serratus anterior muscles. Previous studies have reported that scapular muscle activity is delayed in patients. However, the effect of shoulder elevation speed on the timing of scapular muscle activity has not been clarified.

AIM: The aim of this study was to examine the effect of shoulder elevation speed on the timing of scapular muscle activity.

METHODS: The dominant shoulder of 14 healthy male subjects was assessed. Four shoulder muscles (upper, middle, lower parts of the trapezius; UT, MT, and LT, respectively, and serratus anterior; SA) were investigated by surface electromyography (EMG). A 6-degree-of-freedom electromagnetic tracking device was used to record scapular kinematic data. Subjects performed bilateral shoulder elevation in 3 planes (sagittal, scapular, and frontal planes) at 2 different speeds—slow (4-s elevation and 4-s descent) and fast (1-s elevation and 1-s descent)—in a sitting position. Scapular angles were represented as Euler angle relative to the thoracic segment. EMG data were normalized using the values obtained during maximum voluntary contractions. On EMG, the onset of activity of each muscle was determined as the point at which the muscle activity exceeded by 3 standard deviations from the baseline continuously for more than 100 ms. Similarly, the onset of scapular upward rotation was determined as the point at which the scapular angle exceeded the baseline by 3 standard deviations continuously for more than 100 ms. The timing of muscle activity was calculated by subtracting the EMG onset of activity of each muscle from that of scapular upward rotation. Wilcoxon signed rank test was used to compare the timings of muscle activity between the two motion speeds. All statistical analyses were performed with the p value set at 0.05.

RESULTS: MT and LT activities in the sagittal plane at fast speed occurred significantly earlier than those at slow speed. All muscles except for MT were activated earlier compared to scapular upward rotation at fast speed. In the frontal plane, LT activity at fast speed occurred significantly earlier than that at slow speed. All muscles were activated earlier compared to scapular upward rotation at fast speed. In the scapular plane, MT and LT activities at fast speed occurred significantly earlier than those at slow speed. All muscles were activated earlier compared to scapular upward rotation at fast speed.

CONCLUSION: This study indicates that shoulder elevation speed affects the timing of muscle activity particularly of MT and LT. These findings suggest that faster shoulder elevation may require earlier scapular muscle activity to gain more scapular stability.

MOTC_P2.2 CORRELATION OF THE ELECTROMYOGRAPHIC SIGNAL WITH THE POSTURAL SWAY OF SOCCER PLAYERS DURING THE KICK

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INTRODUCTION: Postural control is a determining factor in the execution of functional movements that require a high performance of the motor control coordination, such as sporting activities. In this study the soccer sports activity was chosen, and more specifically, the technical movement of the kick.

AIM: The objective this study was to investigate the postural sway through the kick's movement control. A vertical ball shooting machine (VBS) with an active target was especially developed to measure the effectiveness of the kick. This system was synchronized with electromyographic signal, accelerometer and force platform in order to recognize the movement.

METHODS: Eleven professional athletes of soccer kicked the ball twenty-five times on target using the VBS system by EMG System do Brasil Ltda. Data analysis was proposed for identification and correlation of the signal behavior of the middle gluteus muscle (GL), tibialis anterior (TA), peroneus longus (FL) and vastus lateralis (VL) in relation stabilometric variables of postural sway before the kick, during the kick and after the kick. It was analysed of stabilometric variables: the mean position, standard deviation, total displacement, amplitude, speed, median frequencies in the anteroposterior (AP) and mediolateral (ML) of the center of pressure (CoP) and direction of oscillation during the controlled kick.

RESULTS: The results showed the same trends in the behavior of the RMS (root mean square) of the gluteus medius muscle (LG), tibialis anterior (TA), peroneus longus (FL) and vastus lateralis (VL) before the kick during the kick and after the kick. This was also observed in the analysis of the variables stabilometric, standard deviation, velocity, median frequency in anteroposterior (AP) and mediolateral (ML).

CONCLUSION: Considering the results of this study, analysis of the behavior of EMG signals of the muscles involved in equilibrium during the kick synchronized with stabilometric variables through the force platform has proven to be an effective tool for analysis of movement in athletes of the soccer players during the execution of the kick controlled.

MOTC_P2.3 POSTURAL SWAY AND ELECTROMYOGRAPHY ANALYSIS ON CLASSICAL BALLET

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INTRODUCTION: The Elevè movement involves the support of body weight and works with different placements of the feet.

AIM: Analysis of postural balance and surface electromyography during amounts of movements done, with two different types of dancing shoes.

METHODS: This study was approved by the Research Ethics Committee. We analyzed 10 dancers, female (19.6 years old , weight 54 kg and height of 1.63 m) who had no bone mioarticular injury in the last three months. All of the dancers had professional experience of at least four years and daily training of six to eight hours. The data were recorded in two stages using two types of dancing shoes: A and B. For analysis of the dynamic and temporal parameters, it was used a balance platform model BIOMEC-400 and electromyography model EMG800C both synchronized (by EMG System do Brasil) Ltda, following the recommendations of SENIAM in relation to EMG procedure of the vastus lateralis (VL), tibialis anterior (TA), peronius longus (PL), and gastrocnemius lateralis (GL) muscles.

RESULTS: All of the dancers rehearsed in wooden floor and used both types of shoes. Most of the ballet dancers made the choice of comfortable shoes. We found out that the shoes B were more effective on postural balance and stability than the shoes A, although they were not as comfortable. Shoes A were found to make the dancers have a greater muscle recruitment compared to the use of shoes B.

CONCLUSION: The study of biomechanical characteristics of the dance on the types of shoes should consider parameters such as FRS by force platform, levels of muscular activity (RMS), distribution of the center of pressure (CoP), velocity, amplitude, frequency in the anteroposterior (AP) and mediolateral (ML) direction for a more comprehensive study for the investigation of parameters that can mitigate the possible damage caused during the practice of dance.

MOTC_P2.4 A COMPARISON BETWEEN PREACTIVITY OF MUSCLES AND ANGLE OF KNEE FLEXION IN DROP LANDING

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INTRODUCTION: In posture control, neuromuscular control is important. Recently it is paid attention that preactivation of muscle helps the limits of neuromuscular controls. The control of the knee position during dynamic movement by the neuromuscular systems may depend on activation of the muscle surrounding the joint before the occurrence of stressful events. Thereby, preactivity can compensate the delay in a response. Moreover preactivity is a very interesting mechanism from a viewpoint of injury prevention. In a drop jump, although the hamstrings activity greets a peak in 50ms grounding, rectus femoris activity greets a peak in 80ms after grounding. However, the influence which preactivity exerts on alignment of landing is not reported.

AIM: The aim of this study was to examine the relationship between preactivation of muscle and knee flexion angle in drop landing.

METHODS: The subject was eleven healthy female university students. The subjects performed drop landing tasks from a box (height, 30cm), with the non-dominant leg. The activities of the vastus medialis, vastus lateralis, semimembranosus(SM) and biceps femoris(BF) were derived from electromyography system. Preactivity of muscles derived the time from which a muscle activity serves as a peak for the period 0.2 seconds before landing. Landing was taken as the time which the perpendicular principle of the force platform began to increase. The 3-D motion caputure was used to obtain the angle of knee flexion at initial contact(IC) and maximal knee flexion(MKF) during the landing. Statistical analysis searched for description of liner correlations between preactivity and IC, MKF with Spearman's product moment test. Differences were considered significant at p-values<0.05.

RESULTS: There were the correlations between knee flexion at IC and preactivity of SM ($r = 0.615$, $p = 0.033$), BF ($r = 0.685$, $p = 0.014$). We found no statistical relationship between preactivity of other muscles and knee flexion at IC, preactivity of muscles and MKF.

CONCLUSION: Knee flexion at IC became large, so that preactivity of and SM, BF was quick. It was suggested hamstrings are adjusting the knee flexion angle before landing. The relationship between preactivity of muscles and MKF was not acquired. It was thought preactivity of hamstrings participates only in IC, and preactivity of muscles dose not participates in MKF, but the muscle activity at the time of landing is related. If the knee flexion angle at the time of landing is large, the risk of ACL injury is mitigable. This result is suggested preactivity of hamstrings is related to a control of the alignment at the drop landing.

MOTC_P2.5 MUSCULAR COORDINATION DURING ARM ELEVATION: AN ELECTROMYOGRAPHIC STUDY

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INTRODUCTION: The minimal bony constraint of the glenohumeral joint permits a remarkable range of motion. Translation of the humeral head on the glenoid occurs when the powerful shoulder muscles contract. Despite the fact that synchronous muscle activation is necessary to limit translation and maintain a stable glenohumeral fulcrum, the coordination between shoulder muscles has not been previously studied during arm elevation.

AIM: The aim of this study was to use electromyography (EMG) to investigate the coordination between the 11 shoulder girdle muscles during arm abduction.

METHODS: Nine healthy subjects with no history of shoulder pathology were included. EMG was recorded from 11 shoulder muscles and 2 muscle groups. Participants completed successive trials of shoulder abduction-adduction in the coronal plane (0-180-0 degrees). Recorded signals were differentially amplified, digitalised and filtered in accordance with international guidelines. Data for the muscle groups was calculated by ensemble averaging the activity of the component muscles. Cross-correlation, an established method for comparing EMG signals, was used to investigate the coordination between muscle groups. The Pearson correlation coefficient (PCC) was calculated for pairs of muscles at the start, middle and end range of abduction.

RESULTS: The activity (normalised RMS amplitude) of the anterior, middle and posterior deltoid, pectoralis major, upper trapezius, serratus anterior, latissimus dorsi, teres major, supraspinatus, infraspinatus and subscapularis was significantly higher during abduction compared to the adduction (p range <0.001-0.017). The mean PCC (+ SD) between the deltoid-rotator cuff muscle groups was 0.95+/-0.05, 0.14+/-0.62 and 0.93+/-0.11 at the start, middle and end range of elevation respectively. The correlation was significantly lower during the middle range of elevation as compared to the start ($p = 0.016$) and end range ($p = 0.017$). No difference was identified for the correlation at the start and end range of motion ($p = 0.950$).

CONCLUSION: The glenohumeral joint relies on muscular co-activation to maintain stability. There is a high correlation between the deltoid and rotator cuff muscle groups at the start and end range of shoulder elevation. As the arm is initially lifted, the activity of the deltoid muscles induces a superior subluxing force on the humeral head; similarly towards the end range of motion deltoid activity results in an inferior subluxing force on the humeral head. Coordinated rotator cuff activity at these times ensures a stable glenohumeral fulcrum. The results contribute to our understanding of normal shoulder function and form a basis for understanding changes associated with pathology.

MOTC_P2.6 EMG ACTIVITY OF UNICYCLE MOTOR RETENTION PAST THE DECADE RESTING PHASE

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Prof Masami Miyazaki; A/Prof Takayuki Watanabe; Prof Tasuku Miyoshi

INTRODUCTION: A study of multivariable behavior naturally raises the question of which reference frames the central nervous system may use to coordinate motor actions. Previous studies were focused planar reaching movements and showed that translation and rotation of the start and target positions evoked joint kinematics. This investigation of the retention at highly skilled motor performance about unicycle task, electromyography (EMG) activity by human leg muscles was prompted by findings from locomotor behavior.

AIM: It was applied unicycle educational program for acquired physical sense of balance in Japanese elemental school. However it was not well known to acquire the motor skill in unicycle and not enough data of its retention. The purpose of this study was to investigate of retention skills in unicycle from over 10 years resting period.

METHODS: It was performed riding unicycle by ten participants for the first time in a minimum decade. They had tried the unicycle back-to-back until 10m for time test by 10 times in a same day. Also it was put on the electrode of the EMG and sensor of three dimensions accelerometer on top of head was recorded into the PC for later analysis.

RESULTS: Three participants were not reached by their own dropping the unicycle unless 2m line from onset each first trial. The overall effect of retention on the average EMG activity was consistent, and it may be seen typical data collection. It was decreased 10 m riding performance time test on unicycle from 7.86 to 4.95 seconds. From the integrated EMG signals recorded during the unicycle riding 10m, no statistical differences were observed throughout the investigation.

CONCLUSION: We examined muscle activation and three dimensions accelerometer in unicycle riding, major found that the retention has been acquired in all subjects. However the first or second trial especially swayed more than continued trails. It was appeared that once acquired motor skill was retention as same as swimming, chopsticks and bicycle riding. However after first two trials, it was increased riding speed dramatically.

MOTC_P2.7 SINGLE-SUBJECT ANALYSIS REVEALS VARIED KNEE MECHANICS DURING STEP LANDING IN RESPONSE TO ISOKINETIC FATIGUE OF THE QUADRICEPS

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INTRODUCTION: The ability to regulate joint stiffness and coordinate movement during landing when impaired by muscle fatigue has important implications for knee function. Unfortunately, the literature examining fatigue effects on landing mechanics suffers from a lack of consensus. Inconsistent results can be attributed to variable fatigue models, as well as grouping variable responses between individuals when statistically detecting differences between conditions. There remains a need to examine fatigue effects on knee function during landing with attention to these methodological limitations.

AIM: The purpose of this study therefore, was to examine the effects of isokinetic fatigue on pre-impact muscle activity and post-impact knee mechanics during landing using single-subject analysis.

METHODS: Sixteen male university students (22.6±3.2 yrs; 1.78±0.07 m; 75.7±6.3 kg) performed maximal concentric and eccentric knee extensions in a reciprocal manner on an isokinetic dynamometer and step-landing trials on 2 occasions. On the first occasion each participant performed 20 step-landing trials from a knee-high platform followed by 75 maximal contractions on the isokinetic dynamometer. The isokinetic data was used to calculate the operational definition of fatigue. On the second occasion, with a minimum rest of 14 days, participants performed 2 sets of 20 step landing trials, followed by isokinetic exercise until the operational definition of fatigue was met and a final post-fatigue set of 20 step-landing trials.

RESULTS: Single-subject analyses revealed that isokinetic fatigue of the quadriceps induced variable responses in pre-impact activation of knee extensors and flexors (frequency, onset timing and amplitude) and post-impact knee mechanics (stiffness and coordination). In general however, isokinetic fatigue induced significant ($p<0.05$) reductions in quadriceps activation frequency, delayed onset and increased amplitude. In addition, knee stiffness was significantly ($p<0.05$) increased in some individuals, as well as impaired sagittal coordination.

CONCLUSION: Pre-impact activation and post-impact mechanics were adjusted in patterns that were unique to the individual, which could not be identified using traditional group-based statistical analysis. The results suggested that individuals optimised knee function differently to satisfy competing demands, such as minimising energy expenditure, as well as maximising joint stability and sensory information.

MOTC_P2.8 THE EFFECT OF SUDDEN PERTURBATIONS ON EMG ACTIVITY DURING CUTTING MANOEUVRES

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Ms Priscila de Brito Silva; Prof Dario Farina; Dr Uwe Kersting

INTRODUCTION: Cutting movements are common while practicing team sports and other physical activities. However, this movement is related to injuries due to changes in the environment and/or execution of a motor task.

AIM: To investigate the alterations in muscular activity of the lower limb following induced perturbations during cutting.

METHODS: Eighteen healthy men (age=28±4years; weight=72±12kg; height=173±6cm) volunteered to perform a 90° cutting task with the right foot on a moveable platform and turn to the left. Subjects performed 10-15 trials to familiarize to the task, followed by another 15 with no perturbation (BASE), and a 16th trial which was suddenly perturbed (unexpected perturbation) (PERT, 10-cm forward displacement, 150-ms duration). Electromyography (EMG) signals were recorded from the tibialis anterior (TA), peroneus longus (PL), vastus lateralis (VL), biceps femoris (BF), adductor longus (ADD), and gluteus maximus (Gmax) muscles of the right leg. Initial contact (IC), absorption period (ABS), propulsion (PRP) period and the whole stance phase (STC) were defined from the vertical force component. The EMG envelopes were normalized (%max) and averaged in epochs of 10 ms before IC (PRE), as well as ABS and PRP epochs. Differences between BASE and PERT for STC and EMG PRE, ABS and PRP epochs were investigated by t-tests, with a significance level at $p<0.05$.

RESULTS: No differences were found for ABS duration (BASE=59±8ms, PERT=59±10ms), STC duration (BASE=324±55ms, PERT=340±57ms), as well as EMG PRE for any muscle ($p>0.05$). During ABS, EMG was lower at BASE when compared to PERT for BF (39±15%max vs 31±14%max, $p<0.05$), ADD (28±9%max vs 22±9%max, $p<0.05$) and Gmax (37±9%max vs 32±11%max, $p<0.05$). In addition, during PRP period, EMG was greater at BASE when compared to PERT for TA (28±11%max vs 33±12%max, $p<0.05$), PER (39±11%max vs 47±13%max, $p<0.05$) and BF (40±10%max vs 48±15%max, $p<0.05$). The absence of changes for STC, ABSDUR and EMG PRE suggests that the subjects were not expecting the perturbation, as hypothesized. Initial adjustments during ABS were mainly related to the hip muscles, while the reduced activity for BF may imply reduced knee joint balance in relation to knee extension. Automatic postural adjustments during PRP involved the ankle joint and an increased BF activity, which can be related to both knee and hip joints.

CONCLUSION: Sudden perturbations during cutting movements cause immediate EMG reductions that may lead to knee joint imbalances, while corrective responses involving ankle and knee/hip muscles occur only after 50-60ms from the perturbation onset.

MOTC_P2.9 UNILATERAL BALANCE TRAINING INDUCES NEUROMUSCULAR CROSS-TRAINING EFFECTS DURING PERTURBATIONS

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Prof Dario Farina; Dr Uwe Kersting; Ms Priscila de Brito Silva

INTRODUCTION: Balance training has been widely used in order to reduce injury incidence, but little is known about the cross-effects that unilateral balance training may generate on the contralateral limb.

AIM: The aim of this study was to investigate the effect of unilateral balance training on the reactive recovery of balance for both the trained and untrained limb.

METHODS: Twenty-three subjects were randomly assigned to a control group (n=10) and a training group (n=13). The latter performed 6 weeks of balance training (single standing on mat and wobble board) for the right leg. The pre- and post-training measurements were based on single leg standing posture on a moveable force platform which moved 6 cm anteriorly. Subjects of the training group were tested on the trained (TR) and untrained leg (UTR), whereas the subjects of the control group were tested only on the right leg (CTR). The center of pressure trajectory length/distance (CPLEN), average speed (CPSPD) and approximated entropy (CPENT) as well as onsets of muscular activation (EMGON) and time to peak (EMGT2PK) from the tibialis anterior (TA), vastus lateralis (VL), rectus femoris (RF) and biceps femoris (BF) were calculated. A 2-way ANOVA for repeated measures was used to verify the effect of limb (TR x UTR x CTR) and training (pre x post).

RESULTS: No effects of training for CPLEN for both anterior-posterior (AP) and medial-lateral (ML) components, as well as the ML CPSPD. On the other hand, AP CPSPD and ML CPENT were reduced after training for TR (~35% both, $p<0.01$). AP CPENT was reduced after training for TR and UTR (~48% and 27% respectively, $p<0.01$). Muscular onsets were also reduced after training for all muscles of TR (~ 19 ms or 16%, $p<0.05$) and UTR (~17 ms or 14%, $p<0.05$) with no significant changes for CTR. Furthermore, the EMGT2PK of UTR was greater for all muscles before training, except for RF (~17 ms, $p<0.05$). However, after training the EMGT2PK was similar among limbs. It is well known that resistance/strength training can provoke contralateral effects, however evidence from balance training is scarce. Balance training improves cortico-motor excitability, spinal and supraspinal reflex components, as well as it induces adaptations of muscles, tendons, ligaments and other connective tissues. All these adaptations may be responsible for ipsilateral adaptations, but cross-effects may be limited to neural components.

CONCLUSION: The TR improvement for CPSPD and CPENT for both AP and ML directions, suggests that balance recovery was enhanced, while UTR showed specific improvements for CP (AP CPENT), accompanied by evident neural adaptations (faster and greater EMG).

MOTOR PERFORMANCE & SPORTS SCIENCE

MPSS_P1.1 ELECTROMYOGRAPHY AND IMPACT FORCE ON TWO TYPES OF DANCING FLOOR WHILE PERFORMING TIP-TOE STANDING TASK IN BALLET (SOUS-SUS)

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INTRODUCTION: Playing surface has been considered as one risk factor of injuries in several sports. Yet, the influence of dancing floor, a possible factor related to injures, on ballet dancers is still unclear.

AIM: To investigate the influences of two types of dancing floor, vinyl and wood surfaces, on peak landing force and muscle activation levels of lower extremity muscles while performing a ballet tip-toe standing task (Sous-sus).

METHODS: Seven female ballet dancers were recruited from department of dance. They wore ballet pointe shoes to perform ballet "Sous-sus" on two different dancing surfaces (vinyl vs. wood). A total of 44 reflective markers and 8 electrodes attached to lower extremities. EMG signals of adductor longus, hamstring, vastus lateralis, vastus medialis, soleus, peroneus longus, tibialis anterior, and medial gastrocnemius on dominant side were collected. Normalized peak vertical ground reaction force and muscle activity were measured. The raw EMG signals of each muscle were filtered with a zero-phase shift Butterworth filter at 4th order band-pass (40-400 Hz). Following rectification, the root mean square (RMS) EMG of each muscle was calculated with a 100-ms moving window. The RMS was normalized to the maximum EMG of corresponding trial. The RMS of each muscle at a 100-ms window before and after peak vertical ground reaction force were calculated and defined as pre-peak and post-peak phases correspondingly. Paired t-test was performed to detect the differences between dancing surfaces.

RESULTS: There was no significant difference between dancing surfaces on peak vertical ground reaction force (vinyl: 2.50 ± 0.40 BW, wood: 2.08 ± 0.4 BW, p= 0.704) and muscle activations except soleus muscle and vastus medials during pre-peak phase. The soleus muscle (vinyl: 0.36 ± 0.24, wood: 0.29 ± 0.21, p= 0.034) and vastus medialis (vinyl: 0.36 ± 0.22, wood: 0.29 ± 0.18, p= 0.003) had significantly greater RMS value on vinyl surface than wood surface during pre-peak phase.

CONCLUSION: The surfaces of dancing floor did not modify peak striking force during Sous-sus. However, the vinyl surface induced grater muscle activation levels of soleus and vastus medialis during pre-peak phase and this indicated that the vinyl surface would facilitate more postural muscle to activate to accommodate following peak force. Therefore, the obvious anticipated feed-forward strategy was used to provide stability while performing on the vinyl surface than wood surface.

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MPSS_P1.2 EMG PATTERNS OF A FULL-SCORE "DEEP SQUAT" MOVEMENT OF THE FUNCTIONAL MOVEMENT SCREEN™

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INTRODUCTION: The Functional Movement Screen (FMS^{TM}) has been widely used in recent years to assess athletes' movement quality. A deep squat screening test was one of major FMS screen test for lower limbs and often used clinically to predict risk level of sport injury for athletes. The past studies have shown that training for improvements in a squat movement could effectively reduce injury. Therefore, an investigation of the activation patterns behind a "fully scored" deep squat movement can clarify the role of major muscles through different phases and provide suggestions for clinical application.

AIM: To investigate the activation pattern of each phase and sequence of trunk and leg muscles in a fully-scored deep squat screening test in FMS^{TM}, and to compare activation levels between muscles in each phase.

METHODS: Three participants capable of doing a full score deep squat according to the FMS^{TM} scoring criteria were chosen. Surface EMG were used to measure trunk and leg muscles activities and the 3D Motion Analysis System was used to capture the deep squat movement in four phases (Downward phase I, II, and Upward phase I, II).

RESULTS: The extensor group was the primary activation referring to all muscles that participated in the deep squat movement. As the height of squat on the decrease ,the firing sequence was from distal to proximal muscles, and reverse while on the increase. Rectus femoris showed more high level activation in Downward phase I, Gluteus maximus showed more high level activation with synergistic muscles, Rectus abdominis in plevis stability in Downward phase II; The activation pattern in Upward phase I was similar to Downward phase II, the same outcome existed between Upward phase II and Downward phase I; Both Gluteus medius and Adductor showed more activation while thighs were parallel to the ground. The flexsor group and extensor group showed the similar in-phase, that indicated the occurrence of co-activation in the deep squat movement.

CONCLUSION: Trunk and leg muscles played different role at different height of squat, the findings suggest that training specific muscle group by adjusting the height of squat. Furthermore, the measures of a fully-scored deep squat provide additional information for comparing some compensatory movement.

MPSS_P1.3 COMPARISON BETWEEN CYCLISTS AND NON-CYCLIST ON LOWER LIMB MUSCLE ACTIVITY DURING PEDALING: AN EMG INVESTIGATION

Dr Kenichi Kaneko, Fuji University

Dr Kazuyuki Mito; Dr Hitoshi Makabe; Dr Masato Takanokura; Dr Kazuyoshi Sakamoto

INTRODUCTION: In recent years there has been interest in a kinesiological motor skill from the view point of the coordination of muscle activities. A pedaling exercise is a simple dynamic motion which adjusts a physiological function to a mechanical property of the ergometer. It is useful to investigate the lower limb muscular activations during the pedaling of the competitive road cyclists and the non-cyclists for understanding a kinesiological motor skill.

AIM: The purpose of this study was to evaluate the lower limb motor skills by comparison of the EMG activities during the pedaling consisting of different loads in the cyclists and those in the non-cyclists.

METHODS: The subjects were five cyclists and five non-cyclists. All cyclists have trained more than 6 years as a top athlete in Japan. Electromyographic activity during ergometric pedaling was measured in the vastus lateralis, the biceps femoris, the tibialis anterior, and the gastro cemius by using of the wireless EMG sensors. The EMG signals were stored on a personal computer through an A/D converter with a sampling frequency of 1 kHz. The pedaling dynamics divided into two phases were the “down phase” and the “up phase” from the view point of the crank angle (down phase; 0 to 180 degree, up phase; 180 to 360 degree, respectively). The %RMS values for the EMG during the pedaling were calculated at a ratio of the RMS for the down phase to the RMS for the up phase. The %RMS values were compared the trained cyclists with the non-cyclists during the pedaling with the middle power load (80%MVC) and the high power load (90%MVC).

RESULTS: The means of %RMSs for the biceps femoris and the gastro cemius were higher than 100% in both pedaling loads. In contrast, the mean of the %RMSs for the vastus lateralis and the tibialis anterior were lower than 100% in both pedaling loads. The individual differences of the %RMSs for the biceps femoris and the gastro cemius were larger than that for the vastus lateralis and the tibialis anterior in the cyclists group. The individual differences of the %RMS during the pedaling with high power load were larger than that with middle power load in the non-cyclists. There was no difference between the cyclists and the non-cyclists for all %RMS values during the pedaling with the middle power load, though, the %RMS values at the tibialis anterior and the gastro cemius during the pedaling with the high power load were significantly difference between the two subject groups.

CONCLUSION: These results suggested that the %RMS values at the tibialis anterior and the gastro cemius during the pedaling with the high power load were useful to evaluate the motor skill of the pedaling exercise.

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MPSS_P1.4 MUSCLE ACTIVITY DURING BACK TUCK SOMERSAULT

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INTRODUCTION: Backward somersault is a basic maneuver in gymnastics. The functioning of the trunk and lower extremity muscles is important for producing jump power and torque when the gymnast is in the air during a somersault. However, the neuromuscular function during a backward somersault is not yet clear.

AIM: To investigate the muscle activity pattern during a back tuck somersault (BTS).

METHODS: Five male college gymnasts participated in this study. Electromyographic (EMG) and motion analysis data were synchronously obtained during vertical jumps (VJs) and BTSs. EMG data were obtained for the rectus abdominis (RA), external obliques (EO), internal obliques (IO), thoracic erector spinae (TES), lumbar erector spinae (LES), and rectus femoris (RF). The experimental task was divided into the following 4 phases: push-off phase (from the lowest point of the knee joint during the crouch to takeoff), initial floating phase (first one-third phase of the period from takeoff to landing), intermediate floating phase (intermediate one-third phase of the period from takeoff to landing), and late floating phase (late one-third phase of the period from takeoff to landing). The activity of each muscle was normalized with respect to the amplitude of the maximum voluntary isometric contraction (%MVC). The %MVC of each muscle was compared between tasks and phases by using repeated two-way analysis of variance ($p < .05$).

RESULTS: Significant interaction was observed in the activity of the RA, EO, and RF. The RA showed significantly high activation during all the floating phases of the BTS. The EO activity during the intermediate floating phase (128.9 ± 105.0 %MVC) of the BTS was significantly greater than that during the VT. The RF activity during the push-off phase (20.6 ± 16.1 %MVC) of the BTS was significantly lower than that during the VT (63.8 ± 16.1 %MVC), whereas the RF activity during the late floating phase (59.3 ± 25.2 %MVC) was significantly greater than that during the VJ (18.0 ± 13.0 %MVC). The phases of the BTS had a significant effect mainly on the activity of the IO, TES and LES; the activity of these muscles during the push-off phase was significantly greater than that during the other phases.

CONCLUSION: These results suggest that the activity of the abdominal muscles increased for producing torque when the gymnast was in the air during the BTS. The RF activity during the takeoff phase of the BTS was lower than that during the VJ.

MPSS_P1.5 EMG ANALYSIS OF TWO PARTS OF PECTORALIS MAJOR MUSCLE DURING MUSCLE STRENGTH TESTING

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INTRODUCTION: The pectoralis major (PM) is a fan-shaped muscle in the upper trunk. This muscle is mainly involved with shoulder adduction and internal rotation movements and has two functional parts: the clavicular part (PMc); and the sternal part (PMs). Although PMc and PMs have always been tested separately in clinics, few studies have provided information about whether chosen contraction direction and arm position are valid conditions for testing the chosen part of the PM (either PMc or PMs).

AIM: This study intended to quantify the contribution of the PMc and PMs during maximal voluntary isometric contraction (MVIC) using surface EMG (sEMG) signals. We hoped the results could provide information to help improve clinical thinking about strength testing for the PMc and PMs.

METHODS: We tested MVIC of the PM in three different adduction contraction directions (A: 30° above the frontal line; B: along the line; and C: 30° below the line) in the position of 90° shoulder flexion. SEMG signals (PMc and PMs separately) and contraction force were recorded simultaneously during MVIC trials. To understand the effects of muscle length, three shoulder rotation positions (0°, 45° and 90° of external rotation) were tested in each contraction direction. Furthermore, to evaluate the contribution of synergist muscles, sEMG recordings of movement-related muscles such as the anterior deltoid, middle deltoid and latissimus dorsi were also included. MVIC force was recorded by a measuring device containing a load cell. Ratios of sEMG amplitudes (PMc:PMs) derived from linear envelopes of raw EMG data were used to interpret the contribution of the PMc and PMs during MVICs. Three MVIC trials were collected from each condition and their averaged data were used in further analysis.

RESULTS: Preliminary results from 12 normal young subjects (using two-way repeated measures ANOVA) showed that only shoulder rotation position significantly affected the contraction force ($p<0.05$). Forces generated in three force directions were not significantly different (9.27±2.10, 9.21±1.97 and 9.37±2.44 kg, $p<0.05$). EMG ratios showed that both force direction and rotation position affected the way PMc and PMs contributed ($p<0.05$). They demonstrated a decreased trend from contraction direction A to contraction direction C (4.21±1.62, 3.44±1.25, and 3.04±1.04 respectively). Lower EMG ratios were found in 90° shoulder rotation (3.24±1.37) than in the other two positions (3.63±1.35 and 3.81±1.47) ($p<0.05$).

CONCLUSION: Our results suggest that shoulder rotation position should be considered as a factor during strength testing of the PM. Contribution of the PMc and PMs during MVIC coincides with the direction of muscle fibers. However, neither force direction used in this study could successfully separate the two parts of the PM muscle.

MPSS_P1.6 EVALUATION BY MUSCLE ACTIVITY FEATURE PARAMETERS OF SURFACE ELECTROMYOGRAPHY FOR LOWER LIMB MUSCLES DURING SKIING

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Prof Tohru Kiryu; A/Prof Yukihiko Ushiyama

INTRODUCTION: Environmental arrangement allowing objective evaluation becomes an important assignment for improving skiing technique. Skiing technique is required to cope with topographical changes in snow ground condition. Besides, muscle strength is required to endure muscle fatigue in a high-speed environment, especially during a critical phase such as consecutive ski turns.

Especially techniques used during critical phase such as weight bearing and reverse weight bearing on turn movement require maturity although they are fundamental skiing movement. The following is an important technique.

1, ski control

2, muscle activity

3, postural control

Thus, objective evaluation is important for improving skiing technique and obtaining high performance.

AIM: In this study, we analyzed the performance of actual skiing with different technique levels, focusing on leg muscular activities during ski control and postural control, in relation to the movement skills.

METHODS: We prepared the feature parameters estimated from surface EMG signals and knee joint angles at each turn, then, analyzed the performance by a cross-correlation for evaluating the relationships between the feature parameters. The following is parameters.

1, τ-max is ski control

2, DiffVL is muscle activity

3, Ratio is postural control

RESULTS: The results showed that the standard deviations of parameters in high-performance skiers were small. Cluster analysis with the k-means method, further, revealed muscle activity patterns in a three-dimensional scatter distribution.

CONCLUSION: This approach leads to an objective evaluation on a ski ground that allows effective training and protects sport injury.

MPSS_P1.7 CHARACTERISTICS OF FOOT REGION MUSCULAR FORCE IN VARIOUS SPORTS ACTIVITIES.

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INTRODUCTION: Performing exercises such as towel gathering during pedal muscle training in order to maintain or improve toe function is essential for athletic performance; however, few studies have investigated the foot muscles in athletes.

AIM: The aim of the present study was to measure and clarify the characteristics of foot region muscular force in athletes from various sports.

METHODS: Subjects were divided into a male university student Athlete Group (n = 37: judo, n = 7; baseball, n = 10, soccer, n = 9; ice hockey, n = 10; mean age, 20.2 ± 1.1 years; mean height, 170.8 ± 5.6 cm; mean weight, 70.5 ± 7.2 kg, mean right foot length, 25.5 ± 1 cm, mean left foot length, 25.5 ± 1 cm) and a male non-athlete group (n = 10; mean age, 21.5 ± 1.1 years; mean height, 170.8 ± 6.1 cm; mean weight, 63.5 ± 10.5 kg, mean right foot length, 25.5 ± 1 cm; mean left foot length, 25.5 ± 1 cm). Dorsiflexion, plantarflexion, inversion and eversion forces were measured in a long sitting position using a hand-held dynamometer. Toe grip strength was measured in a seated position with knees flexed at 90° using an original toe grip dynamometer.

RESULTS: Muscular force was significantly greater in the Athlete Group than the Non-Athlete Group for left foot toe grip and left and right dorsiflexion in baseball players, for left foot toe grip and right plantarflexion in soccer players and for left and right toe grip and left dorsiflexion in ice hockey players ($P < 0.05$). Inversion and eversion forces were significantly stronger in the Athlete Group for all sports than in the Non-Athlete Group ($P < 0.05$).In judo and baseball, there were significant differences in inversion force between the left and right feet ($P < 0.05$).

CONCLUSION: The baseball players and soccer players were all right-handed and right-footed, respectively. For these subjects, toe grip strength is believed to be important in the left foot, which acts as an axis when throwing and kicking the ball. In baseball, strong dorsiflexion force in the left and right feet allows for stable defense when bending to catch the ball. In ice hockey, the toes are important for standing ground during the many contact plays while wearing skates.

Based on the sports investigated, the present findings suggest that foot region muscular force is an important element of athletic performance.

MPSS_P1.8 RELATIONSHIP BETWEEN LOWER-EXTREMITY ISOKINETIC STRENGTH AND GROUND REACTION FORCES IN PROFESSIONAL BASEBALL PITCHERS

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INTRODUCTION: There was evidence about the correlation between ground reaction forces (GRF) and ball velocity in previous studies, but the effect of the lower-extremity isokinetic strength profile on GRF remains unclear. The objective of this study was to identify the correlation between them.

AIM: To investigate GRF in professional baseball pitchers in difference pitching phases and their relationship to the various lower-extremity joint isokinetic strength and the agonist/antagonist torque ratios.

METHODS: Five healthy professional baseball pitchers participated in this study. Two force plates were used to measure the GRF in driving phase and braking phase for each leg during pitching a fast ball. Trials achieving the greatest ball velocities were chosen and ball speeds also was collected. The isokinetic strength of hip, knee, ankle muscles of both the stride and pivot leg were measured at $60^{o}s^{-1}$, $180^{o}s^{-1}$, $300^{o}s^{-1}$, and $360^{o}s^{-1}$ with a Biodex dynamometer, and the ratios of agonist/antagonist torque were calculated.

RESULTS: The effects of the knee isokinetic strength on GRF are larger than the hip or the ankle due to higher correlation(r= 0.75~1.00) than the other joints(r= 0.74~0.80). The strength of the stride leg has a larger effect on GRF in braking phase compared with the pivot leg in driving phase. The isokinetic strength of hip flexion (r= 0.79 at $60^{o}s^{-1}$; 0.87 at $300^{o}s^{-1}$), knee extension (r= 0.91 at $60^{o}s^{-1}$), knee flexion (r=0.99 at $60^{o}s^{-1}$, 0.75 at $300^{o}s^{-1}$), and torque ratios of hip (Extension/Flexion= 0.28~0.91; r= -0.80 at $300^{o}s^{-1}$, -0.76 at $360^{o}s^{-1}$), knee (Extension/Flexion = 1.17~2.24; r= -0.69 at $180^{o}s^{-1}$, -0.80 at $360^{o}s^{-1}$) and ankle (Dorsiflexion/Plantarflexion= 0.78~3.34, r= 0.77 at $180^{o}s^{-1}$, 0.76 at $300^{o}s^{-1}$, 0.73 at $360^{o}s^{-1}$) for the stride leg showed high correlation with applied braking force. It may due to both knee muscle groups co-contract and act as major stabilizers for the braking phase, and the higher hip flexion strength of stride leg may help trunk tilt and forward rotation results in more ground reaction force. Data of the pivot leg however showed inconsistencies with respect to testing velocity.

CONCLUSION: This study suggests the lower-extremity isokinetic strength might have more effects to the GRF in the braking phase than in the driving phase, especially for the knee joint, the role of stabilizer in braking phase, which should be noted by trainers or clinicians while setting up training programs.

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MPSS_P1.9 CORRELATED OSCILLATORY ACTIVITIES ACROSS AGONIST AND ANTAGONIST MUSCLES DURING MAXIMAL CO-ACTIVATION EFFORT

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INTRODUCTION: Maximal co-activation effort may involve multiple oscillatory activities across agonist and antagonist pairs originating from supraspinal and spinal neural networks. However, it is unknown if the low-frequency “common drive” oscillation is involved across agonist and antagonist pairs during maximal co-activation effort.

AIM: The purpose of this study was to identify correlated muscle activation across agonist and antagonist pairs during maximal co-activation effort.

METHODS: Twelve young subjects performed maximal effort of concurrent activation of elbow flexors (agonists) and extensors (antagonists) while maintaining the elbow joint angle at 90 degrees. Surface EMG was recorded from the short head of biceps brachii (BB), brachioradialis (BR), and long head of triceps brachii (TB). Correlations in rectified EMG between muscle pairs were analyzed in the frequency and time domains for 8 s.

RESULTS: Significant coherence (> 95% confidence interval) in rectified EMG was observed between all muscle pairs in the <5 Hz and 5-15 Hz frequency bands in most subjects. When cross correlation function in rectified EMGs was calculated following a low-pass filtering <5 Hz, the significant positive peak was greater in the agonist than antagonist pairs (0.47 ± 0.15 for BB vs. BR, 0.28 ± 0.17 for BB vs. TB, 0.36 ± 0.12 for BR vs. TB, $P < 0.05$) with a small time lag (34.1 ms). When calculated following a band-pass filtering of 5-15 Hz, there was a significant positive peak between the agonist pair (BB vs. BR) and a negative peak between the antagonist pairs (BB vs. TB and BR vs. TB) with a small time lag (5.6 and 15.8 ms, respectively). Significantly greater peak values were observed in cross correlation function in the agonist than antagonist pairs (0.45 ± 0.21 for BB vs. BR, 0.31 ± 0.16 for BB vs. TB, 0.35 ± 0.16 for BR vs. TB, $P < 0.05$).

CONCLUSION: Rectified EMG identified two oscillatory activities during maximal co-activation effort including 1) descending < 5 Hz common drive across agonists and antagonists that are in phase and 2) 5-15 Hz oscillations that may represent spinal reciprocal inhibition between antagonist pairs that are out of phase. These results suggest the presence of correlated activities across agonist and antagonist muscles, but the greater peak values in cross correlation function in the agonist than antagonist pairs suggest the difference in the strength of correlated activity between agonist and antagonist pairs.

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MPSS_P2.1 EFFECTS OF TRAINING WITH CONCURRENT EMG FEEDBACK ON KNEE EXTENSOR STRENGTH AND ACTIVATION

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INTRODUCTION: Maximal voluntary strength of the knee extensors is limited by suboptimal neural activation despite maximal effort (Westing et al., 1990). In a recent study we demonstrated that EMG feedback can be used to acutely enhance knee extensor strength in moderately active females (Ekblom & Eriksson, 2011).

AIM: The current study aimed to investigate possible effects of training with concurrent EMG feedback on strength, level of activation (LOA) and EMG activation, in dynamic maximal voluntary knee extensor actions (MVCs).

METHODS: Twenty healthy, recreationally active men and women were randomized to a EMG feedback (FB group, n=10) or resistance training group (RT group, n=10). Before and one week after training; strength, LOA, eccentric:concentric EMG-ratio and antagonist co-activation was measured in isokinetic (20deg/s) eccentric and concentric MVCs. Electrical stimulation of the femoral nerve was applied to evoke interpolated twitches (IT) during MVCs and resting twitches (RT) during passive movements of the leg. LOA was calculated as 100 x (1-(IT/RT)). Surface EMG was recorded from vastus medialis (VM), vastus lateralis (VL), rectus femoris (RF) and the hamstrings (HAM) muscles.

Training was performed three times per week for five weeks. Each session consisted of maximum isokinetic unilateral eccentric strength training of the knee extensors with (FB group) or without (RT group) EMG feedback. Feedback was provided visually on a computer screen indicating in real-time the activation of the VM, VL, RF and HAM muscles.

RESULTS: Both groups significantly improved knee extensor strength of the trained leg only ($p<0.05$) without any differences between groups ($p=0.32$). Eccentric strength increased more than concentric, by 36% and 14% respectively ($p<0.05$). The training also resulted in a tendency towards an increase in LOA of the trained leg in the FB group (irrespective of action type); from 69 ±15% before, to 81±3% after training ($p=0.097$). Training did not induce any changes in the ecc:con EMG-ratio or in antagonist co-activation.

CONCLUSION: Despite a similar increase in strength between groups, LOA increased only in the FB group, indicating that other mechanisms than improvements in LOA were involved in the strength increase of the RT group e.g. changes in morphological and contractile properties. The increase in strength was action type specific whereas the increase in LOA was similar for eccentric and concentric MVCs. The increased LOA, exclusively in the FB group indicates that EMG feedback might be a viable means to enhance the effects of resistance training over time.

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MPSS_P2.2 STRENGTH TRAINING REDUCES INTRACORTICAL INHIBITION

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INTRODUCTION: Although considerable evidence exists for neural adaptions to short-term strength training, no study has investigated the intracortical influence on strength development.

AIM: Paired-pulse transcranial magnetic stimulation was used to investigate 4 weeks of leg strength training on corticospinal excitability and short-latency intracortical inhibition.

METHODS: Participants (n = 12) were randomly allocated to either a strength training or control group. The strength training group completed 3 supervised training sessions per week (4 sets of 6-8 repetitions at 80% of single repetition maximum) for 4 weeks. Recruitment curves were constructed from stimuli delivered at 10% of maximum stimulator output below the participant's active motor threshold, increasing in 5% increments until motor evoked potential amplitude was saturated. Short-latency intracortical inhibition was assessed using a paired-pulse transcranial magnetic stimulation protocol consisting of a sub-threshold (0.7×active motor threshold) conditioning stimulus, followed 3 ms later by a supra-threshold (1.2×active motor threshold) test stimulus. All motor evoked responses were normalized to the maximal M-wave (MMAX).

RESULTS: There were significant ($p < 0.01$) increases in squat strength and corticospinal excitability, and significant ($p < 0.01$) reductions in intracortical inhibition for the strength training group following the 4 week intervention. There were no changes in any dependent variable ($p > 0.05$) detected in the control group.

CONCLUSION: These findings provide evidence that the increases in corticospinal excitability following short-term strength training are attributed to plasticity at a cortical level via reductions in intracortical inhibition.

MPSS_P2.3 SHORT-TERM DEPRESSION OF SOLEUS H-REFLEX AFTER CALF-RAISE TRAINING WITH NEUROMUSCULAR ELECTRICAL STIMULATION IN HUMANS

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INTRODUCTION: Evoked electromyographic studies suggest that increases in maximal voluntary contraction (MVC) in a few days of isometric resistance training can be accounted for both spinal and supraspinal plasticity in humans.

AIM: The purpose of the study was to examine soleus H-reflex after 10 days calf-raise training with and without neuromuscular electrical stimulation (NMES) training in healthy subjects.

METHODS: Fourteen volunteers were randomly allocated into a resistance training group without (RT, n=7) or with NMES (RT+ES, n=7) of unilateral plantar flexor muscles. The training consisted of 4 sets of right leg calf-raise in standing position with fifteen 5-sec isometric contractions for 10 days. The NMES was applied for the tibial nerve of the ipsilateral leg. Stimulation intensity was gradually increased based on the level of maximally tolerated intensity without pain and discomfort during the training session. Surface electromyography was monitored in resting soleus (Sol) and tibialis anterior (TA) muscles. Sol H-reflex was electrically elicited by tibial nerve stimulation. Peak to peak amplitudes of H-reflex and M-wave were calculated and were normalized by maximal M-wave (Mmax).

RESULTS: No background activity was observed in Sol and TA. Maximal H-reflex was significantly decreased from 0.60 to 0.53 in the RT+ES group ($P = 0.02$) whereas no change in the RT group (from 0.59 to 0.54, $P = 0.14$). Changes between pre and post measures did not differ between group ($P = 0.53$).

CONCLUSION: The present data shows 10 days calf raise training induced spinal inhibitory adjustments in healthy humans.

MPSS_P2.4 THE EFFECTS OF AN ACTIVE WARM UP ON NEUROMUSCULAR CONDUCTION VELOCITY

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Ms Helen de Bree, Victoria University; Mr Phil Seymour, Victoria University; Dr Douglas Whyte, Australian Catholic University

INTRODUCTION: It is well described that there is an increase in neural conduction velocity when one completes an active warm up. Recent research (Pearce et al., In Press) provided evidence that whilst muscular conduction increases, neural conduction does not change following a warm up. However, this previous research measured heart rate as an indicator of warm up, rather than thermoregulation increases.

AIM: This study examined the effect of a generic, active warm up inducing a one degree increase in core temperature on neural and muscular conduction time measured via transcranial magnetic stimulation (TMS) and supramaximal M-wave (Mmax) techniques projecting to the gastrocnemius muscle.

METHODS: Ten participants (7m 3 f; mean age 27 ± 7.1 years) completed an active warm up on a cycle ergometer at an intensity of 75% of their predicted age maximum (220-age) until their body temperature (measured via wireless core sensor thermisters) increased by one degree centigrade from resting values. Ten TMS and Mmax stimuli were delivered (2 sets of 5) prior to and immediately following the warm up exercise. Neural conduction time for both TMS and Mmax were measured as the time between stimulus onset and the initial deflection of the wave form. Muscle conduction time for TMS and Mmax were quantified from the stimulus artefact to the absolute peak twitch response.

RESULTS: Following the warm up protocol, a significant reduction in mean muscle conduction time was found in both TMS and Mmax of 1.70 ms and 1.01 ms respectively ($P<0.001$). However, no change was observed in the neural conduction time with both TMS (0.04 ms) and Mmax (0.06 ms).

CONCLUSION: This study confirms previous findings that muscular conduction speed increases, without changes in neural conduction, when individuals exercise at an intensity sufficiently to increase core temperature by once degree.

REFERENCE:

Pearce et al. (In Press). Neural conduction and excitability following a simple warm up, JSAMS.

MPSS_P2.5 THE EFFECT OF EXPLOSIVE STRENGTH TRAINING ON QUADRICEPS MUSCLE RATE OF FORCE DEVELOPMENT AND MUSCLE ACTIVATION IN RESISTANCE TRAINED MALES

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Dr Jason Siegler

INTRODUCTION: The investigation of individual responsiveness to explosive strength training is of interest to strength and conditioning researchers and coaches. It is thought that high responders to explosive strength training may be identified from baseline normalized contractile rate of force development (RFD).

AIM: To investigate changes in contractile RFD, CI, and muscle activation following an explosive strength training program in a resistance trained population.

METHODS: Twenty-five resistance trained males performed a 4-week explosive strength training program. Maximal quadriceps strength, contractile RFD, and muscle activation were measured before and after the training program. Participants were initially sub-grouped for analysis based on baseline normalized RFD results. Principle component analysis (PCA) was also used to identify dependent variables from the baseline assessment that could be used to investigate whether responsiveness could be predicted from other dependent variables.

RESULTS: No main time or time x sub-group effects were observed for any dependent variable ($p>0.05$). PCA found baseline vastus lateralis (VL) activity explained 46% of the variance in the entire dataset. Training induced changes in maximal RFD were negatively associated with baseline VL activity (adjusted $r2=0.33$, $p=0.003$). Training induced changes in VL activity were positively correlated with changes in maximal RFD (adjusted $r2=0.45$, $p<0.001$). Baseline VL activity was negatively correlated with training induced changes in VL activity (adjusted $r2=0.44$, $p<0.001$).

CONCLUSION: Increases in VL activity and contractile RFD following training may indicate increased efferent neural drive. Decreases in VL activity and contractile RFD indicate a rapid detraining effect, which we believe is associated with an insufficient total volume of exercise. We recommend that explosive strength training programs linearly match the total volume of exercise to the initial performance level of individuals.

MPSS_P2.6 SEMI-RIGID ANKLE SUPPORT AFFECTS MUSCLE COACTIVATION DURING PERTURBED CUTTING MANOEUVRES

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Mr Anderson Oliveira, Aalborg University; Mr Uwe Kersting, Aalborg University

INTRODUCTION: Semi-rigid ankle supports (SRAS) are widely used in order to reduce risk of ankle sprains, which may occur during tasks such as landing or cutting. Despite the efficacy in mechanically constraining ankle inversion, neuromuscular effects of these devices are not well investigated during sudden perturbed tasks.

AIM: Verify whether SRAS affect lower leg muscle activation during perturbed cutting movements.

METHODS: Eleven healthy male (24.5±3.6 years old, 1.75±0.06m, 70±4.2kg) performed 90 degree cutting manoeuvres using a standardized court shoe with (AS) and without (NS) SRAS. Twelve adaptation trials, followed by 24 trials for each condition, were performed over a movable force platform. For both conditions there were unperturbed trials (UNP), forward platform movement of either 4cm (4-P) or 8cm (8-P) randomly distributed. Eletromyographic data from right tibialis anterior (TA), peroneus longus (PL), gastrocnemius medialis (GM) and gastrocnemius lateralis (GL) muscles were obtained, also PL/TA and (GM+GL)/TA coactivation indices were calculated from normalized integrated EMG (iEMG-%max) in three different periods: 50 ms before right foot contact with/on the platform (PRE), first 50ms of stance (EARLY) and between 50 and 150ms of stance (MID). A two-way ANOVA (2 shoe conditions X 3 perturbation conditions) was performed to compare EMG amplitude and co-activation indices for each period.

RESULTS: Although there was no significant effect of platform perturbations, SRAS had significantly reduced PL and GL iEMG, affecting PL/TA and (GM+GL)/TA indices. Peroneus longus iEMG and PL/TA were lower for AS during PRE (PL iEMG: NS=48.06±20.33 and AS=40.96±29.95 %max, p=0.024; PL/TA: NS=0.99±0.48 and AS =0.81±0.57, p=0.029) and EARLY (PL iEMG: NS=52.64±25.72 and AS=46.41±39.96 %max, p=0.012; PL/TA: NS=1.13±0.65 and AS=0.98±0.85, p=0.020) periods. Furthermore, SRAS showed only decreased (GL+GM)/TA for MID phase (GL iEMG: NS=36.09±19.24 and AS=26.16±16.65 %max, p=0.003; (GL+GM)/TA: NS=2.65±1.32 and AS=2.11±1.09, p=0.015) and have not altered TA iEMG. Reduced PL/TA and (GM+GL)/TA coactivation indices may imply higher confidence provided by the mechanical restriction, even when expecting sudden perturbations. In addition, the SRAS may lead lateral ankle muscles to a shortened position, reducing motoneuron excitability and EMG amplitude for PL and GL muscles.

CONCLUSION: The use of SRAS reduces activation of lateral ankle muscles during cutting movements. Moreover, induced perturbations in this protocol did not required additional muscular activation in order to stabilize the joint.

MPSS_P2.7 REMOTE AFTER-EFFECTS OF RESISTIVE STATIC CONTRACTION OF THE FINGERTIPS WITH THE SHOULDER IN A DIAGONAL POSITION ON WRIST ACTIVE RANGE OF MOTION

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INTRODUCTION: It has been shown that after a contraction of the distal muscles, post-activation effects can appear as a remote after effect (RAF) in proximal muscles not involved in the previous voluntary activity (Gurfinkelet al., 1989). To increase active range of motion (AROM) of the wrist joint in normal volunteers, a diagonal position of the shoulder joint and a strong static contraction (SC) of the intrinsic hand muscles resulted in a RAF improvement of the wrist joint AROM (Arai et al., 2008). However, the effects of static shoulder positions and strength of the SC on the AROM in orthopedic patients has not been determined.

AIM: The purpose of this study was to compare the RAF of SC in different positions of the shoulder joint and contractions of the fingertips with different degrees of strength on both the AROM of wrist flexion and the associated surface integrated electromyographic (IEMG) activity of the wrist agonists and antagonists in orthopedic patients. The positions of the shoulder joint were the diagonal position (shoulder flexion (135°) and adduction (45°), and the neutral position was (shoulder flexion (90°) and adduction (0°). The target loads for the fingertips spanned a range from 30% to 40% MVC (weak) and from 70% to 80% MVC (strong).

METHODS: The protocol was approved by the Hiroshima University Higher Degrees Committee for Ph.D. Research Proposals and was performed according to the Declaration of Helsinki. Ten orthopedic patients were randomly selected from 20 patients. Random assignments for the order of the SC conditions were done (weak-neural, strong-neural, strong-neural, and strong-diagonal) for each subject. The change ratio of AROM (CR-AROM) measured with an electrogoniometer after each SC was calculated in comparison with the AROM before each SC, and each %EMG was obtained for the IEMG of each maximal voluntary contraction. A two-way repeated measured analysis of variance (ANOVA) was tested for the effects of position and load.

RESULTS: The results of this study showed that the CR-AROM from a strong SC was significantly larger than a weak SC ($P < 0.05$). The CR-AROM from a diagonal position of the shoulder was also significantly larger than the neutral position ($P < 0.05$). Because of a non-significant correlation coefficient between the improvement of AROM and IEMG, no relationship between AROM and facilitation of the agonist activity was found.

CONCLUSION: Not the amount of resistance but the shoulder position may be the cause of the RAF for increasing wrist AROM in orthopedic patients.

MPSS_P2.8 THE PEAK TIMES OF MUSCLE ACTIVITIES DURING LANDING FROM DIFFERENT ROTATIONS JUMP

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INTRODUCTION: Anterior cruciate ligament (ACL) injury is a common and traumatic knee injury. A majority of ACL injuries are non-contact, many of which occur in response to a cutting maneuver or during an uncontrolled landing from a jump. It is known well that neuromuscular controls lead to prevent ACL injury. However, female athletes often demonstrate insufficient neuromuscular control when performing athletic maneuvers. Preactivities (muscle activities) before landings lead to the appropriate knee position. This timing of preactivities may be aided by neural programming during a planned or expected activity.

AIM: This study was to investigate the peak times of the muscle activities during landing from five different degrees rotations jump.

METHODS: The subject was ten healthy female (mean age; 23.5 ± 2.4 years, weight; 50.3 ± 3.7 kg, height; 158.5 ± 4.7 cm). The subject was to jump landing from vertical jump, 90 degrees rotations jump, 180 degrees, 270 degrees, and 360 degrees. These rotations jumps are all right-handed rotations. The subject was instructed to fold their arms across their chest, to land as naturally as possible with both feet on the landing plate and to keep about 2 seconds with landing posture. The electromyography (EMG) signals of the following muscles were determined simultaneously on the left leg of all individuals: the rectus femoris, the vastus medialis, the vastus lateralis, the semimembranosus, the biceps femoris, the medial head of the gastrocnemius, the medial head of the gastrocnemius, and the fibularis. EMG activity was captured by an EMG system (SX230; Biometrics Ltd. UK). The sampling frequency of the EMG was 2000Hz. For this subject, the ground reaction forces generated during landing from jump were recorded using a force plate (MA8000; ANIMA Corp. Japan). These data were measured at the times of initial foot-ground contact(IC). The sampling frequency of the force platform was 250 Hz. We used the data of 0.2 seconds intervals before and after IC.

RESULTS: In all jump landings the peak mean times of the muscle activities of the semimembranosus and the medial head of the gastrocnemius resulted in significantly earlier than the quadriceps ($p < .05$). There is no significant difference between the hamstrings, the quadriceps and the gastrocnemius.

CONCLUSION: The peak times of the muscle activities of the semimembranosus and the medial head of the gastrocnemius are earlier than the others during landing from rotation jump. It is known well that the both muscle activities lead to the greater knee flexion and posterior movement of tibia and decrease more knee valgus laods. Therefore these can reduce ACL injury. Increased muscle activity before and after IC is important for stabilization.

MPSS_P2.9 THE BODY IMPACT OF UKEMI AS A CONSEQUENCE OF JUDO THROWING TECHNIQUES

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INTRODUCTION: 114 fatal accidents caused by Judo practices at schools have been reported over the past 28 years, with 74 of these described as "traumatic head injuries related to shocks of throwing and falling techniques". The Judo techniques which most frequently caused this injury were Osoto-gari, reported in 16 cases, followed by Seoi-nage, reported in eight cases.

AIM: In this research, the objectives were to evaluate movements of falling techniques (Uke) in Osoto-gari, Seoi-nage and Ouchi-gari training, and to obtain knowledge about the safety of throwing techniques in Judo practices.

METHOD: Our participants were five elite Judo athletes who performed throwing techniques (Tori), and three well experienced Judo athletes who performed falling techniques (Uke). All participants were in similar weight categories.

Participants classified as Uke did Ukemi movements in response to each technique they were exposed to. We analyzed 15 Ukemi movements in total. All the throwing and falling techniques were videotaped with three synchronized high-speed video cameras (300Hz). Subsequently, three-dimensional kinematic data at each measurement point were collected by using the direct linear transformation technique.

RESULT: The results revealed that the body contact patterns in Ukemi against Ouchi-gari were analogous to those in basic Ushiro Ukemi, while those against Osoto-gari and Seoi-nage were different. In performances of Ouchi-gari, upper limb, then trunk and finally head reached the tatami flooring, while in the case of Osoto-gari the order was upper limb, head, trunk and lower limb.

CONCLUSION: In Ukemi performed by Judo experts it was recognized that the vertical velocity of the head decelerated by approximately 60 percent. Therefore, we consider that the reaction of the pectoral girdle and upper limbs to throwing techniques is related to the onset of traumatic head injury.

MOTOR UNITS

MOTU_P1.1 COMPARISON OF THE ACTIVATION OF TWO INSPIRATORY MUSCLES IN TRUNK ROTATION: IMPLICATIONS FOR THE INTEGRATION OF VOLUNTARY AND INVOLUNTARY DRIVE

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Dr Anna Hudson, Neuroscience Research Australia; Prof Andre De Troyer; Prof Simon Gandevia

INTRODUCTION: The parasternal intercostal muscles and the diaphragm are two major inspiratory muscles in humans. However, based on the muscle fibre orientations, these muscles may have a role in voluntary postural tasks involving movement of the trunk, such as trunk rotation.

AIM: To compare the activation of the parasternal intercostal muscles and the diaphragm during breathing and during voluntary trunk rotation, we performed separate experiments to understand the integration of voluntary and involuntary drives to these muscles.

METHODS: Intramuscular electromyographic (EMG) recordings were made from the parasternal intercostals and the diaphragm on the right side in six healthy subjects during resting breathing in a neutral posture, during an isometric axial rotation of the trunk to the right ("ipsilateral rotation") or left ("contralateral rotation"), and during resting breathing with the trunk rotated.

RESULTS: The parasternal intercostals were active during ipsilateral rotation but were consistently silent during contralateral rotation. In contrast, the diaphragm was silent during rotations in either direction. The inspiratory activity in the parasternal intercostals with the trunk rotated was substantially increased for ipsilateral rotation to 201 ± 19% (mean ± SE) of the peak inspiratory activity in neutral breaths, motor unit discharge frequencies were increased (14.3 ± 0.3 vs. 11.0 ± 0.3 Hz) and new motor units were recruited. In contralateral rotation, parasternal intercostal activity decreased to 72 ± 4% of that in neutral breaths, the inspiratory discharge frequency of units decreased (10.5 ± 0.2 vs. 12.0 ± 0.2 Hz) and units were derecruited. For the diaphragm, inspiratory activity with the trunk rotated in either direction was essentially unaltered and the discharge frequency of single motor units remained at 13-14 Hz in the different postures.

CONCLUSION: The parasternal intercostals have a postural function and participate in trunk rotations, whereas the diaphragm does not. Furthermore the voluntary postural contraction of the parasternal intercostal muscles alters the output of the motoneurones during inspiration in a direction-dependent manner. Thus, we conclude that the voluntary and involuntary drives are integrated at the level of the spinal cord.

MOTU_P1.2 MOTOR UNIT FIRING PATTERN IN TYPE 2 DIABETES MELLITUS PATIENTS DURING SUSTAINED LOW FORCE CONTRACTION

Dr Kohei Watanabe, Kyoto University

Dr Ales Holobar; Mr Toshiaki Miyamoto; Dr Kazuhito Fukuda; Dr Roberto Merletti; Dr Toshio Moritani; Dr Marco Gazzoni

INTRODUCTION: Recent estimates indicate that 171 million people in the world suffered from diabetes in the year 2000 and this is projected to increase to 366 million by 2030. For the prevention and management of type 2 diabetes mellitus (T2DM), exercise has been strongly recommended. While the responses to exercise in metabolic and cardiovascular systems have been well reported in this pathology, detailed physiological response in neuromuscular system during exercise has not been fully understood.

AIM: The aim of this study was to investigate motor unit firing pattern in T2DM patients.

METHODS: Eight elderly men with T2DM (70.3±7.1 years, duration of T2DM: 7-28ys) and eight elderly healthy men without T2DM (CON) (72.0±3.6 years) participated in this study. They performed a sustained isometric contraction at 10% of maximal voluntary contraction force of the knee extensors for 120 s. During the contraction, multi-channel surface electromyography (SEMG) was recorded from vastus lateralis (VL) muscle. Using an electrode grid made of 13 rows and 5 columns of electrodes with 8mm inter-electrode distance. Recorded EMG signals were decomposed with the Convolution Kernel Compensation (CKC) technique (published by Holobar et al in 2009). After the decomposition, identified motor units (MUs) were manually verified by an investigator using visual inspector software. In this study, only MUs active from the beginning to the end of the contraction (55 out of 154 for T2DM group and 49 out of 139 for CON group) were considered. Mean and coefficient of variation (CoV) of instantaneous firing rate (IFR) were calculated from the discharge times of each identified MU at the beginning (10 -20 s), the middle (60-70 s), and the end (110-120 s) of contraction.

RESULTS: In both groups, mean IFR decreased with time ($p < 0.05$) and no significant differences in time course of mean IFR have been observed between the groups. Contrary, CoV of IFR was larger in the T2DM group comparing with the CON group at the middle (11.2±4.8% for T2DM, 9.0±4.0% for CON) and at the end (12.2±5.8% for T2DM, 10.1±5.2% for CON) of the contraction ($p < 0.05$).

CONCLUSION: High variability of MU firing rate was shown in T2DM patients during sustained low force contraction. This result might be partly caused by poor regulation of motor unit firing rate due to altered afferent input from peripheral receptors to motor neurons relating with diabetic peripheral neuropathy.

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MOTU_P1.3 MOTOR UNIT RECRUITMENT AND FIRING RATE IN MEDIAL GASTROCNEMIUS MUSCLES DURING EXTERNAL LOADING IN STANDING IN HUMANS

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INTRODUCTION: There is limited information on the relative importance of motor unit (MU) recruitment versus firing rate modulation in the gradation of force. Most of what is known has been performed in isometric contractions, with virtually no data from functional tasks. One functional task, quiet stance, requires the activation of ankle plantarflexor muscles. Whereas the soleus muscle demonstrates tonic electromyographic (EMG) activation in standing, the EMG in medial gastrocnemius (MG) muscle demonstrates more responsiveness to external loading.

AIM: To determine the extent to which the increase in MG EMG activity during external loading in standing is mediated by MU recruitment and/or an increase in MU firing rate.

METHODS: Subjects stood on a force platform with surface EMG electrodes affixed over soleus and MG bilaterally. A belt placed around the hips was attached to a horizontal cable in front of the subject. Loading was applied through the belt by adding weight in 0.45 kg increments every 30 seconds to a maximum of 2.25 kg. Motor unit recordings were obtained in MG using intramuscular fine wire electrodes. The firing rate was calculated at two points in time: 1) the mean of five interspike intervals (initial ISI) immediately after application of the load and 2) the mean of 5 s of discharge while maintaining the load (steady state). The MUs were classified as low-load or high-load threshold, when recruited with the first two loads or the last three loads, respectively.

RESULTS: Each external load resulted in a forward movement of the center of pressure. No MUs were recorded in quiet stance. Once recruited, the same MUs were active with subsequent loads. There were 9 MUs recruited with the first load, 10 with the second, 4 with the third. Many additional MUs were recruited in the highest two loads but only 6 could be discriminated. Once recruited, the initial MU ISI was on average only 17 ms shorter than that found in the steady state for the low-load threshold MUs. Furthermore, the steady state discharge of these MUs demonstrated little change in rate with increasing loads (mean of 3 ms). The high-load threshold MUs demonstrated greater modulation in firing rate. The initial ISI of these MUs was 40 ms shorter than that during steady state firing.

CONCLUSION: The high-load threshold MUs modulated their firing rate with external loads. The low-load threshold MUs demonstrated limited firing rate modulation; consequently, MU recruitment was required to produce the forces necessary to respond to external loads in standing. These data form the necessary background to understand how neurological conditions, such as stroke, affect postural control and force gradation during functional tasks.

ACKNOWLEDGEMENT: Funding from NSERC Canada.

MOTU_P1.4 ASSOCIATION OF MOTOR UNIT DISCHARGE BEHAVIOR IN GASTROCNEMIUS MUSCLE WITH POSTURAL AND JOINT ANGLE SWAYS DURING QUIET BIPEDAL STANCE

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INTRODUCTION: In human quiet bipedal stance, the activation of triceps surae muscle contributes to counteract the postural sway. The surface EMG during quiet bipedal stance suggests that gastrocnemius muscle (GAS) intermittently discharges, while soleus muscle (SOL) shows relatively steady activation. However, the physiological significance of this GAS activation pattern remains to be elucidated.

AIM: The present study investigated the physiological characteristics of GAS discharge pattern, at the level of single motor unit (MU), in quiet bipedal stance. The discharge pattern of each single MU was qualitatively evaluated, in conjunction with the postural and joint angle fluctuations.

METHODS: Eight young subjects maintained quiet bipedal stance, with eyes closed, on a force platform for 60 s. Each subject performed four trials. The anteroposterior sways of center of body mass (CoM) and knee and ankle joint angles were simultaneously recorded by means of a set of high-resolution laser displacement sensors. In each of two heads of GAS, intramuscular EMGs were recorded with two pairs of bipolar wire electrodes. From the recorded intramuscular EMG, action potentials of single MU were extracted. The time-series data of single MU discharge rate, CoM, foot center of pressure (CoP), and knee and ankle joint angles were obtained. To assess the relationship between fluctuation of MU discharge rate and postural and joint behaviors, the cross-correlation function (CCF) was calculated between these time-series data.

RESULTS: In total, 76 MUs were analyzed. The CCF for each MU demonstrated that anterior sways of CoP and CoM followed the increase of MU discharge rate, with a time delay of approximately 300 ms. The result of CCF between MU discharge rate and sways of joint angles was different among MUs. In 36 MUs, the increase of MU discharge rate cross-correlated both with dorsiflexion of ankle joint and with flexion of knee joint. On the other hand, in nine MUs, the increase of MU discharge rate cross-correlated both with dorsiflexion of ankle joint and with extension of knee joint.

CONCLUSION: The present result demonstrated that discharge behaviors of MUs in GAS were not uniform, in terms of the relationship with joints' movements. This suggests that MUs in GAS are categorized into some groups, and each of which has different function for postural control.

ACKNOWLEDGEMENTS: This study was supported by a Grant-in-Aid from the Uehara Memorial Foundation.

MOTU_P1.5 MOTOR UNITS RECRUITMENT PATTERN OF PLANTAR FLEXOR SYNERGISTS DURING PROLONGED QUIET STANDING

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INTRODUCTION: Muscle activities dramatically alternate among synergistic muscles to minimize the muscle fatigue (Kouzaki & Shinohara 2006). This synergistic muscle relation might contribute to the maintenance of human bipedal standing for a prolonged time. However, it is not clear whether such alternation occurs during prolonged bipedal standing.

AIM: The purpose of present study examined the muscle activities of individual plantar flexors during quiet standing for a prolonged time. To this end, we measured the motor unit (MU) discharge pattern of plantar flexor synergists.

METHODS: Subjects (22-39 year) maintained a quiet stance barefoot on a force platform with their eyes open for 60 min. Motor unit activity was recorded throughout the task with bipolar fine-wire electrode (diameter = 0.05 mm) inserted into the soleus (SOL), medial gastrocnemius (MG), and lateral gastrocnemius (LG) muscles. Action potentials were discriminated based on waveform amplitude, duration, and shape.

RESULTS: MUs of SOL continuously discharged for entire task. In contrast, MUs of MG and LG exhibited phasic activity. Furthermore, in the latter half of standing (> 30 min), an alternating pattern of MUs activity between MG and LG was observed. This result indicates that motor units of plantar flexors are not continuously activated by rather the individual MUs involuntarily alternate between periods of activity and silence. With respect to continuous activity of SOL's MUs, discharges of individual MUs were investigated. As a result, each MU did not continuously discharge, rather they repeated between periods of activity and silence. This means that the MUs activity rotates within the SOL during prolonged quiet standing.

CONCLUSION: These results may suggest that alternate MUs activity is rationalized strategy for maintaining erect posture for a long time with attenuating fatigue.

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REFERENCSES: Kouzaki M & Shinohara M. Journal of Applied Physiology 101(3): 715-720, 2006.

MOTU_P1.6 MUSCULAR ACTIVITY IN MAXIMUM VOLUNTARY CONTRACTION OF M. QUADRICEPS FEMORIS —TESTING WITH MECHANICAL VIBRATION (MECHANOMYOGRAM: MMG)

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INTRODUCTION: Physiological data in muscle contraction includes action potential or electromyogram (EMG) and mechanomyogram（MMG）,where EMG and MMG are the electric vibration before muscular contraction and the mechanical vibration after muscular contraction, respectively. Many researchers had reported correlation between action potential and muscle strength, but not between MMG and muscle strength.

AIM: Our research focused on MMG or mechanical vibrations in muscle construction.

METHODS: Subjects were 28 adults (15 men and 13 women, average age 28.9). The muscular strength was measured with BIODEX System 3. With flexion of the knee joint 70°, the ratio of isometric knee extension strength to body weight was calculated. Next, MMG was measured with CCI 3D accelerometer. Both MMG and muscular strength were measured concurrently at six points: respective two places on three muscles of vastus medialis, rectus femoris, and vastus lateralis, where two places were taken by 5 cm and 10 cm from the upper edge of patella. The power spectrum was calculated by auto-regression (AR) model with four degrees. Total power (TP) was determined by multiplying sum of power spectrum within the specified frequency range by fundamental frequency. Simple correlation coefficient was used to find correlation between MMG and muscle strength.

RESULTS: The maximum TP in MMG was obtained at the point in the vastus medialis muscle located approximately 5 cm from the upper edge of the patella. In addition, maximum mechanical vibrations were obtained in the horizontal direction. Also, the significant positive correlation was found between MMG and muscle strength.

CONCLUSION: Andriacchi (1984) showed that in knee extension in isometric contraction, the maximum action potential was obtained in the vastus medialis muscle. Likewise, the maximum MMG was obtained there in our research. This demonstrates that knee joint extension correlates with the vastus medialis muscle. In addition, the maximum MMG was obtained in the horizontal direction rather than the front/back or vertical direction. That was probably because amplitude was more limited in the front/back or vertical direction due to the tendon or skin under tension caused by the fully stretched anterior femur. Many things are still unknown regarding muscle contraction when full muscular strength is delivered. However, the findings from our research may lead to discovery of new muscle functions. In addition, the significant positive correlation between MMG and muscular strength means that MMG may become new indicator to test isometric muscular strength.

MOTU_P1.7 USING SURFACE ELECTROMYOGRAPHY TO ASSESS CHANGES IN MOTOR UNIT POTENTIAL MORPHOLOGY POST-STROKE.

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INTRODUCTION: Muscular weakness is a major impairment limiting motor function following a hemispheric stroke. One mechanism that may contribute to muscle weakness may be the structural changes of the motor unit (MU) including motoneuron (MN) denervation and reinnervation of paretic muscles. Currently, our knowledge of the extent of such MU structural change post-stroke is limited by the need to acquire suitable recordings from intramuscular electrodes. A novel surface EMG (sEMG) recording and decomposition system for MU analysis has recently been developed. The system utilizes a unique surface electrode that is non-invasive and could potentially yield a large number of MUs recorded from paretic muscle.

AIM: To examine potential MU (size) redistribution as well as MN reinnervation post-stroke, using MU potentials recorded from sEMG to characterize MUAP shape and amplitude.

METHODS: EMG data was collected and analyzed using the Delsys sensor array and Delsys decomposition program. Data was collected from two hemiparetic stroke subjects who performed isometric abduction force tasks using the index finger. Estimates of the MUAP features were calculated through the STA method (Hu et al., In preparation). Three variables were used to estimate the MU sizes: P-P amplitude and P-P duration and RMS of the MUAP.

RESULTS: A total of 194 MUs from the affected side and 198 MUs from the contralateral side were extracted from subject 1. The distribution of the estimated MU sizes was such that the P-P amplitude and RMS of MUAP shifted to smaller values on the affected side as compared to the contralateral side and the P-P duration shifted to longer values. In this subject there were a greater number of MUs with multiple phases. In subject 2, a total of 85 MUs from the affected side and 112 MUs from the contralateral side were extracted. Subject 2 differed from subject 1, exhibiting mainly an absence of larger MUs, with similar P-P MUAP durations between the two sides. In addition, the number of phases in the analyzed MUAPs was similar between the two sides.

CONCLUSION: The results indicate a structural change of the MU pool; namely, the number of large MU is reduced and the number of small MU is increased on the affected side, which may suggest either partial denervation of large MNs or overall atrophy of the tested muscle. The contrasting results of the two subjects reveals the differential diagnostic capability of this novel sEMG recording and decomposition system.

MOTU_P1.8 THE MOTOR UNIT POTENTIAL DISTRIBUTION OVER THE SKIN AS A FUNCTION OF THE MOTOR UNIT DEPTH IN THE HUMAN BICEPS BRACHII

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Dr Miriam González; Dr Francesco Negro; Dr Dario Farina

INTRODUCTION: Interpretation of global surface EMG (sEMG) has been proved difficult because of the inability of the traditional (2 electrode) recording configuration to detect activity at the level of single motor units (MUs). The spatiotemporal profiles of surface motor unit potentials (sMUPs) that result from high-density recordings of the sEMG provide valuable information on the generating motor unit. The major limiting factor of high-density EMG techniques is that they apply to superficial MUs only since an excessive depth of the target MU leads to sMUPs with relatively unchanged spatiotemporal profiles.

AIM: To investigate the spatial distribution of monopolar and bipolar sMUPs along the fibre direction (longitudinal), perpendicular to the fibre direction (transverse) as a function of the motor unit depth.

METHODS: Multichannel surface and intramuscular electromyographic (EMG) signals were simultaneously recorded in monopolar configuration from the biceps brachii muscle of 10 subjects during 60-s isometric contractions at 20% of the maximal torque. Bipolar potentials were obtained by subtracting successive monopolar MUPs in the longitudinal direction. Two needles, with lengths of 15 mm and 25 mm, were used to record two populations of MUs with statistically different depths. Multichannel sMUPs of the target motor unit were obtained by spike-triggered averaging.

RESULTS: The effective width of the innervation zone, i.e., the extension around the innervation point within which marked amplitude changes occur is estimated to range between 16 and 32 mm for both monopolar and bipolar sMUPs.

For bipolar recordings, superficial and deeper sMUPs have a similar relative amplitude variation along the fibre direction. In the case of monopolar signals, however, superficial MUPs show marked amplitude variations around the innervation zone, whereas deeper MUPs exhibited a more uniform longitudinal variation.

The transverse extent of surface potentials, that is, the distance over the skin surface where sMUPs have amplitudes higher than 50%, lies between 24 and 32 mm for bipolar potentials and between 72 and 96 mm for monopolar potentials.

CONCLUSION: The effective width of the innervation zone ranges between 16 and 32 mm for both monopolar and bipolar sMUPs. The longitudinal variation of bipolar sMUPs is less dependent of the MU depth than that of monopolar sMUPs. The transverse extent of monopolar sMUPs is three times larger than that of bipolar sMUPs.

MUSCLE FATIGUE

MUSCLE FATIGUE

MFAT_P1.1 SEX DIFFERENCES IN RESPONSE TO COGNITIVE DEMAND DURING A FATIGUING CONTRACTION IN OLD ADULTS

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Mr Hugo Pereira; Ms Bonnie Schlinder-DeLap; Dr Tejin Yoon; Mr Vincent Spears

INTRODUCTION: Cognitive demand imposed during sustained isometric contractions can increase fatigue and reduce steadiness in young adults, especially women; the mechanism for increased fatigue involves initial strength (Yoon et al. J Appl Phyiol, 107: 1486, 2009). Aging results in marked reductions of strength and cognitive function but the impact of increased cognitive demand on performance of sustained isometric contractions in old men and women is not known.

AIM: (1) To compare the time to task failure and steadiness (force fluctuations) for a submaximal fatiguing contraction in the presence and absence of increased cognitive demand in old men and women; and (2) to determine the association between functional performance and changes in fatigue with cognitive demand.

METHODS: Old adults [7 women (72.0 ± 5.8 yrs) and 5 men (71.6 ± 7.4 yrs)] performed an isometric fatiguing contraction at 20% of maximal voluntary contraction (MVC) force until task failure with the elbow flexor muscles during 3 separate and counterbalanced sessions: (1) stressor session (Stress) in which cognitive demand involving mental subtraction by 13's starting from a 4 digit number was imposed during the fatiguing contraction; (2) mental-attentiveness session (MA), designed to not increase stress (subtraction by 1 s); and (3) control session (CON) with no mental-math task imposed.

RESULTS: Old men were stronger than old women (71.2 ± 11.3 vs 33.2 ± 4.6 Nm respectively; $P<0.01$). Time to task failure was briefer for the stress session compared with the MA and control for old women (CON: 20.2 ± 7.4 min vs. MA: 18.1 ± 5.3 min vs. Stress: 12.6 ± 4.5 min) but not for old men (CON: 9.6 ±7.3 min vs. MA: 9.8 ±4.4 min vs. Stress: 10.2 ± 5.1 min, session × sex: $P=0.04$). The percent difference in time to task failure between sessions [(CON – Stress/CON) ×100] was negatively associated with: a) the baseline MVC torque ($r2$ = 0.69, $P<0.01$); and b) the distance walked in 6 minutes ($r = -0.67$; $P = 0.03$). The stress session had larger force fluctuations (SD/mean of the force) than control at the start of the contraction for both sexes (session × time effect: $P=0.01$).

CONCLUSION: The increased fatigability of a low-force fatiguing contraction when cognitive demand was imposed was greater for old women than old men. Age-related reductions in strength may amplify the effects of stress on motor fatigue in old women. The loss of steadiness with stress and fatigue however, was universal to both men and women. The associations between the greater fatigue (with imposed cognitive demand), functional performance and initial strength suggest that women maybe at greater risk for an age-related decline in motor and cognitive processes and reduced functional capacity.

MFAT_P1.2 THE EFFECT OF FATIGUE HIP ABDUCTORS ON SINGLE-LEG STANCE POSTURAL CONTROL AND MUSCLE CONTROL

Mr Matsuda Tadamitsu, Ryotokuji University

Mr Tozawa Ryousuke; Mr Miyajima Shigeki; Mr Koyama Takayuki; Mr Takanashi Akira; Mr Kawada Kyohei; Ms Shiota Kotomi; Mr Nogita Yoshiharu; Mr Uchikoshi Kenta; Mr Koshida Sentarou; Mr Endou Motohiro

INTRODUCTION: Previous research combining fatigue has mainly focused on hip abductor muscles. However, little is known of the consequences of single-leg postural control when hip abductor muscle be tired.

AIM: The purpose of this study was to clarify postural control and muscle activity of the gluteus medium and musculus erector spinae in a single-leg stance before and after hip muscle abductor fatigue.

METHODS: Subjects were 22 healthy male adults (mean age; 21.4 yrs) with no significant medical history or current medical problems. The subjects were enrolled after obtaining written informed consent. Postural balance was measured with a Gravicorder GS-31P stabilometer (Anima Co.) in two trials of 30s each, under conditions of static upright posture with eyes open. We examined postural control and muscle activity in a single-leg standing position before and after hip muscle abductor fatigue using Biodex (Sakai Co.). A statistical analysis was performed using a paired t-test before and after muscle fatigue, and Pearson's rank was obtained for muscle activity associated with postural control($p<0.05$).

RESULTS: The results indicated a significant increase in stability indices, a decrease in gluteus medius muscle activity, and an increase in right musculus erector spinae activity after fatigue. There was a positive correlation between the increase in right musculus erector spinae activity and increase in postural control.

CONCLUSION: It is believed that postural control increased in the orientation related to the working of the muscles due to their fatigue, and that muscle activity increased to compensate.

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MFAT_P1.3 EFFECTS OF ABDUCTOR MUSCLE FATIGUE ON UNILATERAL DROP LANDING

Mr Chang Young Kim, Yonsei University

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INTRODUCTION: Of the 77% of sports-related injuries that occur in the lower extremities, the knee (21%) and ankle (18%) make up a majority. ACL (Anterior Cruciate Ligament) rupture injury occurs frequently in sporting events. Landing from a jump or changing direction are movements commonly associated with sports-related knee injury.

AIM: The purpose of the current study was to compare the effects of hip abductor muscle fatigue on unilateral drop landing between males and females.

METHODS: Fifteen healthy males (age: 29.6±2.07yrs; weight: 75.4±5.12kg; height: 177.6±5.70cm) and fifteen healthy females (age: 22.6±3.29yrs; weight: 57.9±5.68kg; height: 163.4±4.64cm) were recruited for this study. Three-dimensional motion data were sampled at a rate of 200 Hz using eight infrared cameras (VICON MX-F20, Oxford, UK). Ground reaction force data were sampled at 2000 Hz with one force plate (ORG-6 AMTI, Watertown, MA, USA). Participants performed three pre-fatigue and post-fatigue unilateral drop landings. Subjects performed a hip abductor fatigue protocol consisting of side-lying continuous hip abduction to fatigue. Two-way repeated ANOVA measures were used for statistical analysis. Alpha was set at $p < .05$.

RESULTS: Hip abduction angles differed between males and females at peak vertical ground reaction force (males: -1.24±3.99° to -1.10±5.64°; females: 5.72±3.72° to 6.99±5.86°; $p < .000$). Greater increases in hip adduction angle were observed during post-fatigue than during pre-fatigue. Female subjects demonstrated greater hip adduction angles than male subjects. In regard to knee kinematics, results differed between males (3.29±3.15° to 1.92±3.11°) and females (-3.13±5.57° to -6.00±5.23°; $p < .000$) in knee valgus angle at peak vertical ground reaction force. After hip-abductor fatigue, females showed an increased knee valgus angle at peak vertical ground reaction force.

CONCLUSION: Based on previous studies of knee injuries, a large knee valgus angle observed post-fatigue may increase the probability of an ACL injury compared to angles observed in a pre-fatigue state. The larger change in kinematics in women demonstrated that hip abductors do play a more important role in controlling knee motion for women than men when landing from a jump. This difference is identified as one reason why women face a higher risk of lower-extremity injury. Therefore, it may be necessary to enhance hip abductor muscle strength and fatigue resistance (e.g., in the gluteus medius muscle) to ensure safe execution of movements such as sudden changes (e.g., cutting) in sport events.

MFAT_P1.4 EFFECT OF FATIGUE ON BALANCE PERFORMANCE AND MUSCLE ACTIVATION IN BALLET DANCERS

Miss Yi-An Chen, National Cheng Kung University

Dr Cheng-Feng Lin

INTRODUCTION: Fatigue, defined as a decreased force generating capacity, is an inevitable phenomenon in athletes during their routine training. Fatigue is said to decrease the ability of movement control in the aspect of musculoskeletal system and neuromuscular system and may potentially lead to injury. Ballet dancers are at high risk of ankle and foot injuries, especially after long duration of dancing or training. However, few studies evaluate the effect of fatigue on ballet dancers' balance control.

AIM: To examine the effect of fatigue on the balance ability and muscle activations in ballet dancers.

METHODS: Three female ballet dancers participated in this study. They were asked to perform a 10-sec Retiré, a task supporting with non-dominant leg in ballet turnout position while the working leg is flexed and placed around the knee joint of the supporting leg. A motion analysis system with eight Eagle Digital Cameras recorded three-dimensional videographic data and synchronized with one Kistler force plate and Delsys Electromyography to record ground reaction force and muscle activity during Retiré in non-fatigue and fatigue condition. The COP parameters including maximum COP displacement in the antero-posterior (AP) and medial-lateral (ML) directions, mean speed, and 95% COP ellipse area were used to evaluate the balance ability and were normalized to the each dancer's foot length (FL) and foot placement. Root mean square (RMS), co-contraction index (CCI) and median frequency (MF) were used to assess the muscle activity strategy.

RESULTS: After fatigue, ballet dancers had increased COP displacement in both AP (pre-fatigue: 0.11±0.02 FL, post-fatigue: 0.21±0.13 FL) and ML directions (pre-fatigue: 0.16±0.05 FL, post-fatigue: 0.44±0.35 FL), mean speed (pre-fatigue: 0.32±0.06 FL/sec, post-fatigue: 0.48±0.11 FL/sec) and the area of COP traveling (pre-fatigue: 0.03±0.01 FL2, post-fatigue: 0.14±0.14 FL2). Ballet dancers also had decreased RMS on medial gastrocnemius (pre-fatigue: 68.67±45.31, post-fatigue: 42.88±25.23) and the smaller CCI of ankle in the sagittal plane (pre-fatigue: 59.63±7.13%, post-fatigue: 49.20±7.74%) after fatigue protocol.

CONCLUSION: After fatigue, ballet dancers presented poor balance ability and altered muscle activity. According to our findings, a proper design of training program to avoid fatigue is necessary for ballet dancers.

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MFAT_P1.5 INFLUENCES OF DIVERSE SEATED POSES ON WORK-RELATED STRESS

Prof Osamu Nitta, Tokyo Metropolitan University

Prof Ken Yanagisawa; Dr Masanobu Kinosita; Mr John Surya

INTRODUCTION: It is assumed that performing a desk job for many hours causes mental stress for the worker. It has been widely accepted that simple physical exercise is effective for stress reduction, but a relationship between exercise and stress has not been identified.

AIM: The purpose of the present study was to examine the possibility of stress being reduced by facilitation of physical exercise in subjects under great stress, who were instructed to perform a desk job for a limited time.

METHODS: Nine healthy male adults (age range: 20-22 years) participated in this study.

All subjects were instructed to perform a desk job for one hour prior to intervention. Subjects allocated to the experimental group were instructed to take a sitting position on a non-rigid chair that was developed originally and to perform a desk job for 30 minutes while their trunk remained unstable. Blood samples of 5 ml each were collected from subjects' cubital veins before and after the experiment. The blood sampling was performed by Dr Kinoshita. Samples were subjected to component analysis after the experiment. Serum prolactin (PRL) and salivary amylase (s-AMY) levels were determined. Blood PRL levels were determined with ARCHITECT analyzer i2000. The data were statistically analyzed using a matched t-test, with significance level set at $p<0.1$.

This study was conducted with the approval of the Ethics Committee of the Tokyo Metropolitan University.

RESULTS: The mean PRL level before the experiment, 3.25 (SD 8.13) ng/ml, was increased to 8.40 (SD 3.25) ng/ml after the experiment, indicating significant change. The mean s-AMY level before the experiment, 50.88 (SD 18.44) U/L, was decreased to 48.86 (SD 17.07) U/L after the experiment, also indicating significant change.

CONCLUSION: These results demonstrate that blood PRL and s-AMY levels are increased in subjects under stress. In the present study, subjects were instructed to perform a desk job for an hour immediately prior to the experiment. Assuming that they were under great stress before the experiment, decreases in blood levels of both components were identified post-intervention. The results imply that stress is reduced by workers sitting on an unstable chair. It is known that working while seated on a hard chair increases stress. These findings indicate that sitting on an unstable chair, which allows the worker's trunk to move freely, and the application of light exercise are effective methods for improvement in blood circulation and for stress reduction.

MFAT_P1.6 ANALYSIS OF MUSCULAR FATIGUE FOR WOMEN WITH CARRYING A BABY

Dr Mayumi Kuno-Mizumura, Ochanomoizu University

Dr Yasuyuki Yoshida, Ochanomizu University

INTRODUCTION: During pregnancy and postpartum, daily physical activity tend to decrease for women, which may lead to increase risks for cardiovascular diseases. For postpartum women, carrying a baby is an additional physical task which my cause muscular fatigue to induce the decrease in daily physical activity. However, no studies had examined muscular fatigue during carrying a baby.

AIM: So the aim of this study was to investigate muscle activity and perceived exertion during standing posture with carrying a baby in arms.

METHODS: Subjects were eight healthy Japanese young females aged 20 to 23 yrs old. Subjects were asked to stand with 8kg-weighed baby dummy in their arms on a force platform for 15 minutes. Surface electromyograms (sEMG) were recorded from sternocleidomastoid,　trapezius, biceps brachii,　and erector spinae muscle. Perceived exertion of the whole body, neck, shoulder, arm, low back, and leg were recorded every 3 minutes according to Borg scale. Maximal voluntary contraction of each muscle was recorded prior to the standing protocol. EMG activities were normalized by MVC values.

RESULTS: During the first 3 minutes of standing, sEMGs expressed as %MVC were 3.3 for sternocleidomastoid muscle, 4.8 for trapezius muscle, 12.6 for biceps brachii muscle, and 5.2 for erector spinae muscles. Comparing sEMG of each muscle during the first 3 minutes and that during the last 3 minutes, only trapezius muscle showed significant increase in the last 3 minutes while other muscles showed no significant differences. Although there was significant difference of sEMG during 15 minutes standing with a baby dummy only for trapezius muscle, all perceived exertion recorded for several body sites showed significant increase during 15 minutes standing.

CONCLUSION: These results indicated that posture with a baby would induce muscular fatigue in neck-shoulder region, which might cause neck-shoulder pain for postpartum women.

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MFAT_P1.7 NEUROMUSCULAR FATIGUE AFTER SHORT-TERM MAXIMAL RUN IN CHILD, ADOLESCENT AND ADULT ATHLETES

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INTRODUCTION: Muscle fatigue can be either central or, when the problems are in the processes beyond the neuromuscular junction, peripheral. Maximal short running distances (300-400 m) will increase lactate levels and acidosis resulting in remarkable peripheral fatigue while less is known about the possible role of central fatigue. Based on the present knowledge it is not also clear whether there are any differences in the causes and amount of fatigue between different age groups.

AIM: The purpose was to study the central and peripheral origin of fatigue after short-term maximal run in different age groups.

METHODS: Eight male child (11-14 years) = G1, 8 adolescent (14-16 years) = G2 and 8 adult (18-24 years) = G3 athletes ran 300 m, 350 m and 400 m, respectively, with maximal speed on an indoor track. The following measurements were conducted before and after the run: plantar flexion MVC with max EMG, passive twitch response, maximal M-wave (Mmax), maximal V-wave and blood lactate. In addition, Hmax/Mmax ratio and serum testosterone concentration were measured before fatigue.

RESULTS: Running times were identical (G1 53.6 ± 5.7 s, G2 53.3 ± 2.3, G3 52.1 ± 2.1) (n.s) but blood lactate (G1 10.16 ± 1.07 mmol/l, G2 13.33 ± 3.72 mmol/l, G3 17.41 ± 1.84 mmol/l) after maximal run differed ($P <$ .001-.05) between the groups. Hmax/Max was highest ($P < .01$) (G1 0.73 ± 0.13, G2 0.67 ± 0.17, G3 0.50 ± 0.17) and testosterone concentration was lowest ($P < .001$) in child athletes (G1 3.10 ± 3.46 nmol/l, G2 14.96 ± 4.07 nmol/l, G3 13.60 ± 3.30 nmol/l). MVC decreased significantly only in G3 by 16.05 ± 13.03 % ($P < .01$) and passive twitch torque by 23.73 ± 13.69 % ($P < .01$) in G3 and by 19.20 ± 12.18 % ($P < .01$) in G2. No significant changes were observed in max EMG or Vmax/Mmax in any of the groups.

CONCLUSION: Child athletes with lower basal testosterone concentration levels did not increase their lactate levels as much as especially adult athletes and were also not able to fatigue themselves to the same degree. Child athletes had higher Hmax/Mmax ratio than the other two groups. Endurance athletes have previously been shown to have higher Hmax/Mmax ratio than power athletes and it has been suggested that higher Hmax/Max ratio is related to the endurance type of training background and/or to the predominance of slow twitch fibers. Since there were no changes in maximal EMG or V-wave and passive twitch response decreased it seems that the fatigue in the two older groups was mostly of peripheral origin.

MFAT_P2.1 SENSITIVITY OF SPECTRAL INDEXES OF SURFACE EMG IN PROVIDING INFORMATION ON MOTOR UNIT BEHAVIOR

Dr Francesco Negro, Georg-August University

INTRODUCTION: The spectral analysis of surface EMG (sEMG) is still extensively used to characterize motor unit (MU) recruitment strategies (e.g. [1]), but limitations of this approach have been shown [2].

AIM: We analyze the sensitivity of two common spectral indexes, mean (FMEAN) and median (FMEDIAN) frequency, to identify newly recruited MUs in simulated sEMG signals. The simulations are purposively simple to underline the limitations of EMG spectral analysis to study MU behavior even in simplified conditions.

METHODS: A modified version of the Fuglevand model [3] was implemented (200 MUs) to simulate the generation of muscle force during sustained contractions. The model included a decreasing in discharge rates (10% per 100 s contraction) and a PID controller to maintain the target force level constant. The sEMG model [4] was implemented with parameters used in [5] and the conduction velocity of action potentials decreased over time according to experimental data [6]. Two scenarios were simulated: 1) sustained contractions of 100 s duration at 20 % of the maximal voluntary contraction (MVC) with progressive MU recruitment. 2) Contraction at 20 % MVC for 30 s with frequent MU substitution. For each case, 100 trials were generated for 20 random sEMG libraries. FMEAN and FMEDIAN were calculated for each trial and averaged.

RESULTS: 1) FMEAN and FMEDIAN decreased from the initial values of 113.1 ± 7.5 Hz and 98.5 ± 5.3 Hz to 94.1 ± 6.2 Hz and 81.5 ± 4.5 Hz at the end of the contractions. The number of active MUs increased from 157 ± 2 (beginning) to 168 ± 1 (end). However, there was no association between the newly recruited MUs and FMEAN or FMEDIAN ($P>0.05$ for linear regression). 2) FMEAN and FMEDIAN were 115.2 ± 11.7 Hz and 100.2 ± 11.3 Hz when the first pool of MUs was active (lowest threshold units); 102.1 ± 22.7 Hz and 86.1 ± 23.8 Hz for the second pool (medium threshold); and 122.2 ± 14.4 Hz and 106.0 ± 14.8 Hz for the third pool (high threshold), thus not showing an association between recruitment thresholds and spectral indexes.

CONCLUSION: The power spectrum of the sEMG is influenced by factors other than MU behavior and thus it does not provide reliable information on MU recruitment, not even in the simplified conditions of these simulations.

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MFAT_P2.2 ACUTE MUSCULAR FATIGUE FOLLOWING HIGH INTENSITY FAILURE AND NON-FAILURE RESISTANCE EXERCISE SESSIONS

Dr Paul Marshall, University of Western Sydney

Mr Benjamin Dowswell

INTRODUCTION: Acute fatigue is thought to be a crucial component for the success of a resistance exercise program. The acute fatigue responses to failure or non-failure training modes has not been well investigated.

AIM: To examine the acute fatigue responses (motor unit activation, maximal isometric force output, and muscle fibre conduction velocity) to resistance exercise performed with a constant volume-load using repetitions performed to failure (RF) or not to failure (NRF), and long (3 minute) versus very short (20 second) inter-set rest periods (ISRP's).

METHODS: Fourteen resistance trained participants completed four different protocols involving 20 repetitions of the front squat exercise prescribed at 75% of a 1-repetition maximum. Maximal force output (N), motor unit activation (mV), and muscle fiber conduction velocity (CV) were measure before (PRE), immediately following (IP), one-minute following (1P), and 5-minutes following (5P) each session.

RESULTS: Maximal isometric force output decreased ($p < 0.001$) at IP, 1P, and 5P,

similarly between all protocols. There was no difference in motor unit activation between

24 protocols or from PRE observations at IP. Muscle fibre conduction velocity decreased ($p < 0.05$) IP following short-rest/failure exercise and increased ($p < 0.05$) IP following non-failure exercise. Motor unit activation during exercise increased for all protocols apart from the long-rest/non-failure session.

CONCLUSION: Due to the reduction in exercise time and enhanced acute fatigue responses, the failure and short rest protocol is likely the most promising, albeit demanding, training protocol. The results of this study are confined to an acute training session and cannot be generalized to expected training effects.

MFAT_P2.3 F WAVES IN ABDUCTOR DIGITI MINIMI ARE REDUCED AFTER MAXIMAL VOLUNTARY CONTRACTIONS

A/Prof Janet Taylor, Neuroscience Research Australia

Dr Serajul Khan, Neuroscience Research Australia; Prof Simon Gandevia, Neuroscience Research Australia

INTRODUCTION: Voluntary activity appears to lead to a reduction in the responses of motoneurones to synaptic input but it is not clear if this represents a change in the properties of the motoneurones or a presynaptic mechanism (e.g. 1, 2).

AIM: The current study aimed to determine whether F waves, which are recurrent discharges of motoneurones after antidromic activation and do not depend on synaptic input, are also reduced in an activity-dependent manner.

METHODS: Electrical stimuli (100 µs duration) were delivered to the ulnar nerve proximal to the wrist. EMG was recorded through electrodes over abductor digiti minimi (ADM) with different filtering to examine F waves (200-1000Hz) or M waves (16-1000Hz). The right hand was held in a myograph which measured little finger abduction force. In study 1, on two days, subjects (n=8) received supramaximal ulnar nerve stimuli to evoke F waves. Two sets of 30 stimuli (0.5 Hz) were delivered before and 6 sets after a maximal voluntary contraction (MVC) of the little finger into abduction. The MVC lasted 10 s on one day and 1 min on the other. In study 2, subjects (n=8) performed a 2-s MVC and later a 2-min MVC with sets of 30 supramaximal stimuli delivered before and after each contraction. In study 3, subjects (n=8) again performed a 2-s and later a 2-min MVC. Ulnar nerve stimuli before and after the contractions were set to evoke M waves of 25%, 50% and 100% of maximum. In each study, the areas of the F wave and/or M wave were measured for each stimulus. 10 consecutive potentials were averaged before analysis.

RESULTS: After 10-s and 1-min MVCs, F waves were significantly depressed by 40±8% and recovered over ~3 mins ($p=0.021$) with no difference between contractions ($p=0.44$). F waves were also depressed after 2-s (24±6% for <2 min; $p=0.026$) and 2-min MVCs (54.7±7% for ~6 min; $p=0.001$) with greater depression after the long contraction ($p=0.007$). Maximal and submaximal M waves were not changed after a 2-s MVC, but submaximal M waves (25% and 50% maximum) were significantly depressed for 1 min after the 2-min MVC ($p<0.05$).

CONCLUSION: The results demonstrate an activity-dependent depression of the F wave in ADM. This depression does not match the time-course of changes in the submaximal M wave and therefore is not due to the activity-dependent reduction of excitability of motor axons. We conclude that voluntary activity alters the properties of the axon initial segment or soma of the motoneurones.

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MFAT_P2.4 MUSCLE ACTIVATION PATTERNS OF QUADRICEPS SYNERGISTS INCLUDING THE VASTUS INTERMEDIUS DURING FATIGUING DYNAMIC KNEE EXTENSIONS

Dr Hiroshi Akima, Nagoya University

Mr Akira Saito, Nagoya University

INTRODUCTION: Fatigue-related muscle activities have been widely examined during isometric contractions using surface electromyography (EMG); however, few investigations have addressed the EMG activity of the quadriceps femoris (QF) during dynamic contraction against submaximal inertial loads. In terms of the human QF, three surface synergists, the vastus lateralis (VL), vastus medialis (VM), and rectus femoris (RF), have been tested in muscle fatigue studies. However, no information has been reported on the vastus intermedius (VI), which is located in the deep region of the QF, during dynamic knee extension tasks.

AIM: This study investigated the muscle activation patterns of the QF synergists including the VI during fatiguing dynamic contractions against two submaximal inertial loads using surface EMG.

METHODS: Nine healthy men (mean age, 24.6 ± 7.3 years) performed repetitive dynamic knee extensions at 70% one-repetition maximum (1RM) and 50% 1RM to failure. Muscle activation of the VI, VL, VM and RF was recorded using surface EMG (sampling rate, 2 kHz) as performed previously (Watanabe & Akima 1999). The root mean square of each repetition was normalized by the 1RM. During 1RM and submaximal fatiguing tasks, the subjects were specifically instructed to lift the weight and achieve full knee extension for 3 s and lower the weight for 3 s in a controlled manner. The knee-joint angle was measured during the tasks using an electrogoniometer and EMG data were stored in a personal computer via an A-D converter.

RESULTS: As expected, the EMG activities in all tested muscles during the 70% 1RM task were significantly higher than those during the 50% 1RM task. In both fatiguing tasks, the EMG activities of the four synergists linearly increased with time during the concentric phase; however, they appeared to plateau during the eccentric phase throughout the tasks. While a significant increase in the EMG activity of the RF started from 25% of the time to exhaustion during the 70% 1RM task, it started from 75% of the time to exhaustion during the 50% 1RM task. The EMG activity pattern of the VI was similar to those of the VL and VM during both exercise loads. Interestingly, the EMG activity of the VL was significantly higher than those of the VM and VI during the eccentric phase of the 50% 1RM task.

CONCLUSION: These results suggest that muscle activation response to fatiguing tasks varies depending on the exercise loads during both concentric and eccentric phases: the RF showed plastic properties between the two loads, while the VI, VL, and VM looked constant across the two loads.

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MFAT_P2.5 AGE-RELATED DIFFERENCE IN TIME TO FAILURE OF A SUBMAXIMAL FATIGUING CONTRACTION IS ASSOCIATED WITH MODULATION OF MUSCLE ACTIVITY

A/Prof Sandra Hunter, Marquette University

INTRODUCTION: Older adults are able to sustain a submaximal isometric fatiguing contraction longer than young adults (Hunter et al, JAP, 99, 890, 2005). Although the mechanisms can largely be attributed to muscular mechanisms, the recruitment range is often less in older adults and activation of the motoneurone pool dampened. Whether, modulation of muscle activity during an isometric fatiguing contraction contributes to age-related differences in time to task failure is not understood.

AIM: To determine the contribution of modulation in the muscle activity of the elbow flexor muscles during submaximal isometric fatiguing contractions of young and old adults.

METHODS: 12 young (6 men, 6 women; mean ± SD; 21.5 ± 3.2 yrs) and 13 older adults (6 men, 7 women; 69.4 ± 4.6 yrs) performed sustained isometric fatiguing contractions at 30% of maximal voluntary contraction (MVC) until the target force could no longer be achieved. Voluntary activation was assessed using an interpolated twitch during MVCs before and after the fatiguing contraction. The electromyogram (EMG) of biceps brachii, brachioradialis and triceps brachii during the fatiguing contraction was divided into 5 equal segments (20% of time to failure). Using wavelet transform, the structure of the interference EMG signal was calculated for the following frequency bands: 13-30, 30-60, 60-100, 100-200 and 200-300 Hz. The EMG power was normalized to the total power across all segments and frequency bands.

RESULTS: Old adults had a longer time to task failure than young adults (5.8 ± 1.4 vs 9.6 ± 5.1 min, $P = 0.01$). Young and old adults had similar levels of voluntary activation before the fatiguing contraction (94.4 ± 3.2 vs 90.9 ± 8.3 %, $P= 0.2$) with similar reductions for both age groups after the fatiguing contraction. Fluctuations in force (SD/mean) and EMG bursting activity of the biceps brachii increased during the fatiguing contraction but at lesser for the old adults than young ($P < 0.05$). The normalized EMG power of brachioradialis muscle in 30-60 Hz band (nBR30-60) increased during the fatiguing contractions ($P < 0.001$). There was a significant negative correlation between time to task failure and the change in nBR30-60 ($r2 = 0.20$, $P = 0.02$), indicating that subjects who exhibited lesser increase in nBR30-60 were able to sustain the contraction longer.

CONCLUSION: The longer time to task failure was associated with less modulation in brachioradialis muscle activation by the end of the fatiguing contraction. Thus, older adults achieve a longer time to task failure with less change in the piper band power (30-60 Hz) of the brachioradialis EMG that is thought to be driven by the contralateral motor cortex and lower EMG bursting activity of the biceps brachii.

MFAT_P2.6 THE IMPACT OF FATIGUE CAUSED BY SPRINT RUNNING ON THE MEDIAN POWER FREQUENCY OF THE HAMSTRING MUSCLE GROUP

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Dr Anthony Shield, Queensland University of Technology; Dr Morgan Williams, University of Glamorgan; Ms Nuala Dear, Queensland University of Technology; Mr David Opar, Queensland University of Technology

INTRODUCTION: Hamstring strain injuries (HSI) are the predominant non-contact injury in many sports. Intermittent running has been shown to result in preferential reductions in eccentric hamstring strength, which may increase the risk of sustaining a HSI. The eccentric specific nature of this decline in hamstring function implicates central mechanisms, as peripheral fatigue mechanisms tend to impact upon both concentric and eccentric contractions modes. However, the median power frequency (MPF) of the surface electromyography signal has yet to be examined in the fatigued hamstring following intermittent sprint running.

AIM: To determine the impact of fatigue induced by intermittent sprinting on the MPF of the medial and lateral hamstring muscles.

METHODS: Fifteen recreationally active males completed 18 × 20m overground sprints. Maximal strength (concentric and eccentric knee flexor and concentric knee extensor) was determined isokinetically at the velocities of ±1800.s-1 and ±600.s-1 while hamstring muscle activation was assessed using surface electromyography, before and 15 minutes after the running protocol.

RESULTS: Overground intermittent sprint running caused a significant reduction in eccentric knee flexor strength (27.2 Nm; 95% CI = 11.2 to 43.3; p=0.0001) but not concentric strength (9.3 Nm; 95% CI = -6.7 to 25.3; P=0.6361). Also, following intermittent sprinting, MPF of the lateral hamstrings showed a significant decline eccentrically at both -1800.s-1 (5.26; 95% CI = 0.34 to 9.84; p=0.0452) and -600.s-1(2.96; 95% CI = 0.15 to 7.54; p=0.0347). However, there was no significant decline concentrically at either speeds (p>0.05). Furthermore, there were also no significant declines in the medial hamstring MPF following intermittent sprinting (p>0.05).

CONCLUSION: Sprint running induced fatigue led to an eccentric specific reduction in knee flexor torque, as well as a decline in eccentric, lateral hamstring MPF. Furthermore, MPF was suppressed across both contraction modes for the medial hamstrings. These findings indicate that fatigue is associated with the declines in MPF of the lateral hamstrings following intermittent sprint running. However, this decline is potentially contraction mode specific, with decreases in MPF only occurring during eccentric contractions. This association between fatigue and MPF may also indicate that conduction rates and fibre type recruitment of the lateral hamstrings, during eccentric contractions may be significantly altered following sprint running.

MFAT_P2.7 MUSCULAR FATIGUE IN PATIENTS WITH MASSIVE ROTATOR CUFF TEARS: AN ELECTROMYOGRAPHIC STUDY

Dr David Hawkes, The University of Liverpool

Dr Margaret Roebuck, The University of Liverpool; Prof Simon Frostick, The University of Liverpool; Prof Anthony Fisher, The University of Liverpool; Dr Omid Alizadehkhaiyat, The University of Liverpool; Dr Graham Kemp, The University of Liverpool

INTRODUCTION: Massive rotator cuff tears (MRCT) are prevalent in the elderly population and cause pain, weakness and functional disability. Muscular fatigue has not been previously studied in relation to MRCT. This represents a gap in the literature; identifying fatigable muscles can support the development of evidence-based physiotherapy programmes.

AIM: The study aimed to investigate the fatigability of the shoulder muscles in patients with a MRCT during a prolonged forceful hand grip task using electromyography (EMG).

METHODS: The control group (CG) comprised 14 healthy volunteers. Twelve patients, with a two or more tendon rotator cuff tear, confirmed by imaging, were included in the MRCT group (MRCTG). EMG signals were recorded from 13 shoulder girdle muscles, differentially amplified, digitalised and band-pass filtered in accordance with international guidelines. Painful shoulder conditions precluded an accurate assessment of maximal isometric shoulder contractions and therefore a hand gripping task was used as part of the fatigue protocol. Subjects were tested while seated: the shoulder was neutrally rotated and abducted to 30o in the scapula plane with the elbow fully extended. Three trials of maximal hand grip were performed. EMG was recorded while participants performed a sustained contraction at 25% of grip MVC for 45 seconds. The median frequency was calculated in 1s epochs and normalised to the initial value; least square linear regression was used to assess the average rate (in %/min) of median frequency change (fatigue index).

RESULTS: The repeatability of the methods was established by re-testing 4 subjects 2-8 weeks after initial assessment; no significant inter-session effects were identified. Significant fatigue progression was seen in the anterior, middle and posterior deltoid, pectoralis major and brachioradialis for both study groups and in the supraspinatus and subscapularis in the CG. In the MRCTG, significantly greater fatigue was evident in the anterior and middle deltoid (CG:-2.6%/min; MRCTG:-9.8%/min; $p=0.001$ and CG:-5.0%/min; -9.0%/min; $p=0.044$ respectively) and pectoralis major (CG:10.9%/min; MRCTG:--10.7%/min; $p=<0.001$).

CONCLUSION: Patients with a MRCT must compensate for the deficient rotator cuff muscles and achieve a stable glenohumeral fulcrum for arm movement. In the MRCTG, increased fatigue of the anterior and middle deltoid reflects the greater activity necessary to compensate for the lost supraspinatus abduction torque. In this testing position, significantly greater fatigue in the pectoralis major reflects an attempt to balance the destabilising forces of the deltoid and maintain glenohumeral joint stability. Rehabilitation protocols ought to consider the important balance necessary between these muscles.

MFAT_P2.8 NON-SYSTEMATIC REDUCTION IN THE FREQUENCY CONTENT OF MULTI-CHANNEL EMG RECORDINGS FOR BICEPS BRACHII DURING A SUSTAINED SUBMAXIMAL CONTRACTION

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Prof Dick F Stegeman; Prof Roger M Enoka; Prof Jaap H van Dieen

INTRODUCTION: The frequency content of EMG signals recorded with conventional bipolar electrodes decreases monotonically during a sustained contraction. However, conventional bipolar recordings provide only a limited view of total muscle activity. Alternatively, multi-channel monopolar surface EMG recordings from detection sites distributed over the muscle provide a more complete measure of changes in the distribution of muscle activity during sustained fatiguing contractions. Furthermore, the use of principal component analysis (PCA), to eliminate common information increases the reliability of the EMG signal.

AIM: To analyze the spatial distribution of changes of the frequency content of PCA-processed multi-channel EMG activity recorded from biceps brachii (BB) during a sustained submaximal contraction.

METHODS: Ten healthy men sustained a target force of 20% MVC (force feedback) with the elbow flexors for 50% of endurance time (3±1 min). We measured flexion force at the wrist and surface EMG with 63 ± 4 electrodes homogeneously distributed over the entire BB. The monopolar EMG channels were high-pass filtered, PCA-processed (remove common information), and the median of the frequency content was determined for all channels over BB. We analyzed the range, mean and the difference of the median frequency over three 10-s time windows (TW1-3: start, middle, end).

RESULTS: There was a substantial range of median frequencies across all BB recording sites (min: 52.7±6.6 Hz, max: 107.1 ± 20.4 Hz), which did not change significantly with TW (P=0.468). The average median frequency of the BB recordings declined significantly across TW (P<0.001). There was a 5% reduction between TW1-2 and a 2% decrease between TW2-3 (74.9±11.9, 71.1±11.3, 69.1±10.9 Hz). However, median frequency did not decrease with time at all BB recording sites; about 22±16% of the channels showed an increase over time. Larger differences between recording sites were found between TW1-2 (min: -22.7 ± 7.6, max: 17.7 ± 14.6 Hz) than between TW2-3 (min: -14.0 ± 8.8, max: 10.7 ± 13.9 Hz).

CONCLUSION: There was considerable heterogeneity in the changes in frequency content of localized EMG activity in BB during a sustained contraction. On average, there was a 7% reduction in median frequency, but median frequency increased in 22% of the BB recordings during the sustained contraction. The physiological adjustments responsible for changes in the frequency content of EMG signals from BB during fatiguing contractions exhibited considerable variability.

ACKNOWLEDGEMENT: Swiss National Science Foundation (No. 115183) for a post-doctoral fellowship at the Neurophysiology of Movement Laboratory, CO, USA.

NEUROLOGICAL DISORDERS

NDIS_P1.1 DO SKELETAL MUSCLE PROPERTIES RECOVER FOLLOWING BOTULINUM TOXIN TYPE A TREATMENT?

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INTRODUCTION: Botulinum toxin type-A (BTX-A) is a frequently used treatment to relax spastic muscles by blocking acetylcholine release at the motor endplate. Although considered safe, previous studies have shown that BTX-A injections cause atrophy and muscle degeneration in target and non-target muscles. BTX-A treatments often comprise repeat injections every 3-4 months due to its time limited action. Depending on the injection/recovery protocol, muscle function may be compromised after BTX-A treatments. However, muscle recovery following BTX-A injections is anecdotal with no systematic research backing of clinical claims.

AIM: To investigate if muscle properties fully recover following a six months BTX-A treatment protocol.

METHODS: Twenty-seven NZW rabbits were divided into 5 groups: Control (n=5), BTX-A+0M (n=5), BTX-A+1M (n=5), BTX-A+3M (n=5), BTX-A+6M (n=7). Control animals received equal volume saline injections. Experimental animals received monthly BTX-A injections (3.5U/kg) unilaterally for six months, and were evaluated after 0, 1, 3, and 6 months of recovery (BTX-A+0M/+1M/+3M/+6M). Outcome measures included isometric knee extensor strength, muscle mass, and area fraction of contractile material in injected and non-injected muscles. Muscle mass and strength were assessed by weighing the muscles and measuring the maximal isometric strength via femoral nerve stimulation. The percentage of contractile material was determined histologically by the area fraction of contractile material to total muscle cross-sectional area.

RESULTS: Muscle strength was partially and completely recovered in the injected and non-injected muscles at BTX-A+6M animals, respectively. Maximum strength was already reached for BTX-A+1M animals, with no further recover at 3 and 6 months. Muscle mass recovered in a similar manner to strength. The area fraction of contractile material in Control group was 96%. The area fraction of contractile material partially recovered in the injected hindlimbs only for the 6 month recovery animals. The percent area fraction of contractile material on the non-injected contralateral showed no recovery in the 1, 3, and 6 months recovery group animals compared to BTX-A+0M animals.

CONCLUSION: Skeletal muscle properties following a six months BTX-A treatment protocol did not fully recover in injected and contralateral quadriceps muscles. While strength/mass were partially recovered, there was no apparent recover in the contractile material, suggesting that strength/mass recovery occur at a different rate than structure. Since structure is typically not evaluated in patients receiving BTX-A treatments, measurements of strength/mass may not appropriately reflect the long-term structural damage in muscles following BTX-A treatment.

NDIS_P1.2 ABNORMAL ISOMETRIC TRUNK KINETICS IN CHRONIC STROKE MAY BE DUE TO LATERALIZED TRUNK IMPAIRMENTS

Mr Sam Perlmutter, Northwestern University

INTRODUCTION: It has been suggested that bilateral projections to the trunk may minimize trunk impairment in survivors of unilateral stroke. The only quantitative studies regarding the impairment of the trunk after stroke have only focused on strength measures in a single plane.

AIM: The aim of this study was to quantify and identify differences in primary and secondary trunk kinetics in chronic stroke subjects during the generation of a maximum isometric torque.

METHODS: Using a custom-built device with a 6-DOF load cell, multi-directional isometric trunk control of 14 stroke and 14 control subjects were evaluated in a seated posture. Subjects performed maximum voluntary efforts of trunk torque in 6 directions. EMG electrodes were placed on seven pairs of trunk muscles. Visual feedback of only the intended torque (primary torque) was displayed to the subject. All other torques (secondary torques) were not shown.

RESULTS: No significant difference of primary torque was found between groups. The stroke group generated larger axial torque towards the paretic side when compared to the non-paretic side, wherein the control group did not differ between sides. The stroke group coupled non-paretic axial torque during trunk flexion and paretic axial torque during trunk extension. During torque generation in the sagittal plane, the stroke group had larger activations and greater asymmetries in erector spinae and latissimus dorsi muscle groups. This suggests inefficient or abnormal trunk control as opposed to weakness of trunk musculature which is likely to contribute to trunk discoordination.

CONCLUSION: Overall trunk strength was similar between groups. Asymmetry was only seen in stroke group in that they generated larger torque when twisting towards the “Paretic” side of the body. Differences between groups in secondary trunk coupling were observed during primary torque generation in the sagittal plane –a task that required symmetrical control of both sides of the trunk. Stroke coupling was explained by increased activation of non-paretic extensors during flexion as well as non-paretic flexors and paretic extensors during trunk extension. Our future work will add another degree of freedom to the visual feedback to determine if each group is truly constrained to the kinetic couplings observed in this observational study. We hypothesize that control subjects will be able to modulate coupling while stroke subjects will not.

Hemiparetic stroke may result in a more lateralized deficit in trunk control than previously thought. This may be due to disruption of corticofugal projections to the brainstem and spinal cord which are necessary for control of trunk musculature ipsilateral to the lesioned hemisphere.

NDIS_P1.3 RESISTANCE TRAINING IMPROVES HAND AND FINGER DEXTERITY IN ESSENTIAL TREMOR PATIENTS: A PRELIMINARY STUDY

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INTRODUCTION: Essential tremor (ET) is a common progressive neurological disorder among older adults. ET can cause considerable disability in many activities of daily living that require the dexterous use of the hands and fingers. Given that pharmacological and surgical interventions that are used to reduce the tremor-related disability in ET can have adverse reactions and lose effectiveness over time, alternative therapies should be investigated. Resistance training (RT), by virtue of its ability to produce neural adaptations would appear such a candidate.

AIM: The aim of this preliminary study was to determine if a short-term upper limb RT program can improve strength, fine manual dexterity, and quality of life in individuals with ET.

METHODS: A single group, dual pretest-posttest intervention study was performed involving six participants (age: 74 ± 7 years) who were clinically diagnosed as having ET (years diagnosed: 19 ± 7 years). All participants performed two baseline tests of fine manual dexterity separated by a week of regular activity, and then a 6-week RT program followed by a 6-week detraining period. Training involved unilateral dumbbell bicep curls, wrist flexion and wrist extension exercises performed twice a week. Outcome measures included upper limb strength (5 repetition maximum - 5RM); fine manual dexterity (Purdue Pegboard Test - PPT), Short Form 36 (SF-36) and the ET specific Quality of Life in Essential Tremor (QUEST).

RESULTS: The RT program resulted in significant increases in four of the six upper limb strength measures. Significant improvements in the PPT were observed for the single hand components of this test. PPT performance improved immediately following the RT program for the most affected limb, but these changes took longer to be observed for the least affected limb. No significant changes in the SF-36 or QUEST scales were observed.

CONCLUSION: Overall, unilateral fine manual dexterity improved for ET patients following a simple RT program. The findings of this preliminary study provide clear evidence that RT is worthy of further investigation as a therapy for improving functionality in ET patients.

ACKNOWLEDGEMENT: We wish to thank the Auckland Medical Research Foundation who funded this study and Susan Yoffe from the New Zealand Essential Tremor Support Group for assisting in this study.

NDIS_P1.4 ADJUSTMENT OF GAIT ASYMMETRY BY CURVED WALK IN INDIVIDUALS POST-STROKE

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INTRODUCTION: When we walk on a curvature path, systematic alteration of the gait behaviour, for example, prolongation of the stance time and shift of center of body mass to inner side occurred. As a separated phenomenon, hemiplegic patients has a certain extent of gait asymmetry, for example, reduction of the stance time in the paretic side and shift of body weight in intact side.

AIM: To test the hypothesis if hemiplegic patients walk on a curvature path with paretic side inside, environmental constraint due to curved walk would act effectively to improve on the gait asymmetry.

METHODS: 22 hemiplegic patients (9 chronic and 13 semi-acute) walked along straight line and different three curvature path (radius=3.5, 2.5, 1.5m) in both clockwise (CW) and counter-clockwise (CCW) directions with their comfortable speed. The timing of heel contact, toe off, and vertical body load was recorded by foot sole sensor (F-Scan, Nitta Inc., Japan). The extent of gait asymmetry was evaluated with paretic-intact ratio of stance time (temporal asymmetry) and total body load during stance phase (weight bearing asymmetry).

RESULTS: While temporal asymmetry was not altered due to curved walk, body weight shifted to paretic side when the patients walk along curvature path with paretic side inside even the case of mild curvature path (radius=3.5m).

CONCLUSIONS: Observed body weight shift can be regarded as the result of physical constrains due to curved walk. Since curved walk enable patients to apply much weight to the paretic side without effort and attention, this is an effective method for the improvement of the gait asymmetry in individuals post-stroke.

NDIS_P1.5 THE EFFECTS OF CONTINUOUS PASSIVE MOTION ON HYPERTONIA OF SOLEUS IN INDIVIDUALS WITH CEREBRAL PALSY

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INTRODUCTION: Cerebral palsy (CP) is a group of disorders of the development of movement and posture but often changing motor impairment syndromes. The spastic subtypes are the most common manifestations of cerebral palsy who perform movement difficultly due to hypertonia. In addition to decrease of descending inhibition control, changes in spinal circuitry functions, such as hyperactivity of alpha and gamma motoneuron and reduction of presynaptic inhibition, may cause increased tendon reflex and hypertonia in individuals with CP. There are many ways to improve the hypertonia. Past studies showed that the polyarticular movement training might increase joint range of motion and reduce the hypertonia. However, the polyarticular movement training is difficult for adult individuals who have severe spasticity. The single joint movement training may achieve the same effect as the polyarticular movement training.

AIM: The purpose of this study was to investigate the effects of continuous passive range of motion (CPM) training on the improvement of soleus hypertonia in individuals with CP.

METHODS: This study included 8 adult individuals with spastic CP (mean age = 22 years old), who received the 4-week ankle CPM training for 1 hour per day, 5 days per week. The ankles CPM training was performed with a range from plantarflexion 5° to dorsiflexion 5° at 60 rpm. The effects of CPM training on soleus hypertonia in individuals with CP were measured by the maximum Hoffman reflex (H/M ratio), the post-activation depression of Hoffman reflex (PAD), disynaptic Ia inhibition, and modified Ashworth scale (MAS). The leg girth, ankle range of motion, and visual analogue scale (VAS) of pain were also measured. The repeated one-way ANOVA was used for statistic analysis, the statistical significance was set as $p<0.05$.

RESULTS: After 4-week CPM training, the maximum H/M ratio of 8 individuals with spastic CP had significant decrease ($p<0.001$). The PAD significantly improved ($p<0.001$, $p=0.040$, and $p=0.032$ at 0.2 Hz, 1 Hz and 2 Hz, respectively). Disynaptic Ia inhibition was not changed. The MAS score was decreased significantly ($p=0.001$). Leg girth was not changed. The ankle range of motion significantly increased ($p=0.001$). The VAS score significantly decreased ($p=0.004$).

CONCLUSION: The 4-week CPM training improved the soleus hypertonia of adult individuals with CP. The CPM training could be a safe and appropriate clinical intervention for the individuals with cerebral palsy.

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NDIS_P1.6 THE INFLUENCE OF DIABETIC NEUROPATHY ON ELECTROMYOGRAPHY OF THE LOWER LIMBS FROM THE PERSPECTIVE OF CONTINUOUS WAVELET ANALYSIS AND MULTIVARIATE TECHNIQUES

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INTRODUCTION: EMG alterations of diabetic neuropathic individuals during gait are subtle and still not consistent between authors. All of these studies in this population used conventional EMG analysis in temporal domain comparing discrete parameters from linear envelopes. The wavelet transform allows an analysis of specifics events at different frequency bands within the EMG signal, while maintaining time resolution.

AIM: Analyze the influence of diabetic neuropathy in muscle recruitment strategies during gait cycle using continuous wavelets in a multivariate perspective through Principal Component Analysis (PCA).

METHODS: Surface EMG of tibialis anterior (TA), vastus lateralis (VL) and gastrocnemius medialis (GM) of diabetic patients (DG=100) and non-diabetic individuals (CG=100) were acquired in gait cycle, sampled at 2kHz and synchronized with 2 foot-switches. Energy (En) and frequency (Fr) were compared between groups in the whole gait cycle and in each gait phase (weight acceptance, midstance, propulsion and swing) using t tests. PCA was used from a multivariate perspective to understand more globally the muscle recruitment patterns of this population.

RESULTS: DG presented lower EnGM in the propulsion phase ($p=0.012$), higher EnVL in whole cycle ($p=0.002$) and in midstance ($p=0.002$), and higher EnTA at weight acceptance ($p<0.001$) compared to CG. PCA showed two different patterns according to the variables that most influence the variability of the signal: in GC were FrTA=-0.58, EnTA=0.75 and EnVL=0.72; in GD were FrGM=0.70, EnGM=-0.57, FrTA=0.63.

CONCLUSION: The DG presented lower EnGM in the phase that it is most recruited and the higher EnVL in DG could be an extensor compensatory activity of a more proximal muscle since the distal muscle (GM) is not producing the necessary energy to overcome the propulsion phase. The higher EnTA in DG may indicate that this population is overusing this muscle and expending more energy than necessary to perform the same task as CG. Excessive waste of energy accelerates cell degeneration further compromising other motor functions. Across the gait cycle, PCA allowed us conclude about the influence of these 3 dimensions of EMG (time, intensity and frequency) in each group. There was a greater influence of Fr and En of GM in the EMG variability for DG suggesting a different muscle fibers recruitment strategy from the CG that did not present the same influence.

The comparison of En over time identified significant changes in diabetic patients' energy production but PCA also showed more alterations in diabetic motor strategies. We could identify that diabetics need other strategies with different muscle energy production and frequencies to do their daily activities.

NDIS_P1.7 DISTANCE BETWEEN DETECTED INNERVATION ZONE AND BOTULINUM TOXIN INJECTIONS IN CERVICAL DYSTONIA TREATMENT: A HIGH-DENSITY SURFACE EMG STUDY

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INTRODUCTION: Botulinum toxin (BTX) injections are the most common and effective treatment in cervical dystonia and spasticity disorders. BTX blocks the release of acetylcholine at the neuromuscular junction of the muscle, leading to a reduction in unwanted contractions. Clinically administered BTX injections take place without any knowledge of the actual innervation zone (IZ) location. We showed that in healthy subjects BTX injections 1 cm away from the main IZ of the muscle was 46% less effective than injections at the detected IZ (Lapatki 2011).

AIM: This study aims to quantify the distance between the location of BTX injection and the location of the IZ as obtained with high-density surface EMG (HDsEMG) in cervical dystonia patients.

METHODS: Two neck muscles, i.e. the sternocleidomastoid (SCM) and the splenius capitis (SC), were investigated in 14 cervical dystonia patients after BTX treatment. Muscle activity during voluntary contractions was recorded using HD-sEMG with an electrode grid consisting of 9x14 electrodes. The IZ can be characterized by a phase reversal of the signal in the bipolar montage in fiber direction. The IZ was determined by an automated method as well as visually by an HD-sEMG expert. The automated method detects the phase reversal and identifies the IZ by using a continuous wavelet transform to detect motor unit action potentials and calculating correlation coefficients between consecutive channels in fiber direction. A sign switch in this correlation coefficients corresponds to the phase reversal at the IZ location. The IZ found by the HD-sEMG expert and the automated method were compared and related to the position of the actual BTX injection.

RESULTS: The distance between the IZ found by the HD-sEMG expert and the position where the clinician administered the BTX was 1.5±0.6 cm for the SCM and 2.2±1.4 cm for the SC muscle. The IZ was localized consistently around the midpoint or in the superior part of the muscle at 64.6±7.9% (SCM) and 56.2±12.4% (SC) of total muscle length. Sensitivity and specificity of the automatic IZ detection method were 80% and 83%, as validated by the gold standard. Note that in a number of patients the IZ could not be detected because of a lack of EMG signal amplitude due to therapeutic muscle paralysis.

CONCLUSION: In this study the distance between IZ and BTX injection was 1.7 cm which could lead to a reduced therapeutic efficacy of BTX. Hence, we propose that precise targeted BTX injections towards the IZ using HDsEMG could maximize the BTX effect and reduce therapeutic costs in dystonia treatment. The detection algorithm proposed here could help in the automatic and objective localization of the IZ in HD-sEMG recordings.

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NEUROPLASTICITY

PLAS_P1.1 EXCITATORY AND INHIBITORY CORTICOSPINAL RESPONSES IN THE TRAINED AND UNTRAINED LEG FOLLOWING 4 WKS UNILATERAL LEG STRENGTH TRAINING: A TMS STUDY

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INTRODUCTION: Cross education refers to the unilateral training of one limb that results in improvement in strength in the contralateral untrained limb. Evidence of neurophysiological mechanisms underpinning cross education has been shown in upper limb studies, however currently, cross education studies investigating the neurophysiological mechanisms in lower limbs are limited.

AIM: This study investigated corticospinal responses, using transcranial magnetic stimulation (TMS) in both the trained and untrained legs following 4 wks of unilateral leg strength training.

METHODS: Using a between-groups design, 18 participants (18 to 35 years) were randomly allocated into a trained group (7m; 2 f) or control group (7m; 2f). The trained group completed unilateral leg press training, 4 sets of 6-8 repetitions at 85% of their one-repetition maximum (1-RM), 3 times per week for 4 wks. The control group did not undertake any specific training and maintained usual levels of daily activity. Prior to and after 4 wks, all participants were tested for maximum leg extension force, and muscle thickness (imaging ultrasound). TMS measures, motor evoked potential (MEP) and silent period (SP duration), were taken from the contralateral motor cortex projecting to the rectus femoris muscle in both legs.

RESULTS: Maximum leg extension force increased 21.2% ($P<0.01$) and 17.4% ($P<0.01$) in the trained and untrained legs respectively. No change in muscular thickness was observed in the trained group. No changes were observed in MEP amplitude projecting to both legs in both the trained and control groups, however in the trained group SP duration reduced by 17.7 ms in the trained leg ($P<0.01$) and 25.1 ms in the untrained leg ($P<0.01$). No change in SP duration was observed in the control group

CONCLUSION: The results show that heavy load unilateral leg strength training improves strength in the contralateral untrained leg. Although no change in corticospinal excitability was observed, the reduction in SP duration observed in both motor cortices demonstrates a neurophysiological mechanism underpinning strength improvement in both the trained and untrained limbs.

PLAS_P1.2 SHORT-LATENCY AFFERENT INHIBITION IS REDUCED AND AFFERENT FACILITATION IS ENHANCED FOLLOWING NEUROMUSCULAR ELECTRICAL STIMULATION

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Mr Austin Bergquist; Ms Sarah Roshko; Mr Cameron Mang

INTRODUCTION: The afferent volley generated during neuromuscular electrical stimulation (NMES) can increase the excitability of corticospinal (CS) circuits that control movement. For individuals with damage to sensorimotor pathways, this increased excitability is thought to underlie improvements in function that occur after NMES rehabilitation programs. This increased excitability is thought to involve changes in cortical circuits, but the effects on circuitry interposed between the ascending afferent volley and descending corticospinal (CS) pathways are not well understood.

AIM: The present study was designed to determine whether changes in these circuits may contribute to the increases in CS excitability observed after a single session of NMES. We hypothesized that, consistent with a net increase in CS excitability, short latency afferent inhibition (SAI) would be reduced and afferent facilitation (AF) would be enhanced after NMES.

METHODS: Nine healthy volunteers participated. To assess changes in CS excitability, 20 motor evoked potentials (MEPs) were evoked in the first dorsal interrosseus muscle using transcranial magnetic stimulation (TMS) delivered at 120% resting MEP threshold before and after 40 min of NMES over the ulnar nerve. To assess changes in cortical circuits interposed between the afferent volley and CS pathways, SAI and AF were tested by delivering an electrical stimulus to the ulnar nerve either 18-25 ms (SAI) or 28-35 ms (AF) before TMS of M1. Conditioned MEPs were compared to unconditioned MEPs evoked in the same trials. TMS intensity was reduced after the NMES so the amplitude of unconditioned MEPs was similar before and after NMES.

RESULTS: MEPs evoked at 120% resting MEP threshold increased by ~1.7-fold after the NMES ($p=0.03$), demonstrating that NMES enhanced CS excitability. Before NMES, there was a 25% attenuation of MEPs evoked at the SAI interval (compared to unconditioned MEPs) ($p=0.03$), but the same conditioning test interval did not alter MEPs following NMES ($p=0.44$). At the AF interval, conditioned MEPs were not different from unconditioned MEPs before NMES ($p=0.97$), but were facilitated by 33% following NMES ($p<0.01$). Conditioned MEPs at both intervals were larger following NMES than before it ($p<0.01$), despite similar amplitude of unconditioned MEPs before and after NMES ($p=0.94$).

CONCLUSIONS: These changes in circuits that transmit the ascending afferent volley to CS pathways were consistent with the increase in CS excitability. The changes in both inhibitory and excitatory circuits suggest that during an NMES session, a given ascending afferent volley will have a greater effect on increasing CS excitability. Such altered sensorimotor integration may contribute to improvements in motor function following NMES.

PLAS_P1.3 DOES CURRENT INTENSITY AFFECTS THE SIZE OF ANODAL-TDCS INDUCED CORTICOMOTOR EXCITABILITY IN HEALTHY INDIVIDUALS?

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INTRODUCTION: Anodal transcranial direct current stimulation (a-tDCS) is a painless cortical modulatory technique with no or minimal side effects which can be applied by an inexpensive battery-operated device. In this technique a positive electrode (anode) is placed over the primary motor cortex (M1) of target muscle(s) and the negative electrode (cathode) is secured over the opposite supra orbital region. Literature indicates that in healthy individuals, the induced corticomotor excitability is larger at higher intensities. No study to date has systematically compared the size of a-tDCS-induced corticomotor excitability at different current densities in healthy individuals.

AIM: To compare the effects of four different a-tDCS current intensities on the size of corticomotor excitability of the extensor carpi lateralis (ECR) muscle in healthy individuals. We hypothesised that larger current intensities induce larger changes in corticomotor excitation.

METHODS: Ethics approval was obtained. Eight right handed healthy volunteers were tested in four separate sessions at least 48 hours apart. Corticomotor excitability of dominant M1 of resting ECR was assessed before, immediately, 10, 20 and 30 minutes after a 10 minute application of a-tDCS. Four different current intensities (0.3, 0.7, 1.4 and 2 mA) were compared on separate days. The electrode size in all experiments was kept constant at 24 cm2. The outcome measure for the assessment of corticomotor excitability was peak-peak-amplitude of motor evoked potentials (MEPs) elicited by a single-pulse TMS device (Magstim Company Limited, UK). Peak-peak-amplitude of 12 MEPs in each assessment point were averaged and used for data analysis.

RESULTS: One-way repeated measures ANOVA for each intensity showed a significant main effect for time ($p<0.05$). Post-hoc analysis revealed that compared to baseline value, corticomotor excitability significantly increased immediately post intervention and this increase remained above the baseline value at all post intervention assessments. Comparison of pre and post intervention changes in the last three intensities (0.7, 1.4 and 2mA) indicates a linear relationship between the intensity of a-tDCS and the size of corticomotor excitability changes. This linear arrangement does not exist for the first two intensities (0.3 and 0.7 mA). Interestingly the size of changes for lower intensity (0.3 mA) was larger than the changes for higher intensity (0.7 mA).

CONCLUSION: We hypothesised that larger current densities of a-tDCS induces larger changes in corticomotor excitatability. The findings in this study partially support this hypothesis. Different trends for the effects of the first two intensities may indicate that different mechanisms are responsible for these changes.

PLAS_P1.4 CHANGE IN MOTOR CORTEX EXCITABILITY OVER THE DURATION OF NEUROMUSCULAR ELECTRICAL STIMULATION WITH VOLUNTARY DRIVE

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INTRODUCTION: Neuromuscular electrical stimulation (NMES) is commonly used to treat foot drop while walking and to improve hand grasp in patients with spinal and upper motor neuron lesions. These peripheral afferent inputs by NMES may play an important role in plastic changes in the central nervous system. Moreover, voluntary contraction (VC) with NMES has been reported to assist in stroke patients. However, it is difficult to understand by electromyography how VC with NMES affects primary motor cortex (M1) excitability, because the surface electromyography is affected by electrical artifacts due to NMES. Therefore, in this study we used a mechanomyogram (MMG) to analyze M1 excitability, which is not affected by electrical artifacts, during NMES.

AIM: In this study, the prolonged changes in M1 excitability during NMES with and without VC using motor evoked potentials (MEPs) were investigated by transcranial magnetic stimulation (TMS) and recorded with MMG.

METHODS: Participants comprised 22 healthy individuals (mean age: 29.1±5.9yrs). NMES was applied to the muscle belly of the extensor carpi radialis (ECR). The stimulus frequency was 100 Hz with pulse duration of one millisecond, and on–off time of five seconds each. Total stimulation time was 32 minutes. The stimulus strength was the sensory threshold×1.2, and this produced sensation without muscle twitch or pain. Subjects achieved 20% maximum VC (MVC) of wrist extension by ECR voluntary muscle contraction through visual feedback or release after each five-second repetition. MEP was recorded from both the flexor carpi radialis (FCR) and ECR muscles by using TMS under the following three conditions: 1) at rest with NMES (RS); 2) 20% MVC with NMES (VS); and 3) 20% MVC alone (VA). MEPs were recorded ten times during each trial for six periods of 0-32min from the beginning of the task. TMS was performed using a figure-of-eight–shaped coil. All MEP amplitudes were normalized to the mean at rest MEP amplitude for each subject. Data were analyzed using repeated measures analysis of variance (ANOVA), and lasting MEPs were compared with control MEPs using the Dunnett's test. Significance was accepted at $P < 0.05$.

RESULTS: In the RS group, M1 excitability was slightly increased throughout the trial duration (ECR; N.S, FCR; $P < 0.05$). In the VS group, M1 excitability was prominently enhanced in ECR after 24 minutes ($P < 0.05$), while, in the antagonist muscle (FCR), M1 excitability was more inhibited than in the control muscle throughout the trial duration ($P < 0.05$). In the VA group, M1 excitability was slightly increased in both muscles and throughout the trial duration (N.S).

CONCLUSIONS: VC with NMES increases M1 excitability for the stimulated muscle, and M1 in the antagonist muscle may affect reciprocal modulation by combining NMES with voluntary drive.

PLAS_P1.5 CORTICOMOTOR PLASTICITY FOLLOWING CROSS-EDUCATION STRENGTH TRAINING

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INTRODUCTION: It is well recognized that unilateral strength and skill training improves motor performance of not only the practiced limb, but also in the unpractised contralateral homologous limb. Neural adaptations have been implicated, because the cross-transfer of strength occurs in the absence of muscle hypertrophy. Recent investigations have shown that unilateral strength training leads to adaptive changes in the primary motor cortex ipsilateral to the training limb (iMI) in the form of increased corticospinal excitability.

AIM: Determine whether increases in corticomotor excitability and reductions in SICI of the iMI modulates the cross-transfer of strength following heavy-load, controlled tempo strength training of the knee extensor muscles.

METHODS: Right leg dominant participants ($n = 14$) , were randomly divided into either a strength training (ST) or control group. The ST group completed 9 training sessions (4 sets of 6-8 repetitions of single right leg squats).

RESULTS: We observed a 41% increase in right leg strength, and a 35% increase in strength of the untrained left leg ($p < 0.01$). There was a significant increase in motor evoked potential (MEP) amplitude recruitment curve for the untrained left leg ($p < 0.01$). SICI of the iM1 decreased by 21% for the untrained left leg ($p < 0.01$).

CONCLUSION: The findings provide evidence for corticomotor adaptation for cross-education leg strength training within the iM1 that is modulated by changes in interhemispheric inhibition.

PLAS_P1.6 NEURAL MECHANISMS UNDERLYING CHANGE IN THE IPSILATERAL PRIMARY MOTOR CORTEX EXCITABILITY DURING UNILATERAL RHYTHMIC ISOMETRIC CONTRACTIONS OF FINGER MUSCLE

Mr Kazumasa Uehara, Hiroshima University

Mr Takuya Morishita; Prof Kozo Funase

INTRODUCTION: It is thought that a rhythmic movement is one of the important factors in a human movement. However, little is known of change in an underlying neural circuit within ipsilateral primary motor cortex (ipsi-M1) while performing a unilateral rhythmic movement following an auditory cue.

AIM: To investigate the neural mechanisms underlying change in the ipsi-M1 excitability during a unilateral rhythmic isometric contraction of index finger (i.e., rhythmic movement) at three different frequency of rhythm, intracortical inhibition, interhemispheric inhibition (IHI) and related motor legion connectivity using a transcranial magnetic stimulation (TMS) technique were examined.

METHODS: A total of twenty eight healthy volunteers (twelve females, age range: 21-28 years) participated in this study. All of them were asked to perform a unilateral rhythmic isometric contraction of left-index finger in response to three different frequency of auditory cues (1, 2, and 3Hz) as accurate as possible. Surface EMG activity was taken from both FDI muscles. In the intracortical inhibition, we assessed short intracortical inhibition (SICI) and long intracortical inhibition (LICI) within ipsi-M1 by paired-pulse TMS consisted of a conditioning stimulation (CS) and test stimulation (TS). Regarding the SICI, subthreshold CS and TS were given to left-M1 in the FDI hot spot at inter stimulus interval (ISI) of 3ms. Regarding the LICI supratheshold CS and TS were given to left-M1 in the FDI hot spot at ISI of 100ms. In the IHI, supratheshold CS was delivered to right-M1 in the FDI hot spot prior to TS was given to and left-M1 in the FDI hot spot at ISI of 10ms. In the related motor legion connectivity during the task, we investigated contralateral dorsal premotor cortex (contra-PMd) to ipsi-M1 connectivity. A suprathreshold CS was delivered to right-PMd prior to TS was given to left-M1 in the FDI hot spot at ISI of 10ms.

RESULTS: While performing unilateral repetitive isometric contraction of index finger abduction at 2Hz condition, the ipsi-M1 excitability was significantly decreased as compared to 1Hz and 3Hz conditions in response to single-pulse TMS. In addition, PMd-M1 connectivity and LICI were closely associated with change in the ipsi-M1 excitability. In contrast, change in the IHI and SICI within ipsi-M1 were not.

CONCLUSION: PMd-M1 connectivity and LICI within ipsi-M1 dominantly operate to control change in the ipsi-M1 excitability while performing the different frequency of unilateral rhythmic isometric contractions.

PLAS_P1.7 THE FEASIBILITY OF USING CEREBELLAR STIMULUS RESPONSE CURVES TO INVESTIGATE CHANGES IN EXCITABILITY OF CEREBELLAR PROJECTIONS TO PRIMARY MOTOR CORTEX

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Prof Paul Yielder, University of Ontario Institute of Technology; Mr Hushyar Behbahani, University of Ontario Institute of Technology; Mr Luc Holland, University of Ontario Institute of Technology; Prof Bernadette Murphy, University of Ontario Institute of Technology

INTRODUCTION: Cerebellar transcranial magnetic stimulation (TMS) offers a valuable way to study the effects on cerebellar connections to the primary motor cortex (M1) allowing the cerebellar influence of different types of motor training and motor sequence learning on M1 to be compared. The original cerebellar TMS studies were performed by Ugawa in 1995. He found that the optimal timing for cerebellar to M1 connections was 5 to 7 msec. However, he also adopted a paradigm where the stimulus intensity to be used was 5% below the threshold for eliciting cervicomedullary motor evoked potentials (CMEPs). CMEPs cannot be elicited in all subjects, even at maximal stimulator output (MSO) meaning that a large number of potential subjects would need to be excluded from cerebellar studies. The main reason given for stimulating at 5% below CMEP threshold is to ensure that CMEPs are not contaminating the MEP recordings.

AIM: Therefore our aim was to develop a new protocol using cerebellar stimulus-response (S-R) curves to investigate changes in the excitability of cerebellar connections to M1.

METHODS: 6 subjects participated in a TMS stimulus-response (S-R) curve trial. Focal TMS was applied over the motor cortex using a figure of eight coil to find the optimal position for the first dorsal interossei muscle to determine the intensity required to elicit a test MEP of 1 millivolt peak to peak for each subjects. A custom double cone coil with minimal wrapping was centred over a line intermediate between the inion and the mastoid process at the level of the mastoid process. Eight cerebellar conditioned MEPS were elicited in random order at each of 70, 75, 80, 85 and 90% of MSO for the cerebellar TMS unit, which was stimulated 5 msec in advance of the TMS unit stimulating M1. At the end a separate trial of 90% of stimulator output on its own with no test MEP was elicited to determine if CMEPS were elicited by the cerebellar conditioning stimulus on its own. Peak-to-peak amplitudes were measured and the cerebellar S-R curve generated.

RESULTS: Repeated measures analysis of variance (ANOVA) on averaged MEP amplitude for each stimulus intensity indicated that significant modulation of the test MEP occurred at all levels of cerebellar stimulation ($p<0.05$). A priori contrasts indicated significantly greater levels of modulation of M1 excitability at 80 and 90% of MSO as compared to 70% of MSO. There were no CMEPs elicited in any of the subjects at 90% of stimulator output.

CONCLUSION: Cerebellar TMS recruitment curves offer a promising way to study the influence of cerebellar excitability changes following motor sequence training.

ORAL NEUROPHYSIOLOGY

ORAL_P1.1 THERE IS CORRELATION BETWEEN ELECTROMYOGRAPHY AND MUSCULAR THICKNESS OF MASSETER AND TEMPORALIS MUSCLES ON PATIENTS TREATED OF HEAD AND NECK CANCER?

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INTRODUCTION: The mastication functioning is an important factor that have been studied on the last years. A lot of factors can interfere in this functioning and can cause important signals and symptoms. Head and Neck cancer and its treatment can be one of these factors. Than, it is necessary to study the masticatory muscles comportment about its electromyographic activities and its muscles tickness as in people who received cancer treatment well in health people.

AIM: The aim of this clinical study was to evaluate the electromyographic activity and the muscle thickness of masseter and temporalis muscles of patients submitted to head and neck cancer treatment and compare this data with those persons that had never received this type of treatment.

METHODS: The experimental group consisted of 11 patients (mean age 50 years) with head and neck cancer treatment finalized at least 6 months. This cancer treatment was based on radiotherapy focused on local of different types of head and neck cancer lesions. The control group consisted of 11 subjects paired with experimental group according to age, gender and oral situation. The electromyographic activity (sEMG), evaluated by the data of Root Medium Square of masseter e temporalis muscles, was carried out by Myosystem Br-1 electromyographer at maintenance of positions: rest, protrusion, right and left laterality, maximal parafilm clenching; and at dynamic activities like: opening and closing the mouth, deglutition, chewing of bilateral parafilm, chewing of right side, of left side and of habitual side of a mastication tester. Muscle thickness was measured with a SonoSite Titan ultrasound tool using a high-resolution real-time 56mm/10 MHz linear-array transducer. Ultrasound images were obtained from the bilateral masseter and temporal muscles at rest and at maximal voluntary contraction. sEMG data were normalized by maximal clenching. Pearlson correlation test was used to discover if the correlation between muscle thickness and sEMG is different or not on two groups analyzed: patients treated to head and neck cancer and health persons.

RESULTS: Patients that were submitted to cancer treatment revealed negative correlation between sEMG and muscular thickness at a lot of clinical situations tested, differing to health people that do not revealed correlations between this two types of evaluations.

CONCLUSION: Cancer treatment finalized at 6 months ago, in cases of head and neck cancer, affect the correlation between sEMG and muscular thickness when compared to health people group. In cancer group, when sEMG increase, the muscular thickness decrease; and it was not observed in health group.

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ORAL_P1.2 HEAD AND NECK CANCER CAN AFFECT THE EMG ACTIVITY OF MASSETER AND TEMPORALIS MUSCLES?

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INTRODUCTION: In front of the eight million new cancer cases that occurs today worldwide of which 212.000 are initiated on mouth, is necessary to study more influences of head and neck cancer disease on mastication.

AIM: The aim of this clinical study was to evaluate the electrical activity of masticatory muscles of patients with head and neck cancer before start treatment and compare this data with those person that had never had this disease.

METHODS: The experimental group consisted of 10 patients (mean age 45 years) with head and neck cancer diagnostic on first evaluation and with no treatment applied yet. The control group consisted of 10 subjects paired with experimental group according to age, gender and oral situation. The electromyographic (sEMG) activity of masseter and temporalis muscles was carried out at situations: rest, protrusion, right and left laterality, opening and closing mouth, parafilm clenching and chewing. Inter-group comparisons were made using independent sample t-test. Significance level was set at $P<0.05$.

RESULTS: There are statistic differences between groups in all postural activities tested (rest sig. value = 0.13, protrusion sig. value = 0.14, right and left laterality sig. value = 0.006 and 0.22). On dynamic situations evaluated like opening and closing mouth, parafilm chewing and clenching was not verified statistic differences comparing groups.

CONCLUSION: The presence of head and neck cancer lesion can affect the maintenance of rest and postural position of mandible. The cancer group revealed less activity of masseter and temporalis muscles when compared to control group during postural position maintenance. People with head and neck cancer has a poor EMG activity during maintenance of mandibular postural position when compared to people that don't has this disease.

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ORAL_P1.3 EFFECTS OF ORAL IMPLANTS ON MASTICATORY MUSCLES: SEMG STUDY

Mrs Moara De Rossi, USP

Mrs Carla Moreto Santos; Ms Ligia Franco Oliveira; Mr Migliorança Reginaldo; Mr Simone Cecilio Hallak Regalo

INTRODUCTION: Dental implants has been extensively used by dentistry with proved cosmetic results, however there are no scientific data regarding the effects of this type of rehabilitation in the masticatory muscles. Therefore investigations about the electrical activity of masticatory muscles are essentials to prove the functional success of this therapy and to scientifically support this clinical procedure.

AIM: The aim of this clinical study was to evaluate the muscular function of patients totally rehabilitated with zigomatic (maxillar) and all on four (mandibular) implants at maintenance of postural position, compared with those having natural dentition.

METHODS: The experimental group consisted of 14 patients (6 men, 8 woman; mean age 60.6 years) using zigomatic implants (maxillar) and all on four implants (mandibular) during at least 6 months; the control group consisted of 14 dentate subjects paired with experimental group according to age and gender. The surface electromyographic (sEMG) activity of masseter and temporalis muscles was carried out at rest (10sec), protrusion (10sec), right and left laterality (10sec) using MyoSystem-Br1 electromyographer, with differential active electrodes. RMS of maximum voluntary dental clenching normalized the RMS values of postural positions. Inter-group comparisons were made using independent sample t-test (SPSS 17.0). Significance level was set at $P<0.05$.

RESULTS: There were none statistically significant ($P>0.05$) differences between groups in all evaluated situations.

CONCLUSION: Implants and dentate patients showed similar postural sEMG values, showing that the implants treatment can be considered as a good option for oral rehabilitation in edentulous patients.

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ORAL_P1.4 EVALUATION OF MASTICATORY EFFICIENCY IN PATIENTS AFTER ANTERIOR CRUCIATE LIGAMENT OF LIGAMENTOPLASTY

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INTRODUCTION: Sports practice is considered an adjuvant for several orthopedic injuries, for example, anterior cruciate ligament injury.

AIM: In the context of injuries such as this, study of the stomatognathic system becomes relevant due to the relationship between postural changes and the stomatognathic system.

METHODS: Participants in this study were 12 men (age: 23±1yrs), divided into two groups. Group 1 constituted six healthy individuals and Group 2 constituted six patients who had undergone reconstruction of the anterior cruciate. Electromyography was recorded from the temporalis, masseter and sternocleidomastoid muscles during maximum voluntary contraction, chewing of peanuts and chewing of raisins. The values obtained were statistically analysed using a t-test for independent samples.

RESULTS: Results obtained in this study indicated low masticator efficiency in all muscles evaluated in both clinical conditions for patients who had undergone anterior cruciate ligament reconstruction.

CONCLUSION: The decreased masticatory efficiency demonstrated in the results of this study reflects an imbalance in muscle activation in the stomatognathic system for individuals who have undergone anterior cruciate ligament reconstruction.

ACKNOWLEDGEMENT: FAPESP (Nº 2010/07513-5).

ORAL_P1.5 ANALYSIS OF THE STOMATOGNATHIC SYSTEM AFTER ANTERIOR CRUCIATE LIGAMENTPLASTY

Mr Bruno Ferreira, São Paulo University

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INTRODUCTION: The Anterior Cruciate Ligament (ACL) plays a major role in maintaining knee joint stability and proprioception. After the ACL injury, the muscle chains can undergo biomechanical changes throughout the system, promoting a reduction in the postural control that may influence the stomatognathic system.

AIM: The purpose of this study was to investigate the presence of postural imbalances can interfere with the mandible position and affect the actions of the stomatognathic system.

METHODS: This study aimed to analyze the effects on the performance of the stomatognathic system after six months following the ACL reconstruction. Forty men , aged between 23 to 29 years , were selected and divided into two groups: Group I comprised 20 healthy individuals with no postural change diagnosis; Group II, 20 individuals who had ACL surgical , unilateral with patellar tendon graft, paired individual to individual (age, weight, respiratory pattern). All of them were submitted to an electromyography in different clinical positions. In addition, a condylar biomechanical assessment was performed through videogrametry.

RESULTS: . In electromyography and videogrametry, a normal standard biomechanical was observed for both groups, however, Group GII – Ligament plasty presented an inhibition of the masticatory muscles and decreased joint kinesthetic.

CONCLUSION: Based on the results obtained, it was concluded that after the reconstruction of the ACL ligaments, individuals presented changes in the stomatognathic system.

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ORAL_P1.6 THE EFFECT OF A LUCIA JIG FOR 30 MIN ON NEUROMUSCULAR RE-PROGRAMMING

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INTRODUCTION: The use of a Lucia Jig is a technique that promotes a neuromuscular reprogramming of the masticatory system and allows the stabilization of the mandible without the interference of dental contacts, maintaining the mandible position in harmonic condition with the musculature.

AIM: This study aimed to electromyographically analyze the activity of the masseter and temporalis muscles in rest position and also during the use of the anterior programming device , Lucia Jig, in place for 0, 5, 10 and 30 minutes, demonstrating its effect on the stomatognathic system.

METHODS: Forty-two healthy dentate individuals (aged 21 to 40 years) with normal occlusion, without parafunctional habits and temporomandibular dysfunction (RDC/TMD) were evaluated through the electromyographic activity of the masseter and temporalis muscles, before placing the neuromuscular re-programming device , Lucia Jig, in rest position after its placement on the upper central incisors .

RESULTS: The results showed some changes in the electromyographic activity of the masticatory muscles in different time periods. The data obtained were compared using the multivariate analysis between the times analyzed with a Lucia Jig. All data obtained were not statistically significant for $p < 0.05$ (SPSS 17.0).

CONCLUSION: The Lucia Jig changed the electromyographic activity by promoting a neuromuscular re-programming. It decreased in most times the activation of the masticatory muscles, showing that this device has wide applicability in dentistry, mainly for individuals carrying temporomandibular dysfunction.

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ORAL_P1.7 FUNCTIONAL ANATOMY MODEL OF THE STOMATOGNATHIC SYSTEM IN PARAPLEGIC ATHLETES AND NON-ATHLETE

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INTRODUCTION: Individuals with spinal cord injury, problems with the upper body may have imbalances of the stomatognathic system in relation to the rest of the skeletal system. Surface electromyography is a test to study anatomical, physiological and neurophysiological the musculoskeletal system.

AIM: The objective was to analyze anatomical model of the stomatognathic system and demonstrate the influence of sport and paraplegia on this system.

METHODS: Participated 20 male subjects, divided into three groups: Group 1 (G1) 05 paraplegics practitioners of athletics with a mean age of 31.08 ± 8.36 years, Group 2 (G2) 05 paraplegics who do not practice physical activity with a mean age of 30.68 ± 6.41 years and Group 3 (G3) 10 subjects without neuromotor impairment with a mean age of 32.05 ± 9.41 years. Were submitted to a electromyographic evaluation of the following medical conditions: No Habitual chewing of Parafilm (NHCP) Habitual Masticatory Efficiency of peanuts (HMEP) and raisins (HMER). The muscles were assessed: right and left temporal (RT and LT), right and left masseter (RM and LM) and right and left sternocleidomastoid (RS and LS). For data collection, were used a brand of electromyograph Myosystem-Br1, twelve channels and for statistical analysis were used the ANOVA test (SPSS version 17.0). This project was approved by the Research Ethics, Case process 13/2010 CEP.

RESULTS: The clinical condition of NHCP, there was an activation pattern for all groups, where the RM and LM are more active than the RT and LT. In the clinical condition of HMEP, there was greater activation of the muscles RT and LT for all groups. In addition, there was a big muscle activation RS and LS. In the clinical condition of HMER, it was for the G3, a balance between muscle activities to RM, LM and RT and LT, which was not observed for G1 and G2. The muscles RS and LS also showed activated in all groups. The data were significant for the RT and LT muscles in the clinical condition of HMER ($p < 0.05$).

CONCLUSION: It was concluded that individuals with special needs had a deficit of the stomatognathic system, showing a commitment in the anatomical model of this system, a pattern associated with postural imbalance.

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ORAL_P1.8 ANALYSIS OF THE STOMATOGNATHIC SYSTEM IN PARAPLEGIC ATHLETES AND NON- ATHLETES PRACTICING ATHLETICS

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INTRODUCTION: The sport has been an early activity indicated for any type of person with disabilities, provide a great competitive spirit, especially for people with physical limitations. Physical activity or sports for the handicapped provides an opportunity to test limits and potential, to prevent secondary deformities and promote the social integration of the individual. In individuals with paraplegia the presence of imbalances between the posture of the mandible from the skeletal system, promoting change in the level of masticatory capacity.

AIM: This study objective understand through electromyographic analysis, ultrasound imaging bite force and the effects of paraplegia in the stomatognathic system performance in athletes and non-physically active.

METHODS: The study included 20 males aged 25 to 45 years divided into three groups: Group 1 (G1), 5 individuals with paraplegia with neurological level of injury to the thoracic and lumbar structures athletics practitioners (professional), Group 2 (G2), 5 individuals with paraplegia with neurological level of injury to the thoracic and lumbar structures not practicing sport and Group 3 (G3 - Control), consisting of 10 healthy subjects without motor problems. Were performed surface electromyography, through electromyographic recordings of the masticatory muscles during rest and postural conditions of the jaw (protrusion, right and left lateral). Analysis was also performed on the thickness of masseter and temporalis muscle and quantification molar maximum force of individuals.

RESULTS: In the clinical condition of rest, the activity of the masseter and sternocleidomastoid remained well marked, especially in those of the G2, not observed in either group a greater activation of the temporalis muscles. In protrusion, all groups showed a typical pattern of contraction to maintain the position. During the lateral movement of the jaw increased electromyographic activity in the temporalis muscle on the same side of the jaw. For the analysis of muscle thickness, it was found that the masseter and temporalis muscles of paraplegic individuals and not-athletes was similar to the thickness muscles of individuals without neuromotor impairment (G3 - Control Group). With regard to the maximum molar bite force, it was found that individuals in groups G1 and G2, paraatletas paraplegic and had higher strength than the G3 for both sides, and the strength of G2 was higher.

CONCLUSION: Based on the results we can conclude that paraplegia with or without the sport promoted changes in the functional activity of the stomatognathic system.

PAIN

PAIN_P1.1 EXPERIMENTAL KNEE PAIN IMPAIR THE STEADINESS OF THE MOTOR OUTPUT IN ALL THREE-DIMENSIONAL FORCE COMPONENTS

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INTRODUCTION: Knee pain is a cardinal symptom in knee osteoarthritis (OA) impairing muscle coordination and the generation of force, resulting in high force variability and increased risk of falls. Previous investigations using an experimental knee pain model have shown that pain elicits reorganisation of muscle activity, which may change the direction of the resultant force. It is however unclear how knee joint pain affects the steadiness of knee extension forces.

AIM: To assess the effects of experimental knee pain on the steadiness of three-dimensional knee extension forces.

METHODS: Fifteen subjects performed isometric knee extensions (13 s duration) at 2,5%, 5%, 20%, 50%, and 80% of maximal voluntary force (MVC). Pain was induced by injections of 6% hypertonic saline into the infrapatellar fat pad, and assessed on a 10-cm visual analogue scale (VAS), with isotonic saline (0.9%) used as control. A six-axis sensor was used to assess the three force components during knee extension. Electromyography from agonist and antagonist muscles were recorded using bipolar surface electrodes. Task-related force variability was assessed by the coefficient of variation of force (CV: standard deviation/mean), while variability of tangential force components was indirectly assessed by the total displacement of the centre of pressure (CoP).

RESULTS: Hypertonic saline induced significantly more pain than isotonic saline (VAS: 3.5±0.6 cm and 0.1±0.05 cm respectively, mean ± SEM). Knee pain elicited higher CV of task-related force at all contraction levels compared with non-painful assessments (40% higher, $P<0.0005$). Total displacement of CoP increased at 5% MVC contraction (42% higher, $P<0.0002$) during painful compared with non-painful tasks, and the activity of m. vastus medialis decreased at 80% of MVC (10% lower, $P<0.007$) during pain compared with other conditions.

CONCLUSION: The present results demonstrate that acute knee pain impair the steadiness of the motor output of the lower limb not only in task-related, but also tangential force components, particularly at low force levels, which may partially explain the impaired ability of knee OA patients to generate and control smooth forces during daily activities. Therefore, knee extensor steadiness training may act as an important cofactor in rehabilitation programs for the improvement of functional performance, especially in patients with relatively well preserved muscle strength.

ACKNOWLEDGEMENT: The study has been financed by Svend Andersen Fonden (Aalborg, Denmark).

PAIN_P1.2 EFFECT OF SHOULDER POSITION ON UPPER LIMB MYOELECTRIC ACTIVITY DURING SIMULATED MILLS MANIPULATION: A NEW MODEL, RELATIONS TO PERIPHERAL NERVE BIOMECHANICS AND SPECIFICITY OF MILLS MANIPULATION.

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INTRODUCTION: Mills manipulation was codified by the British surgeon G. Percival Mills in 1928. Its aim is to break the adhesions between the common extensor tendon in the forearm and the bone, and thus relieve tennis elbow painful symptoms.

AIM: A. Investigate the likely muscular effects of the commonly practiced Mills manipulation for lateral elbow pain (epicondylalgia), B. establish whether muscle responses are influenced by a position that is likely to reduce mechanical tension in the local peripheral nerves, 65 ˚ forward flexion of the shoulder (Variation Position) compared to the usual clinical technique (Standard Position-90˚ abduction in frontal plane).

METHODS: Sample - Eight asymptomatic subjects were tested bilaterally (N=16). Design - Controlled laboratory study using single group, within subject comparison. Myoelectric measurements – Electromyographic (EMG) signals were recorded with a 16 channel portable EMG unit and processed off-line. Measurement of joint positions - three charge-coupled device adjustable cameras sensitive to 10 mm reflective passive markers applied at specific locations on the subject's bodies were used to reconstruct and verify accuracy of body movements during pre-manipulative stretch for Mills manipulation and were correlated with EMG parameters.

RESULTS: Compared with the Standard Position, the Variation Position produced significantly reduced activity (P=0.000) in all test muscles (brachioradialis, biceps brachii , upper trapezius, triceps brachii, pectoralis major) while an increase of myoelectric activity (P=0.002) was recorded in the control muscle (lower trapezius). It is theorized that the test muscles may exert protective effects mediated by mechanical tension in the local peripheral nerves. Subjective data provide support for the theory that the Variation Position was also perceived as less painful by the subjects.

CONCLUSION: Changes in myoelectric activity were in a pattern that suggests integration of muscle and neural mechanisms during Mills manipulation. The increase of myoelectric activity in Lower Trapezius (control muscle) supports the theory that the protective response in experimental muscles is specific, and is probabely not centrally mediated and that may be due to neural tension in the peripheral nerves of the upper limbs.

A position of 65° forward flexion may be used to reduce both mechanical stresses in the peripheral nerves and extraneous muscle activity, making Mills' manipulation potentially safer and more specific when performed in this position.

PAIN_P1.3 EFFECT OF CERVICAL SPINE POSITION ON UPPER LIMB MYOELECTRIC ACTIVITY DURING SIMULATED MILLS MANIPULATION: RELATIONS TO PERIPHERAL NERVE BIOMECHANICS AND SPECIFICITY OF MILLS MANIPULATION.

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INTRODUCTION: Mills manipulation was codified by the British surgeon G. Percival Mills and presented for the first time in 1928 in the British Medical Journal. Its aim is to break the adhesions between the common extensor tendon in the forearm and the bone, and thus relieve tennis elbow painful symptoms.

AIM: A. Investigate the likely muscular effects of the commonly practiced Mills manipulation for lateral elbow pain (epicondylalgia) B. To ascertain if myoelectric activity in the upper limb is influenced by cervical spine position during the pre-manipulative stretch for Mills manipulation C. Establish whether muscle responses are influenced by ipsilateral lateral flexion of the cervical spine which is likely to reduce mechanical tension in the peripheral nerves of the upper limb.

METHODS: Sample - Eight asymptomatic subjects were tested bilaterally (N=16). Design - Controlled laboratory study using single group, within subject comparison. Myoelectric measurements – Electromyographic (EMG) signals were recorded with a 16 channel pocket EMG patient unit and processed off-line. Measurement of joint positions - three charge-coupled device adjustable cameras sensitive to 10 millimeter reflective passive markers applied at specific locations on the subjects' bodies were used to reconstruct and verify accuracy of body movements and were correlated with EMG recordings.

RESULTS: Compared with the standard (anatomical) position of the cervical spine in which Mills manipulation is typically performed, cervical spine ipsilateral lateral flexion produced significantly reduced activity in muscles that restrain the manipulation movement (elbow extension), namely biceps brachii (P=0.018) and brachioradialis (P=0.000). The affected muscles may therefore produce protective effects during the manipulation.

CONCLUSION: Changes in myoelectric activity were in a pattern that suggests that muscle and neural mechanisms may be an integral part of the Mills manipulation. Cervical spine ipsilateral lateral flexion may be used to reduce mechanical stresses in the peripheral nerves and extraneous muscle activity, making Mills' manipulation potentially safer and more specific.

PAIN_P1.4 THE ELECTRODE PLACEMENT SITE IN TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION AFFECTS THE CURRENT PERCEPTION THRESHOLD

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INTRODUCTION: If the placement of electrodes in transcutaneous electrical nerve stimulation (TENS) corresponds to the dermatomic levels of the most severe pain site, it has been suggested that analgesia is effective. This has been considered the objective valuation method for pain, and measurement of the current perception threshold (CPT) has attracted attention. However, there have been few studies which have captured the analgesic effect of TENS by CPT. In addition, no study has measured the response of healthy subjects according to the electrodes placement site in TENS by CPT.

AIM: The purpose of this study was to consider whether the placement site of electrodes in TENS affects healthy persons and postoperative patients, as compared with CPT.

METHODS: Twelve postoperative shoulder patients (pain at the C5 dermatomic region) and twelve healthy subjects who had no pain participated in this experiment. All subjects were randomly assigned to receive TENS (Intelect Advanced Combo: Chattanooga Group) with electrodes placed on either the pain site in the C5 dermatomic region (group A), or the non-painful Th1 dermatomic region (group B). It experimented on each method on separate days. All other parameters – pulse width (200 microseconds), frequency (modulated at 1-250 Hz), intensity (tolerated strength to 40% modulation), duration (20 min) – were kept constant. We measured CPT (Aδ and C fiber) by using a Neurometer NS3000 (Neurotron) in the C5 dermatomic region. The CPTs were evaluated before, during and after TENS. The data were statistically analyzed using repeated measures 2-way ANOVA and Bonferroni tests. P value less than .05 were considered significant. This study acquired the approval of Heisei Memorial Hospital research ethics board (09 - 2).

RESULTS: Among the shoulder postoperative patients, ANOVA detected significant effects for CPT for time (Aδ fibers: $p < .01$; C-fibers: $p = .01$), and time × treatment (Aδ fibers: $p = .03$; C-fibers: $p < .01$). Bonferroni showed significant CPT with Aδ fiber increase as compared with pre-TENS, during TENS (Aδ fibers: $p = .03$; C-fibers: $p = .03$) and post-TENS(C-fibers $p = .03$). Among the healthy subjects, there were no significant effects detected for time × treatment interaction ($p = .32$), but significant effects detected for time (Aδ fibers: $p <.01$; C-fibers: $p < .01$). Bonferroni showed significant CPT increase as compared with pre-TENS and post-TENS (Aδ fibers: $p = .03$,ka-hou C-fibers: $p < .01$).

CONCLUSION: In TENS, when pain was present and the electrode was placed on the dermatomic regions of the pain site, effective CPT increase was suggested. In addition, when pain was not present, increased CPT was suggested regardless of the placement site of electrodes.

PAIN_P1.5 THE EFFECT OF MUSCLE PAIN ON SENSORY AND MOTOR CORTEX

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INTRODUCTION: Pain affects sensory function; yet evidence for its effect on the primary sensory cortex is contentious. Also poorly understood is the interaction between the primary sensory (S1) and motor (M1) cortex in response to pain.

AIM: This study investigated the effect of muscle pain on the primary sensory cortex and examined the relationship between sensory and motor cortex changes in the presence of muscle pain.

METHODS: Somatosensory (SEP) and motor (MEP) evoked potentials were recorded before, during and after the injection of hypertonic saline into the right first dorsal interosseous (FDI). EMG was recorded from right FDI. Amplitudes of the SEP N20-P25-N33 complex and amplitudes and onset latencies for the spinal and peripheral volleys were calculated.

RESULTS: MEP suppression was evident in FDI once pain had subsided. The size and latency of the peripheral and spinal complexes remained constant across time, but the amplitude of the SEP N20-P25-N33 complex was decreased during and subsequent to pain.

CONCLUSION: The current data provide evidence for the temporal relationship between S1 and M1 processing during pain. The N20-P25-N33 complex is thought to reflect cortical processing of the afferent volley that contributes to kinaesthesia and position sense. During pain, this complex is suppressed, while the motor response is unaffected. This suggests that changes in S1 preceed changes in M1 during acute pain.These data provide the first evidence for a temporal relationship between M1 and S1 processing during pain.

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PAIN_P1.6 ETIOLOGICAL FACTORS FOR PREMATURE ANKLE PLANTARFLEXOR ACTIVITY INDEPENDENT OF THE PRIMARY PATHOLOGY

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INTRODUCTION: Premature plantarflexor activity (PPF) during loading response of walking is a frequently observed gait deviation. Muscular weakness and biomechanical alteration have been mentioned in the literature as etiological factors for PPF in groups of patients with specific pathologies [1, 2].

AIM: The aim of this study was to evaluate whether muscular weakness and biomechanical alterations are etiological factors for PPF independent of the underlying pathology.

METHODS: The gait analysis data of 716 patients were investigated retrospectively (1999-2012). They were sorted into seven groups: orthopaedic uni-/bilateral (n=93/176); neurological hypotonic muscles uni-/bilateral (n=12/83); neurological spastic uni-/bilateral with/without adequate trunk control (n=176/119/57). Surface electromyograms of the m. gastrocnemius were recorded according to the SENIAM guidelines during walking. Data processing of the raw signal included filtering (4th order butterworth, 20-500Hz), full wave rectification, envelop calculation, time-normalization to a gait cycle, and amplitude-normalisation to the average value over each cycle. PPF was defined, according to non-dimensional walking speeds of <0.227, 0.228-0.363 and >0.363, as constant activity above 28%, 23% and 31% of the maximum activity over the gait cycle in the first 10% of the gait cycle. The gait profile score (GPS) [3] was calculated as a quantity of overall gait deviation. Clinical testing delivered the mean manual muscle strength (MMS) [4]. For each of the seven patient groups 4 subgroups were formed: 1a) with normal MMS (≥4.5), 1b) with reduced MMS (<4.5), 2a) with normal GPS (≤7.3°), 2b) with abnormal GPS (>7.3°).

RESULTS: PPF is less prevalent in patients with normal MMS than with reduced MMS for all patient groups except in the group of neurological patients with unilateral hypotonic muscles. PPF is less frequent in patients with normal GPS than with abnormal GPS for all of the seven groups.

CONCLUSION: Reduced MMS and abnormal GPS, both are strongly associated with PPF. The small number of neurological patients with unilateral hypotonic muscles might disguise the results in this group. We conclude that muscle strength and kinematic deviation are etiological factors of PPF independent of the primary pathology. Consequently, it is not only spasticity and poor muscle control (as in patients with spasticity) which lead to PPF, and PPF should be regarded as a secondary deviation rather than a primary abnormality.

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PAIN_P1.7 HIGH VARIABILITY IN ACTIVATION OF GLUTEUS MEDIUS DURING DYNAMIC ACTIVITY IN PEOPLE WITH PATELLOFEMORAL PAIN SYNDROME

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INTRODUCTION: Patellofemoral pain syndrome (PFPS) is a common condition in the sporting and general populations. Although the cause of PFPS is multifactorial, altered motor behavior of the vasti and gluteus medius muscles may contribute to chronicity of pain episodes. Confounding findings have been identified in the activation of vasti and gluteus medius muscles in people with PFPS during dynamic activities. This may be due to significant variability in muscle activation of the hip and knee in individuals with PFPS.

AIM: This study aimed to examine whether significant variability of delayed activation in vasti and gluteus medius muscles exists in people with and without PFPS.

METHODS: A total of 40 collegiate students (10 subjects with PFPS and 30 control subjects) participated, with an age range of 18-25 years. All participants were instructed to perform five dynamic tasks (heel rock, heel raise, step up, step down and single leg landing) to examine the activation of the gluteus medius, vastus lateralis and vastus medialis obliquus muscles. Surface electrodes were used for the detection of EMG signals in the specific location of each muscle recommended by Cowan et al (VL and VMO, 2001) and SENIAM (GM) (http://www.seniam.org/). Raw EMG data were collected using the Micro 1401 data acquisition system with Signal software (CED, UK) and analyzed using Matlab 7.0 (Mathworks, USA). Motor coordination of these muscles was evaluated through assessment of temporal parameters of EMG during functional tasks. The onset of muscle activation was identified visually as the time of increase in EMG activity from baseline. Temporal measures of EMG were compared between groups using non-parametric statistical analysis. Ten trials in each task were used to calculate the coefficient of variation (C.V.) of onset of muscle activation.

RESULTS: Significant differences in muscle activation were identified between groups for all three muscles tested ($p<0.05$). During landing, people with PFPS did not have earlier activation of VMO relevant to VL, which may lead to patellar maltracking and may be a precursor of anterior knee pain. In addition, members of the PFPS group demonstrated a significantly higher coefficient of variation (C.V.) of onset time in GM in all tasks, compared to controls (PFPS vs. Controls = 9.8%-60% vs. 0.8%-24.4%; $p<0.05$).

CONCLUSION: During dynamic tasks, individuals with PFPS have less stable motor coordination in the hip joint, which may lead to greater loads and injury in the knee.

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PHYSICAL MEDICINE & REHABILITATION

PMRE_P1.1 ANALYSIS OF EMG ACTIVITY OF THE TRUNK DURING LATERAL TRANSFER IN SITTING ON ACUTE HEMIPARETIC PATIENTS

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INTRODUCTION: It is important to improve lateral trunk control after stroke. However, the characteristics of electromyographic (EMG) activity of the trunk on a tilting platform are still poorly understood.

AIM: The purpose of the present study was to analyze the differences of EMG activity of the trunk during lateral transfer in the sitting position on a tilting platform and a horizontal platform on acute hemiparetic patients.

METHODS: Twenty patients with cerebral infarction (mean age 70.1 years, 11.1 days from onset) participated in this study after providing their written informed consent. Patients were divided into an experimental group or a control group at random. Patients in the experimental group sat without leg support on a platform tilted 10° to the paretic side in the frontal plane, the controls also sat on a horizontal platform. Both groups were asked to move their trunk laterally from the paretic side to the non-paretic side and to repeat 10 times respectively. During this task, we measured bilateral EMG activity of the thoracic paraspinal (TP) and the abdominal external oblique (EO) muscles, and recorded with a video camera in frontal plane. Based on the recorded images, the lateral transfer in sitting was classified into three movements; (1) lateral transfer to the non-paretic side (phase 1), (2) reverse lateral transfer to the paretic side (phase 2), (3) hold a position on the paretic side (phase 3). The percentage change in each phase of RMS for resting position were calculated. The independent t-test was used to compare the two groups in each phase.

RESULTS: In the experimental group, RMS of the EO muscle on the paretic side was significantly higher at phase 1. In phase 2, RMS of the TP on the non-paretic side of the experimental group was significantly higher than the control group. In the phase 3, RMS of the TP and EO on the paretic side of the experimental group were significantly higher than the control group.

CONCLUSION: These results indicated that lateral transfer in the sitting position on a tilting platform could improve EMG activities, especially on the paretic side of the trunk in acute hemiparetic stroke patients.

PMRE_P1.2 APPLICATION OF MAGNETIC RESONANCE IMAGING SIGNAL INTENSITIES FOR EVALUATING THE ACTIVITIES OF SHOULDER CUFF MUSCLES

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INTRODUCTION: Many studies have stated that cuff muscles in the shoulder play a key role in providing stability to the shoulder. However, examining the activities of these muscles by using electromyograms is difficult.

The water density of muscles changes with exercise. Magnetic resonance imaging (MRI) can be performed to detect these changes and evaluate muscle activities. In this study, we examined the activities of cuff muscles by using MRI signal intensities.

AIM: We attempted to evaluate muscle activities by using MRI signal intensities and observed the changes in these signal intensities during an exercise involving external rotation of the shoulder. The aim of this study was to clear the load for muscles that showed changes in MRI signal intensities.

METHODS: MRI was performed in 7 healthy male subjects (age, 19~22 years). Images were obtained using the echoplanar imaging technique. The subscapularis, supraspinatus, infraspinatus, teres minor, and deltoid muscles were analyzed. After the subjects underwent a scan, they performed a shoulder external rotation exercise. One exercise set consisted of 50 rotations. The subjects were asked to lie on a bed with their upper arms held close to the sides of their body and their elbows flexed at 90° as they pulled 6-kg weights. MRI was performed again immediately after the exercise. Each subject performed 10 exercise sets and was scanned 11 times.

MRI scans were obtained in the oblique sagittal plane at the glenoid level. The circumference of the studied muscles was circled, and signal intensities were measured. Statistical analyses of exercise sets were performed using one-way repeated analysis of variance, and a post hoc least-squares difference test was performed. Analyses were performed with IBM SPSS ver. 19, with $p < 0.05$ being considered significant.

RESULTS: The average signal intensities of the studied muscles were as follows (before exercise/after 10 sets of exercise): subscapularis, 73.46/72.64; supraspinatus, 127.55/127.42; infraspinatus, 157.70/203.05; teres minor, 148.50/188.04; and deltoid, 184.41/191.34. The signal intensities of the infraspinatus muscles significantly increased after 2 sets and those of the teres minor muscles significantly increased after 3 sets. However, the signal intensities of the subscapularis, supraspinatus, and deltoid muscles did not increase significantly.

CONCLUSION: In an exercise involving pulling a 6-kg weight, 50–100 repetitions resulted in significant changes in the signal intensities of the external shoulder muscles. These results show that MRI has a high sensitivity for the evaluation of muscle activities. Thus, this method is useful for evaluating the activities of shoulder cuff muscles.

PMRE_P1.3 STATE OF ART IN SURFACE ELECTROMYOGRAPHY DURING HUMAN MOVEMENT IN WATER

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INTRODUCTION: Aquatic exercise is widely used for rehabilitation and functional recovery due to its physical and physiological benefits. However, there is a high variability in reporting on the muscle activity from surface electromyographic (sEMG) signals during aquatic exercise.

AIM: The aim of this study is to review the literature with specific interest in determining if the amount of muscle activity recorded in water is equivalent to out of water when participants were performing the same task**.**

METHODS**:** A literature search was performed to identify studies of aquatic exercise movement. **Study eligibility criteria**: neuromuscular activity in human subjects who performed an aquatic exercise. **Data sources**. PEDro, CINALH, PUBMED, EMBASE, AMED, AgeLine, the Cochrane Library, and SPORTDiscus databases were examined. **Study appraisal and synthesis methods**; Two independent reviewers carried out the critical appraisal.

RESULTS: Twenty-one studies were selected for critical appraisal. Sample size, functional tasks analyzed, and muscles recorded were studied for each paper. The contribution of the clinical implications of the paper was evaluated by two experts.

CONCLUSION: Muscle activity tends to be lower in water-based compared to land-based activity and tends to be lower in distal than proximal muscles during water-based; however more research is needed to understand why. Further EMG studies could support the understanding of more relevant aspects for clinical practice.

PMRE_P1.4 PARAMETER OPTIMIZATION OF SURFACE ELECTRICAL STIMULATION FOR MOVEMENT ASSISTANCE IN JOINTS OF EXTREMITIES

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INTRODUCTION: Surface functional electrical stimulation has received increasing attention as a movement assistance technology for persons with paralyzed extremities because it is noninvasive and easy to use. However, it requires much higher energy than implanted electrical stimulation, and this imposes a tremendous physical burden on paralyzed patients. Selection of stimulation parameters allows for maximum movement with minimal stimulation energy, thus reducing the physical burden on patients.

AIM: We suggest a methodology for optimizing stimulation parameters to achieve maximum movement with minimal stimulation energy by using multiple simulation patterns of surface electrical simulators.

METHODS: We used a burst-modulated high-frequency alternating wave as the stimulation pattern of the electrical stimulator. The waveform extremely safe because it consists of one of two types of waves, namely burst wave and carrier wave. The duration of stimulation in one cycle of the burst wave can be adjusted by changing the duty ratio of generation time to rest time. We performed an experiment to confirm the relationship of the angle of ankle and wrist dorsiflexion with two stimulation parameters (burst cycle and duty ratio) in 30 combinations. The subjects were five healthy subjects and two subjects with right-sided paresis. From the results of these experiments, we identified the maximum angle of wrist and ankle dorsiflexion.

RESULTS: The ankle dorsiflexion of all subjects shows a peak value for similar stimulation parameters (burst cycle: 15 ms, duty ratio: 40 %). On the other hand, the tendency for wrist dorsiflexion varies considerably among the subjects. This contradiction is considered to be due to differences in muscle density. Unlike ankle dorsiflexion, wrist dorsiflexion is a combined effect of some wrist extensor muscles with surface electrical stimulation. In this experiment, we do not observe proportionate relationships between the angle of dorsiflexion and duty ratio. This indicates that tremendous physical burden on patients can be avoided by selecting parameters on the basis of these results.

CONCLUSION: In this study, we present the possibility that maximum movement can be achieved with minimal stimulation energy by selecting stimulation parameters on the basis of the maximum value of the joint angle. In the future, we will gather additional data by increasing the number of subjects, and we will research the effects of optimized parameters in rehabilitation.

ACKNOWLEDGMENT: This study is the result of "Brain Machine Interface Development" carried out under the Strategic Research Program for Brain Sciences by the Ministry of Education, Culture, Sports, Science and Technology of Japan.

PMRE_P1.5 THE NUMBER OF TMS-ELICITED MEPS AFFECTS INTRA AND INTER-SESSION RELIABILITY OF THE UPPER LIMB MUSCLES IN HEALTHY INDIVIDUALS

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INTRODUCTION: Transcranial magnetic stimulation (TMS) is a non-invasive, safe and painless technique for assessment of cortical neuroplasticity in both healthy individuals and patients with neurological conditions. TMS-induced motor evoked potentials (MEPs) have been used as an outcome measure for the assessment of corticomotor excitability changes across a wide range of research. A significant aspect of any clinical or experimental outcome measure including MEP is its test-retest reliability. Reliability refers to 'the consistency of measurements' which tests the stability of scores over time and involves the degree to which repeated measurements provide similar results. Literature indicates that there are links between the number of recorded MEPs and the level of the averaged MEP's reliability. This relationship has not been established for upper limb muscles.

AIM: To investigate the relationship between the number of TMS-elicited MEPs and the level of its intra- and inter-session reliability in the extensor carpi radialis (ECR) and first dorsal interossei (FDI) muscles.

METHODS: Twelve healthy volunteers participated in this study on two separate days at least 48 hours apart. Single pulse TMS (Magstim Company Limited, UK) was used to simultaneously obtain MEPs from the muscles of interest at resting position. Overall, 15 MEPs were recorded and the intra- and inter-session reliability of blocks of 5, 10 and 15 MEPs were compared.

RESULTS: Repeated measures ANOVA and paired t-test revealed no significant time effects in any of the measurements for the ECR and FDI muscles ($P>0.05$). This shows complete consistency between all of the measurements over time. The ICC values indicated a high intra and inter-session reliability of MEP amplitude for both muscles. Intra-session ICCs for ECR ranged between 0.77 (for blocks of 5 MEPs) to 0.99 (for blocks of 15 MEPs). Likewise, the intra-session ICCs for FDI ranged between 0.90 (for blocks of 5 MEPs) to 0.99 (for blocks of 15 MEPs). Inter-session ICCs for ECR ranged between 0.84 (for blocks of 5 MEPs) to 0.97 (for blocks of 15 MEPs). Likewise, the intra-session ICCs for FDI ranged between 0.88 (for blocks of 5 MEPs) to 0.93 (for blocks of 15 MEPs).

CONCLUSION: High intra- and inter-session reliability was achieved for all blocks of 5, 10 and 15 MEPs. The result indicates that even blocks of 5 MEPs produce high levels of reliability but if a higher degree of reliability is required, a recording of 10 or 15 MEPs may become necessary.

PMRE_P1.6 BRAIN ACTIVITY DURING STATIC CONTRACTION OF POSTERIOR DEPRESSION: AN FMRI STUDY

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INTRODUCTION: Facilitation of trunk control is used to influence the extremities (Knott & Voss, 1969). One proprioceptive neuromuscular facilitation (PNF) activity used during treatment is manual resistance to directed pelvic motion of posterior depression (Trueblood et al., 1989). Particularly, the flexor carpi radialis (FCR) H-wave during resistive static contraction of posterior depression (RSCPD) in mid-range of pelvic motion in side-lying has been found to be significantly facilitated during the 100-120 s after RSCPD repeatedly (Arai et al., 2007). However, to the best of our knowledge, the effects of RSCPD on the brain regions responsible for hand activities have not been studied. The remote effects of RSCPD on the hand may be related to brain activity.

AIM: The purpose of this study was to use functional magnetic resonance imaging (fMRI) to compare the regional brain activities occuring during RSCPD on the right side of the pelvis with those occurring during the exercise of holding a ball in the palm of the right hand (Hold).

METHODS: Eighteen healthy right-handed subjects (22.1±1.5yrs) were asked to undertake the two study exercises during exposure to fMRI. Whole-body MRI scans were performed, with MR systems operating at 3.0 T (Gyroscan Intera, Philips Medical Systems, Best, The Netherlands). Areas of significant change in the brain were estimated by preprocessing and statistical analyses of fMRI data, performed using SPM8 software implemented in MATLAB. Block design fMRI was obtained under two conditions, each replicated three times. All results reported here are height thresholded at P value = 0.05, adjusted to control for the familywise error. For group analysis, the one-sample t test using a second-order random effects model was performed to determine regions showing significant fMRI changes across subjects. To determine the overlapping regions of sensorimotor cortex (SMC) activation for each task, an inclusive mask of the SMC contrast was applied to both the early and the late adaptation activation. The regions of interest (ROIs) were then identified, based on the group random effect analysis corresponding to right and left SMC, and the extent of the overlapping regions of SMC activation for each task was determined. This study was conducted with the approval of the Ethics Committee of the Tokyo Metropolitan University.

RESULTS: fMRI studies showed significantly increased activation of the left SMC during both RSCPD and Hold. The region of significant overlap between these two exercises (RSCPD and Hold) is shown projected onto the left SMC.

CONCLUSION: We could suggest the evidence of remote effects of RSCPD on the left SMC as the regional brain activities related to the Hold.

PMRE_P1.7 THE EFFECTS OF RELATIVE TIMING OF TEMPORAL AND MUSCLE OUTPUT RATIOS IN THE CONTROL OF AMBULATION IN PATIENTS WITH STROKE-INDUCED HEMIPLEGIA

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INTRODUCTION:The rhythmic output from the metronome results in rhythmic output from the motor system, and necessary consequence is that the sequence of muscle constriction required for walking is also produced rhythmically(Relative timing:Shapiro,1981).However ,the relative timing of hemiplegic gait have not been clarified.

AIM: Expecting patients with stroke-induced hemiplegia to exhibit relative timing at free walking speeds, we evaluated the relative timing using the walking speed, time ratio, and the muscular activity ratio of the anterior tibial and gastrocnemial muscles.

METHODS: The subjects were 2 patients with right hemiplegia due to cerebrovascular disorder (mean age, 53 years; time after onset, 5 years). Both patients had Brunnstrom stage V motor paralysis of the lower limbs, independent ADL, full marks (126) on the FIM, and no impairment of the cognitive function or higher brain function. Both were capable of walking indoors or outdoors without a stick or brace, and could use public transportation. The task was walking a flat course 16 m long at subjectively “slow”, “comfortable”, and “fast” gait speeds 3 times each.The time ratio(%) ＝ The time of stance phase/（The time of stance phase＋The time of swing phase）×100

The time ratio of the stance to the swing phase (%) was determined by defining 1 gait cycle as 100%.

After full-wave rectification of electromyographic signals, the RMS value of each gait cycle was calculated, and the relative muscular activity (iEMG,%) in the stance and swing phases was determined by defining 1 gait cycle as 100%.

The relative muscular activity (iEMG,%)＝The muscular activity of stance phase/

(The muscular activity of stance phase＋ The muscular activity of swing phase)×100

RESULTS:Since significant differences were observed in the temporal ratio among the “slow”, “comfortable”, and “fast” gait speeds on one-way ANOVA, multiple comparison was performed, which also showed significant differences among the 3 gait speeds. However, no significant difference was noted in the %IEMG between the anterior tibial and gastrocnemius muscles.

CONCLUSION: At “slow”, “comfortable”, and “fast” gait speeds, the walking speed increased according to the subjective gait speed, but the temporal ratio differed. Therefore, the “slow”, “comfortable”, and “fast” gaits are not considered to be performed employing the same gait program, but a characteristic relative timing is considered to exist at each gait speed. However, the %IEMG between the anterior tibial and gastrocnemius muscles suggests no relative muscle activities. Clinically, the concept of walking is considered to be formed by practicing walking at various speeds rather than training to simply increase the gait speed.

PMRE_P1.8 DIFFERENCES IN THE MUSCLE ACTIVITIES IN THE FOREARM MUSCLES IN HEALTHY MEN AND WOMEN

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INTRODUCTION: Balance between flexor and extensor muscle activity is essential for optimal function. This has been demonstrated previously for the lower extremity, trunk and shoulder function, but information on the relationship in hand function is lacking.

AIM: Was to evaluate whether there are qualitative differences in finger extension force (fef), grip force, force duration, force balance and the muscle activities in the forearm flexor and extensor muscles in healthy men and women in different ages.

METHODS: Healthy controls (men, n=65, women, n=40) were included. Primary outcome was muscle activity measured with S-EMG and finger flexion- and finger extension force in Newton (N). The maximal force from the first trial was used as reference value (maximal voluntary isometric contraction, MVIC). The S-EMG activity of the m. extensor digitorum communis (EDC) and the m. flexor carpi radialis (FCR) were measured on the dominant hand when performing seven clinically often used hand exercises. Correlation analysis, second order polynomial regression as well as random forests (RF) based classification and regression techniques have been applied for data exploration.

RESULTS: The relationship between fef and flexion force was significant for both men (r=0.51, p=0.000) and women (r=0.71, p=0.000). Both the fef and flexion forces were correlated to age with values of (r=0.4021, p=0.000) and (r=0.4652, p=0.000), respectively. The coefficient of determination of the second order polynomial model showed that age and gender can explain 51-62% of differences in the force measurements. The RF based model exploiting S-EMG signals was able to explain 47-60% of differences in the force measurements. Muscle activity from hand exercises was significantly related to gender for EDC and muscle activity in FCR showed significant relation to age. Relation between S-EMG and gender was substantiated by the RF classifier, built using the S-EMG signals. The classifier correctly identified 76% of gender cases. A similar classifier built using the force measurements correctly identified 89% of gender cases.

CONCLUSION: This study shows that there are differences between men and women's hand force capacity and that gender and age can explain 51-62% of the differences. Similar percentage of the differences can be explained by the S-EMG signals. Furthermore this study shows that the EDC muscle activity is related to gender and FCR is related to age. In a longer perspective this information is useful for designing optimal training program for adjusted for gender and age.

PMRE_P1.9 PEOPLE WITH PATELLOFEMORAL OSTEOARTHRITIS HAVE SMALLER HIP MUSCLE VOLUMES THAN HEALTHY CONTROLS

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INTRODUCTION: The patellofemoral joint osteoarthritis (PFJOA) is common and associated with knee pain and reduced physical function. However, currently there is limited knowledge of the modifiable impairments associated with PFJOA, which could be targeted in rehabilitation programs. Hip muscle dysfunction may influence PFJ stress and hence, be important in PFJOA.

AIM: The aim of this study was therefore to compare the volumes of the primary hip-abductors (gluteus medius, gluteus minimus and tensor fasciae latae) of individuals with PFJOA, with those of healthy controls.

METHODS: 50 individuals with radiographic and symptomatic PFJOA, aged > 40 years and 13 healthy people aged > 40 were recruited. The cross-sectional area of hip-abductor muscles were manually segmented from each magnetic resonance (MR) axial slice, and used to calculate volume (ICC 0.997). Muscle volumes were normalised to body weight and analyses were performed with and without gender as a co-variate.

RESULTS: There were no differences in characteristics between the PFJOA group (female 40 (63%); age 55 ± 10 yrs; height 1.69±0.09m; weight 76±13 kg) and control group (female 10 (62%); age 52±6yrs; height 1.68±0.10; weight 71±13kg Comparisons of mean normalised muscle volumes revealed significant between-group differences for gluteus medius (mean difference: 95% confidence interval 0.47: 0.08 to 0.86 $cm^3.kg^{-1}$; p = 0.02), gluteus minimus (0.21; 0.09 to 0.33 $cm^3.kg^{-1}$; p = 0.001) and tensor fasciae latae (0.23; 0.03 to 0.42 $cm^3.kg^{-1}$; 0.024). Inclusion of gender as a covariate did not change the significant findings.

CONCLUSION: Individuals with PFJOA had significantly smaller gluteus medius, gluteus minimus and tensor fasciae latae muscles when compared with healthy control individuals. As muscle volume is directly related to peak isometric force output, smaller muscles will tend to be weaker. It is unclear whether hip-abductor weakness is a cause or an effect of PFJOA. Regardless, the present study provides several directions for future research on this relationship.

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PMRE_P2.1 DEVELOPMENT OF A 5×5 DISPLACEMENT-MMG ARRAY TRANSDUCER

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INTRODUCTION: Two-dimensional propagation of a surface electromyogram (sEMG) waveform was clarified by multipoint measurements of sEMG. Madeleine et al. described the multipoint measurement of MMG using piezoelectric accelerometers (P. Madeleine et al. 2008), but target body portion and posture must be fixed securely for the acceleration MMG measurement, because body movement causes a large artifact.

AIM: The aim of this study was to develop a displacement-mechanomyogram (d-MMG) array transducer to measure two-dimensional propagation waveforms of d-MMG on the skin surface.

METHODS: We previously proposed a d-MMG transducer using a photo-reflector (Oka et al. 2008), which improved the errors caused by body movement or artifacts. In this study, we developed a 5×5 d-MMG array transducer composed of 25 photo-reflectors (TCRT1000, VISHAY), nine sEMG electrodes, and electronic circuits. Though the photo-reflectors (7 x 4 x 2.5 mm) were originally designed to function as binary sensors, we utilized them as displacement transducers. They were located every 10 mm two-dimensionally and 10 mm away from the skin surface. Each reflector included an infrared emitter (950 nm) and a daylight blocking filter. Nine sEMG electrodes were located around the d-MMG array. The electronic circuits (driving circuit and amplifier for the reflector, sEMG amplifier, analog-multiplexer, and ADC) were located near the transducer and were connected to the computer with a USB cable. The d-MMG waveforms were sampled at 10 kHz. To avoid lighting interference among neighboring reflectors, five of the 25 reflectors were made to turn on sequentially and the d-MMG was measured in turn.

RESULTS: The dynamic range of the transducer was 1-8 mm, and the output was approximated by a cubic equation. The daylight blocking filter was effective, and the correlation coefficient of transducer outputs between shading and indoor light was 0.9994. In the d-MMG measurement evoked by an electrical stimulation, the twitch waveform was almost identical to that evoked by a laser displacement transducer (LK-G155, KEYENCE). From the 5×5 twitch waveforms, the propagation velocity of evoked d-MMG and the direction of muscle fiber were estimated.

CONCLUSION: We developed a displacement-MMG array transducer to measure two-dimensional propagation waveforms of MMG. A state of the two-dimensional propagation of a muscle contraction waveform will be found by considering the results of this d-MMG and sEMG measurement.

ACKNOWLEDGEMENT: This research was partially supported by a Grant-in-aids for Scientific Research (22300157) from Japan Society for the Promotion of Science (JSPS).

REFERENCES: H. Oka et al., MMO2.2, Proc. ISEK 2008., P. Madeleine et al., MMO1.6, Proc. ISEK2008.

PMRE_P2.2 RELATIONSHIP OF THE INCREMENTAL TEST IN THE DOMINANT AND NON-DOMINANT UPPER LIMB ANALYSIS OF A MYOELECTRIC ACTIVITY AND POSTURE BODY

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INTRODUCTION: Incremental tests are easy to perform, serve as evaluation tools for improving physical capacity, and improve quality of life in everyday activities. They can also act to reduce respiratory symptoms in patients with chronic lung diseases, and for this reason are an emphasised technique in the training of individuals in pulmonary rehabilitation programs. However the study with health individuals is justified to determine the prevalence of pulmonary dysfunction.

AIM: The objective of this study was to ascertain patterns of difference in angle and myoelectric activity using surface electromyography and computerized kinemetry between subjects' dominant and non-dominant upper limbs.

METHODS: Participants were six males aged between 22 and 30 years who did not present with anatomical and functional cardiopulmonary or upper limb problems. Isolated electromyographic evaluations were performed for the following muscles simultaneously with incremental testing: upper trapezius; middle deltoid; biceps brachii; and triceps brachii. Videogrammetry was employed in results analysis, based on the following anatomical landmarks: acromion; manubriums; lateral epicondyle; styloid process of the radius; and EIAS.

RESULTS: The study showed that the myoelectric activity in the dominant limb is greater than in the non-dominant, associated with trunk diversion and mainly observed during the test with the non-dominant upper limb, as computed by the kinemetry evaluation.

CONCLUSION: Despite existing evidence, it can be concluded that there is a difference between testing in the dominant and the non-dominant upper limb, a fact seldom discussed in the literature. This study demonstrates a prevalence of function in the dominant upper limb over that in the non-dominant upper limb.

PMRE_P2.3 EFFECT OF SIT-TO-STAND EXERCISE WITH WEIGHT BEARING BIOFEEDBACK ON THE FUNCTIONAL OUTCOME OF THE AFFECTED LIMB IN ACUTE STROKE PATIENTS.

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INTRODUCTION: It is important to recover the capacity for weight bearing in the affected lower limb following acute stroke. It is thought that rapid recovery of weight bearing ability in a paralyzed limb may improve involved movements, including other related activities of daily living, and prevent secondary involvement.

AIM: Whether a sit-to-stand (STS) exercise with weight bearing biofeedback (WBB) would yield positive effects on weight bearing force in sitting and standing balance, and on exercise-related daily living activities following acute stroke.

METHODS: Subjects were 20 people who were hospitalized within three days of experiencing a first stroke, and who were able to perform STS actions with minor assistance. All subjects gave written informed consent for their participation. Subjects were randomly assigned to two groups: the STS exercise with WBB group; and the conventional physical therapy group. WBB was supplied with an auditory signal that sounded when participants loaded 60 per-cent of their total body-weight on the affected limb. We analyzed the weight bearing force on the affected limb in sitting posture, and the exercise-related items of FIM(functional independence measure). The Mann-Whitney test was used for between-group and the Wilcoxon test for within-group comparisons with SPSS version 18.0.

RESULTS: In both groups, significant improvement ($p<0.05$) was observed for all parameters after intervention. The weight bearing force on the affected limb of WBB group members improved from 19.5kg at beginning to 25.6kg at end of intervention. However no between-group differences were detected in any of the outcome measures, such as motor FIM scores (WBB group = 82.8 and Control group=82.2).

CONCLUSION: We demonstrated that the STS exercise with WBB for acute stroke was not effective in improving symmetrical weight bearing on lower limbs and exercise-related activities of daily living. Further research is needed to confirm the effects of STS exercises with WBB.

PMRE_P2.4 EFFECT OF COMMUNITY BASED TAI CHI TRAINING ON BALANCE IN POST-MENOPAUSAL OSTEOPENIC WOMEN

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INTRODUCTION: Tai Chi (TC) is a mind-body exercise that is growing in popularity. There is evidence suggesting that TC training may help reduce falls and associated risk factors. It shows potential as an effective and safe intervention for women with low bone mineral density, however few studies have assessed the effect of TC on balance in osteopenic women.

AIM: To evaluate whether TC training in osteopenic women improves features of balance control that have been associated with reduced fall risk.

METHODS: A total of 16 post-menopausal osteopenic women (age 62±5.7 years) were recruited for this study. Subjects were randomized so 8 subjects received 9 months of community based TC training in addition to standard of care (TC group), while the remaining 8 subjects (control group) received standard of care alone (daily calcium, vitamin D, and regular exercise). The TC group participated in a minimum of 2 x 1-hour classes per week for the first month, and 1 x 1-hour class per week for the remaining 8 months. Biomechanical and clinical assessments of balance and function were performed at baseline, 3 months and 9 months follow-up, and included: (1) quiet standing tests with eyes closed, and (2) timed 10m tandem walk and timed repeated chair rise tests. Balance control during quiet standing was characterized by sway parameters. Non-parametric statistics was used to test for differences between groups with significance set at 5%.

RESULTS: Fifteen of the 16 subjects (TC=8, control=7) completed follow-up assessments. Nine months of TC training resulted in improved balance control in the TC group compared to the control group. Significant group differences were observed for anterior-posterior path length ($p<0.01$) and average sway velocity ($p=0.03$). The area ellipse of sway also approached significance ($p=0.06$). Clinical tests of balance (tandem walk) and function (repeated chair rises) showed greater improvement in the TC group versus the control group, but these trends were not statistically significant.

CONCLUSION: The results of this pilot study suggest that TC training may have a positive effect on the balance control and fall risk of post-menopausal osteopenic women, expanding on the balance-related benefits of TC observed in older patient groups. TC is a potentially valuable intervention for prevention of falls and fall-related injury in younger and healthier osteopenic women and warrants further investigation.

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PMRE_P2.5 EFFECT OF STATIC STRETCHING OF THE STERNOCLEIDOMASTOID, UPPER TRAPEZIUS AND PECTORAL MUSCLES IN A PATIENT WITH ORAL BREATHING

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INTRODUCTION: The nasal breathing is a physiological process that is present since birth. However, in some situations the nasal breathing is substituted total or partially for the oral breathing. This pathological mechanism occurs mainly in the case of nasal blockage. This oral breathing results in a syndrome characterized by the change of postural alterations and the respiratory standard. Most of them consist of structural adaptation of the head and neck that lead to an increase of the tension on the cervical muscles, leading to a reduction of thoracic expansion of the vital capacity.

AIM: This study has a purpose of identifying the alterations of the vital capacity and thoracic expansion in oral breathing before the static stretching of the sternocleidomastoid, upper trapezius and pectoral muscles.

METHODS: Eight (8) patients of both genders, with mainly oral breathing had been taken care of from 20 to 30 years old, height of 1.50 to 1.70 cm, and weight of 50 to 70 Kg, none of them having had previous history of pulmonary illnesses. The stretching sessions had been done during 3 days with a minimum of two day interval between them, where the vital capacity and the thoracic expansion were evaluated, before and after the stretching. The data were recorded through electromyography EMG800C by EMG System do Brasil, following the recommendations of SENIAM.

RESULTS: A significant increase of the vital capacity and the dynamic of the thoracic expansion were observed in patients with oral breathing.

CONCLUSION: The surface electromyography proved to be an important tool to investigate the effect of the static stretching of the muscle in oral breathing.

PMRE_P2.6 RELATIONSHIP BETWEEN CARDIOPULMONARY RESPONSES ON EXERCISE ONSET AND ANAEROBIC THRESHOLD IN ELDERLY PEOPLE WITH SUBACUTE ISCHEMIC HEART DISEASE

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INTRODUCTION: It had been described that higher aerobic capacity was led to decreased mortality. However little is known about cardiopulmonary responses on exercise onset was under the influence of aerobic capacity.

AIM: We investigated the relationship between cardiopulmonary responses on exercise onset and aerobic threshold in elderly people with subacute ischemic heart disease.

METHODS: Seventeen male subjects who were elderly people with subacute ischemic heart disease (mean age = 64.5years, SD=6.0, range=56-74) participated in this study. We established a standard of subject in this study that their age was further than 55 years and less than 75 years, and was admitted to hospital due to cardiac rehabilitation cause of ischemic heart disease. They underwent submaximal cardiopulmonary exercise test to determine oxygen uptake at anaerobic threshold (AT) used cycle ergometry. Furthermore, the increase of heart rate (HR) and oxygen uptake in 20seconds from exercise onset was calculated as cardiopulmonary responses.

Pearson product moment correlation was used to assess the relationship between cardiopulmonary responses on exercise onset and oxygen uptake at AT. All statistical tests with a P-value<.05 were considered statistically significant using IBM SPSS statistics (ver.19).

RESULTS: The mean increase of HR on exercise onset was 1.6beats (SD=0.9), oxygen uptake on exercise onset was 0.5ml/kg (SD=0.3), and the mean oxygen uptake at AT was 10.6ml/kg/min (SD=1.9). Oxygen uptake at AT was related to HR on exercise onset(r=.52, P<.05), and oxygen uptake on exercise onset (r= .53, P<.05).

CONCLUSION: These results suggest that an easily and safety obtained measurement of physical fitness is related to HR and oxygen uptake in 20seconds from exercise onset. Therefore, HR and oxygen uptake in 20seconds from exercise onset could be helpful to assess aerobic capacity in elderly people with subacute ischemic heart disease.

ACKNOWLEDGEMENTS: The authors would like to thank all of the subjects.

PMRE_P2.7 ANALYSIS OF THE MUSCLE ACTIVITY IN ASTHMATIC CHILDREN DURING ASYMPTOMATIC PERIOD

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INTRODUCTION: The asthma is common in young people of the 0 to 14 years of age.

AIM: The purpose of this study is using surface electromyography during the development of the static stretching protocol.

METHODS: There were 15 children both genders with asthmatic symptoms that were submitted to stretching protocols twice a week during two months. The data of the of sternocleidomastoid, upper trapezius and pectoral muscles were recorded through electromyography EMG800C by EMG System do Brasil, synchronized with thoracic sensor and sensor of pressure, following the recommendations of SENIAM in relation to EMG procedure.

RESULTS: The analysis of the electromyographic signal presented a significant decrease of the muscular activity (teste t, P<0,05). It was verified significant increase of the respiratory muscular force through the PImax and PEmax sensor (cmH20) (teste t, P<0,05). There was a significant increase of the diameter expansion of the thorax.

CONCLUSION: Among the different options treating the asthmatic children, there is a possibility to offer a physical therapy treatment through the static stretching of the respiratory muscles.

PMRE_P2.8 MECHANOMYOGRAPHIC CHARACTERISTICS OF DIAPHRAGM IN PATIENTS WITH MUSCULAR DYSTROPHY OR SEVERE MOTOR AND INTELLECTUAL DISABILITIES

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INTRODUCTION: The diaphragm is a dome-shaped musculofibrous septum which separates the thoracic cavity from the abdominal cavity and plays an important role in respiration. In particular, the most amount of ventilation at rest (approximately 80%) is performed only by contraction of diaphragm. Dysfunction in the diaphragm is considered to be a determinant factor resulting in respiratory failure. The early detection and appropriate treatment of disease based on measurement of contraction force of diaphragm is important not only for health care but also for surviving. However it is difficult to measure contraction force of the internal muscle positioned between the thoracic and abdominal cavity. The mechanomyogram (MMG) may be useful as an indirect measure of diaphragm function since a number of previous studies have reported close relationship between the MMG amplitude and twitch contraction force.

AIM: The present investigation aimed to clarify the MMG characteristics of the diaphragm in two groups of patients who have muscular dystrophy (MD) or severe motor and intellectual disabilities (SMID).

METHODS: The subjects in this study involved 9 patients with MD, 6 patients with SMID and 17 healthy mail adults. A single twitch contraction of diaphragm was elicited by applying electric stimulation to phrenic nerve. The EMG and MMG signal was recorded over the surface of thorax. The peak to peak amplitude of the EMG and the MMG signal and the period of time between the onsets of both the two signals (the MMG latency) were measured. The amplitude ratio of the MMG to the EMG (MMG/EMG) was then calculated as an index of the electro-mechanical efficiency of muscle contraction.

RESULTS: The diaphragmatic EMG and MMG amplitude in both the MD and SMID group was significantly smaller than that in the healthy group. The MD group demonstrated significantly lower electro-mechanical efficiency of muscle contraction while this index was not different between the SMID and healthy group. The MMG latency in the MD and SMID group was longer than that in the healthy group.

CONCLUSION: The results seem to indicate deteriorated diaphragm function in both patient groups. Particularly in the SMID group, it is considered that the number of active muscle fibers may reduce but the remaining muscle fibers maintain normal contraction activities. The results in the MD group appear to reflect malfunction of neuromuscular junction followed by muscular atrophy. These findings facilitate clinical application of the MMG to assessment of the diaphragm function.

PMRE_P2.9 ELECTRICAL MUSCLE STIMULATION IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE IMPROVES MUSCLE WEAKNESS, EXERCISE ENDURANCE, AND ACTIVITIES OF DAILY LIVING

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INTRODUCTION: Systemic manifestations of chronic obstructive pulmonary disease (COPD) include peripheral muscle dysfunction, right-sided heart failure, malnutrition, and depression. These factors contribute to exercise limitation in COPD. We believe the importance of peripheral skeletal muscle dysfunction on exercise capacity in patients with COPD. Alterations in muscle strength in COPD patients primarily involve the lower limb muscles, with quadriceps femoris muscle strength being 20% to 30% lower in patients with moderate to severe COPD as compared to healthy people.

AIM: The purpose of this study was to compare standard voluntary muscle training and electrical muscle stimulation (EMS) training using a newly developed EMS device and protocol. We evaluated muscle strength, endurance, and ability to perform activities of daily living (ADL) related to pulmonary function.

METHODS: A total of 20 patients were recruited and randomly assigned to one of two groups. The control group underwent a program developed by the Rehabilitation Unit of Kyoto University Hospital using an exercise regimen manual recommended by the Japanese Respiratory Society; standard voluntary muscle exercises were performed 5 days per week for 6 weeks. The EMS group underwent EMS training for 6 weeks in addition to the standard rehabilitation protocol (except voluntary resistance training and cycling exercise). The quadriceps femoris, hamstrings, tibialis anterior muscle, and triceps surae were selected for EMS training in this study. The stimulator current waveform was designed to produce co-contractions in the lower extremity muscle groups at a frequency of 20 Hz with a pulse width of 250 µs. The duty cycle was a 5 sec stimulation with a 2 sec pause for a period of 20 min. Quadriceps muscle thicknesses, quadriceps muscle strength, exercise endurance, and ability to perform respiratory-related ADL were evaluated before training, immediate after the 6-week training program, and 3 months after the training program had concluded.

RESULTS: Thigh and calf muscle thickness, quadriceps muscle strength, and exercise endurance increased significantly in participants of the 6-week EMS training program, whereas no significant changes were observed in participants of the voluntary training program. ADL-related pulmonary function improved significantly after the 6-week training program in both groups.

CONCLUSION: For patients with stable COPD, a 6-week EMS training program was effective for maintaining and improving lower body muscle thickness, strength, exercise endurance and ability to perform ADLs. It was found that the beneficial effects of EMS are significantly greater than those of standard voluntary muscle training programs currently employed.

PMRE_P3.1 THE IMMEDIATE EFFECT OF ORTHOSES ON NEUROMOTOR CONTROL OF GLUTEUS MEDIUS AND GLUTEUS MAXIMUS DURING RUNNING IN INDIVIDUALS WITH ACHILLES TENDINOPATHY

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INTRODUCTION: Achilles tendinopathy is a common musculoskeletal disorder being accountable for between 8-15% of all injuries in recreational runners[1]. Whilst the etiology and sequelae of the condition is not yet fully understood, recent evidence suggests that alterations in neuromotor control of the gluteal muscles may be associated with the condition[2].

AIM: The aim of this study was to investigate the immediate effect of orthoses on neuromotor control of gluteus medius and gluteus maximus during running in individuals with Achilles tendinopathy.

METHODS: Thirteen male regular runners with Achilles tendinopathy ran overground at 4m/s under two randomly allocated conditions: (i) running sandals, (ii) running sandals with prefabricated foot orthoses. Surface electromyographic recordings were obtained from gluteus medius (GMED) and gluteus maximus (GMAX). Force plate data determined gait events. The temporal variables were onset of muscle activity relative to heel contact (onset), offset of muscle activity relative to heel contact (offset) and total duration of muscle activity (duration).

RESULTS: With the addition of foot orthoses to the running sandals there was a significant difference in temporal aspects of GMAX activity when compared to running sandals alone. Specifically, the GMAX offset occurred 12ms later (95% CI 3ms to 21ms, effect size 0.7, $p = 0.017$). No statistically significant differences were observed in GMAX onset or duration, nor GMED onset, offset or duration with the foot orthoses condition ($p > 0.05$).

CONCLUSION: This study provides preliminary evidence that immediately following application, foot orthoses alter neuromotor control of GMAX during running in males with Achilles tendinopathy. Further work is required to determine whether changes in neuromotor control of GMAX relates to changes in pain and function in Achilles tendinopathy.

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PMRE_P3.2 NEUROMOTOR CONTROL OF THE TRICEPS SURAE DURING RUNNING IN PEOPLE WITH AND WITHOUT ACHILLES TENDINOPATHY AND THE IMMEDIATE EFFECT OF FOOT ORTHOSES

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INTRODUCTION: Achilles tendinopathy (AT) is a common injury among physically active populations. It has been proposed that altered neuromotor control of the triceps surae may increase differential intratendinous forces and thus be associated with the pain and pathology seen in this condition. However, it is not known if neuromotor differences exist between those with and without this condition.

AIM: The primary purpose of this research was therefore to investigate whether neuromotor control of the triceps surae in distance runners with AT is altered compared to controls (Study 1). The secondary purpose of this research was to investigate the immediate effects of foot orthoses on triceps surae neuromotor control in subjects with AT (Study 2).

METHODS: Surface electromyographic measures were taken from the Soleus (Sol), Lateral Gastrocnemius (LG) and Medial Gastrocnemius (MG) of 34 male subjects (15 with AT, 19 controls) while participants ran over ground at 4m/sec in a running sandal. Force plate data was acquired to determine heel strike and toe off events. For Study 1, comparisons were made between the relative timing of each of the three muscles for EMG onset and offset, i.e. Sol-LG. Sol-MG and LG-MG. For study 2, the same measures were taken while people with AT ran in a prefabricated orthoses.

RESULTS: For study 1, there was a significant difference in the Sol-LG offset times in the AT group, compared to the control group ($p = 0.02$). There were no significant differences for EMG onset times between groups. For study 2, no significant differences were found in the AT group between the footwear only condition and the footwear plus orthoses condition ($p > 0.05$).

CONCLUSIONS: Subjects with AT display altered neuromotor control of the triceps surae compared to controls. Sol offset times were earlier than LG offset times. It is not known whether this is as a result of the pathology or is an aetiological factor in the genesis of AT. Foot orthoses had no immediate effect on the relative timing of the triceps surae. Further research is required to understand the genesis of the neuromotor differences and to determine whether there are any long-term responses to foot orthoses.

PMRE_P3.3 AN ELECTROMYOGRAPHIC STUDY IN VASTI MUSCLES DURING OPEN KINETIC AND CLOSED KINETIC CHAIN SUBMAXIMAL ISOMETRIC EXERCISES

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INTRODUCTION: The rehabilitation programs for patellofemoral dysfunction have been focused on vastus medialis obliquus muscle training in an attempt to improve patellar tracking.

AIM: Aim of the present study was to examine the myoelectric manifestations of muscle activation and fatigue in vastus medialis longus (VML), vastus medialis obliquus (VMO) and vastus lateralis (VL) at different knee joint angles during sustained isometric contractions using open kinetic chain knee extension and closed kinetic chain leg press.

METHODS: Surface EMG signals were recorded with linear adhesive arrays of four electrodes from fourteen healthy young men (Age 23.5±3.2, mean±SD) during isometric knee extension contractions at 10% and 60% of the maximum voluntary contraction (MVC) for 1 min and 20 s respectively at 30, 60 and 90 degrees knee joint angle. Initial values and rate of change (slope) of mean frequency (MNF), average rectified value (ARV) and conduction velocity (CV) of the EMG signal were calculated.

RESULTS: Comparisons between the two force levels revealed that the initial values of ARV and CV for the VL, VML and VMO muscle were greater at 60% MVC compared to 10% MVC (3-way ANOVA; $F=536$; $P<0.001$, $F=49$: $P<0.01$ for ARV and CV respectively). Comparisons between the different muscles demonstrated lower initial values of CV for VMO compared to VL and VLM at 10% and 60% of MVC ($F=15$; $P<0.05$). In addition, initial estimates of ARV were higher for VMO compared to VML at both force levels ($F=66$; $P<0.05$). Comparisons between open and closed kinetic chain exercises revealed higher initial estimates of ARV for open kinetic chain knee extension at both force levels ($F=62$; $P<0.01$).

In addition, the rate of change of MNF was increasing with increasing angle for closed kinetic chain at 60% MVC while it was minimum at 60° degrees for open kinetic chain. No significant differences were observed in the rate of change of CV and MNF for the three muscles.

CONCLUSION: These findings showed that both open and closed kinetic chain exercise activate equally the three portions of the quadriceps muscle, suggesting that selective training of the muscle is not achievable in these conditions.

PMRE_P3.4 A BIOMECHANICAL CHARACTERISATION OF TRICEPS SURAE LOADING TO BETTER UNDERSTAND ACHILLES TENDINOPATHY REHABILITATION

Dr Dylan Morrissey, QMUL

Mrs Saira Chaudhry; Dr Hazel Screen; Prof Dan Bader; Prof Roger Woledge

INTRODUCTION: There is increasing evidence of the efficacy of eccentric loading (EL) of the triceps surae as compared to concentric loading (CL) in the management of chronic Achilles tendinopathy. However, the mechanisms by which EL results in greater therapeutic benefits are unclear.

AIM: The purpose of this series of studies was to measure differences in biomechanical characteristics, including tendon stress, strain, perturbation, muscle activation; during typical EL and CL training protocols with varying load and speed.

METHODS: Thirty healthy volunteers were recruited, consented to participate and were entered into one of three studies. Subjects performed EL or CL on a step mounted on a force plate. To biomechanically characterize the triceps surae response to exercise we combined ultrasonography to track the musculo-tendinous junction (MTJ), motion analysis to track the lower limbs and ultrasound probe, force plates to measure the Achilles tendon force and EMG to measure muscle activation. Load (0 or 18kg) and speed (1rad.s-1), or 0.2rad.s-1) were varied. Fast fourier transform was used to measure tendon perturbation.

RESULTS: Tendon stiffness and modulus varied across the population with mean values as 97.87 ± 59.34 MPa and 0.44± 0.24 GPa during CL and 96.75 ± 42. 5 MPa and 0.43 ±0.17 GPa during EL. A maximum strain of 5.78 ± 1.30% during CL and 6.03 ± 1.42% during EL was measured. These values are within the reported physiological range. No differences were observed between the stress-strain characteristics of the tendon during CL and EL. Muscle activation of both soleus and gastrocnemius was significantly lower in EL than CL. Muscle activation, tendon stress, strain and modulus all increased with load ($p < 0.05$) during both loading types. Higher power vibrations were observed in the 5-6Hz and 8-13Hz range in EL compared to CL ($p < 0.05$). Furthermore, in a narrow 9-11Hz range of power densities, heavy EL demonstrated higher fluctuations ($p < 0.05$) compared to EL, but not for heavy CL. Higher speeds resulted in higher perturbation, particularly in EL.

CONCLUSION: Additional load increased stresses and strain on the tendon irrespective of loading type, however elevated perturbation intensity was observed only during EL and particularly heavy EL. Higher speeds also increased tendon perturbation. If tendon perturbation does promote tendon repair via tenocytic mechano-transduction, our data suggests that the 9-11 Hz range may be key for stimulating healing, with heavy loading leading to even higher perturbations. This may explain, in part, the clinical observation that heavy load training is more effective than bodyweight resistance alone.

PMRE_P3.5 UTILITY OF THE REVOLVING-TYPE DYNAMIC TRACTION SPLINT FOR EXTENSION CONTRACTURE OF THE METACARPOPHALANGEAL JOINT

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INTRODUCTION: The groove-type dynamic flexion (GDF) splint has been used for the treatment of intra-articular contractures, especially extension contractures. However, the GDF splint has been said to have a risk of "book open" phenomenon, because joints are forced to flex from the beginning of the movement. To solve this problem, we developed the revolving-type dynamic traction (RDT) splint to correct flexion while achieving joint traction, in order to enhance joint space.

AIM: The purpose of this study was to assess whether the RDT splint is an effective device for treating metacarpophalangeal (MCP) joint extension contracture.

METHODS: Thirteen patients participated in this study. All suffered from extension contracture following an injury that had occurred within the six months preceding the study. Most suffered from metacarpal bone fractures or phalangeal bone fractures. Participants were randomly assigned to the RDT group or the GDF group. Patients treated with GDF splints (4 patients, 8 hands total) averaged 42 years of age (range: 28-59yrs), while patients treated with RDT splints (9 patients, 9 hands total) averaged 49 years of age (range: 33-62yrs). Patients wore their respective splint devices for 30 minutes at least once a day, over a period of eight weeks. At the start of treatment and after eight weeks, the following parameters were measured in each patient: flexion angle and arc of the MCP joint; grip strength and pain (using a visual analogue scale); and, where relevant, improvement in angle. The force of traction is started from 250gf with both groups and is changed force of traction according to a case.

RESULTS: Both groups showed significant improvement in flexion angle, arc, and grip ($P<0.01$) after eight weeks. Flexion arc was significantly greater ($P<0.05$) in the GDF group (61.5±18.4) than in the RDT group (68.7±12.8). The RDT splint did not produce significant differences in pain, grip and arc.

CONCLUSION: Contractures of the MCP joint occur in the extended position, and are primarily caused by shortening of the collateral ligaments, which lose elasticity. Traction force of the RDT splint extended the collateral ligaments of the MCP joints. This may indicate an improvement in flexion arc in comparison with a GDF splint. Therefore, we believe that the RDT splint is an effective tool for improving a patient's range of motion in the early stages of treatment. Future studies will compare joint space, during treatment with GDF and RDT splints, in order to assess the true usefulness of RDT devices.

PMRE_P3.6 MUSCLE ACTIVITY AND TORQUE DIFFERENCES BETWEEN TRADITIONAL VS. EARLY ACTIVE REHABILITATION PROGRAMS AFTER ACHILLES TENDON REPAIR

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INTRODUCTION: There is evidence to support that early motion of sutured tendons accelerates the return of muscle strength and activation to healthy levels. Early motion is recommended following tendon repair to decrease the unwanted losses due to immobilization. However, the exact functional changes that occur after an early active rehabilitation program compared to a traditional program have not been systematically studied.

AIM: The purpose of this study was therefore to compare the electromyography signals of gastrocnemius medialis, soleus and tibialis anterior muscles, as well as plantarflexor and dorsiflexor isometric torques in 32 male patients that underwent either a traditional (n=11) or an accelerated (n=14) rehabilitation program after Achilles tendon repair.

METHODS: The traditional therapy group underwent six weeks of immobilization of the ankle joint with plaster cast followed by domiciliary rehabilitation program. The accelerated group used a removable immobilization and started rehabilitation exercises 15 days post-surgery.

RESULTS: No differences were observed between groups for both plantarflexor (p=0.812) and dorsiflexor (p=0.069) normalized isometric torques 90 days post-surgery. However both groups showed reduced plantarflexor torques (TRA=39%, ACC=38%) while no decrease in dorsiflexor torque was observed compared to contra-lateral side. No differences were found between groups for both gastrocemius medialis (GM, p=0.621), soleus (SOL, p=0.616) and tibialis anterior (TA, p=0.990) muscles. However all monitored muscle showed activation reduction with respect to the contra-lateral side. The highest activation deficits were observed for SOL (ACC=35%, TRA=30%), while GM had smaller deficits (ACC=23%, TRA=18%).

CONCLUSION: These results indicate that the rehabilitation protocol did not accelerate the recovery in torque and muscle activation. The reduced TA activation (18% for both groups) without a reduction in dorsiflexors torque can be explained by changes on the force-length relation toward short lengths due to the plantarflexed immobilization position. The deficits of GM and SOL activation seems to be related to the PF torque deficits. Considering that the SOL muscle has the biggest activation loss, this muscle must to be the focus of Achilles tendon rehabilitation protocols during physical therapy programs.

PMRE_P3.7 DIFFERENCES IN MUSCLE ACTIVATION IN PATIENTS WITH GOOD AND POOR TENDON-TRANSFER SURGICAL OUTCOMES

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INTRODUCTION: Restoration of upper extremity function is a high priority for individuals with tetraplegia. A common method for restoring pinch strength is to transfer the tendon of a strong brachioradialis (Br) muscle, one of three elbow flexors, to the tendon of the paralyzed flexor policis longus muscle (FPL), a thumb flexor. After surgery, the patient must learn to activate Br in order to pinch. The surgical outcome is assessed by quantifying pinch force magnitude. However, changes in muscle activation patterns in the transferred Br have not been investigated.

AIM: The purpose of this study was to compare the muscle activation patterns of the three elbow flexors during pinch and elbow flexion tasks after Br-to-FPL tendon transfer.

METHODS: Fine-wire EMG signals were recorded from the Br, biceps brachii (BB), and brachialis (B) muscles of four individuals with tetraplegia who had received Br-to-FPL tendon transfers at least 2 years previously (all male, 29-55 years, cervical 5-7 injury levels). Signals were recorded during isometric pinch and elbow-flexion contractions and were decomposed into motor-unit (MU) trains using EMGlab. The activation level of each muscle was determined as the product of the number of active MUs times the mean firing rate. The relative activation of Br was determined as the ratio of the activation level of Br to the sum of the activation levels of all three muscles.

RESULTS: Three participants had good surgical outcomes with maximum pinch forces that ranged from 33-64 N, adequate for many tasks requiring pinch strength. The relative Br activation level of these participants was 95% ± 9% during pinch and 2% ± 3% during elbow flexion. The fourth participant had a poor outcome (pinch force 6 N) and did not use the transfer functionally. His relative Br activation level was 15% during pinch and 10% during elbow flexion.

CONCLUSION: These results show that the participants with higher pinch forces had learned to disassociate the old synergy patterns between Br and the other elbow flexors and to activate the muscles independently in different tasks. Specifically, they had learned to activate Br with minimal recruitment of BB and B during pinch, and to activate BB and B with minimal recruitment of Br during elbow flexion. The participant with low pinch force had not learned to activate the muscles independently during either task. This study suggests that muscle re-education through task-specific training may improve outcomes of tendon-transfer surgeries.

PMRE_P3.8 REMOTE REBOUND-EFFECT OF RESISTIVE STATIC CONTRACTION OF THE LOWER TRUNK ON THE FLEXOR CARPI RADIALIS H-REFLEX

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NTRODUCTION: In spinal cats, ascending propriospinal pathways between the lumbo-sacral and cervical segments exert excitatory and inhibitory actions upon motoneurones innervating muscles of the shoulder girdle, and mainly inhibitory actions on muscles of the forearm (Miller, 1970). However, the remote neurophysiological effects and after-effects of trunk resistive exercise on the extremities in humans have not been studied.

AIM: The purpose of this study was to determine the time-course of the ascending remote effects of a resistive static contraction of the pelvic depressors (RSCPD) used as the lower trunk resistive exercise on the excitability of the H-reflex of the relaxed flexor carpi radialis (FCR).

METHODS: The protocol was approved by the Hiroshima University Higher Degrees Committee for Ph.D. Research Proposals and was performed according to the Declaration of Helsinki. Neurologically intact volunteer subjects were randomly assigned to (1) a handgrip group (n = 6), which participated in contralateral submaximal isometric handgrip exercises, or (2) the RSCPD group (n = 6). One subject in the RSCPD group was excluded because of failure to induce a FCR H-reflex. For each reflex recorded in this study, repeated H-reflexes and M-waves (1 Hz) were sequentially elicited in a row without intervals for a period of 220 s. The period of 220 s was divided into 8 conditions (C1～C8). Condition C1 (four trials) represented the rest phase; condition C2 represented the phases for each resistive exercise; and conditions C3～C8 represented the rest phases after each resistive exercise. For comparison, each H-reflex amplitude during and after each resistive exercise (conditions C2～C8) were normalized to the corresponding H-reflexes recorded in condition C1 to reduce inter-subject variability.

RESULTS: The ICC (1,4) was 0.987 for the M-wave and 0.997 for the FCR H-reflex in condition C1. The two-way repeated-measures ANOVA showed no effect of time or group on the M-ratio. A two-way repeated ANOVA for the H-ratio showed that the time-course produced a main effect but not so for the group. The interaction between group and time course was also significant for the H-ratios. Post-hoc tests revealed that the H-ratio in condition C2 (during the RSCPD) was significantly reduced compared with the H-ratio in condition C4.

CONCLUSION: The post-hoc analysis and a significant third-order polynomial equation suggested that the ascending remote effects induced by the RSCPD on the FCR H-reflex caused an initial reflexive inhibition phase during the RSCPD and a subsequent gradual facilitatory phase after the RSCPD (remote rebound-effect).

PMRE_P3.9 REMOTE EFFECT OF RESISTIVE STATIC CONTRACTIONS OF THE LOWER TRUNK ON THE ACTIVE ROM OF THE WRIST

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NTRODUCTION: To increase the active range of motion (AROM) of the wrist joint in normal volunteers, the diagonal position of the shoulder joint and a strong static contraction (SC) of the intrinsic hand muscles resulted in a remote after effect (RAF) improvement of the AROM of the wrist joint (Arai et al., 2008). Resistive static contractions of the pelvic depressors (RSCPD) in the mid-range of pelvic motion in a side-lying position also increase the flexibility of remote muscles clinically. In patients with severely restricted joint movements, when direct approaches are difficult for improving the AROM are difficult, indirect approaches may be useful. However, at present, there is a little scientific evidence to support this form of intervention for increasing the AROM of remote joints.

AIM: The purpose of this study was to clarify the effects of RSCPD compared with that of the SC of the affected upper extremity on the improvement of AROM of the affected wrist joint by means of randomized trials.

METHODS: The protocol was approved by the Hiroshima University Higher Degrees Committee for Ph.D. Research Proposals and was performed according to the Declaration of Helsinki. Ten orthopedic patients were randomly selected from 25 patients. Subjects were randomly assigned to one of two groups: 1) the SC of the U/E group (control group) (n = 5) performed strong SCs of the intrinsic hand muscles with the shoulder joint in a diagonal position, and 2) the RSCPD group (n = 5). All data collection devices were electronically synchronized via a BNC connector to the Noraxon Myosystem 2000 EMG systems (EMG system), to allow for synchronous collection of the EMG signals, and to the goniometer voltage in order to determine the relationship between the amplitude of the EMG and the MAROM of wrist flexion over a 1-second static phase of flexion. The change ratio of AROM (CR-AROM) measured with an electrogoniometer after each resistive exercise was calculated for a comparison with the AROM before each resistive exercise. The %EMG was also obtained for the IEMG of each maximal voluntary contraction.

RESULTS: The results of the unpaired t-test revealed that RSCPD showed significant improvements of CR-AROM ($p<0.05$). However, we found no evidence of significant changes in the %EMG.

CONCLUSION: The AROM of restricted wrist joints of patients with orthopedic diseases significantly improved more from a RAF immediately following a RSCPD than by a SC of the U/E.

PMRE_P4.1 RELATIONSHIP BETWEEN KNEE CONFIDENCE AND PHYSICAL FUNCTION IN PEOPLE WITH KNEE OA AFTER ACLR

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INTRODUCTION: Post-traumatic knee osteoarthritis (POAK) is common after anterior cruciate ligament reconstruction (ACLR). For individuals with POAK, low knee confidence may be related to physical function. Knee confidence can be assessed with the Knee Injury and Osteoarthritis Outcome Score (KOOS) using a question concerning how much the individual is troubled by lack of confidence in their knee.

AIMS: This study aimed to: (i) compare knee confidence in people with and without POAK after ACLR; and (ii) evaluate the relationship between knee confidence and physical function in those with POAK.

METHODS: 50 participants, 5-12 years post ACLR: 30 participants (14 male, 16 female, age 45±11yrs, height 172±8cm, and body weight 78±14kg) with radiographic OA; and 20 people without OA (14 male, 6 female, age 40±8yrs, height 171±8cm, and body weight 79±15kg). All participants completed the knee confidence question from the KOOS. All POAKS participants also completed the KOOS-ADL, the Tampa kinesiophobia scale and performance on functional tasks (hop for distance, one leg rise, side to side hop tests).

RESULTS: People with POAKS had significantly lower knee confidence ($p<0.001$) than those with no OA. Lower knee confidence was associated with lower score on the KOOS-ADL and Tampa kinesiophobia scale, and reduced performance on the hop for distance ($p=0.008$), one leg rise ($p=0.001$) and the side to side hop ($p<0.001$) tests.

CONCLUSION: Individuals with POAK following ACLR reported lower knee confidence than those without knee OA and lower knee confidence was associated with poorer physical function. Addressing deficits in perceived confidence may aid in increasing functional performance.

PMRE_P4.2 THE IMMEDIATE EFFECTS OF FOOT ORTHOSES ON DISTAL KINEMATICS IN INDIVIDUALS WITH PATELLOFEMORAL JOINT OSTEOARTHRITIS

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INTRODUCTION: Patellofemoral joint (PFJ) osteoarthritis (OA) is increasingly recognised as an important source of knee pain and morbidity. Increased foot pronation, which combines subtalar joint (STJ) eversion, abduction and ankle dorsiflexion (DF), may contribute to greater PFJ loading by increasing tibial rotation via the ankle mortise. As such, interventions that decrease pronation may reduce PFJ loading and possibly pain. While foot orthoses can change kinematics in young adults with PFJ pain, they have not been investigated in an older OA cohort.

AIM: To investigate the immediate effects of foot orthoses on STJ and ankle kinematics during walking in individuals with PFJ OA.

METHODS: A within-subjects, repeated measures trial utilised participants with PFJ OA involved in a larger randomised clinical trial (age ≥ 40 years; PFJ osteophytes on skyline radiographs; anterior knee pain during PFJ loading activities e.g. steps, squatting). Data were collected during walking under two conditions: i) sandal (Nike Strap Runner); and ii) sandal with prefabricated foot orthoses (Vasyli International) for 10 walking trials (self-selected speed) using a nine-camera VICON motion analysis system (Oxford Metrics, Oxford, UK), and three AMTI force plates. An eight-segment biomechanical model was constructed using OpenSim software (Simbios, Stanford University, CA, USA) and used to compute all kinematic data. For each participant, peak angles were calculated for subtalar eversion and ankle dorsiflexion. Paired t tests investigated changes in peak angles between the shoe and orthosis conditions ($p < 0.05$), while changes in peak angle with orthoses were plotted to evaluate patterns of change.

RESULTS: 18 participants completed the study (12 females; age 55±9). Significant reductions in ankle DF were seen with orthoses compared to shoes (mean difference 1.48°, 95% CI 0.55° to 2.42°). Data plots revealed that the majority of participants demonstrated reductions in peak DF (15/18 participants, 83%). In comparison, more variable responses in STJ eversion were observed, with 6 of the 9 participants who demonstrated STJ changes showing reductions in peak eversion angle. This was reflected by nonsignificant changes in peak eversion (-0.63°, -1.7° to 0.45°).

CONCLUSION: Findings indicate that ankle DF was the component of pronation that was most consistently affected by foot orthoses. Such adaptations may represent a possible method to reduce PFJ loading and OA-related pain.

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PMRE_P4.3 PELVIC INSTABILITY AND DELAYED ONSET OF THE LUMBAR MULTIFIDUS DURING PRONE HIP EXTENSION IN PATIENTS WITH TOTAL HIP ARTHROPLASTY

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INTRODUCTION: Lumbopelvic pathokinematics coupled with hip disability have been demonstrated after total hip arthroplasty (THA). Coordinated regulation of the muscles around the hip and trunk is essential for the stability of the lumbopelvic region; however, the pattern of the hip and trunk muscle activity with respect to pelvic motion remains to be elucidated in patients with THA.

AIM: The aims of this study were (1) to evaluate pelvic motion and muscle activity in patients with THA and healthy individuals, and (2) to investigate the relationship between hip and trunk muscle activity and pelvic motion in patients with THA.

METHODS: Twenty-one women who underwent THA (age, 62.5 ± 6.6 years) and 12 age-matched healthy females were enrolled. All of the subjects provided informed consent. Participants were instructed to perform active hip extension from 30° of flexion to 0° of hip extension while keeping the knee extended. Movement started upon presentation of a visual cue using 2 (right and left) LEDs. Illumination of each diodes indicated which leg was to be raised. The participants were instructed to perform the task as rapidly as possible. Three-dimensional angular displacements of the pelvis were recorded using a motion capture system. Surface EMGs were recorded at the semitendinosus (ST), gluteus maximus (Gmax), erector spinae (ES), and lumbar multifidus (MF) on the side of leg extension. The onset of activity in each muscle was determined. The average root-mean-squares EMG amplitude of each muscle during movement was calculated. For patients with THA, 5 tasks with the affected leg were included in the analysis; for the controls, 5 tasks with the nondominant leg were included. The means of the 5 trials were used for analysis. The differences in the pelvic angle, EMG onset time and EMG amplitude were analyzed between the control and patient groups. In the patient group, the relationships between muscle activity onset time, muscle activity, and pelvic angle changes were tested.

RESULTS: The anterior tilt and rotation of the pelvis tended to increase in patients with THA, although only the rotation angle differed significantly ($p < 0.01$). The onset time of the MF was significantly delayed in patients ($p < 0.05$). The EMG amplitude of the ST was significantly increased in patients. In the patient group, delayed onset time of the MF was significantly associated with increased anterior pelvic tilt ($r = 0.47$, $p < 0.05$).

CONCLUSION: Patients with THA showed delayed onset time of the MF at the initiation of the hip movement, and this was related to the increased anterior tilt of the pelvis during hip extension. These findings suggest that the recruitment pattern of the MF may be a notable component in the evaluation and treatment of patients with THA.

PMRE_P4.4 IMMEDIATE EFFECTS OF UNLOADER KNEE BRACE ON PAIN AND CONFIDENCE IN INDIVIDUALS WITH OSTEOARTHRITIS AFTER KNEE RECONSTRUCTION

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INTRODUCTION: Anterior cruciate ligament reconstruction (ACLR) is a well recognized risk factor for post-traumatic knee osteoarthritis (OA). Knee OA can have a substantial impact on quality of life (QOL), general and mental health, and participation in exercise and work related activities. Thus, targeted conservative interventions with the potential to reduce pain, improve QOL are critical.

AIM: This study aimed to evaluate the immediate effects of an unloader knee brace on (i) pain and (ii) confidence in the knee during functional tasks, in individuals who have developed post-traumatic knee OA 5-12 years post-ACLR.

METHODS: Twenty-eight participants (13 male, 15 female), age 45±11.6yrs, height 171.9±8cm, body weight 78.3±14.8kg, were tested. The KOOS-symptoms was 62±29, KOOS-pain was 59±37, KOOS-ADL (activities of daily living) was 59±42, KOOS-sport and recreation was 61±29 and KOOS-knee related QOL was 59±26.

RESULTS: There was a significant bracing effect, with reduced pain during the step-down test ($p=0.035$) and greater confidence during the single leg hop for distance ($p=0.004$), side to side hop ($p=0.003$) and single leg rise ($p=0.006$) in the braced conditions. There were no differences observed between the adjusted and unadjusted brace conditions except for confidence during the single leg rise, where greater confidence was observed when wearing the adjusted brace than the unadjusted brace ($p=0.025$).

CONCLUSION: In younger individuals with post-traumatic knee OA following ACLR, the unloader knee brace resulted in greater knee confidence in hop and single leg rise tasks, and reduced pain in step-down task, regardless of frontal plane adjustments.

PMRE_P4.5 GREATER PERFORMANCE IN PHYSICAL FUNCTION IS RELATED TO IMPROVED OUTCOMES IN PEOPLE WITH EARLY-ONSET HIP OSTEOARTHRITIS

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INTRODUCTION: Hip osteoarthritis (OA) is associated with significant personal and societal burden. Early onset hip osteoarthritis (EOHO) affects adults <50 years, with symptoms of pain, impaired physical function and reduced quality of life (QoL) commonly experienced. Diagnosis of EOHO is difficult, with hip arthroscopy enabling accurate grading of chondropathy in people with this condition. Whilst physiotherapy treatment is often used to reduce pain and improve physical function in EOHO, little is known of the relationship between physical impairment and associated outcomes of pain and functional capacity. Knowledge of this relationship may assist physiotherapists in providing targeted intervention to alter physical impairments and therefore improve patient outcomes in people with EOHO.

AIM: To examine the relationship between patient-reported outcomes (pain, symptoms, activity of daily living (ADL), sport and QoL) and physical impairments (range of motion (ROM), strength, functional performance) in people with EOHO who have undergone hip arthroscopy 12-24 months previously.

METHODS: 51 consecutive hip arthroscopy patients (female=30; age=38±12; height=1.73±9; weight=78±13; BMI=26.6±6.7; waist girth=80±12) 12-24 months previously from a single surgeon, were recruited who had chondropathy diagnosed at time of surgery as ≥Outerbridge grade I. BMI, waist girth and physical activity level data were collected, and participants completed the Hip Dysfunction and Osteoarthritis Outcome Score (HOOS) (five subscales: pain, symptoms and stiffness, ADL, sport and recreation and QoL), and were tested for hip ROM and normalised hip joint peak torque (NPT), and one leg rise (OLR) and side bridge (SB) functional tests. The relationship between the subscales of the HOOS and physical impairments was examined using the Pearson Correlation Coefficient (*r*) ($p<0.05$).

RESULTS: Higher scores in the subscales of the HOOS correlated with greater hip flexion (FL) and internal rotation (IR) ROM at 90˚hip FL ($p<0.05$); with greater performance in all measures of hip joint strength (NPT); and greater performance in OLR ($p<0.01$) and SB ($p<0.05$). Linear regression analyses revealed hip extension (EX) peak torque was independently associated with HOOS-pain ($r^2=0.208$; $p<0.001$) and HOOS-ADL ($r^2=0.231$; $p<0.001$), and hip EX and adduction peak torque were associated with HOOS-QoL ($r^2=0.279$; $p=0.038$). For the hip ROM measures, lower hip FL range was independently associated with HOOS-pain ($r^2=0.408$; $p<0.001$), HOOS-ADL ($r^2=0.397$; $p<0.001$) and HOOS-QoL ($r^2=0.262$; $p<0.001$).

CONCLUSION: In people with EOHO who are between 12-24 months post hip arthroscopy, greater physical function (hip FL and IR ROM, hip EX strength) was associated with lower pain and higher physical function and QoL. This knowledge may assist physiotherapists in providing targeted rehabilitation programs to address these physical impairments and thus improve pain, function and QoL in people with EOHO.

ACKNOWLEDGEMENTS: Physiotherapy Research Foundation Beryl Haines Memorial Grant

PMRE_P4.6 CHANGES OF INTER-JOINT COORDINATION DURING STAIR NEGOTIATION IN PATIENTS WITH ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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INTRODUCTION: The knee instability might be improved after anterior cruciate ligament (ACL) reconstruction surgery. However, the movement pattern among the joints of the lower extremity might still not fully recover. Stair negotiation is one of the common functional activities that would challenge knee joint in our daily living. Thus, we need to understand how the joint coordination changes after ACL reconstruction in stair negotiation for the development of rehabilitation protocol.

AIM: The purpose of the present study was to investigate the changes of the inter-joint coordination during stair negotiation in patients with ACL reconstruction.

METHODS: 5 patients with unilateral ACL reconstruction (3 males, 2 females, mean age: 26.8±5 years old) and 5 healthy adults (3 males, 2 females, mean age: 25.8±2 years old) participated in this study. Subjects were instructed to perform stair ascent and descent on a 4-steps stair (stair height: 16 cm, stair tread: 30 cm) with their self-selected speed. A motion analysis system was used to record the kinematic data. Phase plane and angles of the hip, knee and ankle joint were calculated ($\phi = \tan^{-1}(\omega/\theta)$) using the normalized angular position (θ) and angular velocity (ω). Continuous relative phase of hip-knee and knee-ankle were also calculated. Root-mean-square difference, cross-correlation coefficient and deviation phase of continuous relative phase were computed to quantify the difference for magnitude, temporal similarity and variability, respectively, among the operated side, non-operated side of patients and controls.

RESULTS: Root-mean-square differences of hip-knee and knee-ankle was increased in the operated side than the non-operated side during stair ascent. Cross-correlation coefficient of hip-knee and knee-ankle were similar between the operated side and the non-operated side. Deviation phase of hip-knee and knee-ankle of the operated side was increased than the non-operated side and controls during stair ascent.

CONCLUSION: During stair ascent, the magnitude and variability in inter-joint coordination of lower extremity were changed among the operated side, non-operated side of patients and controls.

ACKNOWLEDGEMENTS: This work was supported by National Science of Council in Taiwan awarded to Dr. Hsu (NSC 98-2218-E-002-037).

PMRE_P4.7 EFFECT OF DIFFERENCE OF RESISTANCE PART ON ACTIVITY RATIO OF VASTUS MEDIALIS OBLIQUUS / VASTUS LATERALIS DURING KNEE EXTENSION

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INTRODUCTION: To reduce the anterior shear force of the tibia, resistance is applied more proximally to the tibia during knee extension exercises in an anterior cruciate ligament-deficient knee. The effect of difference resistance part on vasti muscles activity during knee extension has not been clarified.

AIM: The aim of this study was to clarify the vastus medialis obliquus (VMO) and vastus lateralis (VL) activity which influences patellar stability, based on the difference between the distal and middle resistance parts during knee extension.

METHODS: Eight healthy male volunteers (mean age: 20.5 ± 1.2 years; mean height: 180.4 ± 1.7 cm) participated in this study. Two types of knee extension task were conducted using the Biodex System 3 torque machine (Biodex Medical System, Inc.). At first, a pad for applying resistance was fixed to the distal part of the leg as “distal resistance”. Another pad was fixed to the middle part of the leg as “middle resistance”. Distal and middle parts were defined as 75% and 60% of the distance from the adductor tubercle to the distal tip of the medial malleolus, respectively. Each knee extension torque measurement of the distal or middle resistance was recorded during isometric contraction (with the knee at 60 degrees of flexion), increasing linearly from 0 to the maximal voluntary contraction (MVC), in a 5-second period. Before each measurement of knee extension torque, subjects performed a few trials to practice contracting, smoothly and maximally. Electromyography (EMG) was recorded from the VMO and VL during each knee extension task, using an MQ8 EMG unit (Kissei Comtec. Co., Ltd.). An integrated EMG (IEMG) of 250 ms before and after points generating 20, 40, 60, and 80% of MVC knee extension torque was calculated using the BIMUTAS-video (Kissei Comtec. Co., Ltd.). Furthermore, IEMG was normalized by each %MVC torque. The IEMG ratio of VMO/VL at the same contraction level was compared between the “distal resistance” and “middle resistance” sites, using a paired t-test.

RESULTS: The IEMG ratio of VMO/VL for middle resistance increased significantly compared with distal resistance at the 20%MVC level. There were no significant effects of the IEMG ratio of VMO/VL at the 40, 60, or 80%MVC levels.

CONCLUSION: These results suggest that the activity ratio of VMO/VL which stabilizes the patella increases with middle resistance at the 20%MVC level during knee extension.

PMRE_P4.8 MULTI-MUSCLE SYNERGY CHANGES IN ROTATOR CUFF DISEASE

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INTRODUCTION: Bernsteins idea of the motor control by the elimination of the redundant degrees of freedom with using flexible synergy is evolved on. Functional muscular synergies are understood as individual phenotypes of sensomotoric system, which are regulated along two parallel pathways, descending signals and sensoric information from effectors at the same time

AIM: The goal of the study is to evaluate the multi-muscle synergies of the upper limb at the accurate defined of hand movement. Uniform motions were defined by holding the handy gyroskope. Circumduction of the hand was initiated freely, but in the following intervals it is maintained peripheral sensoric inputs generated by servomechanism action of the gyroscope. Our PEMG study documents actual relationships between activation of proximal and distal muscles of upper extremity and their changes in patiens with rotator cuff disease.

METHODS: In the main file were 37 healthy subjects, average age 27,7 years, the control file presented by patients with the rotator cuff lesion in amount 32, average age 38,6 years. Muscles electrical activity was measured by surface electromyograph MyoSystem 1400 (Noraxon). Have been scanned 7 muscles: m. serratus anterior (SA), m. trapezius - pars ascendens (TR a.), m. trapezius - pars transversa (TR t.), m. latissimus dorsi (LD), m. infraspinatus (INF), mm. extensores antebrachii (EXT), m. flexores antebrachii (FL). PEMG records were standardly processed and evaluated with program MyoResearch 2.10. For statistical processing were used multiples of activation values of individual muscles. For evaluation of strength of the relation individual couple muscles has been used arithmetical correlated method.

RESULTS: In the PEMG recording the healthy probands proved to have statistically close correlations between activities of the proximal muscles m. SA and INF and, at the same time, the activity of extensors of the forearm. In patients with degenerative pathology of the rotator cuff the distribution of muscular activities between acral and shoulder girdle muscles was completely different and the apparent decrease of extensor output in the forearm as well as m. SA was accompanied by prevailing activity of m. LD and m.Tr a.

CONCLUSION: The results of the experiment are useful for physiotherapists clinical practice. They show a direct functional relation between the activity of forearm muscles and the activity of the shoulder rotator cuff muscles. At the same time, the importance of terapeutic facilitation of m. SA for functional renovation of motoric activities of the shoulder and function of the whole upper extremity, including hand manipulation.

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POSTURE, BALANCE & GAIT

POBG_P1.1 FUNCTION OF THE RECTUS FEMORIS IN STANDING

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INTRODUCTION: The primary muscles involved in standing are thought to be the gluteus maximus (a mono-articular muscle of the hip joint), the vastus lateralis (Vl, a mono-articular muscle of the knee joint), and the rectus femoris (Rf, which acts simultaneously on both the hip and knee joints). However, because the Rf flexes the hip joint and extends the knee joint, it produces motions that are not necessary for standing. There is therefore a discrepancy between the general understanding of the muscles used in standing and the actual muscles used therein.

AIM: In this study, kinesiological electromyographic analysis was used to determine the primary muscles used in standing in 2 different postures. We also attempted to clarify Rf function by using a model with a simplified muscle arrangement of 3 pairs of 6 muscles. These muscles included the antagonistic mono-articular muscles of the hip joint and knee joint, and the antagonistic bi-articular muscles that act simultaneously on the hip and knee joints.

METHODS: Under 2 experimental conditions: ordinary standing and standing while keeping the trunk vertical. The muscular activity of the legs was measured with both a constant center of gravity at the hip, and with a shifting center of gravity.The surfaces of 7 different muscles of the legs were examined: the Vl, Rf, lateral hamstrings, and gluteus maximus in the thigh; and the lateral gastrocnemius (Gs), tibialis anterior, and soleus muscle in the lower leg.

RESULTS: During normal standing, no discharge of the gluteus maximus, lateral hamstrings, or soleus muscle was found, while significant muscle discharge was confirmed in the Vl and Rf. This suggests that the gluteus maximus is not a primary muscle in standing, despite current opinion.

CONCLUSION: Results from theoretical analyses and robot analyses have shown that one function of the Rf and other antagonistic bi-articular muscles and antagonistic mono-articular muscles of the thighs is controlling output and direction relative to the 6 directions of the tip of the heel. When a person stands up, the 3 muscles that act to extend the hip joint—the gluteus maximus, Vl, and Rf—control the output in a vertically downward direction to lift the body relative to the tips of the heels. However, the results of this study did not demonstrate any involvement of the gluteus maximus. When the Rf contracts, it moves the torso in a direction that would send the torso backward, which is different than the vertically downward direction required to raise the body. This suggests that the muscle activity of the Rf does not contribute to the external force needed during standing, but rather acts as a parallel link for automatically generating ground force in the direction of the center of gravity.

POBG_P1.2 NOVEL APPROACH FOR UNDERSTANDING POSTURAL CONTROL STRATEGY USING REAL-TIME FEEDBACK MOVABLE FORCE PLATE

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INTRODUCTION: Postural control relies on multisensory processing and its interaction to automatic control system which dominantly involves quick-responded reflex and vestibular system. Such control system enables us to maintain seemingly-unstable bipedal posture without conscious awareness. Additional cortical demand would be increased when one faced to uncertain surroundings or unstable ground surface. We here attempt to develop real-time feedback movable force plate system to get a better understanding of human postural control.

AIM: To observe postural responses due to augmented/reduced postural sway realized by established real-time feedback system.

METHODS: 17 healthy volunteers stood on the movable force plate with eyes closed while support surface moved in-phase (reduced sway) and anti-phase (augmented sway) to the center of mass (CoM) displacement detected by laser sensor. Center of pressure (CoP) and muscle activity in the soleus (Sol) and gastrocnemius (Gas) muscles were recorded for the quantification of postural strategy in total seven different conditions, that is, three different feedback gains (15, 30, 45% of natural sway) for both in- and anti-phase and control condition (normal sway).

RESULTS: The results demonstrated that CoP sway speed was gradually increased with feedback gain in anti-phase condition. The mean power of high frequency component of CoP (>1Hz) and EMG in the Sol and Gas (8-12Hz) under anti-phase condition was significantly larger than those under in-phase condition. Time-shift between CoP velocity and Gas EMG calculated by cross correlation analysis was significantly shorter in anti-phase condition.

CONCLUSIONS: Anti-phase feedback causes an increase of the contribution of automatic neural control, presumably spinal reflex, system which is supported by the result of increasing the 8-12Hz power and shorter delay of EMG activity in response to CoP velocity. The real-time feedback system we developed in this study has a potential for accomplishing implicit adjustment of postural control strategy, and provide a novel methodological approach for further investigation regarding postural control system.

POBG_P1.3 WITHIN-SESSION RELIABILITY OF CENTRE OF PRESSURE (COP) MEASURES OBTAINED DURING THE PERFORMANCE OF A BATTERY OF POSTURAL CONTROL TASKS IN A GROUP OF HEALTHY MALE INDIVIDUALS.

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INTRODUCTION: The postural control (PC) of an individual can be quantified by centre of pressure (COP) displacements measured on a force platform. Evaluating different aspects of PC (static, dynamic and functional) using a battery of tasks is considered a more holistic approach than evaluating any single task. However the inherent variability of the COP signal and influence of performing a task in a battery on the subsequent task performance could affect the reliability of COP measures.

AIM: Therefore the aim of this study was to establish relative (Intraclass correlation coefficients (ICC)) and absolute (standard error of measurement (SEM)) reliability, and also the systematic variation of COP measures obtained during the performance of a battery of PC tasks by a group of healthy males.

METHODS: For the purpose of this study, 4 tasks namely bipedal and unipedal stance, limits of stability (LOS) and a lifting task were included in the battery for evaluating static, dynamic and functional PC respectively. 36 healthy male participants (mean age 40±13 years) performed 3 trials of each task on a force plate on three independent testing occasions (11 minutes each) within a single testing session (40 minutes). 2-3 minutes of rest periods were provided between testing occasions. COP signals obtained during the task performance were post-processed to derive time-domain COP distance and area measures. $ICC_{(2, 1)}$ and SEM% were calculated to derive relative and absolute reliability estimates of COP measures respectively. Repeated measures analysis of variance (RM_ANOVA) was used to evaluate for systematic variation of COP measures.

RESULTS: 14 out of 18 COP measures for each tasks included in the test battery showed excellent relative (≥0.75) and acceptable absolute (≤15 SEM%) reliability. Among the 14 COP measures, two COP measures (total excursion and mean velocity) had excellent reliability and acceptable SEM percentages in common for all the tasks. Generally the area measures (95% confidence circle and ellipse area) displayed very high SEM% (≥20 SEM%) except for the lifting and LOS task. RM_ANOVA demonstrated a significant ($p \leq 0.05$) systematic variation in COP measures of most of the tasks; displaying both fatigue and learning related influences, except COP measures of postures at the maximal stability limits (a component of LOS task).

CONCLUSION: Excellent within-session relative and absolute reliabilities of COP measures of all the tasks in the test battery were demonstrated. Systematic variations were exhibited in most of the tasks due to repeated performance in the single testing session. Although systematic variation exists, the chosen battery of tasks was reliable and can be recommended for researchers for a holistic evaluation of PC.

POBG_P1.4 INFLUENCE OF TRANSLATION FREQUENCY ON POSTURAL CONTROL STRATEGY DURING PASSIVE POSTURAL MOVEMENT

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INTRODUCTION: The stabilizing torque for upright standing is necessary to keep the center of mass (COM) within the base of support. The ankle extensor torque generated by a triceps surae muscles (i.e., the medial gastrocnemius (MGAS), the lateral gastrocnemius (LGAS) and the soleus (SOL)) can be evoked passively and actively for posture control strategy. Previous studies have reported the central nervous system organizes postural patterns depending on translation frequency. However, it was not clear that the relationship between translation frequency and muscle activity.

AIM: The purpose of this study was to quantify the relationship between body sway and muscle activity by using cross-correlation function (CCF) and to examine the influence of translation frequency during passive postural movement.

METHODS: Nine healthy male subjects participated in this study. They stood on a force platform quietly and were applied translational sway: 80 mm forward and backward shifts with sin wave from 0.2 to 0.8 Hz. Electromyographic (EMG) signals of the tibial anterior (TA), SOL and MGAS were recorded by 1000 Hz sampling frequency. The center of pressure (COP) in anterior-posterior direction was calculated from force platform data. The COM, hip and ankle joint angles were calculated from the coordinates of reflex markers measured by motion capture device.

RESULTS: The postural control strategy (the inter-segmental coordination pattern) depended on translation frequencies, and the EMG of triceps surae muscles preceded the center of pressure, and also preceded the center of mass in all set translation frequencies. These results suggest that the anticipatory neural control is modulated by translation frequency.

CONCLUSION: We confirmed the previously reported findings that the inter-segmental coordination pattern is dependent on translational frequency. By comparing the results of CCF analysis among translational frequencies, we suggest that the postural control mechanism might be modulate the level of muscle activity depended on translation frequency, and keep a fixed preceding time for motor command during passive postural movement.

POBG_P1.5 DYNAMIC POSTURAL BALANCE IN YOUNG HEALTHY MEN: PHYSIOLOGICAL AND NEUROMUSCULAR PARAMETERS IN THREE POSTURAL CONDITIONS

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INTRODUCTION: Surface electromyographic (sEMG) measurements were associated to a passive dynamic postural board to analyze center of pressure (COP) parameters and neuromuscular responses in dynamic conditions.

AIM: The aim of this study was to understand the complex postural control mechanism responsible of the postural stability maintenance on a dynamic balance platform moving (±15°) in medium-lateral plane (M-L), in different somatosensory conditions: bipodalic versus monopodalic stance; with and without visual inputs: eyes open (EO) versus eyes closed (EC).

METHODS: Fifteen young males (average age: 26 ± 2 years, height 176 ± 7 cm, weight: 71 ± 7 kg, right foot length: 26,5 ± 1,4 cm) were studied on a force platform (Tecnoboby Prokin PK 214 P, Bergamo, Italia), and by a biaxial trunk accelerometer (TK-Trunk Sensor). Moreover, six circular adhesive electrodes (CoDe-ConcentricDetenction – Spes Medica, Battipaglia, Italia) were placed unilaterally from external oblique, erectors column, tensor fascia lata, gracilis, tibialis anterior and peroneus longus muscles to analyze their muscular activation patterns.

RESULTS: Only the mean velocity in A-P plane of center of pressure displacement (COPd) and the mean angular velocities in M-L plane of board tilt (Bt) and trunk tilt (Tt) were found to be a simple and reliable way to asses postural stability in recruited subjects (60%<ICC<80% and SEM<5%), during EO conditions. Variance of trials was found greater (30%) than variance of days for all sensory conditions evidencing the role of learning effect. During dynamic postural condition an ordered delay sequence COPd→Bt→Tt was observed. Both trunk average rectified value (ARVt) in M-L plane and electromyographic values showed a greater trunk intervention in monopodalic than in bipodalic condition and during test with EC. In 66% of the total time of trials, Bt and Tt moved in the same direction, this postural behaviour supported by electromyographic findings means that people did not use opposite trunk movements to control board balance. Finally, the comparison between the best and the worst performances provided information about the most effective postural strategy in each sensory condition.

CONCLUSION: During EC condition to follow Bt with the Tt on the same side seems more promising as balance strategy whereas, with EO, trunk strategy was not correlated with the increase of postural performance.

POBG_P1.6 THE CHARACTERISTICS OF SIT-TO-STAND MOVEMENT IN INFANTS AGED 1 YEAR: A PRELIMINARY STUDY

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INTRODUCTION: Sit-to-stand (STS) movement requires coordinated movement of multiple body segments. However, the kinematic characteristics of STS movement in infants have not been fully clarified.

AIM: The aim of this study is to clarify the kinematic characteristics of STS movement in infants.

METHODS: Five infants (2 males and 3 females) aged 13 to 14 months and 5 young adults (3 males and 2 females) aged 21 to 22 years old took part in this study. This research study was conducted after having obtained the approval of Osaka Prefecture University research ethics committee (2011P05). In order to assess STS movement, a motion analysis system consisted on 2 cameras (Kinema tracer: made by Kissei Comtec, Japan) (30fps) was used. Markers were placed unilaterally on the following body landmarks: lateral aspect of the 5th metatarsal head, lateral malleolus, lateral femoral condyle, greater trochanter, and acromion. A chair, as high as the subject's knee joint in sitting position, was prepared. STS movement was performed in bare feet, and there was no time restriction. STS movement data which included the total duration of STS movement and angular movement of each joint (trunk, hip, knee, and ankle) were collected and compared.

To compare the sampled data, non-parametric unpaired t-test was used. Statistical analysis was performed using commercial statistics software (SPSS v.16). Statistical significance was set at $p = 0.05$.

RESULTS: There was no significant difference on the total duration of STS movement in two groups. The total duration of STS movement of infant group was 2.39±0.65 seconds, that of adult group was 1.95±0.16 seconds. The transitional trunk angular movement was significantly decreased in infant group (42.1±7.4 degrees), compared with that of adult group (54.6±5.2 degrees). On the other hand, the transitional ankle angular movement was significantly increased in infant group (17.2±7.0 degrees), compared with that of adult group (3.8±3.9 degrees).

CONCLUSION: These findings suggest that the pattern of STS movement in infants is characterized by less trunk flexion and more ankle dorsiflexion, compared with that of adults. These observed movements between trunk and ankle might enable infants to stand from the sitting position independently.

POBG_P1.7 THE DEVELOPMENT OF A FORCE PLATE FOCUSED ON INFANTS' MOVEMENTS: AN EXPERIMENTAL STUDY OF RELIABILITY FOR MEASUREMENT

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INTRODUCTION: Force plates (FPs) can record higher ground reaction force than humans' weight. Thus, FPs provide us with objective information concerning more dynamic movements, such as running and jumping. However, infants' movements, such as sit-to-stand actions and gait, generate little ground reaction force. Therefore, one question of importance is whether existing FPs measure infants' movements accurately. In order to analyse infants' movements, an original FP (TF-3040-A; made by Tech Gihan, Japan) (size: 40×30×5cm; weight: 7kg) focused on measuring lower ground reaction force was developed. This FP can be set at three ranges: 300N; 600N; and 1000N.

AIM: The aim of this study was to clarify the accuracy of measurements taken by our newly developed FP.

METHODS: In order to determine accuracy, a load test was performed. A 200g weight (1.96N) was loaded on the FP. This weight was distributed over nine points in the FP: the center; the four corners; and the four midpoints of each corner. This test was performed once. The FP was set at the 300N range, and vertical ground reaction force (Z axis) was recorded by analysis software (made by Tech Gihan), with a 100 Hz sampling rate. We then recorded the data when this weight put on the FP was sampled for 0.5 seconds. To compare the sampled data at each point across the FP, a repeated one-way analysis of variance (ANOVA) was used. Statistical analysis was performed using commercial statistics software (SPSS v.16). Statistical significance was set at $p = 0.05$.

This research study did not require approval from a research ethics committee as it did not involve human or animal subjects.

RESULTS: There was no significant difference in vertical ground reaction force between the nine points ($P = 0.096$). The mean value of ground force reaction on nine points was recorded as the range 1.87±0.19N to 1.96±0.18 N.

CONCLUSION: Our newly developed FP succeeded in recording lower ground reaction force. This finding suggests that the FP is suitable for measuring infants' movements. We believe that this newly developed tool can help to improve understanding of the mechanisms involved in infants' motor development.

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POBG_P1.8 STRIDE TIME SYNERGY IN RELATION TO WALKING DURING DUAL TASK

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INTRODUCTION: Increased stride-to-stride time variability has been observed in dual task situations and among elderly fallers [1]. Variability is therefore often regarded as an indicator of poor gait performance. However, some degree of movement variability is perfectly normal. From a synergistic point of view elemental and performance variables may represent good and bad components of variability [2].

In this study we propose that the gait pattern can be seen as an on-going movement synergy in which each stride is corrected by the next stride (elemental variables) to ensure a steady gait (performance variable).

AIM: The aim of this study was to evaluate stride time synergy and to identify good and bad stride variability in relation to walking during dual task.

METHODS: Thirteen healthy young participants walked along a 2x5 meter figure-of-eight track at a self-selected comfortable speed. Stride time was measured by heel contacts and the stride-to-stride difference (s-t-s) was evaluated. Each s-t-s was plotted against the following s-t-s in a coordinate system. Variability was evaluated in diagonal directions in the plot; i.e. good variance was evaluated with respect to a straight line with a positive slope going through the mean of the strides, and bad variance with respect to a similar line with a negative slope. The general variance coefficient (CV%) was also computed. The effect of introducing a concurrent cognitive task (dual task: counting backwards in sequences of 7) was evaluated.

RESULTS: The variance coefficient (CV%) increased significantly from 1.59 to 1.90 ($p<0.05$) when shifting from single to dual task. With respect to the synergy approach, the good/bad variance ratio during single task was: 2.53 (CI95%: 2.07-3.00). When shifting to dual task the good/bad ratio was 2.28 (CI95%: 1.99-2.57) ($p=0.21$).

CONCLUSION: The good/bad variability in the stride-to-stride time differences was larger than 1.0 indicating a synergy pattern. Gait synergy was found fairly robust and complementary to CV in presence of an additional cognitive load. These preliminary findings suggest that a synergy perspective on gait variability may provide a new approach to gait assessment.

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POBG_P2.1 FACTORS ASSOCIATED WITH RESTRICTED HIP EXTENSION DURING GAIT IN WOMEN AFTER TOTAL HIP ARTHROPLASTY

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INTRODUCTION: The reduction in walking ability of patients after total hip arthroplasty (THA) does not improve sufficiently. Several previous studies have reported patients having reduced hip extension in late stance phase during gait after THA. Reduced hip extension may be related to short stride length and slow gait speed; therefore, improvement of the hip motion during gait should be focused during rehabilitation. However, the factors affecting the decrease in hip extension remains unclear.

AIM: The aim of this study was to evaluate the clinical factors associated with restricted hip extension during gait in women after THA.

METHODS: In this study, total 54 women participated (unilateral THA, n=32; bilateral THA, n=22; age, 61.8 ± 6.7 years) and total 76 legs were analyzed. The passive range of motion in hip extension (HROM) was measured using a goniometer. Maximal isometric strengths of the hip abductor, extensor, flexor, knee extensor and flexor were measured using dynamometer. The peak hip extension angle (PHEA) during gait was recorded using a motion capture system. Pearson correlation coefficient (r) was used to determine the significance of association between the passive HROM and muscle strength and PHEA. In addition, the passive HROM and muscle strength values were applied to a stepwise multiple regression model in order to determine the contribution of each variable to PHEA.

RESULTS: PHEA showed significant correlations with the passive HROM ($r = .30$), muscle strength of the hip abductor ($r = .41$), hip flexor ($r = .25$) and knee extensor ($r = .340$). PHEA was not significantly associated with muscle strength of the hip extensor and knee flexor. Multiple regression analysis showed that the passive HROM ($\beta = .25$) and muscle strength of the hip abductor ($\beta = .37$) were significant contributors to PHEA (R2 = .23).

CONCLUSION: This study revealed that, in particular, the passive HROM and muscle strength of the hip abduction influenced restricted hip extension during gait in women after THA. The present results suggest that the rehabilitation strategies after THA should focus on extending the passive HROM and strengthening the hip abductor muscles in order to improve restricted hip extension during gait.

POBG_P2.2 INTERLIMB COMMUNICATION BETWEEN KNEE FLEXORS IN THE LATE STANCE PHASE OF HUMAN WALKING

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INTRODUCTION: Interlimb coordination is essential to the smooth organization of human movement, such as during walking. Stubbs et al. (2009, 2011) recently found that electrical stimulation to the tibial nerve of the ipsilateral leg elicited a short-latency (onset 37-41 ms) crossed spinal inhibition response in the soleus muscle of the contralateral leg during sitting and walking. This provided indirect evidence for the presence of commissural interneurons (spinal neurons crossing from one side of the spinal cord to the other) in humans. The response was likely mediated by fast conducting Ia muscle afferents. Crossed spinal reflex responses (onset 62 ms) have also been observed following unexpected unilateral ankle joint rotations during gait (Mrachacz-Kersting et al., 2011). The later response latency is likely due, in part, to the asynchronous input to afferent nerve fibers following muscle stretch compared to the synchronous input generated by electrical nerve stimulation.

AIM: Given the strong contralateral spinal connections arising from quadriceps and hamstrings muscle afferents in animal models (Arya et al., 1991) and ipsilateral connections found in humans (Pierrot-Deseilligny et al., 1981), unexpected knee joint rotations were predicted to elicit contralateral reflex responses during human gait that are functional in nature.

METHODS: We applied unilateral extension and flexion perturbations (8°, 300°/s) to the left knee joint during the late stance phase (50%) of human gait. Five participants (28±8 years) walked on a treadmill at 3.0 km/hr while perturbations were applied every 3-5 steps. Electromyographic (EMG) data were measured from the left rectus femoris (iRF) and biceps femoris (iBF) and from the right rectus femoris (cRF), biceps femoris (cBF), tibial anterior (cTA) and soleus (cSOL).

RESULTS: Following the extension perturbation we measured a distinct stretch reflex response in the iBF (average onset latency 25±7 ms) and in the cBF (average onset latency 75±5 ms). The average size of the cBF response was 259±244% above background activity. Infrequent reflex responses were observed in the other contralateral muscles. Following the flexion perturbation we measured a distinct stretch reflex response in the iRF (average onset latency 19±5 ms), but not in any of the contralateral muscles.

CONCLUSION: The cBF response may signify a preparation of the contralateral leg for early load bearing. The onset latency of the response indicates a likely spinally mediated pathway, although cortical contributions cannot be excluded.

ACKNOWLEDGEMENT: Acknowledgements go to Obel Family Foundation.

POBG_P2.3 KINEMATIC VARIABILITY DURING THE INITIATION STRIDE IN GAIT COMPARED TO STEADY STATE WALKING.

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INTRODUCTION: Steady state stride variability is well documented in human movement research; however, little is known about its characteristics associated with gait initiation and subsequent transition into steady state walking.

AIM: The aim of this study was to describe the underlying kinematics describing the early depression and subsequent recovery of variability during barefoot and shod walking.

METHODS: Sagittal plane knee and ankle joint angular displacements from the first four strides from nine subjects were resolved into their first difference to represent variability at various stages within the gait cycle (GC). Furthermore, joint coordination strategies were assessed by way of a coupling angle derived from a vector coding technique to provide an insight into the underlying mechanisms for the observed variability. IEMG from selected lower leg muscles was also analysed. Outcome measures were tested for main and interaction effects using 2x4 design (condition[2] x stride[4]).

RESULTS: Results revealed a significant depression in first stride knee and ankle joint variability with stride effects observed during pre-heel strike (0-10% GC; F=122.4, p=0.00; F=22.1, p=0.00; respectively), loading (0-10% GC; F=102.5, p=0.00; ankle only), early stance (10-20% GC; F=37.2, p=0.00; knee only) and late stance (40-60% GC; F=11.6, p=0.00; F=13.9, p=0.00). During swing (60-90% GC), first stride variability was in fact greatest (F=17.1, p=0.00; knee only) when compared to subsequent strides. Interaction effects were found in both pre- and post TA IEMG (F=13.4, p=0.00; F=8.7, p=0.00; respectively) as well as main effects noted in the median frequency for this muscle. Footwear was shown to significantly increase joint displacement variability, particularly at the knee. Furthermore, significant stride and condition effects were found in one or more of the four types of coordination strategies adopted by the knee and ankle joint.

CONCLUSION: The findings show that joint variability recovers and remains present from the second stride following achievement of steady state gait; which appears to be achieved during the swing phase of the initiation stride. A phase lag is evident during the gait cycle in the initiation stride compared to steady state walking and in shod walking compared to a barefoot condition. Future work should consider these underlying biomechanics when neural network models attempt to gain an insight into the central mechanisms that contribute to walking dynamics.

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POBG_P2.4 THE RELATIONSHIP BETWEEN COACTIVATION DURING EYE-CLOSED STANDING AND ANKLE INSTABILITY DURING THE GAIT CYCLE IN INDIVIDUALS WITH HEMIPLEGIA

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A/Prof Koji Ohata; Ms Saori Shibuta; Mr Yu Hashiguchi

INTRODUCTION: Coactivation of lower limb muscles contributes to postural stability in individuals with hemiplegia after stroke. However, the role of coactivation in standing balance and gait has not been completely investigated. Eye-closed standing (ECS) inducing mild postural instability is an easy method of assessing balance impairments. If excessive coactivation is observed during ECS, coactivation can affect other postures because of limited balance ability. Thus, measuring electromyographic (EMG) pattern of coactivation during ECS is useful to assess the characteristics of balance impairments in individuals with hemiplegia.

AIM: To estimate the difference in gait EMG patterns in lower limb muscles between individuals with hemiplegia classified by the extent of coactivation during ECS.

METHODS: Fourteen subjects with hemiplegia after stroke (53.9±12.2 years, Brunnstrom stages III:6 and VI:8) participated in this study. EMG signals were bilaterally recorded in the tibialis anterior (TA), medial gastrocnemius (MG), and soleus (SO) muscles during eye-open standing (EOS), ECS, and gait. Maximal isometric voluntary contractions (MIVC) were recorded for 3 seconds. Simultaneously, maximal isometric torques (MIT, Nm/kg) were measured using a hand-held dynamometer for ankle dorsiflexors and plantarflexors in both paretic and non-paretic limbs. MIVC amplitudes of all muscles were divided by each MIT. Next, EMG parameters during EOS, ECS, and gait were normalized by each MIVC/MIT value. EMG parameters of 5 gait cycles (GCs) were averaged and expressed as a percentage of GC (%GC). GC was divided into the following 3 phases: loading response phase from 0% to 10%GC, mid and terminal stance phase from 10% to 50%GC, and swing phase from 60% to 90%GC. Subjects were classified into the following 2 groups by the extent of coactivation: the coactivation (C) group and the no-coactivation (NC) group. In the former, EMG averages of TA and MG or SO for 5 seconds during ECS were bilaterally higher than the value of the averages plus 1 standard deviation during EOS. Wilcoxon signed-rank test were performed to compare EMG parameters of all muscles during EOS with during ECS. EMG averages in each of the 3 phases of GC were compared between groups using the Mann-Whitney U test.

RESULTS: All participants had significantly higher amplitudes in all muscles of both limbs during ECS than during EOS. The C group had significantly lower SO activity in the paretic limb during 10% to 50%GC than the NC group; however, there were no significant differences in TA and MG activities between groups.

CONCLUSION: Individuals with excessive coactivation of lower limb muscles during ECS have low SO activity during the stance phase of the paretic limb, thus leading to ankle instability.

POBG_P2.5 THE INFLUENCE OF RAISED HEEL INSOLE ON LOWER EXTREMITY JOINT KINEMATICS IN YOUNG MALES DURING WALKING

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INTRODUCTION: Recently, many young male wear raised heel insoles (RHI), however the effect of RHI on lower extremity joint kinematics are not clearly understood.

AIM: The purpose of this study was to investigate the effects of different types of RHI [Poly Urethane Insole (PIS), Air Cap Insole (AIS), Gel Type Insole (GIS)] on lower extremity joint angles, ground reaction forces during gait, as well as comfort as reflected by the subjective comfort rating scale.

METHODS: Eighteen young male (age; 25.9±2.10 yrs, height; 175.3±5.0 cm, weight; 77.4±7.5 kg) with no lower limb neuromuscular disorders participated in this study. Flexion-extension movements of the hip, knee, and ankle were studied, and lower extremity joint angles were measured during the gait cycle. Each subject wore athletic shoes fitted with 4 cm RHIs, while the control group wore normal athletic shoes (Addidas, FTY No.CLU 600001). The average of the three trials were used for analysis. Three-dimensional motion data were sampled at a rate of 200 Hz using eight infrared cameras (VICON MX-F20, Oxford, UK). The ground reaction force data were sampled at 2000 Hz with one force plate (ORG-6 AMTI, Watertown, MA, USA). There were five events identified during the stance phase (i.e., heel contact, opposite toe off, mid stance, opposite heel contact, and toe off). One-Way ANOVA were used to observe differences among lower extremity joint angles and GRF. Alpha was set at .05.

RESULTS: The subjective comfort rating was higher (i.e., more comfortable) for different PIS and GIS than the AIS ($p < .05$). Walking with the RHIs showed greater plantarflexion angles at heel contact, opposite toe off, mid stance, opposite heel contact, and toe off ($p < .05$). Walking with the RHIs showed larger knee flexion angles at mid stance and smaller knee flexion angles at toe off ($p < .05$). Walking with the RHIs showed larger hip flexion angles at mid stance ($p < .05$). Significant differences were observed for ground reaction force in the medial-lateral direction for Fx1, Fx2, Fx3, breaking force (Fy1) and the progression force (Fy2) in the anterior-posterior direction. Furthemore, significant differences were observed in the vertical direction for Fz1, Fz2, Fz3 ($p < .05$).

CONCLUSION: These results showed that wearing shoes with a RHI had significant influence on walking pattern and potential to induce chronic alterations in the musculoskeletal system among males.

POBG_P2.6 CONTROL OF TOE TRAJECTORY AND LOWER LIMB JOINT KINEMATICS DURING WALKING OVER UNEVEN TERRAIN

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Mr Joel Martin; Prof Rezaul Begg; Dr William Sparrow; Mr Simon Taylor

INTRODUCTION: If the control of toe trajectory and lower limb kinematics for normal unobstructed walking have been well described, very little is known about how these are affected during walking over uneven terrain.

AIM: To examine the swinging-toe trajectory and lower limb joint kinematics when walking over uneven terrain.

METHODS: Ten males (18-25 years) completed 60 trials of overground walking with four conditions of obstacles: 0, 1, 2, 3, that were specifically positioned at the mid step-length location. Three-dimensional kinematics of the lower limbs was recorded using an Optotrak motion capture system (Northern Digital Inc.). The point on the foot representing the toe was located at the distal inferior surface of the great toe (subjects walked bare-footed). From the vertical dimension of the toe trajectory during the swing phase, three key events were obtained: maximum toe clearance 1 (Max 1); minimum toe clearance (MTC); and maximum toe clearance 2 (Max 2). These three discrete states of the swing-cycle provided three probability distributions for the gait trajectories of interest: vertical toe displacement, and lower limb joint angles. Repeated measures ANOVA were used to test the effect of obstacle height on the different gait variables measured.

RESULTS: Manipulations of obstacle height resulted in significant changes of the vertical toe displacement at Max 1 ($p<0.001$, from 4.2±0.7 cm to 8.3±1.9cm) and MTC ($p<0.001$, from 2.6±0.7 cm to 7.2±1.5cm), but not at Max 2. The changes in the kinematics of the lower limb induced by an augmentation of obstacle height consisted in increases of ankle dorsiflexion (from -16.4±4.6 degrees to -6.52±5.6 degrees at Max 1, $p<0.001$; from -5.6±3.2 degrees to -1.4±3.6 degrees at MTC, $p<0.001$), knee flexion (from 67.9±3.9 deg to 78.0±7.3 degrees at Max 1, $p<0.001$; from 56.6±3.8 degrees to 61.9±5.7 degrees at MTC, $p<0.001$) and hip flexion (from 18.7±5.7 degrees to 30.6±7.9 degrees at Max 1, $p<0.001$; from 32.3±4.7 degrees to 41.4±6.9 degrees at MTC, $p<0.001$). No significant changes were found in the lower limb joint kinematics in the coronal plane at the three key events.

CONCLUSION: Clearing obstacles of moderate height when walking on an uneven terrain requires adjustments of the vertical toe clearance in the first part of the swing phase (Max 1 and MTC) obtained through adjustments of the kinematics of the three main joints in the sagittal plane.

POBG_P2.7 COMPARISON OF FASCICLE OF THE MEDIAL GASTROCNEMIUS DURING BAREFOOT AND HIGH HEEL WALKING

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Mr Sung Cheol Lee, Yonsei University; Mr Hae Dong Lee, Yonsei University; Mr Dae Yeon Lee, Yonsei University

INTRODUCTION: The interaction of the gastrocnemius medialis (GM) muscle tendon complex during walking is critical for both force production and movement efficiency. The isometric contraction of the muscle results from tendon lengthening which allows minimal mechanical work to be done by the muscle. It allows the muscle to work around optimal force region of the force-velocity and/or length relationships. Therefore, when the GM muscle supports body weight, it does so efficiently. However, wearing high heels places the GM muscle-tendon complex in a shortened position. These changes may influence the contraction pattern of the GM muscle during walking.

AIM: The aim of this study was to investigate the effect of high heel shoes on the contraction pattern of the GM muscle fascicles during walking.

METHODS: Three female (height: 166.6+3.2 cm, body mass: 63.3+8.9 kg, age: 23.6 yrs.) walked on a treadmill at 3km/h under 2 different conditions: barefoot and wearing 7cm high heel shoes. Fascicle lengths measured from ultrasound image and the level of activation of the GM using surface EMG was simultaneously measured. A motion capture system with eight cameras operating was also used to record kinematics of the ankle and knee joints.

RESULTS: The fascicle length changes show different patterns between two conditions. The GM fascicles during barefoot walking remained isometrically contracted in the single support stance phase. In contrast, during high heel walking, the fascicles were lengthened until the end of the single stance phase. Besides, during high heel walking, the maximum and minimum fascicle length was reduced by 21-28% compared to barefoot walking.

CONCLUSION: The GM fascicles during high heel walking remained eccentric contraction in the single support stance phase. Therefore we predict that only a little of elastic energy could be saved. In addition, the range of the fascicle length change is less than the barefoot walking, thus located the bottom of the ascending limb of the length-tension curve. Therefore, force generating capacity of high heel walking will be small than barefoot walking.

POBG_P3.1 EFFECTS OF VIRTUAL REALITY AND TAICHI IN SUBJECT OLDER ADULTS: COMPARATIVE STUDY

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INTRODUCTION: The use of technological tools that contribute to the functionality and the quality of life of the individuals have been indicated as fundamental in the current political policies. These therapeutic alternatives can improve postural control and balance in older adults.

AIM: Comparing the effects of a traditional therapy (Taichi) with a technological therapy based on virtual reality on a group of older adults.

METHODS: Two groups of healthy older adults are formed, who belong to independent communities from the central zone of Chile. Group of Taichi (n=5) and group of virtual reality (n=7) are trained in their respective communities during 6 weeks with a frequency of 3 times per week. Each group is evaluated at the beginning and at the end of the training total, with a static posturographic platform. Two models evaluation: standing (phase with eyes open and eyes closed), and standing with optokinetic fields. The studied variables were area and speed of displacements of the CoP. The t test and ANOVA was used to establish the significant differences.

RESULTS: During the standing balance evaluation, the virtual reality training session generated a reduction in the area of movement of the CoP, both in the phase with the sight to the front (P=.003) and in the phase with eyes closed (P=.04). No significant differences were seen in this variable after the Taichi training session. Following both training sessions significant differences occur in the average speed of the CoP; virtual reality training session generates slower movements (P=.02) and the Taichi movements are faster (P=.019). The Taichi training session shows an increase in the CoP area during the optokinetic fields (P=.02).

CONCLUSION: The training with virtual reality generates changes in the postural control and the balance in older adults, in a more efficient way than the training with Taichi.

POBG_P3.2 EFFECTS OF HIGH-SPEED PEDALING ON FALL AVOIDANCE STEP IMPROVEMENT AND MUSCLE ACTIVITY PATTERN CHANGES IN THE LOWER LIMB OF ELDERLY WOMEN

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INTRODUCTION: A rapid step is necessary to recover balance and prevent a fall during instances of falling such as tripping. Age-related decline in movement speed delays the fall-avoidance step thus causing the elderly to fall when they trip. However, agility training, such as alternate stepping, can improve step velocity, which is reflected by the alteration of muscle activity pattern of lower limbs during rapid stepping.

AIM: The aim of this study was to ascertain whether agility training in the elderly by using high-speed pedaling can functionally improve involuntary rapid stepping for fall prevention. Surface EMG and motion analysis were used for kinematic evaluation of the involuntary rapid step.

METHODS: Eight healthy women aged 75 years and above participated in the study. Each subject gave informed consent prior to the enrollment. Training included 2 sessions per week for 5 weeks on the cycle ergometer. Each session comprised 10 sets of 5-s maximal sprints starting from a stationary position, with a 25-s recovery. Pedal load was 1% of body weight. Tether-release method (Hsiao-Wecksler ET, 2008) was used to evaluate the fall avoidance step before and after the training. In this method, subjects are released from a forward-leaning position and instructed to regain their standing balance by taking a single step forward. Lower extremity motions, foot-floor reactions, and myoelectric signals of the swing leg were measured during the step response.

RESULTS: Step time significantly decreased and step velocity increased after training. Muscular latency time between release and activity onset was reduced in the knee flexor muscles of the stepping leg during rapid stepping. In addition, switching of onset-offset muscle activities between the knee flexor and extensor muscle was smooth.

CONCLUSION: Hi-speed pedaling training improved step velocity during the fall avoidance reaction, and this functional change was manifested in the activities of the femoral muscle of the swing leg. The increased step velocity appears to be derived from the change in the timing of muscle activities.

POBG_P3.3 INFLUENCE OF AGRICULTURAL QUAD BIKE USE ON POSTURAL CONTROL WHILE LIFTING.

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INTRODUCTION: Vehicle induced whole-body vibration (WBV) is considered to be a risk factor for the development of low back pain (LBP). Traditionally WBV induced alterations in spinal discs were considered as the predominant cause of such LBP. However recent research demonstrates exposure to occupational WBV resulted in delayed spinal muscular response to unexpected load, altered spinal proprioception, and disturbed central postural control sub-systems (vestibular and visual system). Thus exposure to WBVs can alter feedback and feed-forward supraspinal motor control strategies, putatively putting the spine in a vulnerable position for injury during manual lifting tasks. A high annual prevalence (57%) of LBP exists among New Zealand rural workers exposed to high levels of WBV from driving quad bikes.

AIM: This research investigates whether postural control during lifting is altered when rural workers are exposed to quad bike driving induced WBV.

METHODS: 34 healthy male rural workers (mean age:40.3±10.6 yrs.) drove a quad bike for 30 minutes on a pre-marked farm track representing a typical New Zealand farm terrain. Exposure to WBV while driving was determined by continuously recording the vibration signals using an accelerometer placed at the level of the seat. All participants stood on the force plate in a normal stance and lifted a load weighing 15kgs from the floor (lift origin) and placed it on a stool (lift destination) positioned at a right angle to the initial position. Recorded Centre of pressure (COP) signals recorded from the force plate during the lifting task performed prior to quad bike driving (TI) and twice post-driving; immediately (TII) and 10 minutes post-driving (TIII) were processed to derive the COP root mean square sway distance (RMSSD).

RESULTS: All participants were exposed to high levels of WBV in the vertical direction (vibration dose value:11.1m/s$^{1.75}$); well above the ISO recommended exposure action limits (9.1m/s$^{1.75}$). Means and standard deviations for RMSSD at TI, TII and TIII were 49.4 ± 8.8mm, 51.5 ± 9.5mm and 51.6 ± 9.7mm respectively. Repeated measures ANOVA with post-hoc Boneferroni tests determined a statistically significant ($p \leq 0.05$) increase in the mean RMSSD between TI and TII (p=0.026), TI and TIII (p=0.022) but no difference between TII and TIII (p>0.5).

CONCLUSION: This increase in the magnitude of postural sway during lifting demonstrates negative alterations in the postural control of rural workers following a period of quad bike driving. These changes may be associated with the injuries related to occupational activities following a period of quad bike driving.

POBG_P3.4 THE EFFECT OF A MICRO VIBRATION TO PERONEAL MUSCLE ON THE STABILITY OF ONE LEG STANDING

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INTRODUCTION: A vibrational stimulation has been used as a device of physical modalities. Recent studies demonstrate the effect of the whole- body vibration which gives large amplitude and powerful stimulation, and provokes the tonic vibration reflex. Meanwhile, the micro vibration device is developed and has been already used in the sports field.

AIM: There are few reports that demonstrated usage, adaptation or effectiveness of the micro vibration device. The aim of this study was to demonstrate the effect of the micro vibrational stimulation on the postural sway.

METHODS: Sixteen healthy subjects (12 men and 4 women) participated in this study. The subjects had no history of orthopedic disease in past 3 months, and their mean age, height, and weight were 21.9±2.1 years, 164.7±6.8 cm, 60.9±7.4 kg, respectively. All subjects provided written informed consent. Two feedback disk (FBD, diameter: 33mm, thickness: 11mm, weight: 10g, vibration frequency: 200Hz, amplitude: 2μm, BLAF inc, Japan) were used for micro vibrational stimulation to peroneal longus and brevis muscle. The stability of one leg standing was measured using a gravicoder GS-3000 (data sampling 20Hz, Anima Co., Tokyo, Japan). During one leg standing, fluctuation of the center of gravity (COG) was recorded for 20s with the eyes opened and closed respectively. The parameters of postural sway were length (LNG), envelope area (ENV), rectangle area (REC), root mean square area (RMS), length per envelope area (LNG/ENV), deviation of mean X (DMX), and deviation of mean Y (DMY). The postural sway data were measured pre-stimulation and during stimulation. A paired T test was used to compare the each parameter of pre- and during stimulation.

RESULTS: During micro vibration, LNG significantly decreased with the eyes opened, and LNG, ENV and REC significantly decreased with the eyes closed. COG was transferred postero-medially by micro vibration (significant move of DMX and DMY). During stimulation, all subjects could not perceive the micro vibration from FBD.

CONCLUSION: The micro vibration to peroneal muscle decreased the postural sway of one leg standing. It was thought that this result was due to temporary enhancement of somatosensory feedback response by increasing the sensitivity of peroneal muscle spindle or cutaneous sensory input.

This study showed an improvement of standing stability by micro vibrational stimulation. This means a clinical usefulness of FBD as a micro vibrational stimulator.

POBG_P3.5 IMPROVEMENT OF STANDING STABILITY BY PLANTA PEDIS VIBRATION STIMULI

Prof Masaki Yoshida, Osaka Electro-Communication University

INTRODUCTION: Considering the increment of the aging population, the prevention of falls will become increasingly important. One fall prevention method is the improvement of standing stability. We have already reported that standing stability was improved by the stimulation of the planta pedis with sinusoidal mechanical vibration. The points that we stimulated were the root of the first toe, the root of microdactyly and the heel. We will be able to make a smaller device, if we can reduce the number of stimulus points.

AIM: The aim of this study was to find the most effective point of stimulation among the root of the first toe, the root of microdactyly and the heel.

METHODS: We made the device which can stimulate the planta pedis. The device is comprised of an oscillator, an amplifier and vibrators. The vibrators were put on an insole. The subjects were three healthy males. Each subject stood on an insole, and stimulation intensity was set to 90% of his personal vibration threshold. The subjects did not feel vibration even if we vibrated their planta pedis during the experiment. The subjects stood on an insole that was placed on a center of gravity deflection meter. During the measurement period, each subject closed his eyes, assigned both hands to his waist and stood on one leg. Stimulation was subject to the following five conditions: 1) no vibration; 2) costimulation to three points; 3) stimulation only to the root of the first toe; 4) stimulation only to the root of microdactyly; 5) stimulation only to the heel. We performed experiments five times for each condition.

RESULTS: Standing stability was evaluated by the center of gravity deflection area, the locus length of the center of gravity, and the standing time. The most effective condition was the costimulation to three points. In the case of only one stimulation point, the root of the first toe was the most effective point.

CONCLUSION: It becomes clear that stimulation applied to the root of the first toe has almost the same effect as costimulation of three points.

As a result, we can downsize our device and it will become possible to use our device in daily life.

POBG_P3.6 EFFECTS OF HORIZONTAL IMPEDANCE OF SUPPORT BASE ONTO THE HUMAN POSTURAL CONTROL

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Miss Keiko Chiba, Iwate University; Mr Daiki Sakamoto, Iwate University; A/Prof Yoshihiro Hagihara, Iwate University; A/Prof Takeshi Sato, Jissen Women's University; Prof Takashi Komeda

INTRODUCTION: The center-of-pressure (COP) is a useful methodology for investigating the human bipedal stance. It has been suggested that traditional COP measures provide few insights into the control of posture, since they ignore the dynamic characteristics of COP movement. On the basis of the COP measurements of the human bipedal postural oscillation, though frequencies of the oscillation had reported while upright standing, there are no results concerning the horizontal impedance of the support surface and the direction of the velocity vector of the COP coordinates changing from a certain point to the following respect.

AIM: We hypothesized that it is a necessary and sufficient condition that a forward and backward COP vector have a nearly equal appearance ratio for the COP coordinates to converge in a specific range. In addition, it was also uncertain whether or not the COP vector in a normal impedance environment was maintained under a different horizontal impedance environment. Hence, the aims of this study were: 1) to examine the transition of the COP vector while subjects stand upright on a force platform, and 2) to investigate the behavior of the COP vector under three different horizontal impedance environments.

METHODS: We constructed the 6-DOF motion base powered by eight pneumatic actuators; which could tune the vertical and horizontal impedance of the support surface with changing the applied air pressure. Seven healthy subjects participated in this study. In order to gain the COP coordinates while quiet standing with their eyes opened/closed, they were asked to stand on a base plate, which had four pressure sensors, placed on the motion base. The air pressure had applied in four conditions (0, 0.1, 0.2, and 0.3 MPa).

RESULTS: COP vector shows the bi-phasic gauss-like wave form as already demonstrated by authors. Although the COP area and the travel distance increased with the increase of the applied air pressure compared with those of normal impedance condition (0 MPa), the maximum area and travel distance had appeared under 0.2MPa condition.

CONCLUSION: The bi-phasic gauss-like wave patterns for COP vector did not depend on the changes in the impedance for horizontal direction. The 0.2 MPa condition may represent the resonance frequency of the body oscillation.

ACKNOWLEDGEMENTS: Authors thank for SMC Corp. supplying the experimental devices; and Mr. Hasegawa and Mr. Fujisawa, at Iwate Industrial Research Institute, with their helps.

POBG_P3.7 THE EFFECT OF HANDRAIL ON MUSCULAR ACTIVITY OF THE TRUNK AND LOWER EXTREMITIES DURING SIT-TO-STAND TASK.

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INTRODUCTION: Sit-to-stand (STS) is a very important movement for inpatients in rehabilitation. To carry out STS tasks, hemiplegic patients use a handrail on their non-affected side. However, there are few studies about laterality of muscular activity of the trunk and lower extremities during STS with handrail.

AIM: Purpose of this study was to clarify about laterality of muscle activation during STS with handrail assistance among healthy subjects.

METHODS:

Participants: Ten healthy right handed subjects (5 males; mean age 24 years; mean hight 166.8cm; mean weight 54.0kg) participated in this study. All subjects gave written informed consent for their participation.

Experiment: To determine the effect of handrails on STS, subjects carried out the task under two conditions: no handrail (NHR); and right hand on handrail (RHR).We adjusted the height of the chair to subject's lower thighs and also adjusted the handrail to allow subjects to drop their arm and flex their elbow joint 30 degrees in standing.

Surface electromyogram (EMG) activity was recorded from the trunk and lower limb muscles. Target muscles were as follows: bilateral(R- and L-) obliquus externus (EO); rectus abdominis (RA); erector spine (EP); rectus femoris (RF); biceps femoris (BF); tibialis anterior (TA); and gastrocnemius (GC). A total of 14 muscles were selected.

Procedure of analysis: We decided points (starting point, seat-off point, and ending point) and phases (anterior tilting [AT] and standing up [STU]) from movement of the body by analyzing the digital video footage. In each phase, we calculated integrated EMG per second (IEMG/sec).

Statistical analysis: Wilcoxon matched pairs signed ranks test were used to compare two conditions' data in each phase. The level of significance was 0.05 for the analysis.

RESULTS: By using the handrail, IEMG/sec increased in the right side EP (0.09７→0.13mv), RF (0.0068→0.012mv) and TA (0.012→0.018ｍｖ) during the AT phase. By contrast, IEMG/sec decreased in the left side EO（0.0070→0.0057ｍｖ） and GC (0.0061→0.0053) during the STU phase ($p<0.05$).

CONCLUSION: The effect of handrail use appeared in the increasing activation of extensor muscles in the handrail side during the AT phase, and in the decreasing activation during the STU phase on the side opposite the handrail. This could be considered a counter effect of pulling on the handrail and the result of weight shifting to the handrail (right) side by using it. This information is valuable as basic knowledge for therapists who teach STS using handrails.

POBG_P3.8 NEUROMUSCULAR RESPONSES DURING THE PERFORMANCE OF A CHAIR RISING EXERCISE IN AQUATIC AND DRY LAND

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Mr Carlos Cano-Herrera

INTRODUCTION: In aquatic physiotherapy programs are used the functional tasks, which are quite important during the activities of daily living. Knowing the degree of muscular activation during the performance of these functional tasks is important for physiotherapists, in order to find out which can be used in each moment (on dry land or in water).

AIM: The purpose of the present study was to analyze the neuromuscular responses during the performance of a chair rising (CR) exercise in aquatic and dry land environments at the same cadences.

METHODS: 10 healthy subjects (five males and five females (mean ± SD): age, 22.0 ± 3.1 year; height, 172.8 ± 9.0 cm; weight, 63.9 ± 17.2 kg) were recruited for study. The procedure started with using a telemetry EMG system from the following muscles on the right side: the quadriceps – vastus medialis (VM), the quadriceps – rectus femoris (RF), the long head of the biceps femoris (BF), the tibialis anterior (TA), the gastrocnemius medialis (GM), the soleus (SOL), the rectus abdominis (RA) and the erector spinae (ES). After the MVC tests the subjects performed one set of five repetitions for the CR (47 cm) exercise on dry land with the right cadence (20 beats per minute). After the dry land procedure, the subjects performed the same task in the water inside a pool with a depth of 100 cm. The raw electromyography signal was recorded with a 1000Hz sampling frequency. Filtering of the raw EMGs was performed with low- and high-pass filters. Average EMG data were normalized to the greatest 1-s average EMG during MVC from each muscle.

RESULTS: % MVC was different for all muscles during the (CR) exercise chair rising in water or dry land. Were significance higher on dry land than in water normalized signals from VM (17.3%), RF (8,8%), BF (4,3%), TA (13,9%), GM (3,4%), (SOL (6,2%). However, were higher in water than on dry land normalized signals from RA (-26,6%) and ES muscles (-22,6%).

CONCLUSION: Muscle activity tends to be lower in water-based compared to land-based activity; however core muscles are showed higher activity. Findings have showed that a (CR) chair rising exercise in aquatic and dry land environments at the same cadences present different patterns of neuromuscular activity. This should be considered in the clinical and research implications.

ROBOTS IN REHABILITATION

ROBO_P1.1 THE DEVELOPMENT OF A STANDING SUPPORT SYSTEM FOR PARKINSON DISEASE PATIENTS

Prof Osamu Nitta, Tokyo Metropolitan University

Prof Ken Yanagisawa; Mr Yasunari Fujimoto; Mr John Surya

INTRODUCTION: It is recognized that Parkinson disease patients' motions are characterized by loss of smoothness in weight shifting.

AIM: In the present study we assessed the force applied to a center of balance during a standing motion with a handrail to develop a standing support system.

METHODS: The subjects were 8 patients with Parkinson disease and 11 healthy young persons as controls. This study was conducted with the approval of the Ethics Committee of the Tokyo Metropolitan University. The subjects were instructed to slowly stand up from the seat of a chair. The force and the load, which were applied to the floor and the handrail, respectively, during the motion were recorded in three dimensions, the direction of movement, a horizontal direction, and a vertical direction. The data were combined, and a vector of the force to the center of balance was calculated. The data on differences in the mean values between the two groups were statistically analyzed by unmatched t-test ($p<0.05$). On the basis of the results of the data analysis we calculated motions of support, which would raise the patients' motions to those of the controls to design a support system.

RESULTS: As a result of the analysis, the mean angle of the vector applied to a center of balance to the floor at the start of a standing motion was 85.02°(SD 3.86) in the patient group, while 76.68°(SD 4.18) in the control group. Thus, the angle was significantly high in the Parkinson disease group.

CONCLUSION: The moment Parkinson disease patients started standing up from a sitting position on the chair with a handrail, the angle of vector of the force applied to a center of balance to the face of the floor was high, as compared to that in the controls. This result indicated that the angle increased the load during a standing motion. The results suggested the possibility of a standing motion being smoothed by the application of torque in a forward direction to a standing motion in Parkinson disease patients. On the basis of these results we produced a program, which would allow patients to perform an anterior traction motion with an electric wheelchair during a standing motion. As a result of demonstration of this program in 2 Parkinson disease patients, who had been unable to stand up without support, they could stand up smoothly.

ROBO_P1.2 A NEW SOFTWARE ENVIRONMENT FOR HIGH-DENSITY EMG RECORDING, REAL TIME ANALYSIS AND ONLINE FEEDBACK

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Prof Dario Farina, Department NeuroRehabilitation Engineering, Goettingen University; Dr Ning Jiang, Otto Bock HealthCare Gmbh

INTRODUCTION: As part of the development of a control system for upper limp prostheses based on high-density EMG (HD-EMG), a novel system for HD-EMG recording, real time analysis and online feedback has been designed and implemented. The system was designed with the purpose of testing online algorithms for myoelectric control of prosthetic systems.

AIM: The limitations of Matlab prevented the recording of HD-EMG data in long recordings, which is necessary for investigating adaptive algorithms for EMG processing which would accommodate electrode shift, hand position and other influences. Thus, the proposed system aims at solving this limiting factor. Further, the new system aimed at real time analysis and feedback.

METHODS: The experimental part makes use of a custom-designed modular electrode matrix. With combination of 2 or 3 of such matrices, HD-EMG recording around the proximal third of the forearm can be obtained. Up to 192 channels and additional up to 64 optional EMG channels for discrete invasive or noninvasive electrodes can be recorded using a custom-designed EMGUSB2 amplifier (OT Bioelettronica, Italy). The recorded signal is streamed in real-time to a Matlab recording environment, called DynDOF, which is used to both present the visual prompts to the subjects and simultaneously record the corresponding HD-EMG signals. The recorded EMG data is synchronized with the visual prompts, and saved as a continuous binary data stream. The recordings are of arbitrary duration without the limitation imposed by Matlab's .mat format. This allows analyzing adaptive algorithms for compensating issues, such as muscle fatigue and electrode shift.

RESULTS: The presented recording system was tested in several studies with both supervised and unsupervised myoelectric control algorithms. The system has been used for myoelectric control paradigms, including both classic pattern recognition and regression approaches targeting at simultaneous and proportional control.

CONCLUSION: We developed a new software environment for HD-EMG acquisition and online analysis. The target presentation is intuitive for simultaneous movements and easily to understand by most subjects. This is particular important due to the fact that Matlab does not support both data writing and online analysis. This environment provides a stable and reliable testing environment for further development of myoelectric control systems with focuses on real time online feedback.

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ROBO_P1.3 THE EFFECT OF UPPER LIMB SUPPORT ON THE KINEMATICS OF SAGITTAL PLANE REACHING IN STROKE

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INTRODUCTION: Upper limb paresis following stroke is severely disabling and the likelihood of full recovery is poor. Intervention programs have been specifically tailored to promote upper-arm function, many of which utilise some form of constraint for the paretic arm. Constraining the upper arm reduces the degrees of freedom to be controlled during movement, minimising resistance and decreasing task difficulty. This allows patients to overcome the effects of severe upper-arm weakness and coordination difficulties during training. It is important to determine, however, how constraint of the upper arm influences kinematic movement parameters during reaching. That is, to demonstrate the effectiveness of constraint in movement rehabilitation, the constraint device must be shown to promote reaching kinematics that approximate those of healthy individuals.

AIM: The aim of the present study was to determine whether the "SmartArm", a validated constraint device used for promoting upper-arm recovery post stroke, influences stroke patient's movement kinematics such that they approximate those of healthy control subjects during a reaching task.

METHODS: Fifteen stroke survivors with upper limb paresis and fifteen neurologically intact controls undertook a reaching task under three conditions: i) constrained, using the SmartArm's low-friction track; ii) supported, where the forearm rests on a table during reaching, and iii) free, where no support is provided during the reaching task. Three dimensional kinematic data of the forearm, upper arm, shoulder and trunk were obtained from reflective markers placed on appropriate anatomical landmarks and recorded using a three-camera optoelectronic motion capture system.

RESULTS: Results showed that stroke patient's movement kinematics were most similar to those of healthy controls when they completed the reaching task using the SmartArm constraint device. Their movement kinematics differed most from healthy controls during the supported and free conditions.

CONCLUSION: We conclude that therapeutic interventions for upper-arm paresis post stroke using the SmartArm device are likely to promote recovery by enhancing the normal use of movement kinematics during upper-arm reaching.

ROBO_P1.4 PRELIMINARY RESULTS OF TIMING OF MUSCLE ACTIVATION DURING REACH-TO-GRASP MOVEMENTS IN HEALTHY ELDERLY AND STROKE PATIENTS

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Mrs Gerdienke Prange; Mr Jaap Buurke; Mr Hans Rietman

INTRODUCTION: Many stroke patients have to cope with deficits in motor control of the affected arm and hand, such as a decreased ability to open the hand. Rehabilitation aims to improve function to increase the level of independence of the stroke patient. The last decades electrical stimulation (ES) has been increasingly applied in post stroke rehabilitation. A way to enhance functional practice with ES is multichannel ES (mcES) to support hand opening. For this, knowledge of Muscle Onset Offset Profiles (MOOP) of muscles involved in hand opening is needed to develop stimulation algorithms that control mcES that supports hand opening in stroke patients.

AIM: The aim of the present study is to compare MOOPs of muscles involved in hand opening between healthy elderly and stroke patients.

METHODS: Subjects performed 10 reach-to-grasp movements towards a cylindrical object. Kinematics of the trunk, arm and hand were measured with VICON. Hand opening was defined as the 3D Euclidian distance between markers on the tip of the thumb and index finger. Surface electromyography (sEMG) was recorded from the abductor pollicis brevis (APB), extensor digitorum (EDI), extensor carpi radialis (ECR), extensor carpi ulnaris (ECU), extensor pollicis brevis / abductor pollicis longus (EPB), flexor carpi ulnaris (FCU) and the flexor carpi radialis (FCR). Measured EMG signals were converted into signal energy with the Teager-Kaiser Energy Operator (TKEO), after which on- and offset times were determined by means of the Approximated Generalized Likelyhood Ratio (AGLR) algorithm and were used to create MOOPs. Timelags in muscle activation were identified by means of crosscorrelation between MOOPs of each muscle in both groups.

RESULTS: A total of 29 subjects (19 healthy elderly and 10 mildly affected stroke patients, Fugl-Meyer > 40) participated in the study. Compared to healthy elderly, hand opening was significantly delayed in stroke patients. The shapes of the MOOPs of both groups were highly similar, $r > 0.96$. Compared to healthy subjects, in this group of mildly affected stroke patients, muscle activation of APB, ECR and ECU was significantly delayed by 6.8, 4.7 and 5.2 % of the reaching phase, respectively.

CONCLUSION: Since delayed hand opening is related to delayed activation of ECR, ECU and ABP in stroke, mcES should focus on providing appropriate timing of wrist extension and thumb abductor stimulation. However, other signals than those delayed EMG signals have to be used as potential mcES trigger for hand opening, such as EMG from EDI or positional data. Subsequent research will compare different ways of triggering mcES to support hand opening in stroke patients.

ACKNOWLEDGEMENTS: This research was supported by grant I-01-02=033 from Interreg IV A, the Netherlands and Germany.

ROBO_P1.5 UNIFIED EEG-SEMG PLATFORM FOR ACCELERATED RECOVERY OF MOTOR FUNCTION AFTER STROKE

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INTRODUCTION: The population of persons disabled after stroke has risen dramatically in the past decade, far outstripping the required number of therapists who can administer long term therapy. The effectiveness of rehabilitation will be increased substantially if the patients are able to use a robotic rehabilitation system at home, after having trained on it at the hospital.

AIM: The automated platform described in this paper involves an integrated system that can sense brain and muscle signals with adequate reliability to automate a therapy routine with varying levels of intensity. This platform can also run a hand function orthosis or electrical stimulation device for hemiplegic stroke patients, providing passive and “active” therapy.

METHODS: The key factors which maximize the benefits of brain plasticity are “intensity” of therapy and “engagement” of the patient at mind and body levels, among others. This Unified EEG-SEMG Platform is designed to have: 1) The ability to accept both EEG to SEMG as inputs, interchangeably, and provide bio-feedback. 2) Portability and versatility with a gaming interface that will engage patients. 3) A modified electrode system with a simple arm glove system and headset design. 5) An algorithm that senses performance levels and adjusts intensity of therapy for optimum learning.

RESULTS: Results of some of the SEMG and EEG experiments were reported in various publications. Studies with healthy subjects have shown a high level of operability. Frequency response of the system for real-time EEG signals has been shown to be satisfactory for quantitative analysis. A pilot study with stroke patients has shown encouraging results in the recovery of hand function while doing simple tasks.

CONCLUSION: The system will enable a person to work alternatively or jointly with brain and muscle signals in a “mind-body” co-ordinated way. It will enable a patient to alternate between active and passive therapy along with training in deep relaxation. The facility to alternate between robotic movement and FES may allow for better fatigue management and more options in the hands of the therapist and patient. The system is now undergoing further trials with stroke patients in Singapore.

SENSORIMOTOR

SENS_P1.1 ELECTROMYOGRAPHIC PERFORMANCE SCORE FOR TMD DIAGNOSIS

Ms Paula Santos, University of São Paulo

Ms Claudia Ferreira, University of São Paulo; Prof Marco Antonio Silva, University of São Paulo; Prof Guianluca Tartaglia, Università degli Studi di Milano; Prof Claudia Felício, University of São Paulo; Prof Chiarella Sforza, Università degli Studi di Milano

INTRODUCTION: The synthesis of the electromyographic (EMG) data in a performance score may facilitate understanding of results and the diagnosis of temporomandibular disorders (TMD).

AIM: To study the surface EMG of the masticatory muscles of TMD patients and to analyze the EMG overall performance score ability to differentiate patients from healthy subjects.

METHODS: Seventy-four patients (mean age 33 years, SD 11) with long lasting TMD (more than 6 months) and 36 healthy subjects (mean age 29 years, SD 11) were examined by surface EMG of masseter and temporal muscles during maximum teeth clenching either on cotton rolls or in intercuspal position. EMG indices were calculated with the standardized potentials to determine muscular symmetry (left and right side, percentage overlapping coefficient, POC), potential lateral displacing components (TC) and activity index (ratio between the mean potentials of the temporal and masseter muscles). EMG indices were used to formulate an overall performance score. Standardized weights were then assigned to the variables according to their biological importance and clinical influence in the function of the stomatognathic apparatus: Temporalis and masseter POC were given a 30% weight each: an imbalance of their left-right standardized activity may result in abnormal loads over the TMJs. The TC index was given a 20% weight: the unbalanced contractile activities of the contralateral masseter and temporalis muscles might produce an unstable position of the mandibular condyles in the articular fossa. The activity index received 20%: the occlusal centre can be moved forward when the temporal muscles are prevalent or backward if the masseter muscles are prevalent. The overall performance score was therefore a global z score (for definition, in a population the z score has mean = 0 and SD = 1). The EMG indices and performance score were compared between the groups using unpaired Student's.

RESULTS: During clenching, TMD patients had larger asymmetry in their temporalis muscles (POC temporal = 80.6±13.3%) and masseter muscles (POC masseter = 77.0±15.2%), larger unbalanced contractile activities (TC = 15.9±13.4%) and larger activity index (mean = 17.7±18.2%) than control subjects (POC temporal = 87.6±1.8%, POC masseter = 86.6±1.8%, TC = 9.1±1.2%, activity index = 9.4±8.1%) ($P < 0.01$). The TMD patients overall performance score mean (5.4±6.7) was significantly different of the healthy subjects (0.97±0.5) ($P < 0.001$).

CONCLUSION: The results confirm that subjects with TMD present greater imbalance between the jaw muscles, and the overall performance score can provide useful information for TMD diagnosis.

SENS_P1.2 THE FUNDAMENTAL STUDY ABOUT THE MECHANISM OF PRODUCTION OF THE POSITION SENSE USING THE FATIGUE TASK OF THE SHOULDER ROTATOR MUSCLES

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INTRODUCTION: The position sense has played a role in the maintenance of dynamic shoulder stability. It has been shown in previous studies using a vibration that muscle spindles are especially important for position sense. And it is indicated that joint position was determined by the calculation of afferent signals from the muscle spindles of two antagonistic muscles. However, recent studies indicate that not only the calculation of afferent signals from muscle spindles but also the sense of force was important for the position sense.

AIM: The purpose of this study was to investigate whether the calculation of afferent signals from muscle spindles or the sense of force contributed more to the position sense.

METHODS: The study included 15 healthy subjects. The shoulder position sense of the subjects was tested under two conditions: fatigued shoulder internal rotation muscles and fatigued shoulder external rotation muscles. In each condition, shoulder position sense was measured before and after a fatigue task involving shoulder internal rotator or external rotator muscles. The measurement of position sense and the fatigue task was performed using an isokinetic machine. Position sense was measured in this study by the method in which subjects actively or passively reproduce a memorized angle of shoulder rotation. In the fatigue task, the subject performed concentric contraction of internal rotation or external rotation. To confirm the muscle fatigue, we recorded the surface EMG signals from the pectoralis major muscle (PM) and latissimus dorsi muscle (LD) for the internal rotator muscles, and the infraspinatus muscle (ISP) and posterior deltoid muscle (PD) for the external rotator muscles. The median power frequency (MDF) during 1 sec performed target torque was calculated. The target torque was set to half of the peak torque of internal rotation or external rotation. The differences of the position sense in the various methods (active, passive), and stages (before and after the fatigue task) were compared using two-way analysis of variance.

RESULTS: After the fatigue task of internal rotator muscles, the MDF of the PM and LD significantly decreased. After the fatigue task of external rotator muscles, the MDF of the ISP significantly decreased. The position sense equally decreased after two fatigue tasks. However, there was no interaction (methods and stages) in two conditions.

CONCLUSION: These results indicated that the muscle fatigue decreased the position sense. However, there was no difference between active and passive position sense. Therefore, it was indicated that the sense of force did not contribute to the position sense.

SENS_P1.3 A COMPARISON OF TORQUE GENERATED BY THE HUMAN PLANTARFLEXOR MUCLES USING THREE DIFERENT STIMULATION PROTOCOLS

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Dr David Collins

INTRODUCTION: Neuromuscular electrical stimulation (NMES) can generate contractions through peripheral and central mechanisms. The central contribution can be augmented when NMES at 20 Hz is interspersed with bursts of stimulation at 100 Hz which leads to the development of increased or "extra" torque. We have shown that extra torque was abolished during a nerve block and was associated with enhanced H-reflexes and electromyographic activity that was "asynchronous" from the stimulus pulses, providing strong evidence that extra torque has a central origin.1 In contrast, recently when NMES was applied used a slightly different protocol than our previous work, the extra torque that remained after bursts of high-frequency NMES was not abolished during a nerve block, raising doubt about its central origin.2

AIM: The present experiments were designed to compare extra torque generated using the protocol used by Frigon et al. (Protocol #1, below) and protocols used previously in our lab (Protocols 2 &3).

METHODS: Thus far data have been collected from two subjects. NMES (1 ms pulses) was applied to generate plantarflexion torque, measured using a Biodex dynamometer, with the hip and ankle at ~90°. Protocol 1) 2 Knee extended (170°-180°) with both stimulating electrodes over the gastrocnemius muscles. Protocol 2) 1 Knee flexed (90°), proximal stimulating electrode over the proximal gastrocnemius muscles, distal electrode over soleus. Protocol 3) 1 Knee as above (#2), stimulating electrodes over the tibial nerve. For each protocol 3 trains of NMES (20–100–20 Hz for 3–2–3 s, respectively) were delivered 60 s apart. Torque was averaged over two time intervals (Time1; 2–3 s into the train) and (Time2; 7–8 s into the train) and was normalized to maximal voluntary isometric contractions (MVICs) performed in each position. Extra torque was quantified as the percent increase from Time1 to Time2.

RESULTS: Torque increased 29, 61 and 95 % from Time1 to Time2, for Protocol 1, Protocol 2 and Protocol 3, respectively.

CONCLUSION: The electrode configuration and knee position used by Frigon et al. generated less extra torque than the two protocols previously used in our lab. This may account for the fact that the contractions reported by Frigon et al. had little if any central contribution. This suggests that to generate extra torque from a central origin in the plantarflexors, the stimulation needs to be applied in a way that activates the soleus muscle and not only the gastrocnemius. However, more subjects need to be tested and an analysis of electromyographic activity is necessary to confirm the central contribution to the evoked contractions.

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SENS_P1.4 DESIGN OF AIR-COUPLED MMG SENSOR WITH CONDENSER MICROPHONE

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INTRODUCTION: The mechanomyogram (MMG) is a recording of low-frequency vibrations detectable over contracting muscle and correlates with mechanical activities of muscle fibres. Recent studies have qualitatively shown that the MMG signal detected with an air-coupled MMG sensor is less affected by motion artifact than that with an accelerometer. The air-coupled sensor consists of a condenser microphone and an air chamber. However, the appropriate size of the air chamber for taking MMG measurements has not been determined quantitatively.

AIM: The aim of this study was to design an air-coupled MMG sensor using a condenser microphone, particularly considering the effect of air chamber dimensions on the MMG signal.

METHODS: The amplitude and frequency characteristics of an air-coupled MMG sensor were experimentally examined using a mechanical sinusoid vibration system. Plastic cylinders in three sizes (15, 20 and 25 mm diameters) were used to construct an air chamber. The length of the air chamber was adjusted to 15, 20 and 25 mm using the piston inserted into the cylinder. The other end of the piston was attached to the vibration exciter disc with a screw. The cylinder was fixed firmly to the external basement, isolated from the vibration exciter. Amplitude characteristics were measured by moving the piston sinusoidally with different displacements, at a constant frequency of 30 Hz. To estimate frequency characteristics, sinusoidal vibrations at different frequencies in the range 2-100Hz, with a constant displacement of 10 µm peak-to-peak, were applied to the individual air chamber.

RESULTS: The output of the air-coupled MMG sensor increased linearly with piston displacement up to at least 20 µm peak-to-peak. The slope of the linear regression line (i.e., the gain of the air-coupled MMG sensor) was inversely proportional to air chamber length, while being independent of its diameter. The frequency characteristics reflected a high-pass filter behavior of the air-coupled MMG sensor in chambers of any length and diameter. The difference in gain between 2 and 5 Hz correlated with air chamber size.

CONCLUSION: The results suggest that the amplitude and frequency characteristics of an air-coupled MMG sensor are affected by air chamber size. An air chamber 20 mm in diameter and 15 mm in length is considered to be appropriate for MMG measurements.

SENS_P1.5 THE METHODOLOGICAL STUDY ON THE SCIATIC NERVE STIMULATION BY MEANS OF TRANSCUTANEOUS MAGNETIC STIMULATION

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INTRODUCTION: Transcutaneous magnetic stimulation can be used to induce peripheral nerve stimulation just like electrical stimulation. It is difficult to stimulate the sciatic nerve using electrical stimulation as stimulation to the sciatic nerve is anatomically difficult. Although a lot of studies reported the hamstring muscles function, the function of the individual muscles of hamstring has not yet been clarified. The hamstring function is not elucidated, because there may be mentioned that the hamstring muscles are difficult to induce the evoked electromyography by electrical stimulation of the sciatic nerve. Althoug only one previous research reported to recording of an evoked potential by transcutaneous magnetic stimulation of sciatic nerve, methodological instruction was not clearly described.

AIM: The purpose of this study was to investigate whether the transcutaneous magnetic stimulation method is usable to induce the evoked electromyography of the hamstring muscles via the sciatic nerve.

METHODS: Young healthy subjects participated in this study. Subjects was prone kneeling on the bed. Transcutaneous magnetic stimulation was using a magnetic stimulator, which was connected to a circular coil. The coil head was positioned at the midpoint between the greater trochanter of the femur and the coccyx. The stimulation site defined as this point and the surrounding 8 points. Every spot was stimulated at various intensities. We recorded the evoked electromyography from the semitendinosus muscle, the semimembraneosus muscle, the long head of biceps femoris muscle, and the medial head of gastrocnemius muscle. The difference of the amplitude of evoked electromyography in the stimulation intensity and stimulation site was compared about individual muscles.

RESULTS: We could assess the sciatic nerve mapping evoked electromyography by transcutaneous magnetic stimulation. The amplitude of evoked electromyography depended on the intensity of magnetic stimulation in each muscle. For the stimulation site, the amplitude of evoked electromyography was greater by the outside stimulation than inside.

CONCLUSION: These results indicate that transcutaneous magnetic stimulation is possible to stimulate the sciatic nerve. In order to induce evoked electromyography from the hamstring muscles, the site of magnetic stimulation of sciatic nerve could be better to stimulate at outside of the buttocks.

SENS_P1.6 DO TMS-EVOKED TWITCHES SHIFT TOWARDS TO THE DIRECTION OF HIGH-FORCE BALLISTIC TRAINING ACCORDING TO EXTRINSIC OR MUSCLE-BASED COORDINATES?

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INTRODUCTION: Goal directed movements require accurate transformations of sensory information into motor commands. This sensorimotor transformation involves integration of information that originates in multiple reference frames, such as eye-based (visual), head-based (vestibular), joint-based (skin and joint afferent) and muscle-based (muscle afferent) coordinates. Despite extensive work, there remains uncertainty about how these sensorimotor transformations occur in the central nervous system, and in which reference frame adaptations of sensorimotor mappings occur. We recently showed that repetition of strong, ballistic contractions can alter the direction of force twitches elicited by transcranial magnetic stimulation (TMS) towards the training direction. This suggests that high force training induces corticospinal changes that favour movements towards training direction, however the reference frame of such adaptation is unknown.

AIM: Here we altered the posture of the limb between training and testing with TMS to dissociate whether corticospinal adaptation induced by repeated strong contractions is coded in an extrinsic or muscle-based reference frame. In experiment 1, we explored if the direction of muscle twitches evoked by TMS rotated with the forearm from a neutral to a pronated orientation (according to a muscle-based reference frame), or remained consistent with an extrinsic reference frame. In experiment 2, we explored the shift in direction of TMS-evoked twitches after strong ballistic contractions by rotating the limb to a position which dissociated the extrinsic and muscle coordinates frames.

METHODS: In experiment 1, particpants' (n=12) wrists were passively placed in neutral (0°) and pronated (90°) positions while resting muscle twitches elicited by single pulse TMS were recorded from the right wrist. In experiment 2, resting muscle twitches were recorded from the wrist in pronated (90°) and -45° supinated positions before and after a ballistic, sustained contraction protocol. Each participant performed 4 sets of ballistic sustained contractions towards a direction 90° clockwise from their resting muscle twitches in the pronated position.

RESULTS: In experiment 1, the direction of resting muscle twitches rotated with wrist posture according to a muscle-based reference frame ($p<0.05$). Preliminary data from experiment 2 suggest that resting muscle twitches shift towards training direction after strong ballistic contractions according to an extrinsic reference frame.

CONCLUSION: Although cells in primate M1 can be directionally tuned according either to muscle-based or extrinsic coordinates, the corticospinal neurons activated by TMS appear to be directly linked to activation of specific muscles, rather than movement directions.

SENS_P1.7 A COMPARISON OF TWO NEUROMUSCULAR ELECTRICAL STIMULATION PROTOCOLS ON INCREASING CORTICOSPINAL EXCITABILITY FOR A MUSCLE OF THE HAND.

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INTRODUCTION: The electrically-evoked afferent volley generated during neuromuscular electrical stimulation (NMES) increases the excitability of corticospinal (CS) pathways. Over time, NMES can strengthen CS pathways and improve function for persons with central nervous system injury or disease. However, the influence of different NMES protocols on increasing CS excitability is not well-defined. Typically, NMES is either delivered at intensities sufficient to generate repeated functional contractions for relatively short durations (functional electrical stimulation, FES) or at low intensities for long durations (somatosensory stimulation, SS).

AIM: In the present experiments we compared changes in CS excitability induced by a single session of FES versus SS. We hypothesized that due to the generation of a larger afferent volley, the FES would increase CS excitability more than SS.

METHODS: Both FES and SS were delivered over the median nerve at the wrist (1ms pulse width) in 15 participants. Electromyographic activity was recorded from the abductor pollicus brevis muscle (APB). FES was delivered at 100Hz (20s on–20s off) for 40min to evoke an M-wave that was 5% of maximal. SS was delivered at 10 Hz (500 ms on–500 ms off) at motor threshold for 2h. CS excitability was quantified as the amplitude of 10 motor evoked potentials (MEPs) evoked immediately before and after each NMES session using transcranial magnetic stimulation delivered over the "hotspot" for APB at an intensity that was 1.2 times the resting MEP threshold. A repeated measured analyses of variance test was used to identify differences in MEP amplitude with time (before, after) and protocol (SS, FES) as factors.

RESULTS: MEP amplitude increased following both the FES and SS protocols, but the amplitudes of the increases were not different between the two protocols. There was a significant effect of time on MEP amplitude, averaged across the two protocols MEPS were significantly larger after the NMES than before it (by ~30%). There was no significant main effect of protocol (FES versus SS) and no significant interaction.

CONCLUSION: These results do not support our hypothesis but rather suggest that 40 min of FES increases CS excitability to the same extent as 2 h of SS. This suggests that a shorter session of FES may have similar rehabilitative benefits as a longer session of SS. We are currently conducting experiments to more precisely quantify the time-course of the changes in CS excitability induced by these two NMES protocols.

SENS_P1.8 A CLOSED-LOOP NEUROMUSCULAR AND BIOMECHANICAL MODEL FOR THE STUDY OF MUSCLE CONTROL

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INTRODUCTION: The understanding of the neural strategies for movement control requires neuromuscular models.

AIM: This study presents an integrative model of the generation of movement that includes a model of the motor neuron pool, closed afferent/efferent loop, generation of surface EMG signals, and a realistic control algorithm for tracking the musculotendon segment length.

METHODS: 120 two-compartment Hodgkin–Huxley neuron models represented the motor neuron population, while each motor neuron population was associated to 60 Ia interneurons and 60 Ib interneurons (one-compartment models). Each interneuron innervated 20% of the motor neurons by injecting an inhibitory post-synaptic current into the soma compartment. Based on the simulated motor unit discharge patterns, the muscle forces were simulated (adjusted for force-length-velocity relations and efferent conduction delay), from which the musculotendon dynamics was estimated using a biomechanical model of an antagonist muscle pair. These dynamics determined the afferent activity of 54 muscle spindles, each innervating all agonist motor neurons and to 60% of the interneurons innervating the antagonist. The motor unit force determined the activity of 18 Golgi tendon organs innervating 60% of the interneurons innervating the agonist. After a conduction delay, an afferent discharge involved injection of a post-synaptic current in the receiving neuron. A pre-defined trajectory of agonist musculotendon length was tracked using the control algorithm that estimated the baseline descending drive to the motor neuron populations. Low-passed filtered (100 Hz) white noise with an amplitude proportional to the PID-output was superimposed on the descending drive and zero-mean low-passed filtered white noise was injected into the interneurons to simulate other synaptic inputs. Finally, the surface EMG signal was simulated using a multilayer cylindrical volume conductor model based on the motor neuron discharge patterns.

RESULTS: Simulation results corresponded to experimental observations. For example, a 10% shortening of the musculotendon segment (force: 11% MVC) involved a coefficient of variation for force and motor neuron interspike intervals of ~5% and ~15%, respectively. An extensive validation of other experimental observations, has been conducted.

CONCLUSION: The proposed model is the most complete mathematical representation of the neural mechanisms behind generation of movement so far, since it includes the closed neural loop constituted by the contribution to the neural drive to the muscle of the afferent response to the force and movement generated by the neural drive itself. In this way, the model provides a unique tool for systematically investigating the influence of afferent synaptic input on the neural drive to muscle and the motor output.

SENS_P1.9 CHANGE OF THE SOLEUS HOFFMANN REFLEX IS NOT CONGRUOUS WITH MUSCLE FASCICLE LENGTH CHANGES DURING KNEE ROTATIONS

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INTRODUCTION: There are numerous heteronymous facilitatory and inhibitory connections that exist between synergist and antagonist muscles that may influence the size of the Hoffmann reflex (H-reflex) response.

AIM: To investigate whether passively rotating the knee would result in parallel or differential changes to the soleus (SOL) and medial gastrocnemius (MG) H-reflex amplitudes. Since passive knee rotation alters the muscle length of MG, but not SOL, it was hypothesized that the MG H-reflex would reflect the lengthening or shortening actions that occur during knee rotation, whereas the SOL H-reflex would remain unaltered.

METHODS: Nine healthy adults (5 male and 4 female) participated in the study. MG and SOL H-reflexes were evoked with the knee joint held static at 10° from full extension, or as the knee joint was passively flexed or extended through this 10° point. The ankle joint was braced at 90o and unable to move. Supramaximal stimulation provided a measurement of maximum muscle activation (Mmax). Ultrasound recordings were used to confirm whether the knee rotations altered MG but not SOL muscle fascicle lengths.

RESULTS: Maximum MG and SOL H-reflexes (Hmax) were similarly affected during knee rotations, with both MG and SOL Hmax:Mmax being significantly smaller during knee extension than during the knee flexion (33-43% reduction) and when compared to the static (22-28% reduction) condition. Parallel changes to the MG and SOL H-reflexes occurred despite a differential effect of knee rotation on muscle fascicle lengths. Whereas MG muscle fascicles lengthened and shortened during knee extension and flexion, respectively, SOL fascicles length remained unchanged.

CONCLUSION: Given the strong neural coupling between the MG and SOL motoneuron pools, the results highlight the difficulty in isolating specific variables (e.g., muscle length) when determining the modulatory influences on the triceps surae H-reflex amplitude.

SPINE

SPIN_P1.1 RELIABILITY OF AND RELATIONSHIP BETWEEN MAXIMUM ISOMETRIC LUMBAR EXTENSOR AND HAND GRIP STRENGTH MEASUREMENTS IN HEALTHY, ELDERLY PERSONS

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INTRODUCTION: High levels of trunk muscle strength are related to a decreased risk of musculoskeletal diseases of the spine, good quality of life and mobility especially in the elderly population. Thus, screening for persons with lower than normal back muscle strength values may considerably be of interest in the prevention process of such conditions.

AIM: This study sought 1) to assess isometric back muscle strength in healthy elderly persons, 2) to test short- and long term reliability of these measures, and 3) to relate these measures to hand grip strength; a measure representative for a person's overall muscle strength.

METHODS: A total of 82 healthy persons (~50% females, age range 18-90 years) performed a total of 2 to 3 isometric maximum back extensions on a David Dynamometer (David®, Finland). Thereafter, a total of 3 maximum hand grip strength tests were recorded in a standardized way using a hand grip dynamometer (MSD Europe Bvba®). The best out of two tests were taken. All measurements were repeated after 1 to 2 days and 6 weeks later.

RESULTS: All 82 participants completed the first 2 tests and another 76 the 6 weeks follow up examinations. Subjects' mean age was 51,5 years ± (18-40 yrs: 27.3±6.4; 40-60 yrs: 48.5±4.1; 60+: 70.5±6.3) and their body mass index was 24.9±3.1kg/m². Mean back extension and hand grip strength was lower in the elderly than the young subjects with significant difference between males and females. ICC values for long term reliability were between 0.96 to 0.98 for the 3 different age groups. When maximum back extensions were repeated 1 day after the first test, however, a tendency towards a significantly lower maximum torque was observed. Back muscle extensions and hand grip strength was highly related to each other in all 3 groups (Pearson correlation coefficients range: 0.97 to 0.98).

CONCLUSION: This study provides evidence that maximum isometric back extension tests are highly reliable in the long term, both in young and in elderly persons. A retest after 1 to 2 days, would, however result in lower maximum back performance levels. As back extension torque values were highly related with grips strength measurements, a ratio of back extension torque and hand grip strength might reasonably help to lower the overall variability of the measurements by decreasing age and sex related differences of this measure. Such ratio might be promising in identifying subjects with back muscle extension strength deficits.

SPIN_P1.2 CRITERION VALIDITY AND BETWEEN-DAY RELIABILITY OF AN INERTIAL SENSOR-BASED TRUNK POSTURAL STABILITY TEST DURING UNSTABLE SITTING

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INTRODUCTION: Adequate neuromuscular control of the lumbar spine is required to prevent lumbar injuries. A trunk postural stability test has been proposed, with the use of a chair wobbling around a central pivot and four springs positioned so as to modulate task difficulty. A calibration procedure allows adjusting the spring's position to remove the confounding effect of subject size on performance. An inertial sensor is fixed on the chair to measure postural sway.

AIM: To assess the criterion validity and between-day reliability of the calibration and testing parts of this trunk postural stability test.

METHODS: Subjects with (8 men, 8 women) and without (8 men, 8 women) chronic low back pain performed a calibration procedure, 4 practice trials and three 60-s trials on 2 days (2 weeks interval). The 3rd practice trial was performed with a force-plate under the wobble-chair to measure center of pressure (COP) trajectories. The angular kinematics of the inertial sensor was also tracked by an optoelectronic motion analysis system. Criterion validity was quantified with Pearson's correlations (r). The generalizability theory was applied to estimate the reliability of 39 body sway parameters summarizing the stabilograms created by the inertial sensor angular measures. Indexes of dependability (ID, analogous to intraclass correlation coefficient) and standard errors of measurement (SEM) were computed.

RESULTS: Correlations were high (median r values > 0.86) between the angular kinematics time-series measured with the inertial sensors and (1) COP trajectories or (2) optoelectronic angular measures. The spring positions obtained with the use of the calibration procedure were significantly correlated to the height (r = 0.65) and mass (r = 0.69) of the subjects, allowing to control for the confounding effect of body size on the postural sway performance, as further substantiated by the absence of significant correlations between subject size and 37 out of the 39 body sway parameters. Spring positions showed moderate estimates of reliability (ID: 0.64, SEM: 10%). Three trials were provided acceptable reliability results (ID ≥ 0.75) for approximately half of the body sway parameters, which led overall to 7 parameters showing excellent reliability on both indices (ID ≥ 0.75; SEM ≤ 10%), 24 parameters with excellent IDs and 12 parameters with excellent SEMs.

CONCLUSION: The use of an inertial sensor led to valid estimations of postural sway. A different set of body sway parameters was identified (1) to reliably compare individuals, as substantiated with IDs or (2) reliably follow-up a given individual, as substantiated with SEMs.

SPIN_P1.3 RELATIVE BALANCE OF THE MULTIFIDUS AND LUMBAR ERECTOR SPINAE MUSCLES DURING QUADRUPED UPPER AND LOWER EXTREMITY LIFTS

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INTRODUCTION: Previous research has demonstrated that the lumbar multifidus (MF) muscle selectively atrophied relative to the lumbar erector spinae (ES) muscle in patients with low back pain (Danneels, 2000). Therefore, it is necessary to selectively strengthen the MF muscle relative to the ES muscle. Quadruped upper and lower extremity lifts (QULELs) are used as an exercise for the MF muscle. However, no studies have documented the effect of changing the lifting direction in the extremities or attaching an external load to the extremities during QULELs for the back muscles.

AIM: To examine the effects of changing the lifting direction in the extremities and of loading weight to the extremities during QULELs on the activities of the MF and ES, and to identify the exercise that can selectively strengthen the MS.

METHODS: Sixteen healthy males (22.4 ± 1.3 years) participated in the study. The muscle activity of the left MF and ES muscles was recorded during QULELs using a surface electromyography system (TeleMyo 2400T; Noraxon). Exercise conditions for each QULEL were as follows: (1) right upper extremity raised to 180° shoulder flexion and left lower extremity raised to 0° hip extension (F–E), (2) right upper extremity raised to 90° shoulder abduction and left lower extremity raised to 45° hip abduction (A–A), (3) A–A with 2.5% body weight (BW) weight belt attached to the right wrist (A2.5–A), (4) A–A with 5.0% BW load on the right wrist (A5–A), (5) A–A with 5.0% BW load on the left ankle (A–A5), (6) A–A with 10.0% BW load on the left ankle (A–A10), (7) A–A with 2.5% BW load on the right wrist and 5.0% BW load on the left ankle (A2.5–A5), (8) A–A with 5.0% BW load on the right wrist and 10.0% BW load on the left ankle (A5–A10). The muscle activity was recorded for 3 s and then expressed as a percentage of the maximal voluntary isometric contraction. Friedman and post hoc tests were used to assess differences in the MF and ES muscle activities, and the MF/ES ratio among all conditions.

RESULTS: MF muscle activity during A–A (33.0 ± 8.2%), A–A5 (35.7 ± 8.7%), and A–A10 (40.0 ± 11.3%) was significantly higher than that during F–E (27.9 ± 9.3%), while MF muscle activity during A–A10 was significantly higher than that during A–A and A–A5. MF/ES ratio during A–A (2.80 ± 1.42), A–A5 (2.82 ± 1.46), and A–A10 (2.73 ± 1.47) was significantly higher than that during F–E (2.23 ± 1.15).

CONCLUSION: We suggest that the QULEL with abduction of the shoulder and hip joint and with loading weight to the lower extremity was more effective in increasing the activity and activity ratio of the MF muscle relative to the ES muscle than the conventionally used QULEL with only lifting the extremities in the coronal plane.

SPIN_P1.4 EMG-DRIVEN BIOMECHANICAL MODEL OF THE SPINE DURING EXTENSION AND FLEXION USING OPENSIM

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INTRODUCTION: EMG-driven biomechanical models offer an alternative to inverse dynamics approaches in which muscle activation patterns are predicted from joint moments assuming specific optimisation criteria. While both forward and inverse dynamics approaches offer distinct advantages and disadvantages, forward dynamic approaches in which neural excitation patterns are typically estimated from recorded EMG signals enable muscle activation patterns to be incorporated in a physiologically realistic manner. In this study, an existing musculoskeletal model of the lumbar spine was adapted to incorporate neural excitation patterns derived from surface recorded EMG signals during flexion and extension of the spine.

AIM: The aim of this study was to develop an EMG-driven model of the lumbar spine using the OpenSim platform.

METHODS: Surface EMG data were recorded from three healthy subjects during flexion and extension of the spine. Bipolar surface EMG signals were recorded bilaterally from the multifidus, erector spinae, latissimus dorsi and rectus abdominis muscles during isometric voluntary flexion and extension of the spine. Triaxial accelerometry data was simultaneously recorded at each electrode. Maximum voluntary contraction (MVC) was first recorded for each subject for each muscle group. Subjects were then instructed to perform three repetitions of trunk flexion and extension holding three different loads (3.2 Kg, 8.2 Kg and 13.2 Kg). The root mean square (RMS) value of the EMG signals were calculated and the EMG data were normalised with respect to MVC. The EMG RMS trajectories were then used as inputs to a Hill-type muscle activation model within OpenSim. The estimated neural excitation patterns were applied to the musculoskeletal model and the kinematic trajectory output by the model was compared with the experimentally recorded kinematics.

RESULTS: Preliminary kinematic data were simulated using the EMG-driven OpenSim model and indicted good agreement between recorded and simulated kinematic data.

CONCLUSION: This study introduces an EMG-driven model of the lumbar spine using the OpenSim platform. The model will be further developed and validated by extending the study to a larger number of subjects and to include trunk rotation and lateral flexion.

SPIN_P1.5 SPINAL BENDING PATTERNS IN SAGITTAL PLANE PERTURBATIONS

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INTRODUCTION: Stability of the lumbar spine involves global stabilization of the thorax/head masses as well as local stabilization of the five lumbar vertebrae. Since the upright lumbar spine is inherently instable, the low back musculature continuously stabilizes both the global and local components. Different local bending patterns can result in the same thorax orientation, but lead to different shear and tensile stresses in the musculature, ligaments and spine.

AIM: To evaluate the spinal bending patterns in the lower back by looking at local and global bending resulting from small continuous perturbations.

METHODS: Fifteen healthy subjects, restrained at the pelvis, were perturbed at the T10-level of the spine in ventral direction with continuous perturbations with a maximum amplitude of 4 cm. Sagittal kinematics of all lumbar vertebrae (L1 till L5) and the thorax (T12 & T8) were recorded. Rotations of the local elements (e.g. T12-L1 or L4-L5) were analysed in the sagittal plane, to obtain insight in the bending patterns of the low back.

RESULTS: All subjects displayed similar trunk motions. Three markedly different lumbar bending patterns were observed within the group of subjects: 'Distributed bending' (6 subjects), 'Minor bending above L5' (5) and 'Minor bending above L4' (4). Distributed bending characterizes flexion/extension that is distributed over all vertebrae. Minor bending represents rotations of the low back practically as a 'rigid body', with bending originating at the sacrum and/or in the L5-S1 joint (minor bending above L5) or at the L4-L5 joint (minor bending above L4).

CONCLUSION: For small ventral perturbations markedly different lumbar bending patterns were found in the subjects tested. These bending patterns suggest different stabilization methods (locally and globally) in subjects. EMG measurements of the back muscles (e.g. M. Longissimus) will be affected by the different bending patterns, while muscle reflexes will alter due to differences in lengthening of the muscles. Next step will be to investigate spinal bending patterns in low back pain patients.

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SPIN_P1.6 DOES INCREASED MUSCULAR TENSION ALONG THE TORSO DISTURB POSTURAL EQUILIBRIUM MORE WHEN IT IS ASYMMETRICAL?

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INTRODUCTION: It has recently been shown that a bilateral increase of the active muscular tension along the torso is likely to impair postural equilibrium (Hamaoui et al., 2011). A unilateral increase of this tension, which induces a left / right asymetry in postural muscles activity, could have a more disturbing effect.

AIM: The objective of this study was to determine whether increased muscular tension along the torso impairs postural equilibrium more when it is asymmetrical.

METHODS: Twelve healthy subjects underwent a posturographic examination associated with an original uni and bi-manual compressive load paradigm, designed to set the muscular tension at different controlled levels along one and both sides of the torso. An extensive EMG pre-test was used to map out the main motor muscles of the task and to ensure that a unilateral compressive load was not associated with a bilateral muscular pattern. Respiratory kinematics were recorded by means of two sensing belts fastened around the rib cage and the abdomen. Mean position (X0, Y0), mean deviation (Xm, Ym) and mean velocity (VmX, VmY) of the centre of pressure (CP) were used as indicators of postural equilibrium. Specific frequency domain parameters were calculated from CP and respiratory signals to quantify the respiratory disturbance to posture.

RESULTS: EMG pre-tests showed that the main motor muscles of the compressive load were located at the upper part of the torso, and that their activity along the active side increased gradually with the compressive load level. The posturographic examination revealed that the mean position of the CP along the medial lateral axis (Y0) was systematically higher in left that in right compressive load efforts, i.e. the CP was shifted on the active side. In addition, the mean deviation of the CP along the medial lateral axis (Ym) always displayed higher values in unilateral than in bilateral compressive load conditions. However, these variations were not statistically significant and can only be considered as trends.

CONCLUSION: The specific biomechanical constraints induced by controlled asymmetrical muscular tension along the torso, are compensated for enough to induce negligible effects on postural equilibrium.

SPIN_P1.7 VALIDATION OF A CLINICAL TEST FOR DISSOCIATION OF THE THORAX FROM THE LUMBAR SPINE

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INTRODUCTION: Individuals with chronic low back pain (CLBP) have a reduced ability to differentiate extension of the lumbar spine (induced by activation of short muscles) from extension of the entire spine (induced by activation of long muscles). Despite the clinical importance of reduced spinal dissociation, no clinical tool is available to assess these changes.

AIM: Here we aim to determine the inter-rater reliability of a novel clinical test for dissociation of thorax from the lumbar spine.

METHODS: Eleven healthy male and female subjects (27±3 years) were recruited. Three independent assessors (2 experienced and one novice [new graduate]) and one experimenter (all physiotherapists)) were trained to assess the ability to perform pelvic and lumbar movement in a manner that is dissociated from the upper back. A novel score comprised of five criteria was created. The movements that the subjects were instructed to perform were standardized with a video that presented specific instructions and an example of the movement. The assessors rated the subject's best performance without opportunity for conferral, before and after a two-minute training period that was given by the experimenter to improve their performance. The inter-rater reliability was analyzed by weighted Cohen's kappa coefficient (*k*) with CI of 95% for the total score given by the raters to the subject.

RESULTS: The highest inter-rater reliability achieved between raters was reached in the pre training phase. The best level of agreement was between rater 1 and 2 (*k:* 0.812; CI: 0.683 – 0.927) followed by rater 1 and rater 3 (*k*= 0.69; CI: 0.338 – 0.931) and finally rater 2 versus rater 3 was *k:* 0.626; CI: 0,286 – 0.888). In the post-training phase this trend was maintained but with inferior level of agreement: rater 1 and rater2 (*k:* 0.749; CI: 0.293 – 0.954), for rater 1 and rater 3 (*k*: 707; CI: 0.308 – 0.952) and for rater 2 versus rater 3 (*k:* 0.48; CI: -0.050 – 0.921).

CONCLUSIONS: These results demonstrate that a clinical test of lumbo-pelvic control has good reliability between trained assessors. The assessments performed after the subjects were trained on the task show a change in the rater's behavior. The training condition appears to have caused a bias in the assessors' criteria that can be seen in the variation of the level of agreement between raters after training. Taken together, these data show that the test is most reliable when only the initial assessment is used, and when only experienced examiners perform the assessment. When performed in this manner the levels of agreement are strong enough to consider the test repeatable. Thus the test can be used to assess low back and pelvic movements in different raters.

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SPIN_P1.8 EARLY INDIVIDUALIZED PHYSICAL THERAPY IMPROVES PREPARATORY PELVIC CONTROL AND FUNCTION IN PATIENTS AFTER FIRST-TIME LUMBAR MICRO-DISCECTOMY

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INTRODUCTION: Residual functional complaints are frequently observed after first-time lumbar micro-discectomy (LMDT). As many as 30% of LMDT patients does not return to work and 70% report residual pain. The sit-to-stance-to-sit (STSTS) movement is one of the most commonly performed functional activities which requires both controlled joint movement and precise balance control.

AIM: To determine whether early individualized physiotherapy (PT) improves the performance of a functional task such as the STSTS in patients after LMDT.

METHODS: Twenty-one middle-aged patients after LMDT were randomised into a PT group (n= 9) and control group (n= 12). The individual PT started 2 weeks post surgery and was mainly oriented on patient education, ergonomics and motor control exercises. The control group received usual care, consisting of advice on ergonomics and to stay active. Primary outcomes were evaluated at 2 (baseline), 8 and 24 weeks after surgery. Patients were asked to perform 5 consecutive STSTS movements as fast as possible. Total duration was recorded. The duration of each stance, sit and movement phase was calculated based on center of pressure displacement. The onset of pelvic rotation (S2 accelerometer) relative to trunk movement (T1 accelerometer) was recorded. Differences between groups over time were assessed by repeated measures ANOVA.

RESULTS: Already 8 weeks post surgery the PT group needed significantly less time to perform 5 STSTS movements compared to the controls (14±4s and 26±17s, respectively, $p<0.05$). This shorter time can be mainly explained by a significantly shorter stance phase in the PT group compared to the controls at 8 weeks post surgery (1.54±0.38s and 3.03±1.77s, respectively, $p<0.05$) and a trend to a shorter sit phase (0.67±0.18s and 0.98±1.11s, respectively, $p=0.087$). Compared to baseline the PT group showed a significantly earlier anterior pelvic rotation (compared to trunk movement) at 8 weeks (0.16±0.13s and 0.03±0.09s, respectively, $p=0.05$) and 24 weeks post surgery (0.16±0.13s and 0.01±0.06s, respectively, $p<0.05$) which could not be observed in the controls at 8 weeks (0.03±0.09s and 0.10±0.17s, respectively, $p>0.05$) and 24 weeks post surgery (0.03±0.09s and 0.03±0.05s, respectively, p>0.

CONCLUSION: The STSTS performance was significantly improved in LMDT patients having PT compared to the controls. A more optimal preparatory pelvic control can explain the better STSTS performance, mainly observed in the transition phases (i.e. stance and sit phases) in the patients following PT. Active individualized PT starting 2 weeks after LMDT may play an important role in early improvement of function and return to daily activities.

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SPIN_P2.1 COMPENSATORY MUSCLE ACTIVITY IN TRUNK AND LOWER LIMB MUSCLES DURING MAXIMUM FORWARD REACH IN PATIENT WITH LOW BACK PAIN AFTER SPINAL SURGERY

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INTRODUCTION: Spinal surgery is thought to decrease the symptoms of low back pain (LBP) patient efficiently in orthopedic clinic. However, mounting evidence shows the high re-operation rate after spinal surgery. Swelling, atrophy or fat infiltration of the paraspinal muscles, at the surgery site can cause weakness and pain. High probability of paraspinal muscle damage has been reported during operation procedure, but only few studies have addressed the changes in muscle and functional performance after surgery.

AIM: The purpose of current study was to identify the changes in muscle activity of patients with LBP after spinal surgery. We compared the baseline performance on the day before the surgery to those at 6 weeks post operation.

METHODS: Six patients with LBP (mean age 53.2±16.06 years old) were recruited and were given informed consent and signatures collected before enrollment. Subjects were asked to perform a maximum forward reach task with self-selected speed for three times. Sixteen electromyography (EMG) sensors were placed on 3 trunk and 5 lower limb muscles bilaterally. The forward reach distance and averaged root mean square of the EMG activities were computed in Matlab. The differences in EMG activity between before and after surgery were examined using multiple paired *t*-tests. The significant level was adjusted and set at p value < 0.00625.

RESULTS: The forward reach distance normalized to the individual foot length was not different between pre- and post-surgery. However, the muscle activity of the multifidus (p = 0.002) and medial gastrocneminus (p = 0.001) muscles were significantly decreased whereas the rectus abdominal (p = 0.001) muscles activity were significantly increased.

CONCLUSION: Although the functional performance seemed to be recovered at 6 weeks after surgery, but the muscle firing pattern was altered. The decreased activities in multifidus muscle was compensated by the increased abdominal muscle activities to achieve the same functional performance.

ACKNOWLEDGEMENTS: This work was supported by the National Science of Council in Taiwan awarded to Dr. Hsu (NSC 99-2320-B-002-003-MY2).

SPIN_P2.2 ARE BASELINE FEAR AVOIDANCE BELIEFS ASSOCIATED WITH DEEP ABDOMINAL MUSCLE ACTIVATION AFTER EXERCISES FOR CHRONIC LOW BACK PAIN?

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Dr Tom Ivar Lund Nilsen; Prof Jon Magnussen; Prof Ottar Vasseljen

INTRODUCTION: Activation of transversus abdominis has been related to low back pain.

AIM: The aim of this study was to investigate associations between fear avoidance beliefs before and deep abdominal muscle activation after supervised exercises for patients with chronic low back pain.

METHODS: 108 patients with chronic nonspecific low back pain who received 6-8 weeks with supervised exercises participated in this study. Fear avoidance beliefs for physical activity and work were measured before intervention. Deep abdominal muscle activation during abdominal drawing-in maneuver and in anticipation of rapid arm flexion was measured before and after intervention.

RESULTS: High fear avoidance beliefs for physical activity (≥ 16 on the subscale) were negatively associated with transversus abdominis slide after the intervention period. There were no associations between fear avoidance beliefs for physical activity and abdominal muscle onset, transversus abdominis- or obliquus internus contraction thickness ratio. Fear avoidance beliefs for work were not associated with any of the abdominal muscle activation parameters.

CONCLUSION: This study suggests that there is some negative association between fear avoidance beliefs for physical activity before intervention and transversus abdominis recruitment measured by lateral slide after intervention. Fear avoidance beliefs for physical activity might be more relevant to exercise outcome than fear avoidance beliefs for work.

SPIN_P2.3 EFFECT OF HIP ABDUCTION EXERCISE WITH PELVIC FIXATION ON RECRUITMENT OF DEEP TRUNK MUSCLES

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INTRODUCTION: Lumbar stabilization exercises (LSE) are widely performed in clinical and athletic rehabilitation, and many studies have been performed to examine their effect. However the working rationale of LSE protocols remains unclear yet.

AIM: To determine whether hip abduction in the side-lying with pelvic fixation is more effective for promoting deep trunk muscle activity than hip abduction without pelvic fixation, measured using fine-wire and surface EMG.

METHODS: Ten healthy men with no history of cervical, thoracic and lumbar spine disorders participated in the study. Fine-wire electrodes were inserted into both deep multifidus (DM). In addition, surface electrodes were attached bilaterally to the superficial multifidus (SM), lumbar erector spinae (LES), rectus abdominis, transverses abdominis/obliquus internus abdominis (TrA/OI), obliquus externus abdominis and gluteus medius. The amplitude of electromyographic signal was measured during hip abduction in the side lying position with and without pelvic fixation. Study participants performed maximal voluntary contractions for each muscle in various positions to normalize the EMG data.

RESULTS: Hip abduction with pelvic fixation was found to result in significantly more recruitment of all muscles except contra RA, ipsi OE than hip abduction without pelvic fixation ($p < 0.05$). More significant differences were seen in the ipsilateral DM and SM than contralaterally. The increase in DM %MVC was significantly higher than that of RA, OE, TrA/OI, LES, SM and GM ($p < 0.05$). SM % MVC showed a greater significant increase than that of RA and OE ($p < 0.05$). In addition, there was a correlation between DM and SM (Pearson's correlation coefficient = 0.537)

CONCLUSION: Hip abduction training in the side-lying with pelvic fixation might be more effective for recruiting deep trunk muscles for spinal dynamic stabilization than without pelvic fixation.

SPIN_P2.4 TRUNK STABILITY IN ONE LEG STANDING FOR INDIVIDUALS WITH RECURRENT LOW BACK PAIN.

Dr Paul Sung, Korea University

Mrs MH Kim; Mr JM Kim

INTRODUCTION: This prospective study examined normalized stability differences based on dominant side and visual feedback. Subjects with low back pain (LBP) (n=26; 9 men, 17 women) and without LBP (n=28; 11 men, 17 women) participated in this study.

METHODS: All subjects were asked to maintain single leg standing balance with the contralateral hip flexed 90 degrees for 25 seconds. The outcome measures included normalized holding duration and stability. The combined rotation (Rxyz) was also calculated to compare the upper and lower thorax and lumbar axes relative to the core spine axis.

RESULTS: The holding duration was significantly different between groups ($T = -2.21$, $p = 0.03$). The subjects without recurrent LBP (control group) demonstrated longer hold duration times (24.60 ± 4.2 sec) than the subjects with recurrent LBP (21.2 ± 7.1 sec). For the normalized hold duration, there was a significant difference between groups based on visual input ($F = 7.13$, $p = 0.009$). There was also a significant difference in standing stability based on visual input ($F = 93.93$, $p = 0.0001$) and trunk area ($F = 101.51$, $p = 0.0001$). In addition, the normalized stability was significantly different based on dominance and visual input ($F = 11.28$, $p = 0.002$).

CONCLUSION: The trunk stability could prompt an uncoordinated bracing effect with poor proprioception from injury to passive structures or due to interference of pain during central processing of information in subjects with recurrent LBP.

SPIN_P2.5 AN ELECTROMYOGRAPHIC AND KINETIC COMPARISON OF ABDOMINAL MUSCLE ACTIVITY DURING ABDOMINAL STRENGTH TESTS

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INTRODUCTION: Inadequate abdominal muscle performance is frequently identified as an impairment that may lead to functional limitation and disability in persons with low back pain. In order to accurately assess motor performance of these muscles, clinicians need objective measures that are both valid and reliable. Two common abdominal muscle performance tests include the Double Limb Lowering Test and the Lower Abdominal Muscle Progression.

AIM: The aims of this study were to determine the following: the relation between surface electromyography (EMG) activity of the rectus abdominus (RA), internal oblique (IO), and external oblique (EO) muscles during the double leg lowering test (DLLT) and lower abdominal muscle progression (LAMP) grading system levels; the relation between the hip resultant joint moments and assigned DLLT and LAMP grading system levels; and the potential relation between the DLLT and LAMP grading systems.

METHODS: Ten healthy participants (5 male, 5 female) were tested under two conditions (DLLT and LAMP). Surface EMG (Biopac MP100 System) activity of the upper (URA) and lower RA (LRA), IO, and EO muscles was obtained, while joint motion of the lower extremities and pelvis were simultaneously detected using a dual camera CODAmotion (Charnwood Dynamics, UK) motion analysis system. MATLAB (v 7.10.0) was used to write custom codes to process the raw EMG and to determine the resultant hip joint moments (RJM) in a sagittal plane.

RESULTS: Correlations between DLLT grades and hip resultant joint moments (RJM), URA, LRA, IO, and EO EMG percentage of maximal voluntary isometric contraction (%MVIC) were 0.90, 0.72, 0.69, 0.59, and 0.54, respectively ($p<0.01$). Correlations between LAMP grades and hip RJM, URA, LRA, IO, and EO % MVIC were 0.30, 0.68, 0.72, 0.26 and, 0.56, respectively ($p<0.01$). No significant correlation was found between the DLLT and LAMP grades ($p=0.23$).

CONCLUSION: Moderate to good relationships exist between abdominal muscle activity and grades as described by the DLLT and LAMP, except for IO activity during the LAMP test (fair relation). A strong correlation existed between the hip RJM and the DLLT, while there was a fair relation between hip RJM and the LAMP. This finding suggests that the tests measure different qualities of muscle performance and provides support for the use of either test in the assessment of abdominal muscle performance, except when IO muscle testing or external lower extremity force demands on muscle performance are desired. In these instances, the DLLT appears to be a better test. Further testing of these assessments is necessary to determine their responsiveness to change following training and in subjects with other characteristics, such as pain.

SPIN_P2.6 ALTERED PROPRIOCEPTIVE CONTROL IN PATIENTS WITH RECURRENT LOW BACK PAIN DURING A POSTURAL CONTROL TASK IN A LYING POSITION (MINI-BRIDGE)

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INTRODUCTION: Individuals with recurrent low back pain (LBP) have been observed to have a decreased ability to process proprioceptive input depending on the postural demands during standing and sitting. Little is known about the proprioceptive control in a lying position. The lying position is often used in therapeutic exercises and is important for the investigation of the neural basis of these proprioceptive changes in a MRI environment.

AIM: Considering the observed proprioceptive changes in patients with recurrent LBP during standing and sitting, we will determine whether this impaired postural control flexibility can be generalized to a lying position.

METHODS: Postural control characteristics of eight young individuals with recurrent LBP and 17 young healthy controls were evaluated during standing and lying on a stable and unstable support surface (foam). For the lying position, the subjects were positioned in supine lying with their knees bend and feet positioned on a force plate. In this position the individuals were instructed to lift their pelvis slightly from the support surface (i.e. mini-bridge). During this postural condition muscle vibration, a strong stimulus for muscle spindles, was applied to the ankle and back muscles. Differences between conditions and groups were assessed by repeated-measures ANOVA. Post hoc analysis (Unequal N HSD) was performed on significant main and interaction effects to calculate specific effects. Significance level was set at $P< 0.05$.

RESULTS: During standing individuals with recurrent LBP demonstrated significantly larger posterior sways during ankle-back muscle vibration in unstable support surface conditions compared to the healthy subjects ($P< 0.01$). During the mini-bridge on foam the individuals with LBP showed significantly larger center of pressure (CoP) displacements in the distal direction during ankle-back muscle vibration compared to the stable condition ($P< 0.001$). The postural performance based on RMS values was significantly higher on unstable compared to stable support surface (healthy: unstable: 0.012, stable: 0.006, LBP: unstable: 0.017, stable: 0.007; $P< 0.05$).

CONCLUSION: The results of both the standing and lying condition trials indicate the use of a more ankle-steered proprioceptive control in people with recurrent LBP compared to healthy controls. Moreover, these results reinforce the decreased capacity of individuals with recurrent LBP to select a proprioceptive control strategy adapted to the postural demands. In addition, the mini-bridge could be used as a functional postural task in a MRI environment.

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SPIN_P2.7 COMPARISON IN THE LUMBAR LORDOSIS ANGLE BETWEEN PATIENTS WITH CHRONIC PAIN AND ABLE-BODIED PEOPLE

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INTRODUCTION: We have been focusing on the spinal curvature of patients with chronic pain (chronic pain group). According to past findings, thoracic kyphosis (particularly upper thoracic kyphosis) of the chronic pain group was significantly low, compared to able-bodied people (able-bodied group), but there was no significant difference in the lower thoracic kyphosis between both groups. The curvature characteristics of the chronic pain group had been studied only in the thoracic vertebra. Therefore, our research focused on the lumbar lordosis angle in order to make a further investigation.

AIM: Our research aimed to compare the lumbar lordosis angle between the chronic pain group and the able-bodied group.

METHODS: Subjects were 60 people: 30 able-bodied people (15 men and 15 women, average age of 26.8 ± 3.5) and 30 patients with chronic pain (15 men and 15 women, average age of 27.2 ± 5.6).Both the upper and the lower lumbar lordosis angles were identified by radiograph in sagittal plane. In the research, the angle formed by the topside of L1 with the underside of L3 was defined as the upper lumbar lordosis angle. Also, the angle formed by the topside of L4 with the base of the sacrum was defined as the lower lumbar lordosis angle. Then, a comparison was made in both angles between the chronic pain group and the able-bodied group. In the statistical test, Welch's t-test was used with less than 1% of a significance level.

RESULTS: There was no significant difference in the upper lumbar lordosis angle between the chronic pain group (10.9±4.5°) and the able-bodied group (9.5±5.1°).In contrast, the lower lumbar lordosis angle of the chronic pain group was 38.6±8.6°, which was higher than that of the able-bodied group (29.8±5.2°).

CONCLUSION: The findings from past and our research showed that the chronic pain group had the upper thoracic kyphosis decreased but the lower lumbar lordosis angle increased as compared with the able-bodied group. According to researchers including Gelb D.E.(1995), thoracic kyphosis correlates with lumbar lordosis. Based on such report, it is assumed that the upper thoracic kyphosis and the lower lumbar lordosis affect each other and cause the unique posture of patients with chronic pain. Our next challenge is to study not only a correlation between the upper thoracic kyphosis and the lower lumbar lordosis and its factors, but also the curvature characteristics of the entire vertebrae including the cervical spine.

SPIN_P2.8 POSTURAL STABILITY AND KINEMATIC CHARACTERISTICS IN INDIVIDUALS WITH AND WITHOUT RECURRENT LOW BACK PAIN.

Dr Paul Sung, Korea University

Mrs MH Kim; Mr JM Kim

INTRODUCTION: Even though a number of studies have evaluated postural adjustments based on kinematic changes in subjects with low back pain (LBP), lumbar spine stability has not been examined for abnormal postural responses with visual feedback.

AIM: The purpose of this study was to evaluate the stability in three regions of the spine based on dominance side and visual feedback. Subjects with (n=26; 9 men, 17 women) and without (n=28; 11 men, 17 women) recurrent low back pain (LBP) participated in this study.

METHODS: All subjects were asked to maintain single leg standing balance with the contralateral hip flexed 90 degrees for 25 seconds. The outcome measures included the duration of standing balance and the combined stability based on rotation (Rxyz) with and without visual input. The spine regions included the upper and lower thorax and lumbar axes relative to the core spine axis which represent spine root.

RESULTS: The subjects without recurrent LBP demonstrated longer hold durations than the subjects with recurrent LBP (F=12.81, p=0.001). The combined stability was significantly different based on dominance side (F=4.37, p=0.04), visual input (F=11.33, p=0.001), and spinal region (F =101.72, p=0.002). In addition, the combined stability of the spinal region had an interaction with visual input between groups (F=4.50, p=0.03). The combined stability of the spine root (0.52 ± 0.03) was lower compared to the other regions of the spine in subjects with recurrent LBP.

CONCLUSION: The kinematic changes of postural stability are different based on dominance side and visual feedback between subjects with and without recurrent LBP. Possible kinematic rehabilitation training of the core spinal axis could be used in the prevention of falls. Follow-up randomized controlled trials are needed to investigate the characteristics of postural adjustability in order to enhance both biomechanical and neuromuscular function in subjects with recurrent LBP.

SPIN_P2.9 PROCESSING OF CONFLICTING PROPRIOCEPTIVE SIGNALS DURING STANDING IN PEOPLE WITH AND WITHOUT RECURRENT LOW BACK PAIN

Ms Lotte Janssens, University of Leuven

A/Prof Simon Brumagne, University of Leuven; Ms Madelon Pijnenburg, University of Leuven

INTRODUCTION: Proprioceptive input from leg and trunk muscles plays an important role in balance control. Previous studies investigated the role of proprioception of particular body segments through local muscle vibration on ankle or back muscles, respectively. However, little is known about the spatial reweighting of proprioceptive input during simultaneous vibration on different body locations.

AIM: To assess the proprioceptive weighting mechanisms during conflicting proprioceptive signals during standing in individuals with and without low back pain (LBP).

METHODS: Postural sway characteristics of 34 healthy young individuals (H) and 13 young individuals with recurrent LBP were evaluated on a force plate during upright standing on a stable and unstable support surface (i.e., foam pad), respectively. Center of pressure (CoP) displacement was determined with vision occluded in three muscle vibration conditions as follows: 1) triceps surae (TS) vibration; 2) erector spinae (ES) vibration; 3) concurrent TS-ES vibration. Muscle vibration (60Hz, 0.5 mm), a strong stimulus of Ia afferents, was initiated 15 seconds after the start of the trial for the duration of 15 seconds. When TS are vibrated and the central nervous system (CNS) is using these signals for postural control, a postural sway in backward direction is expected. When ES are vibrated, a healthy subject is expected to show a postural sway in forward direction.

RESULTS: All subjects shifted their CoP posteriorly during TS vibration and anteriorly during ES vibration, both on stable (H= -8.4±3.7cm, LBP= -11.4±4.7cm and H= 4.5±3.6cm, LBP= 4.1±3.3cm, respectively) and unstable support surface (H= -4.8±2.7cm, LBP= -8.5±2.6cm and H= 7.5±3.5cm, LBP= 4.8±1.3cm, respectively). Concurrent TS-ES vibration resulted in a similar posterior sway as in the TS vibration only condition when standing on a stable support surface (H= -7.7±5.1cm, LBP= -9.2±4.9cm, $p > 0.05$). However, on an unstable support surface all healthy individuals significantly decreased reliance on ankle proprioceptive signals compared to the stable support surface condition (-0.1±2.8cm, $p < 0.001$). In contrast, the individuals with LBP still showed a significant posterior sway compared to the healthy individuals (-3.8±3.6cm, $p < 0.005$).

CONCLUSION: The CNS decreased the reliance on ankle proprioceptive signals and switched to a more multi-segmental control strategy when the postural task complexity increased (foam pad condition) in healthy individuals. However, individuals with LBP did not show this capacity to gate conflicting proprioceptive signals (ankle versus back) adapted to the specific postural needs.

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SPIN_P2.10 QUANTIFYING FAVOURABLE LOW BACK MUSCLES DURING QUIET SITTING AND STANDING: PRINCIPAL COMPONENT ANALYSIS (PCA) BASED APPROACH

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INTRODUCTION: There are many assessment methods for Low Back Pain (LBP) based on the surface electromyography (sEMG) signals. Nevertheless, there is no consensus about the most appropriate muscles to be recorded. Principal Component Analysis (PCA) is a method of data reduction that aims to produce a small number of derived variables that can replace a larger number of original variables with minimum loss of information. We used PCA to calculate the most appropriate muscles to be recorded for sEMG based LBP assessment.

AIM: We recorded sEMG signals on 3 healthy subjects, and 3 patients with LBP during quiet sitting and standing. Then, we applied PCA on sEMG in order to quantify the most appropriate muscles to be recorded.

METHODS: We acquired 8-channel sEMG from the erector spinae (ES), latissimus dorsi (LD), quadratus lumborum (QL), and oblique external (OE) muscles on the left and right side of the back. Subjects were instructed to sit/stand still for 25 seconds, and then to follow the therapist's instructions for posture improvement and to sit/stand still for another 25 seconds. We cropped sEMG signals into 5-second intervals before and after therapist's correction. Then, we applied PCA on modified sets of data, in which we eliminate a pair of muscles one by one. Initial conditions necessary to apply PCA were checked with the determinant (< 0.00001), the Kaiser-Meyer-Olkin (KMO) (> 0.5), and the Bartlett's test of sphericity ($p < 0.05$) methods.

RESULTS: PCA showed that in 30% of data sets, when omitted right and left LD muscles, the loss of information was minimal compared to other data sets (for ES 25 %, for QL 10 %, and for EO 25 %). The maximum loss of information was found in 45 % of data sets when QL was omitted compared to other data sets (for ES 25 %, for LD 20 %, and for EO 25 %). In 6 % of data set, we could not apply PCA, since the initial conditions were not met.

CONCLUSION: The results indicate that the most important muscle for posture correction during both quiet standing and sitting, both in patients and healthy subjects is QL, while the least information is carried by the LD muscle. Nevertheless, future experiments with larger sample size, and larger number of recorded muscles should be performed in order to confirm obtained results.

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ULTRASOUND: MUSCLE & TENDON

USMT_P1.1 ACUTE EFFECT OF STATIC STRETCHING ON THE STIFFNESS OF HUMAN GASTROCNEMIUS MUSCLE ASSESSED WITH ULTRASOUND SHEAR-WAVE ELASTOGRAPHY

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INTRODUCTION: Stretching exercises for the gastrocnemius are commonly prescribed to increase the range of motion for ankle dorsiflexion for fitness and rehabilitation. However, the magnitude and duration of changes in the stiffness of muscle belly with stretching exercise are unknown. Recent development of novel ultrasound shear-wave elastography has opened the possibility for objectively quantifying muscle stiffness (Shinohara et al. 2010).

AIM: To examine the acute effect of static stretching on the localized muscle stiffness of gastrocnemius belly in vivo with the novel ultrasound shear-wave elastography.

METHODS: Ten healthy volunteers (5 men and 5 women; age: 21.8 ± 1.2 years, height: 167.1 ± 6.0 cm, body mass: 60.0 ± 8.6 kg) performed standing wall stretching that consisted of dorsiflexion to the participants' volitional end range of motion (ROM) and holding the position for 5 min with brief breaks every minute. Longitudinal ultrasonic images of the medial (GM) and lateral (GL) gastrocnemius muscles were obtained at 30% proximal of the right lower leg length while the subject was relaxed at the neutral ankle position and knee full extension in the prone position. From these images, muscle stiffness was assessed before (pre-stretching), immediately after (post-stretching), and at 5, 10, 15 and 20 minutes after stretching with ultrasound shear-wave elastography (AixPlorer; Supersonic Imagine, France). Based on shear-wave propagation velocity, muscle stiffness was quantified in kPa on spatial average of Young's modulus in each muscle fascicular area.

RESULTS: The reproducibility of Young's modulus was confirmed by the intra-rater intraclass correlation coefficient (0.98 for GM, 0.96 for GL) between measurements. After the stretching, ROM increased ($p < 0.05$) immediately by 3.9 ± 1.2 deg (31%) and returned to the baseline in 20 min. Compared with the pre-stretching value (GM: 27.6 ± 5.9 kPa, GL: 22.1 ± 4.4 kPa), Young's modulus decreased ($p < 0.05$) at post-stretching (GM: 23.6 ± 3.3 kPa, by 12%; GL: 19.0 ± 3.6 kPa, by 13%) and up to 15 min after stretching (GM: 24.4 ± 3.9 kPa at 5 min, 25.0 ± 3.7 kPa at 10 min; GL: 19.8 ± 3.3 kPa at 5 min, 19.2 ± 2.7 kPa at 10 min, 20.4 ± 3.0 kPa at 15 min).

CONCLUSION: The findings indicated that a 5-min static stretching decreased the resting gastrocnemius stiffness by12-13% that returned to baseline levels within 15-20 minutes. Quantification of muscle stiffness with stretching would provide useful information for clinicians to develop effective treatments for improving joint flexibility.

USMT_P1.2 VALIDITY OF MEASURING FASCICLE LENGTH OF THE VASTUS INTERMEDIUS IN CADAVERS DIRECTLY AND BY ULTRASONOGRAPHY

Mr Ryosuke Ando, Nagoya University

Prof Masaki Katayose, Sapporo Medical University; Prof Keiichi Akita, Tokyo Medical and Dental University; Prof Mineko Fujimiya, Sapporo Medical University; A/Prof Hiroshi Akima, Nagoya University; Mr Akira Saito, Nagoya University; Mr Keigo Taniguchi, Sapporo Medical University

INTRODUCTION: The velocity of muscle contraction is closely related to the fascicle length of the activating muscles (Burkholder et al. 1994), which is considered an important functional property of skeletal muscle. The quadriceps femoris (QF) plays a significant role in human movement, but little is known about the vastus intermedius (VI) because of its anatomical location and/or undefined specific function during knee joint actions. Furthermore, the anatomical characteristics of the VI, such as fascicle length estimated based on medical imaging or on direct measurements during dissection have not been documented in detail.

AIM: The aim of this study is to determine the validity of fascicle length estimated using ultrasonography by comparing with direct measurement of that in cadavers.

METHODS: The fascicle length of the VI and vastus lateralis (VL) of eight legs in five cadavers was measured (mean posthumous age, 83.0 ± 5.0 years), which were fixed by Thiel method (Benkhadra et al. 2011). Longitudinal ultrasonographic images were acquired from the skin surface of the VL at the mid-thigh to visualize the VI and VL. Fascicle length was measured from ultrasonographic images using linear extrapolation as described (Austin et al. 2010; Blazevich et al. 2009). The skin and subcutaneous fat were then removed and the layers of VI and VL were cut parallel to the visible fascicle direction. The length of visible VI and VL fascicles were directly measured using a caliper. We used the Wilcoxon test and intraclass correlation coefficients (ICC) to compare the validity of values estimated ultrasonographically with those measured directly.

RESULTS: Ultrasonographic images of the VI and VL were obtained from all eight legs, and these were sufficient to estimate fascicle length. The estimated and directly measured values at each muscle did not significantly differ (VI, 81.4 ± 15.2 mm vs. 79.2 ± 12.5 mm, $p = 0.26$; VL, 82.3 ± 7.7 mm vs. 85.1 ± 7.1 mm, $p = 0.12$). The ICC (3,1) values between the estimated and directly measured lengths of the VI and VL were 0.859 and 0.753, respectively.

CONCLUSION: The length of fascicles of the VI were estimated using linear extrapolation with less than 2% error, which was slightly smaller than the VL estimated by ultrasonography (3%). This information improves understanding of the functional properties of the VI and provides a unified comprehension of the human QF.

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USMT_P1.3 A NEW MATRIX OF ELECTRODES TRANSPARENT TO ULTRASOUND: DESIGN AND TEST

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INTRODUCTION: Simultaneous quantification of muscle movement and activation is currently limited to different muscle regions. Sampling ultrasound (US) images and sEMG from the same muscle region would require the US probe to lie over the electrodes. In this case, the view of muscle tissue would be hindered by the acoustic impedance of conventional electrodes while the US gel interposed between US probes and skin would likely lead to short-circuits.

AIM: To overcome such limitations we developed and tested a new EMG system transparent to US.

METHODS: Our matrix of electrodes combines a sticky and a dense layer of silicon. The sticky layer provides adherence to the skin and minimizes echoes due to air bubbles. The dense layer, supports a flexible printed circuit. Individual wires connect the printed circuit to 8x4 circular cavities (5mm diameter; 1cm distance) in the sticky layer. Electrical contact between wires and skin is ensured by filling cavities with conductive paste. The acoustic impedance of these layers and the skin are similar, ensuring negligible echo at the skin-matrix interface.

Electrode-skin contact was characterized by impedance measurements taken in the frequency band 10Hz-1kHz. To test for potential interference from US probe on sEMG, M-waves were detected from the medial gastrocnemius of five subjects, with and without the US probe on the matrix. The number of channels showing artefacts or missing contacts and the normalized mean square error (NMSE) between M-waves acquired in both conditions were regarded as quality indexes. The quality of US images was tested by quantifying movement of a spring immersed in a customized phantom. With a motorized device, sinusoidal changes were applied to the spring length with regular amplitudes (0.2-0.7mm) and frequencies (0.2-3.0Hz). Changes in spring length were estimated from US images collected with and without the EMG-US matrix.

RESULTS: Electrode-skin impedance was comparable with that obtained with conventional electrodes of similar size. The likelihood of observing missing contacts and movement artefacts in sEMG was not affected by the US probe on the matrix. Similarly, NMSE between M-waves recorded with and without US probe was 2.7±1.8%. Regardless of how fast or how largely the spring moved, no significant differences were found between the predicted length change of the spring with and without the matrix.

CONCLUSION: Results indicate that the matrix allows joint sEMG and US investigations from the same portion of muscle without significant distortions of both US images and sEMG.

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USMT_P1.4 MEDIAL GASTROCNEMIUS MOVEMENT AND ACTIVATION ARE ASSOCIATED LOCALLY: SINGLE CASE STUDY

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INTRODUCTION: Different methods have been used for the investigation of skeletal muscle activation. Indwelling electrodes, for example, provide electromyograms (EMGs) directly related to the action potentials of nearby muscle fibres. When collected from the skin surface, instead, EMGs ensure a global, though indirect, representation of muscle activity. Ultrasonography can quantify muscle movements, which at low levels of activation will result from interaction between active and passive tissue components. The spatial association between myoelectric activity and the resulting changes in muscle shape has however yet to be quantified.

AIM: We investigate the local correspondence of activation and movement of medial gastrocnemius (MG) fascicles. If MG contracts as a single volume, then, we would expect the movement of fascicles within a single ultrasound (US) view to correlate equally strongly with surface EMGs detected at different calf regions.

METHODS: A new matrix of electrodes (8x4 electrodes; 1 cm IED) transparent to US was used to sample surface EMGs from different MG regions. The matrix was positioned on the left calf of one male subject, with its centre roughly located at the muscle belly (i.e., electrodes covered the superficial aponeurosis). Digitized US images (80 fps) were taken along the MG length with a linear probe aligned parallel to, and positioned between, columns 2 and 3. US images and EMGs were recorded while the subject isometricaly performed: i) a series of sporadic bursts of plantar flexion torque, at 2% MVC and; ii) staircase profile of plantar flexion torque (4–8–12–8–4 %MVC) lasting 50s. Local modulation in MG activity was calculated by squaring and low-pass filtering (4 Hz) each single-differential EMG. Spatial cross-correlation applied to US images was used to calculate changes in muscle length, defined by movement of 16 regions-of-interest defining deep and superficial borders of the fascicle region.

RESULTS: Average movement correlated locally with MG activation. Regardless of whether the subject performed sporadic or continuous plantar flexions, correlation coefficients were higher for channels located closer to the probe central location. Interestingly, correlation between movement and EMG activity in the longitudinal direction was about 2.5 times larger than that in the transversal direction.

CONCLUSION: If results observed here extend to the sample of 12 subjects currently being analysed, then, MG movement is likely associated to activation of fibres residing nearby the field of view of US probes.

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USMT_P1.5 THE ACUTE EFFECTS OF STATIC STRETCHING AND HOLD-RELAX STRETCHING ON MUSCLE STRENGTH, ELECTROMYOGRAPHIC ACTIVITY AND MUSCLE STIFFNESS

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INTRODUCTION: Static stretching (SS) and hold-relax stretching (HRS) are common methods for improving flexibility and performance. However, whether or not there are differences between acute effects of SS and HRS on muscle strength, electromyographic activity, and muscle stiffness is unclear.

AIM: This study aimed to investigate the differences between acute effects of SS and HRS on muscle strength, electromyographic activity, and muscle stiffness of gastrocnemius.

METHODS: The subjects comprised 18 healthy males (mean age: 21.9 ± 1.2 years). SS and HRS were performed on the same subject with at least 1-week interval. SS of 2 min comprised 4 repetitions of SS maneuver, which was held at the maximum dorsiflexion angle, i.e., the maximum angle achieved by the participants without pain, for 30 sec. HRS of 2 min comprised 4 repetitions of HRS maneuver, which was held at the maximum dorsiflexion angle after 5 sec of maximum isometric contraction of plantar flexors. The maximum isometric strength of plantar flexors and electromyographic activity were measured before and immediately after SS and HRS. Muscle strength of plantar flexors was measured at a 0° ankle angle. The electromyographic activity of medial and lateral gastrocnemius and tibialis anterior muscles was measured using an electromyogram system during measurement of muscle strength, and the root mean square for a 3-sec period was calculated. The change in passive torque was measured using a dynamometer, while the ankle was passively dorsiflexed from 0° to 30°. Muscle-tendon junction (MTJ) displacement during passive dorsiflexion was simultaneously measured by ultrasonography. Muscle stiffness was defined as the value obtained by dividing the change in passive torque by MTJ displacement. For all variables, significance of differences between before and immediately after stretching was determined using the Wilcoxon signed-rank test. The change rates (%) before and after stretching were calculated. Differences between the change rates of SS and HRS were determined using the Mann–Whitney U test. Differences were considered statistically significant at an alpha level of $P < 0.05$.

RESULTS: Muscle strength and muscle stiffness decreased significantly after both SS and HRS. There was no significant difference in electromyographic activities before and immediately after SS and HRS. The decrease rate of muscle strength in SS was significantly higher than that in HRS. The decrease rate of muscle stiffness in SS was also significantly higher than that in HRS.

CONCLUSION: These results suggested that both SS and HRS have acute effects on muscle strength and muscle stiffness of gastrocnemius; however, effects of SS are greater than those of HRS.

USMT_P1.6 MUSCLE-TENDON INTERACTION DURING THE DOLPHIN KICK

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INTRODUCTION: In human running, impact force can be stored and utilized as elastic energy. In swimming, however, it remains questionable whether elastic energy are utilized during human movements under water.

AIM: The purpose of the present study was to examine the muscle-tendon behavior during the dolphin kick under water.

METHODS: In the swimming pool, each subject (n=7) was requested to perform the dolphin kick movement during swimming and was restrained by the tube belt during dolphin kick. Surface EMGs in the vastus lateralis (VL) and biceps femoris (BF) muscles as well as the knee joint angular data by goniometer were measured. Fascicle lengths of VL were determined using ultrasound. Instantaneous muscle-tendon unit (MTU) length of VL during swimming were estimated by knee joint angular data and the tendon length of VL was calculated by subtracting the horizontal part of fascicle length in the direction to the aponeurosis from the MTU length.

RESULTS: The VL MTU was stretched by 77±13 mm and was shortened by 73±14vmm. The VL fascicles and tendon were stretched by 17±15 and 59±18 mm, respectively. Those following shortening amplitudes were 16±16 and 56±17 mm, respectively. When the knee was flexed (the stretch phase of the VL muscle), the EMG of the pre-activated and stretch phases were very low. In the following knee extension phase (the shortening phase of VL muscle) , the VL muscle was activated.

CONCLUSION: During dolphin kick, the VL fascicle and tendon may behave similarly to the VL MTU. However, the muscle activation profiles did not follow the stretch-shortening cycle concept. The tendon elasticity may play important role during human movements not only on land but also under water. However, there is a specific muscle-tendon interaction during the dolphin kick movement under water.

USMT_P1.7 EFFECTS OF TENDON STRAIN MAGNITUDE ON THE TENDON STIFFNESS IN HUMAN MEDIAL GASTROCNEMIUS IN VIVO.

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INTRODUCTION: Tendon serves as an elastic linkage between bone and muscle. The alteration of structural and material properties allows tendon to adapt to mechanical loading environment. Tendon mechanical properties are influenced by frequency, duration and magnitude of load. In a previous study, contraction of long durations led to a significant change of tendon stiffness, however contractions of short durations led to no changes. Kubo et al. showed that tendon stiffness was influenced by tendon strain magnitude using joint range of motion (ROM). However, these studies have not directly assessed tendon strain magnitude.

AIM: The aim of the present study was to investigate the effects of tendon strain magnitude on the tendon properties of the human medial gastrocnemius (MG) in vivo.

METHODS: Seven male and seven female volunteers performed two separate exercises. The first one was a HDB (heel-drop exercise on a block). The other one was a HDL (heel-drop exercise on level floor). Two exercise regimens were executed 1-month apart from each other. The subjects completed a session of 150 heel-drop exercises. Before and immediately after the heel-drop exercise, all subjects were evaluated for ankle plantarflexor torque and stiffness of the MG tendon. A dynamometer was used to determine ankle joint torque during maximum isometric at 10 degrees plantarflexion. Ultrasound imaging technique was used to visualize musculotendinous junction of the MG and to determine tendon elongation. Furthermore, Infrared cameras were used to measure distance from distal end of linear probe to insertion of calcaneus, allowing for the measurement of tendon strain.

Differences in stiffness of the MG tendon between HDB and HDL were compared using a paired t-test at a significance level $\alpha = .05$.

RESULTS: In the present study, tendon strain in HDB was significantly greater than on HDL ($p<.05$). The results showed that increase in tendon stiffness following HDB was significantly greater than that following HDL ($p<.05$).

CONCLUSION: For acute exercise, tendon stiffness was found to be influenced by magnitude of tendon strain. Possible reasons of the results could be attributed to tendon CSA (cross-sectional area) and/or intrinsic structural changes. Although we could not provide tendon CSA, no acute change in the CSA of the MG tendon would be the main reason for the change in tendon stiffness based on the findings of previous studies. It seems that the magnitude of tendon strain might result in intrinsic structural changes, rather than changes in the tendon CSA.

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USMT_P1.8 ASSOCIATIONS OF MUSCLE STIFFNESS AND THICKNESS WITH MUSCLE STRENGTH AND MUSCLE POWER IN ELDERLY WOMEN

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INTRODUCTION: It is well established that muscle mass decreases with age, and that the loss of muscle mass contributes to muscle weakness. Previous studies have reported that skeletal muscle viscoelastic stiffness (muscle stiffness), quantified by a soft-tissue stiffness meter probe, also influences strength generation in healthy young subjects. However, age-related changes in muscle stiffness and the effects of muscle stiffness on strength generation in elderly people are unclear.

AIM: The aim of this study was to investigate the influences of age on muscle stiffness and to examine the relationship of muscle stiffness and muscle thickness with muscle strength and muscle power in elderly women.

METHODS: The subjects were 16 healthy young (mean age 20.3 years) and 34 healthy elderly (mean age 84.2 years) women. Muscle stiffness of the right quadriceps femoris muscle was measured at rest and during a maximal voluntary isometric muscle contraction using a myotonometer, a computerized, electronic tissue compliance meter. Muscle stiffness, defined as the quantified amount of force required per tissue displacement, was determined by the value dividing the pressure by the displacement distance as the probe was pressed onto the skin overlying the muscle with a pressure of 15 N. Muscle thickness, including the rectus femoris and the vastus intermedius was measured using B-mode ultrasound imaging with an 8-MHz transducer. Quadriceps strength and the chair stand test were used to represent muscle strength and muscle power, respectively. Quadriceps strength of the right side was measured with a hand-held dynamometer during maximal isometric contraction of the knee extensor. The chair stand test measured the time required to stand five times from a standard chair.

RESULTS: There were significant differences in muscle stiffness between resting and contracted conditions among the young but not among the elderly women. Muscle stiffness during contraction, the rate of change in muscle stiffness during contraction, and muscle thickness were significantly greater in young women than in elderly women. Pearson correlation coefficient analyses showed that muscle stiffness during contraction and the rate of change in muscle stiffness during contraction were significantly associated with muscle power in elderly women, whereas no correlation was found between muscle strength and muscle stiffness.

CONCLUSION: This study suggests that the increase in muscle stiffness during voluntary muscle contraction is limited in elderly women compared with young women, and that muscle stiffness may be related to muscle power rather than muscle strength in elderly persons.

USMT_P1.9 NEW METHODOLOGY FOR POSITIONING THE ULTRASOUND PROBE TO IMAGE THE ABDOMINAL MUSCLES — A PILOT STUDY

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INTRODUCTION: Ultrasound imaging is a new tool in both research and physical therapy practice. Because it is non-invasive and includes a feature to show both the static and dynamic function of muscle tissue, it becomes an indispensable tool for this work.

AIM: To investigate whether a new positioning of the ultrasound probe may facilitate the uptake of architecture parameters of the abdominal muscles.

METHODS: One male and one female participant were chosen for this pilot experiment. The female participant was 32 years of age, with a body mass of 56kg and height of 1.60m. The male participant was 28 years of age, with a body mass of 70kg and height of 1.75m. Both subjects provided written consent prior to commencement of the study. They were instructed to assume a supine position with the hips and knees flexed. The ultrasound device used for this experiment was an Aloka SSD 4000 set at 51 Hz, with a probe of a linear array of 60 mm in diameter and penetration depth of 7.5 Mhz (ALOKA Inc. Tokyo, Japan). Evaluations were conducted of the following parameters: area cross section; total muscle length; muscle thickness; fascicle length; and angle of penation. The positioning of the ultrasound probe was done in a manner different from that consistently reported in the literature. Rather than simply positioning the probe on the abdominal wall in a horizontal and/or vertical position, followed by the orientation of space according to the guidelines described by Lieber et al., 2010, made in the fresh corpses to the position of the external obliquus muscles, internal obliquus muscles and transversus abdominis muscles. Through this spatial configuration, the ultrasound probe was positioned at 125° for the external obliquus muscles at 145° for the internal obliquus muscles, and 170° for the transversus abdominis muscles in relation to horizontal plan.

RESULTS: Regarding the qualitative aspects of ultrasound imaging, the position taken in this study allowed for greater clarity and ease in viewing muscle architecture parameters.

CONCLUSIONS: This new methodology for positioning the ultrasound probe over the abdominal muscles yields encouraging results in enabling visualization of the parameters tested in this pilot study.

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