ISEK 2014

XX Congress of the International Society of Electrophysiology and Kinesiology

BOOK OF PROCEEDINGS

Welcome to ISEK 2014

Dear Participants, dear Colleagues,

We are proud that Rome was the city chosen for the XX ISEK Congress and we are honored to have organized this event with the supervision of the ISEK Council.

Rome University Foro Italico is unique in Italy, being the sole to be entirely dedicated to human movement and sport sciences. Since many years, the research in motor control, neurophysiology of movement, biomechanics, motor rehabilitation and apllied sciences in exercise and sport, have been of vital importance to the University, the Faculty of Movement Sciences, and to the range of companies involved in the translational aspects of this research. We are relatively young; however our effort in biomechanics and biomedical engineering, exercise physiology, motor control and training, health and exercise has been already appreciated by the national and international academic community.

We are grateful to the Rector of our University, Fabio Pigozzi, for supporting and sponsoring this event. The Department of Movement, Human and Health Sciences is committed to establish and disseminate technological and medical competencies within the health scene. The Department is represented in the Council of the Society for Electrophysiology and Kinesiology and in the Editorial Board of its Journal since several years. As in previous ISEK congresses, this Congress will be the occasion for the exchange and discussion of new ideas within the broad field of electrophysiology and kinesiology. The Congress program links all the aspects of movement function in healthy and pathological conditions, as part of an integrated approach which includes biomechanics, motor control, neurophysiology of movement, and motor rehabilitation.

Several outstanding Keynote Lecturers will provide the frame for this program by covering aspects of neural control of movement, rehabilitation, and sports science. We thank all of them for accepting our invitation.

The program is further enriched by a series of Special Sessions on advanced topics and by six Pre-congress Workshops. The organizers of the Workshops and Special Sessions have provided a major scientific contribution to this event.

We are also grateful to the many people who helped organizing this Congress, particularly to the staff of the Congress Secretariat by DueCi Promotion, to Claudia Marvisi (graphic designer) and to the whole crew of the Exercise Physiology Laboratory. We like also to thank Elsevier that sponsored the K.P. Granata Award.

Finally, we particularly thank you all for coming to Rome and participating in the XX Congress of the International Society of Electrophysiology and Kinesiology.

Our hope is to provide a platform for constructive discussion and integration of approaches from different disciplines, which is a tradition of ISEK. Our efforts will be fully rewarded if the event will stimulate new ideas in young and senior researchers and new collaborations. We will do our best to make your stay in Rome enjoyable and fruitful.

Francesco Felici (Congress Chairman)

Ilenia Bazzucchi (Congress Scientific Chair)

Alessandra Conti (Congress Scientific Chair)

Leonardo Gizzi (Congress Scientific Chair)

Andrea Macaluso (Congress Scientific Chair)

Massimo Sacchetti (Congress Scientific Chair)

Paola Sbriccoli (Congress Scientific Chair)

Local Scientific and Organizing Committee

Conference Chair:

Francesco Felici, MD,
Head of Exercise Physiology Lab - LIFE
Department of Movement, Human and Health Sciences
University of Rome "Foro Italico"

Committee Members

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Alessandra Conti, BSc
Francesco Figura, MD
Andrea Macaluso, MD, PhD
Massimo Sacchetti, PhD
Paola Sbriccoli, MD, PhD

Leonardo Gizzi MEng, PhD

International experts panel

Moshe Solomonow, PhD
Editor in Chief, Journal of Electromyography & Kinesiology, U.S.A.

Roberto Merletti, PhD
Laboratory for Engineering of the Neuromuscular System (LISiN), Politecnico di Torino, Torino, Italy

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Scientific Program

Keynote Lectures

Basmajian Lecture

MOTOR CONTROL, BIOMECHANICS, STABILITY & TISSUE BIOLOGY OF THE LUMBAR SPINE IN REPETITIVE LOADING; A MODEL OF CUMULATIVE EXPOSURE DISORDER.

Solomonow M.
Musculoskeletal Disorders Research Lab, Bioengineering Division, Dep of Orthopedic Surgery.
University of Colorado, Denver, CO., USA

Cumulative lumbar disorder is common in individuals engaged in long term performance of repetitive and static occupational/sports activities with the spine. The triggering source and of the disorder, the tissues involved in the failure and the biomechanical, neuromuscular, and biological processes active in the initiation and development of the disorder are not known. The hypothesis is forwarded that static and repetitive (cyclic) lumbar flexion-extension and the associated repeated stretch of the various viscoelastic tissues (ligaments, fascia, facet capsule, discs, etc.) causes micro-damage in their collagen fibers followed by an acute inflammation, triggering pain and reflexive muscle spasms/hyper-excitability. Continued exposure to activities, over time, converts the acute inflammation into a chronic one, viscoelastic tissues remodeling/degeneration, modified motor control strategy and permanent disability. Changes in lumbar stability are expected during the development of the disorder.
A series of experimental data from in-vivo feline is reviewed and integrated with supporting evidence from the literature to gain a valuable insight into the multi-factorial development of the disorder. Prolonged cyclic lumbar flexion-extension at high loads, high velocities, many repetitions and short in between rest periods induced transient creep/laxity in the spine, muscle spasms and reduced stability followed, several hours later, by an acute inflammation/tissue degradation, muscular hyper-excitability and increased stability.
The major findings assert that viscoelastic tissues sub-failure damage is the source and inflammation is the process which governs the mechanical and neuromuscular characteristic symptoms of the disorder. A comprehensive model of the disorder is presented. The experimental data validates the hypothesis as well as provide insights into the development of potential treatment and prevention of the disorder.

MUSCLE-TENDON INTERACTION DURING EXERCISE AND FATIGUE: SPECIFIC RELEVANCE TO SPORT

Komi P.

Professor Emeritus - University of Jyväskylä
Founder of the Biomechanics Research Lab

It has been a long experience that when two locomotor activities such as vertical jumps are performed in succession, the second one is consistently higher than the first one. This potentiation effect due to countermovement action was later called as “wind-up” movement (Asmussen and Sorensen 1971) until Norman and Komi (1979) named it as stretch-shortening cycle (SSC). SSC is the natural way the skeletal muscles function during locomotion, and it has been mostly demonstrated in walking, running, jumping and throwing. The fundamental characteristics of SSC have been examined quite extensively with isolated muscle models (e.g. Cavagna et al, 1965 and 1968) and also with human muscles (e.g. Bosco et al 1981; Komi, 1983). By definition, SSC refers to the lengthening (stretch) of the active muscle followed immediately by shortening in the push-off phase of the leg extensor muscles, for example. The basis for the use of SSC instead of pure concentric muscle actions is simple: the neuromuscular system makes an effort to perform the movement as efficiently as possible. In SSC the active stretching phase (eccentric phase, also called negative work) allows storage of elastic energy which can be utilized partly in the subsequent shortening (concentric phase; positive work). The centrally controlled preactivation combined with the active eccentric phase prepare the muscle to receive the “impact” and store this elastic energy. The passive (non-active) muscle can only store a minimum amount of elastic energy.

One very important point in the discussion of SSC potentiation is the interaction between fascicles and tendon structures. The definition of SSC as given above, relates to the entire muscle–tendon unit (MTU), and consequently the mechanisms may be too simplified. In fact the fascicles may not necessarily, and in some instances not at all, follow the stretch-shortening pattern of MTU. Depending on the imposed impact load the fascicles may show lengthening, which can be very short- lived and consequently the possible reflex induced force potentiation may not be visible with standard type Ultrasound machines of lower scanning frequency (Ishikawa and Komi, 2008). The present report will emphasize how this fascicle-tendon interaction will be influenced by the type of muscles, intensity of effort, aging process, fatigue and training. It is believed that considerable amount of information is already available to demonstrate how this interaction applies to various sport activities. The very latest observation points to the influence of specific type of training on the fascicle-tendon interaction. Depending on the type of training, i.e. when the short contact hopping training on the ground is compared with the longer contact jumps in trampoline, the adaptation processes differ considerably between these two athlete groups. The short contact training results in specific adaptations in the fascicles making them grow less than the training with the longer contact hopping. There are also considerable differences in adaptation of the activation profiles of the muscles including the onsets of the EMG activity before contact on the ground. This type of specific influence emphasizes that the behavior of the human neuromuscular function is under very specific control systems which make its understanding more and more interesting, but also more challenging.

TELEREHABILITATION: USING AMBULATORY SENSING AND PERSONALISED FEEDBACK TO COACH PEOPLE WITH CHRONIC DISORDERS

Hermens H.

Roessingh Research & Development.
Professor Telemedicine at University of Twente, Research Institutes Mira and CTIT

The growing number of people with chronic disorders in our western society puts a great pressure on our healthcare system. Primary chronic conditions cannot be cured but daily behavior has a major effect on the severity of secondary problems and quality of life. Changing behavior however requires intensive support during daily activities, which is not feasible with a human coach.

A new coaching approach is feasible by combining Biomedical Engineering with Information and Communication Technology, creating so-called Personal Health Systems (PHS). These mobile health systems use on body sensing, combined with smart reasoning and context aware feedback to support the user with developing and maintaining a healthier behavior.

Three examples of PHS will be given:

(1) Treatment of neck/shoulder pain. EMG patterns of the Trapezius muscles are used to estimate their level of relaxation and personal vibrotactile feedback is given, to enable the person to learn when his muscles are insufficiently relaxed. This PHS has been evaluated in several experimental studies with positive results and in a large clinical trial in the European Myotel project.

(2) Promoting a healthy activity pattern. Using a 3D accelerometer sensor wirelessly connected to a smartphone the user is given feedback about his activity pattern in relation to his personal goal. Here the focus is on the optimization of timing and content of the feedback in real time, using machine learning techniques, to optimize adherence. Several clinical studies were carried out showing that activity patterns can be changed

(3) Management of stress during daily living. Here the focus is till on the quantification of stress using a combination of different sensor signals (EMG, ECG, skin conductance, respiration). The challenge is to determine a personal model that enables real time assessment of the level of stress. Lab experiments as well as free living experiments have been carried out showing that modeling stress is feasible but requiring an individual approach.

The rapid development of suitable ambulant sensors during the past years and the increasing power of smartphones do make Personal Health Systems feasible and consequently a promising and challenging way forward to promote healthy behavior in people with chronic conditions.

MUSCLE ACTIVITY PATTERN DEPENDENT PAIN DEVELOPMENT AND ALLEVIATION

Sjøgaard G.

Professor - University of Southern Denmark
Chief investigator - Queensland University

Muscle activity is a cornerstone in physical activity during work and leisure, and is for decades considered to provide health benefits irrespectively of the muscle activity pattern performed and whether it is during e.g. sports, transportation, or occupational work tasks. Accordingly the international recommendations for public health-promoting physical activity do not distinguish between occupational and leisure time physical activity. However, in this body of literature, attention has not been paid to the extensive literature documenting occupational physical activity to impair health - in particular musculoskeletal health in terms of muscle pain. Focusing on muscle activity patterns and musculoskeletal health more specific aspects regarding exposure profiles and body regional pain is pertinent. Static sustained muscle contraction for prolonged periods often occur in the neck/shoulder area during occupational tasks and may underlie muscle pain development in spite of rather low relative muscle load. Causal mechanisms include a stereotype recruitment of low threshold motor units (activating type 1 muscle fibers) characterized by a lack of temporal as well as spatial variation in motor unit recruitment. In contrast during physical activities at leisure and sport the motor recruitment patterns are more dynamic including regularly relative high muscle forces – also activating type 2 muscles fibers - as well as periods of full relaxation. Such activity is unrelated to muscle pain development. However, delayed muscle soreness may develop following extensive eccentric muscle activity (e.g. down-hill skiing) with peak pain levels in thigh muscles 1-2 days after the exercise bout and a total recovery within 1 week. This is in contrast to the chronic muscle pain profile related to repetitive monotonous work tasks. The painful muscles showed adverse functional, morphological, hormonal, as well metabolic characteristics. Of note is that intensive muscle strength training actually may rehabilitate painful muscles, which has been proven repeatedly in randomized controlled trials. The training recovered maximal muscle activation and strength, which allowed for decreased relative muscle load during occupational repetitive work tasks. Exercise training induced adaptation of metabolic and stress-related mRNA and protein responses in the painful muscles, and which was in contrast to the responses during repetitive work tasks per se.

STABILIZATION STRATEGIES FOR UNSTABLE DYNAMICS

Morasso P.

Senior Researcher - Italian Institute of Technology
Director of the Motor Learning Rehab. Lab.

The stabilization of the human standing posture was originally attributed to the stiffness of the ankle muscles but direct measurements of the ankle stiffness ruled out this possibility, leaving open the door to feedback stabilization driven by proprioceptive signals. This solution, however, could be implemented with two different kinds of control mechanisms, namely continuous or intermittent feedback. The debate is now settled and the latter solution seems to be the most plausible one. On the other hand, stabilization of unstable dynamics is not limited to bipedal standing. Indeed many manipulation tasks can be described in the same framework and thus a very general protocol for addressing this kind of problems is the use of haptic virtual reality where instability is generated by some kind of divergent or saddle force field. Several studies have been carried out in this area showing that human subjects can choose to adopt a stiffness or feedback strategy as a combination of biomechanic and task constraints and can learn to switch from one strategy to the other if it is feasible or can be forced to use one or the other is unfeasible. This is relevant for example, for the design of ergonomic man-machine interfaces.

ADVANCED APPROACHES TO FUNCTIONAL ELECTRICAL STIMULATION (FES)

Popovic D.

Professor - University of Serbia
Editor - Journal of Automatic Control

The ultimate goal of the neural engineering implemented for rehabilitation is to improve the quality of life of subjects with sensory-motor impairment. At this point, there is no known rule which technique will work the best and the clinical studies and the feedback from the users are the only measure of the success.

In rehabilitation of movements the aim is to activate joints in a way to restore sensory and motor function as much as possible in humans with sensory-motor impairments. The biological organisms have evolved control systems to suit many of species and physiological functions, while the engineering resulted with very sophisticated methods that are appropriate to suit man-made systems. The two streams are converging in the area of rehabilitation.

This presentation proposes the integration of the two strategies. The strategies implemented in most of rehabilitation devices have so far been fairly simple, and have been developed largely in relation to the design of machines rather than to the design of nervous systems. Recent developments in bioengineering benefit from the neurophysiologic findings and fast grow of computing power and are converging to those in analogous natural systems. Neurorehabilitation is where the two strategies meet. Neurorehabilitation is a method that allows the preserved structures to find their best use if appropriately trained. The intensive, task dependent training shows dramatic effects in the rehabilitation of humans with disabilities and this is facilitated with appropriate modern technology.

Neural engineering is where the ultimate successes is coming. The development of new implantable devices that interface directly the central and peripheral nervous system, strengthen by wireless communication, opens new horizons. The implanted technology and micromachining make dramatic impact and provide that has been difficult to imagine, yet the intelligent control that resembles to natural control is the link that would make this approach into an effective rehabilitation treatment.

In parallel, the current technology allows the quantified assessment. This assessment is necessary to objectively measure functional impairments and identify the biomechanical and neurophysiologic changes caused by the injury or disease. This facilitates essential customization of rehabilitation systems for specific needs of individual patients.

ROLE OF THE LOWER LIMB MUSCLES IN BALANCE CONTROL

Cresswell A.

Professor - Queensland University
President of the International Society of Biomechanics

Introduction: The evolutionary move from quadrupedal to bipedal stance brought with it significant anatomical changes to the foot and lower limbs. The increase in height of the centre of mass as well as the reduced base of support necessary for two limbs stance must have presented a significant challenge to the central nervous system in maintaining balance, which of course underpins the majority of any locomotor activities we perform. For many years, researchers have known that the integration of sensory information from a wide variety of sources in conjunction with appropriate motor commands is vital for postural stability. We also know that changes to the sensorimotor system through ageing or disease can disrupt balance control, leading to poor quality of life and in many cases falls and possible fractures.

The idea that standing balance can be modelled as an inverted pendulum has been a favoured approach in understanding balance control. For quiet standing and even when standing is challenged by small force perturbations, motion about the ankle joint is all that seems to be required. In fact during quiet standing motion about the ankle joint in the sagittal plane is approximately 1.25o at a dominant frequency of approximately 0.35 Hz. These motions result in significant displacements of the centre of mass and the resultant ground reaction force, the latter of which is primarily achieved through activation of the ankle plantar flexors and dorsiflexors.

Here I will present data from several studies that have focused on the sensorimotor function of the lower limbs in quiet standing and during perturbed stance. Our results have shown that sensory input from the plantar flexor muscles is highly dependent upon standing posture, as the amplitude of the Hoffman reflex significantly varies with sway position and sway direction. The sway position and direction effects appear to be limited to changes in excitability at the spinal and corticospinal levels, as revealed by transcranial magnetic and electrical stimulation.

Recent research we have undertaken has focused on the postural role of tibialis anterior muscle during standing. In these studies, electromyographic activity from tibialis anterior was relatively constant; while changes in its fascicle lengths were tightly coupled with changes in sway position. Unlike fascicles from the plantar flexors, the ability of tibialis anterior fascicles to follow sway position suggests that it is well placed to provide accurate and relatively straightforward sensory information about sway position and direction to the central nervous system. Whether this mechanism is maintained during more challenging postural tasks such as support surface translations was also tested. The results indicated a dual role for tibialis anterior in response to forward surface translations. At the start of the perturbation, tibialis anterior has the potential to sense the destabilisation by a stretching of its muscle spindles. Its subsequent activation appears to help correct the postural instability by rapidly moving the centre of pressure backward behind the centre of mass.

The plantar intrinsic foot muscles also have the ability to play a significant role in balance control. Our results indicate that activation of these muscles increases with increasing postural demand and that their activation is significantly correlated with postural sway.

The above findings further support our awareness that the muscles of the lower limbs are integral to the maintenance of standing balance and indirectly provide additional knowledge toward how they may be targeted in both rehabilitation and training.

THE NEURAL CONTROL OF COACTIVATION REVISITED

Duchateau J.

Professor - Free University of Brussels
Director of the Laboratory of Applied Biology

Coactivation is classically defined as the concurrent activation of antagonist muscles during the activation of agonist muscles (Kellis, 1998). It is associated with an active inhibition of the antagonist motor neurones by pathways that are organized to induce inhibition of antagonists (reciprocal inhibition) in parallel with the primary excitation of the agonists (Crone & Nielsen, 1994). Solomonow and co-workers proposed that the functional role for antagonist coactivation is to stabilize the involved joint, to equalize pressure over the articular surface and to prevent relative bone displacement (Solomonow et al., 1988; Baratta et al., 1988).
Coactivation is usually quantified by computing the ratio between the electromyographic (EMG) activity of an antagonist muscle and its EMG activity during a maximal voluntary effort when acting as an agonist. This procedure can lead, however, to technical problems affecting the quantification of antagonist coactivation due, for example, to the non linearity of the EMG to force relation and to the amount of cross-talk. Despite these limitations, it has been reported that the degree of coactivation is modulated as a function of the characteristics of the movement (type of muscle action, angular position, speed,…) and chronic changes in physical activity (training, ageing, …).
It has been proposed many years ago that coactivation is mediated by a descending "common drive" and that the central nervous system controls agonist and antagonist muscles as a single motor neurone pool (De Luca & Mambrito, 1987). However, recent studies from our laboratory reported a very specific spinal modulation of the antagonist muscles during the course of a submaximal fatiguing contraction. Because the agonist-antagonist ratio remained constant during the task, this observation suggests that antagonist coactivation cannot be simply controlled by a centrally mediated common drive (Lévénez et al., 2005; 2008). In contrast, agonist and antagonist muscles should be controlled differently, either by a separate descending drive to their respective motor neurone pool or through a specific modulation of spinal inhibitory pathways.
The main purpose of this talk will be to emphasis the specific modulation of antagonist coactivation in different conditions and to revisit the mechanisms underlying the neural control of coactivation.

Wednesday July 16th 2014

Oral Sessions:

Special Session: Is it time to update existing recommendations for the use of surface electromyography? (Sala Cesarea 9.00-11.00)

Session organizers:
Vieira T, Botter A, Gazzoni M
LISiN – Politecnico di Torino

Session abstract:
Notwithstanding the remarkable, technological advances made on surface electromyography, several basic issues remain open. Motor unit action potentials might now be sampled with hundreds of surface electrodes distributed in different arrangements. As such "high-density" technology opens new fronts to the study of muscle activation, we become progressively more aware of unresolved, crucial issues related to the interpretation of surface electromyograms, be them detected with multiple or with a pair of electrodes.
Some examples of typical open questions certainly tormenting the diligent researchers are: Do I need to use arrays of electrodes to pursue my clinical/applied/basic research goal? What if I have no access to such system of electrodes? What contributions have the use of arrays of electrodes provided to addressing key issues in surface electromyography (e.g., normalisation, crosstalk, inter-electrode distance)? If setting standards in surface electromyography was a difficult task when recordings were limited to the use of a couple of electrodes, standardising the technique in all its form seems an unachievable task. Moreover, considering skeletal muscles present an assortment of architectures and sizes, unifying standards across muscles might not be possible at all. It is perhaps time we consider revisiting the issue of standardisation, using the same rigorous approach conceived in the past (SENIAM concerted action) on one hand and our current understanding on the other hand.
In this special session, we do not wish to address each of the questions posed here, as there might not be a single valid answer to each of them. In this session, we rather wish to promote a collective discussion on whether and how to update existing recommendations in surface electromyography, specifically in relation to the positioning of electrodes.

Outline of the Session

Our key message to participants:
It is perhaps not possible to define general recommendations for the positioning of surface electrodes. The most appropriate electrode positioning depends on the size and architecture of the muscle studied. Most importantly, electrode positioning is strictly related to the question one wishes to answer (i.e., is the research question of interest related to the estimation of conduction velocity, of the degree of muscle activity, of the onset of muscle activity, of the myoelectric manifestation of fatigue or of any other EMG parameter?). Recommendations for electrode positioning should control for these and other issues.

Our short term, chief goal:
An updated structure of recommendations for the positioning of bipolar electrodes will be proposed to participants of the Session. After collecting valuable feedback from participants, we will then identify crucial aspects likely relevant to updating the recommendations for electrode positioning.

Our long term, chief goal:
Our ultimate goal would be collecting and integrating sufficient evidence into a book of guidelines for surface EMG users. These would then be updated periodically based on novel insights. With the support from the International Society of Electrophysiology and Kinesiology and from the Journal of Electromyography and Kinesiology, these guidelines would be disseminated online to users of both traditional (bipolar) and advanced (high-density) surface EMG techniques.

Outcome of the Session:
A list of key points identified collectively as relevant for the updating of current recommendations for electrode positioning will be drafted. They will be summarised in the Journal of Electromyography and Kinesiology.

Schedule of the Session:

Is it time to update existing recommendations for the use of surface electromyography?

This Special Session will be split into two parts, each lasting one hour. In the first part, brief speeches will illustrate some key methodological issues in surface EMG to participants. In the second part these issues will be discussed in relation to the recommendations currently available for the positioning of surface electrodes. Finally, at the last half of the Special Session second part, the Editor-in-Chief of the Journal of Electromyography and Kinesiology, Prof. Solomonow, will provide participants with key highlights concerning the submission of manuscripts to the Journal.

Timetable of events

First Part:

Key issues in surface electromyography

9.00 – 9.10: *Session organisers*, LISiN, Poltecnico di Torino
Prof. Jean-Michel Gracies, Cretèil, France
Session Opening

9.10 – 10.00: *Presentation of key topics*

New issues in surface electromyography

Prof. Taian Vieira; LISiN, Politecnico di Torino and EEFD, Universidade Federal do Rio de Janeiro - *Representation of muscle activity in the surface EMGs*

Dr. Didier Staudenmann; Movement and Sport Science, Department of Medicine, Faculty of Science, University of Fribourg, Switzerland - *Heterogeneity of muscle activity associated to fatigue*

Prof. Kohei Watanabe; School of International Liberal Studies, Chukyo University, Japan - *Regional muscle activation is associated to muscle function*

Classic issues in surface electromyography

Prof. Adrian Burden; Department of Exercise and Sport Science, Manchester Metropolitan University, UK. *Normalisation*

Prof. Dario Farina; Bernstein Center for Computational Neuroscience, University Medical Center Göttingen, Georg-August University, Göttingen, Germany - *Cross-talk*

Second part:

Updating SENIAM recommendations for electrode positioning and key messages to authors

10.00 – 10.30:*Session organisers and speakers - An updated structure of recommendations for the positioning of bipolar electrodes will be proposed to participants. Reasons for why and how updating SENIAM recommendation will be stated to participants*.

10.30 – 11.00: Prof. Moshe Solomonow and Dr. Tanya Wheatley - *Presentation of key highlights regarding the submission of manuscripts to the Journal of Electromyography and Kinesiology*.

Is it time to update existing recommendations for the use of surface electromyography?

Special Session: Developing humanoids to understand humans (Sala 1LM 9.00-11.00)

Session Organizers:

Dr. Diego Torricelli, CSIC, Spain
Prof. Jose Luis Pons, CSIC, Spain
Prof. Katja Mombaur, University of Heidelberg, Germany

The development of human-like robots is arousing interest in the bioengineering and health care communities, due to the high potential of bio-inspired robots to serve as test bed of motor control theories. Validating the biomechanical, neural and cognitive principles found in humans is of utmost importance for the development of more effective assessment and rehabilitation solutions. The European projects H2R and Koroibot (www.h2rproject.eu, www.koroibot.eu) propose this joint special session to bring together researchers interested in understanding the key principles of human locomotion through their embodiment into human-like structures.

The contribution will be mainly focused on the following key questions:
-Which are the key biomechanical, neural and cognitive principles behind human walking and posture?
- To what extent are humans and humanoids similar?
- Which is the role of simulation in understanding biological principles?
- How can "human-likeness" be measured on a quantitative basis?
- Is human motion guided by optimality principles?
- Which are the main applications to rehabilitation robotics?
- How can learning be appropriately formalized and applied?

Developing humanoids to understand humans

BENCHMARKING SCHEMES FOR THE ASSESSMENT AND COMPARISON OF HUMAN-LIKE LOCOMOTION SKILLS.

Torricelli D[1], Gonzalez J[1,2], Pons JL[1]

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AIM: The use of benchmarks to evaluate the performance of legged locomotion has great potential for the development of better rehabilitation devices and the definition of quantitative clinical measures. Within the project H2R, and in collaboration with several other European projects, we are proposing a methodology for the generation of benchmarking schemes focused on the human likeness of bipedal walking. The main goal is to develop a set of metrics and criteria that can quantitatively estimate how close the performance of a bipedal system – being either a humanoid, a prosthetic device, an exoskeleton, or an impaired individual – is to the performance of a healthy human.
METHODS: Our method is based on the following steps: i) the definition of what human-likeness is, and how it can be measured; ii) the study of the state of the art of the methods currently used in robotic and clinical scenarios to evaluate walking and standing performance; iii) the identification of the most relevant benchmarks that can be applied to different kinds of legged systems, thus allowing realistic comparisons; iv) the development of benchmarking procedures and web-based tools that will facilitate a standardized application of the proposed benchmarks in most laboratory and clinical settings; and v) the constitution of open-access databases of human/robotic performance data, which will be made available to the community to promote a unified framework of benchmarking. All these steps have been accompanied by the involvement of the international community with the constitution of an international network specifically focused on benchmarking of bipedal locomotion[1].
RESULTS: To this date a preliminary proposal of a benchmarking scheme has been made, which includes the main benchmarks characterizing human walking and standing performance. The proposed benchmarks accomplish two main requirements: i) they can be quantitatively measured, and ii) they can be applied to various bipedal systems. The scheme is structure in three sections, which include the conditions/perturbations considered, the benchmarks for human likeness that can be applied in each condition, and the devices and protocols that should be applied to calculate the required benchmarking values.
CONCLUSION: So far, the proposed scheme has been discussed only in the humanoid robotics community with high interest. In the Special Session "Developing humanoids to understand humans" at ISEK2014 – of which this abstract represents the opening contribution – we want to stimulate a multidisciplinary discussion that will allow us to improve the applicability of these benchmarks to the clinical scenario, in particular about their implications on quantitative diagnostics and their applications for the design of better robot-assisted rehabilitation.
ACKNOWLEDGEMENT: This research is supported by the European Seventh Framework Programme FP7-ICT-2011-9, under the grant agreement no 60069 - H2R "Integrative Approach for the Emergence of Human-like Robot Locomotion".

[1] http://www.h2rproject.eu/jointhenetwork.html\

MODEL-BASED OPTIMIZATION FOR HUMANOID ROBOTS IN THE KOROIBOT PROJECT

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AIMS: The goal of the European ICT project KoroiBot (www.koroibot.eu) is to improve the overall walking capabilities of humanoid robots, which is an important prerequisite for tackling all different tasks foreseen for humanoid robots (e.g. to work in disaster response, in space or as personal assistants in factories, hospitals or households). In KoroiBot, we study very different types of walking motions starting with human observation, such as walking on even ground and slopes, walking on rough and soft terrain, climbing up and down stairs, balancing over beams, step stones or sea-saws, all with and without handrails, as well as interaction and manipulation tasks while walking. The research focus in KoroiBot is to develop new motion generation and control methods for existing hardware, but, as one of the final outcomes of the project, we will also use these methods to derive optimized design principles for next generation robots. The KoroiBot consortium gathers several state of the art robot platforms: HRP-2 and HRP-4, Armar-IV, iCub/Coman, Leo, TUlip and Romeo.
MODEL-BASED OPTIMIZATION IN KOROIBOT: While two other KoroiBot talks in this ISEK session will focus on the robotics aspects and the human motion studies, the purpose of this talk is to highlight the aspects of mathematical models, optimization and optimization-based model predictive control for this project.
Optimal control techniques are used to increase humanoid walking performance, by maximal-ly exploiting the humanoid's limits for every motion. For humanoid robots with their redun-dant degrees of freedom, optimization can help to turn the redundancy into a benefit rather than a burden. Inverse optimal control is applied to identify human motion objectives from experimental recordings in different walking situations which can then be transferred to humanoids after developing appropriate transfer rules. Nonlinear model predictive control will be used in the project for online control of humanoid walking with the aim to used walking models of higher accuracy also in this online case.
ACKNOWLEDGEMENT**:** Financial support of the KoroiBot project by the European Union under Grant Agreement No. 611909 is gratefully acknowledged.

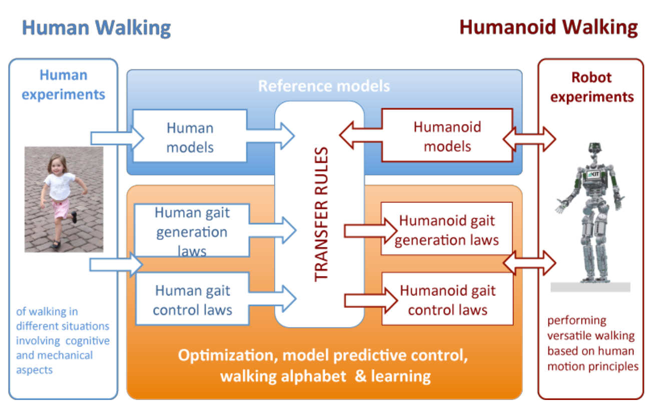

Figure 1: The KoroiBot methodology: learning from humans to improve humanoid motions using mathematical models, transfer laws and optimization

POSTURAL ROBOTS FOR UNDERSTANDING HUMAN SENSORIMOTOR PROCESSING

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AIM: Postural control in human subjects is studied by investigating and modeling their ability of biped balancing external disturbances. The identified posture control model is then implemented into a custom made humanoid robot. The robot's postural responses are directly compared to the human responses in the human laboratory. The aim of this approach is to bring more human-likeness into the control of rehabilitation and prosthetic devices.
METHODS: Experiments are performed applying exactly known external disturbances such as support surface tilt and measuring the human / model / robot balancing responses in terms of body sway and center of pressure (COP) shifts. Data analysis comprises frequency response functions across a frequency spectrum of 0.017-2.4 Hz. The modeling process is focused on the role of sensory fusion mechanisms in the feedback control (proprioception, vestibular, vision). It is based on findings from human self-motion perception studies where sensory signals are fused to internally reconstruct physical variables and, in a further step, to estimate the external disturbances having impact on the body. The humanoid robot uses artificial sensory systems and pneumatic 'muscles' that are used for torque-controlled actuation of the hip and ankle joints (2 DoF).
RESULTS: We show that the robot's balancing responses resemble the human responses in terms of similar frequency response functions. Similarity also applies to automatic adjustments when changing disturbance magnitude, disturbance modality, and sensor availability- a feature called sensory re-weighting in humans. Furthermore, human-like coordination between hip and ankle joints emerges in the robot experiments from the multi-sensory feedback control.
CONCLUSION: The obtained match between the human data and robot data suggests that the identified sensor fusions and posture control mechanisms capture important aspects of the human balancing system. The experiences with the 2 DoF robot led us extend the control concept by adding further DoFs. In generalized form, this allowed to implement a modular control architecture where adjoining control modules are synergistically interconnected to exchange sensory information and disturbance estimates. In this system, complexity scales linearly with the number of DoFs.
ACKNOWLEDGEMENT: Supported by the European Commission (FP7-ICT-600698 H2R)

Developing humanoids to understand humans

THE HUMANOID ROBOT: A TOOL FOR INFERRING AND REPRODUCING HUMAN MOVEMENT

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AIM: This work aims at showing that the robotics approach to anthropomorphic systems motion generation provides a new constructive way of analyzing and inferring the organization of human movement.
METHODS: Humanoid robotics has motivated the development of advanced motion generation methods enabling to cope with the complex tree-like structure of the anthropomorphic body and the instability of the bipedal posture. These methods consist in solving the inverse kinematics or inverse dynamics under a hierarchy of tasks and constraints by using powerful hierarchical quadratic programming solvers. The main advantage of this approach is that it enables generating whole-body movements in a generic way while taking into various kinds of unilateral constraint such as rigid contacts or obstacle avoidance. Making hypotheses on how complex movements in humans are organized, one can design such stack of tasks and constraints to generate automatically similar movements on anthropomorphic systems. Then going back and forth from human motion observation to humanoid motion generation, and tuning up the parameterization of the stack of tasks provides an efficient approach for inferring the organization of human movement.
RESULTS: Different whole body tasks involving whole-body walking and reaching movements are considered. Experimental results are presented in which the humanoid robot HRP-2 is controlled to perform such movements by using the stack of tasks approach. The dynamic features of these movements are then compared with the ones of similar human movements. Similarities and differences between synthesized and observed movements are then analyzed discussed, showing the potential of this constructive approach.
CONCLUSION: An efficient tool for generating whole-body movements in anthropomorphic systems is proposed opening the way for interesting synergies between biomechanics and robotics.
ACKNOWLEDGEMENT: This work was supported by the FP7 European project Koroibot and the French PSPC Project Romeo2.

Figure 1: The humanoid Robot HRP-2 and a dancer executing similar movements.

IMPULSIVE CLOSED-LOOP CONTROL OF HUMAN LOCOMOTION

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AIM: In this study we explore the modularity of 15 lower limb muscles across 9 individuals performing locomotion tasks at five different speeds and elevations. Then, we create a low-dimensional computational model that synthetizes the observed modular excitation patterns. Finally, we use the low-dimensional synthetized modularity model to inform a closed-loop musculoskeletal simulation of human locomotion.
METHODS: Using non-negative matrix factorization we derive a four-dimensional representation of muscle modularity from 15 lower limb muscles' experimental electromyograms. We then employ non-linear regression methods to parameterize regularities in the observed muscle weightings across locomotion speeds and ground inclination. A set of single-impulsive Gaussian curves are fitted to each non-negative factor and parameterized as a function of gait cycle, locomotion speed and ground elevation. A subject-specific musculoskeletal model is scaled and calibrated to each individual to match anthropometry and muscle-force generating capacity. The subject-specific musculoskeletal model is then driven using synthetic modularity model built from the parameterized Gaussian primitives and the weightings regression functions. A closed-loop controller is developed to minimally adjust the input excitation and enable close tracking of reference joint moments measured during each subject's locomotion task.
RESULTS: Results show that synthetic muscle excitations closely match the muscle excitation mechanisms from novel subjects that were not used for building the synthetic model. Closed-loop, excitation-driven, musculoskeletal simulations of locomotion show that the input excitations only need to be minimally adjusted in order to track the given task in the joint moment domain.
CONCLUSION: Results suggest human locomotion has a robust and well-structured muscular modularity that can be synthetized and parameterized as a function of locomotion speeds and ground inclination across individuals. Simulation results show that dynamically consistent patterns of excitations can be created my minimal signal modulations. This suggests the synthetic excitation model might reflect some feature of the descending neural drive to muscles. Furthermore, the musculoskeletal model-based, minimal modulation applied to the driving synthetic excitations might reflect feedback-based modulation mechanisms such as muscle reflexes and responses to the physical and sensory interaction with the environment. These aspects require a structured research in the future.
ACKNOWLEDGEMENT: This work was supported by the European Seventh Framework Programme FP7-ICT-2011-9, under the grant agreement no 60069 - H2R "Integrative Approach for the Emergence of Human-like Robot Locomotion" and by the European Research Council (ERC) via the ERC Advanced Grant DEMOVE.

Physical Rehabilitation and Medicine 1 (Sala 2LM 9.30-11.00)

DECREASED HIP MUSCLE ACTIVATION IN PERSONS WITH PATELLOFEMORAL PAIN COMPARED TO THOSE WITHOUT PAIN IN SELECTED THERAPEUTIC EXERCISES RECOMMENDED FOR REHABILITATION – PRELIMINARY FINDINGS USING FINE-WIRE EMG

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AIM: Decreased activation and weakness of the gluteal muscles is thought to contribute to excessive hip internal rotation and adduction in persons with patellofemoral pain (PFP).(1,2) Alternatively, abnormal hip kinematics in person with PFP may be the result of excessive activation of the tensor fascia lata (TFL), which is an internal rotator of the hip. In a recent publication, our group identified therapeutic exercises that are effective in activating the gluteal muscles while limiting activation of the TFL in healthy persons.(3) To date, it is not known if there is a difference in how persons with PFP activate the gluteal muscles and TFL while performing these exercises. The purpose of the current study was to determine if the EMG activity of the gluteal muscles and the TFL differs between persons with PFP and those who are pain-free, while performing selected rehabilitation exercises. We hypothesized that persons with PFP would exhibit greater activation of the TFL and reduced activation of the gluteus maximus and medius when compared to pain-free controls.

METHODS: To date, twenty-six subjects between the ages of 18-50 (6 with a diagnosis of PFP and 20 pain-free controls) have been tested. Fine-wire electrodes were inserted into the TFL, gluteus medius middle fibers (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 quadruped hip extension with the knee extending, sidelying clam, and unilateral bridging exercises. These exercises were previously determined to emphasize gluteal activation while minimizing TFL activation.(3) A metronome paced the movements. The mean root-mean-square (RMS) of the EMG signal in each exercise was normalized to MVIC, for each muscle. Two-way repeated measures ANOVAs (group x exercise) were performed for each muscle (alpha=.05).

RESULTS: The results of the ANOVAs for the TFL and SUP-GMAX revealed significant main effects for group. When averaged across exercises, the PFP group exhibited significantly higher TFL EMG activity (in %MVIC) than the control group (28.8 ± 17.5 vs. 14.9 ± 11.5; mean ± sd) and significantly lower SUP-MAX activity than the control group (21.0 ± 12.6 vs. 35.8 ± 21.2). No group difference for GMED activity was found.

DISCUSSION: Our data suggest that persons with PFP activate the TFL at greater levels, and the gluteals at similar or lower levels than pain-free individuals, during exercises previously found in pain-free individuals to emphasize the gluteals over the TFL. This is potentially problematic as over-activation of the TFL during rehabilitation may carry over to functional tasks. Thus, EMG biofeedback/neuromuscular retraining may be important to include in a PFP rehabilitation program to ensure proper activation of the appropriate muscles, to maximize the therapeutic value of hip strengthening exercises. A limitation of the study is the small and unequal sample size. As such, these preliminary findings should be viewed with caution.

CHRONIC PROFESSION-LIMITING PROBLEMS IN MUSICIANS: UNDERLYING MECHANISMS AND NEUROPLASTIC ROUTES TO RECOVERY

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AIM: Musicians are subject to a wide range of medical problems related to the physical and psychological demands of their profession. A conventional rehabilitative approach is to regard both causes and solutions as specific. Methods commonly involve direct treatment to reduce inflammation, physiotherapy to address muscle weakness and imbalances, and a graded return to playing. Increasingly, performance-related problems are acknowledged to be the result of a number of intrinsic and extrinsic factors acting synergistically, and multidisciplinary approaches are recommended. However, analysis of problems in relation to holistic factors is usually descriptive, with mechanistic under-pinning largely absent.
The approach presented here considers the working hypothesis that problems arise from mal-adaptive selection within a perception-selection-action feedback loop, and that breaking the loop at the point of selection gives the possibility of preventing potential problems and overcoming existing problems. The aim of this study is (i) to establish whether in playing, violinists and violists exhibit a common diagnosable musculokinematic pattern unnecessary for performance, and (ii) to test a methodology for revealing and reducing that pattern in individuals.
METHODS: Twenty-one violinists/violists repeated seven progressively demanding playing tasks in six series which involved two external feedback interventions (ultrasound feedback of the neck muscles followed by verbal feedback of movement) based on principles of minimising task-irrelevant a priori selections, and three necessary controls.
RESULTS: At significance $p<0.05$, multivariate discriminant analysis of full-body, kinematic and electromyographical data showed progressive reductions in the extent to which a common musculokinematic pattern was exhibited using ultrasound and verbal interventions. The differences were characterised by reductions in most muscle activities and key movement elements, including elevation and internal rotation of the shoulder, axial rotation of the torso, and anterior and caudal movement of the head.
CONCLUSIONS: Violinists and violists exhibit a common, diagnosable whole-body musculokinematic pattern that is unnecessary for performance and associated with chronic profession-limiting injury. External feedback, targeted at minimising individual *a priori* musculokinematic selections unnecessary for performance is efficacious in achieving individual change. This methodology has potential for reducing problems resulting from accumulative feedback of mal-adaptive selections within a perception-selection-action feedback cycle, including limitations in performance, and sensory input predisposing occupational dystonia and profession-limiting injury.

MUSCLE CO-CONTRACTION AROUND THE KNEE IS INCREASED WHEN WALKING WITH AN UNSTABLE SHOE CONSTRUCTION

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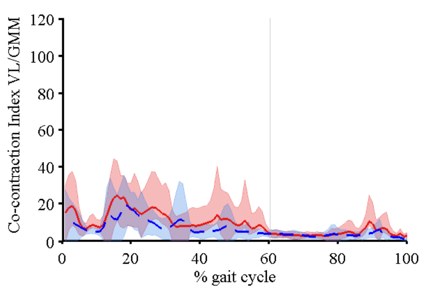
AIM: The purpose of this study was to compare co-contraction levels around the knee when walking with an unstable shoe construction compared to walking with a regular shoe.
METHODS: In this study data of one previously conducted study focusing on gait biomechanics during walking with a regular and with an unstable shoe constructions, Masai Barefoot Technology (MBT), was used retrospectively. 12 healthy (7 male and 5 female) participants (age: 25 ± 6 years, height: 174 ± 7 cm, mass: 68 ± 10 kg) were asked to walk with both, a regular shoe and with the MBT shoe at self-selected walking speed at a 10-meter walkway. Surface EMG data were recorded and time normalized to one gait cycle. Resulting linear envelopes were then amplitude normalized to the mean peak muscle activity of all valid control shoe trials (= 100%). This time series then was used for calculating the co-contraction indices (CCI) for following opposing muscle groups: vastus medialis to biceps femoris (VM/BF), vastus lateralis to biceps femoris (VL/BF), vastus medialis to gastrocnemius medialis (VM/GMM), vastus lateralis to gastrocnemius medialis (VL/GMM) and tibialis anterior to gastrocnemius medialis (TA/GMM).
RESULTS: Comparing co-contraction between opposing muscle groups around the knee when walking with MBT and regular shoes revealed some statistically significant alterations. For the first half of stance, CCI increased for VL/GMM ($p = 0.002$; 95% CI: 2.1-7.1) and for VM/GMM ($p = 0.007$; 95% CI: 1.5-7.1) (see Figure 1). Both, VM/GMM and VL/GMM, showed trends towards an increase of co-contraction level ($p < 0.1$) during the second half of stance, but failed to reach significance. Co-contraction for VM/BF also showed a significant increase for walking with MBT shoes during first half of stance ($p = 0.046$; 95% CI: 0.1-8.3). Neither TA/GMM nor VL/BF showed significant differences during first or second half of stance.
CONCLUSION: Results were highly consistent to an earlier published study focusing on CCI when walking with MBT shoes. Based on the findings of this study, it can be concluded that MBT shoes significantly increase co-contraction between the quadriceps and gastrocnemius muscles when walking at self-selected walking speed.



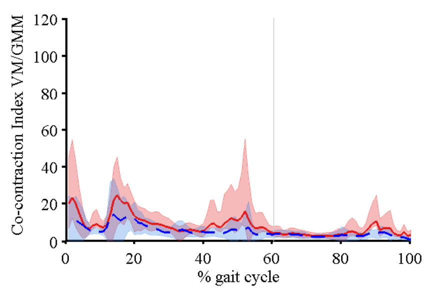


Figure 1: Mean co-contraction index (CCI) for VM/GMM and VL/GMM wave forms and the corresponding standard deviation for walking with the stable shoes (dashed line) and MBT shoes (solid line). The vertical line shows toe-off.

EIGHT WEEKS OF MOTOR INTENSIVE ANTI-GRAVITY TRAINING IMPROVES FUNCTIONAL PERFORMANCE IN PATIENTS WITH PARKINSON'S DISEASE

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AIM: Parkinson's disease is associated with severe motor deficits as the disease progress. Positive effect of intensive physical training has been documented. However, balance deficit and fear of falling in patients with Parkinson's disease (PD) complicates the application of intensive loco-motor training in a natural environment. The aim was to study the effect of motor intensive loco-motor training, performed in a safe body-weight (BW) supported environment, on performance in balance related tasks in PD.
METHODS: Male PDs (n=13, age 63, Hoehn-Yahr 2.1) and a healthy reference group (CON) (n=17, age 58) participated. PD performed progressive high-intensive loco-motor training (3x1 hour per week for 8-weeks) on a lower-body positive pressure treadmill (AlterG P200, AlterG, USA). The training included motor training: challenged the patient's ability to perform adaptations to sudden changes of motor demand (walking, running, skipping, chasse and jumping) at 20-100% BW and aerobic training: walking/running at 50% BW (1,2). Effect measures were five-repetition sit-to-stand test (STS) and a medio-lateral dynamic balance test (MLB) (40 side-to-side movements) both performed as fast as possible on a force plate. Completion time and functional rate of force development (RFD_f) (ΔGround reaction force/Δt at 30-70% of maximal vertical (STS) and medio-lateral (MLB) ground reaction force) were calculated.
RESULTS: Training improved the STS completion time by 24% (9.9 s to 7.5 s, $p<0.001$) and PD post training was no longer different from CON (7.4 s, $p=0.853$). In accordance, a 23% training-induced increase in RFD_f during chair-lowering (vertical force decline) (8.0 xBW/s to 9.8 xBW/s, $p=0.003$) to the level of CON (10.3 xBW/s, $p=0.545$) and a tendency of improved RFD_f during chair-rising (vertical force incline) ($p=0.09$) were found. Training tended to decrease completion time in MLB (20.9 s to 19.3 s, $p=0.095$) but PD post training was still significantly slower than CON (12.4 s, $p=0.029$). RFD_f during medial and lateral movements were increased by 19% (1.72 xBW/s to 2.04 xBW/s, $p=0.014$) and 16% (2.02 xBW/s to 2.36 xBW/s, $p=0.003$), respectively, but were still slower than CON (medial 3.28 xBW/s, $p=0.01$; lateral 3.77 xBW/s, $p=0.007$).
CONCLUSION: Body-weight supported high-intensity loco-motor training improved performance of STS in PD in terms of reduction of completion time and increased RFD_f during lowering, and tended to improve MLB completion time through improved RFD_f in the medio-lateral direction despite the sagital orientation of the training. The RFD_f's are produced by several muscle groups during whole-body movements. As no training effect was found in RFD during powerful isometric knee extension in the PD group (3) it is suggested that the training may have induced changes in inter-limb coordination resulting in the increased movement velocities in the balance related tasks.

ACKNOWLEDGEMENT: The study was supported by the Parkinsons' Disease Association.
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2: Rose, MH et al., Arch. Phys. Med. Rehabil., vol 94, pp. 687-692, 2013
3: Rose, MH, Rehabil. in Parkinson's Disease, PhD Thesis, University of Copenhagen, 2013

MULTIFIDUS MUSCLE FIBRE DISTRIBUTION CHANGES AFTER AN INTERVERTEBRAL DISC LESION: PROPERTIES AND POSSIBLE MECHANISMS

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AIM: Changes in the structure and behavior of the multifidus muscle are present in back pain. There is some evidence from cross-sectional evidence of differences in muscle fibre distribution in people with pain, but it remains unclear whether these changes are the result of injury and/or pain. Animal studies that have shown that changes in gross morphology of the muscle (muscle cross-sectional area) can be induced by injury to the spine. Although these changes are considered important for persistence of back pain and its recovery, the mechanisms are poorly understood. There remains a significant gap in the understanding of back muscle changes in people with pain. This study investigated the effect of an experimentally induced intervertebral disc (IVD) lesion on the distribution of slow, fast and intermediate muscle fibres in the multifidus muscle in sheep. A further aim was to study whether muscle fibre changes were paralleled by local gene expression of the pro-inflammatory cytokines Tumor Necrosis Factor-alpha (TNF-α) and interleukin 1β□□□□-□β□.
METHODS: The L1-2, L3-4 and L5-6 IVDs of 11 castrated male sheep received left anterolateral partial thickness annular lesions. Six control sheep underwent no surgery. Multifidus muscle tissue was harvested 6 months after IVD injury at L4 for muscle fibre analysis using immunohistochemistry, and L2 for cytokine analysis with PCR for local gene expression of TNF-α and □□-□β.
RESULTS: All injured IVDs developed degenerative change with loss of disc height and reduced nucleus pulposus proteoglycan. The proportion of slow muscle fibres in multifidus was less in the lesioned animals both ipsilateral and contralateral to the lesion. The greatest reduction in slow fibres was in the deep medial muscle region. A greater prevalence of intermediate fibres on the uninjured side implies a delayed fibre type transformation on that side. TNF-α and □□-□β gene expression in multifidus was greater on the side of the lesion than the muscle of control animals.
CONCLUSION: These data provide definitive evidence of muscle fibre changes following induction of an IVD lesion and a parallel increase in TNF-α and □□-□β expression. Pro-inflammatory cytokine changes provide a novel mechanism to explain behavioral and structural changes in the multifidus muscle after back injury.
ACKNOWLEDGEMENT: Funding was provided by the National Health and Medical Research Council of Australia.

NMES RESISTANCE TRAINING IN PATIENTS WITH FACIOSCAPULOHUMERAL MUSCULAR DYSTROPHY

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AIM: We studied the effect of a bilateral 8-week neuromuscular electrical stimulation (NMES) training of the tibialis anterior (TA) muscles in patients with facioscapulohumeral muscular dystrophy (FSHD) on motor function, muscle strength and endurance.
METHODS: Ten patients with FSHD and 6 healthy participants (HP) performed three 20-minute NMES training per week over 8 weeks. Maximal voluntary isometric contractions (MVC) in ankle dorsiflexion (DF) and plantar flexion (PF) and a 2-minute sustained maximal isometric ankle dorsiflexion both associated with surface electromyography recordings (EMG) of the TA and the soleus (SOL) muscles were measured.
RESULTS: No effect of the NMES training was found in any investigated variable for either group. Patients with FSHD were found to exert a lower force production than healthy participants ($p<0.05$) associated with a lower maximal TA EMG amplitude during the DF MVC ($p<0.01$). During the 2-minute sustained MVC, the percentage of force loss was lower for the FSHD patients ($p<0.05$; Pre-training: HP: 54.2 %; FSHD: 35.9 %; Post-training: HP: 62 %; FSHD: 37.6 %) , but the percentages of TA EMG loss amplitude after the 2-minute MVC were found to be similar in both groups before (HP: 43 %; FSHD: 25.3 %) and after the training (HP: 39.4 %; FSHD: 38.4 %).
CONCLUSION: The results confirm that patients with FSHD are weaker than healthy participants, and our results also suggest that the intrinsic contractile properties of the TA are altered in patients with FSHD. In addition, the group of patients with FSHD showed lower force losses during the 2-minute sustained MVC, indicating that they were experiencing a lower amount of muscle fatigue compared to the HP group. Moreover, the lack of training effect may be explained by three factors. First, the NMES protocol was not strenuous enough and/or parameters of stimulation were neither adequate to improve ankle strength, muscle endurance and motor function for the group of patients with FSHD nor for the healthy participants. Second, the absence of training effects may be explained by the NMES protocol which was designed for the patients with FSHD, likely not appropriate to induce strength gains in healthy participants. Third, the NMES training may have induced overreaching and post-tests performed as soon as possible after the last training potentially hid adaptations.
ACKNOWLEDGEMENTS: The University Hospital Centre of Nice; the Norwegian Research Council; the French Ministry of Foreign Affairs; the Swedish Research Council VR2011-3128.

NEUROMUSCULAR DYSFUNCTIONS IN PATIENTS WITH CHRONIC GROIN PAIN – SYSTEMATIC REVIEW.

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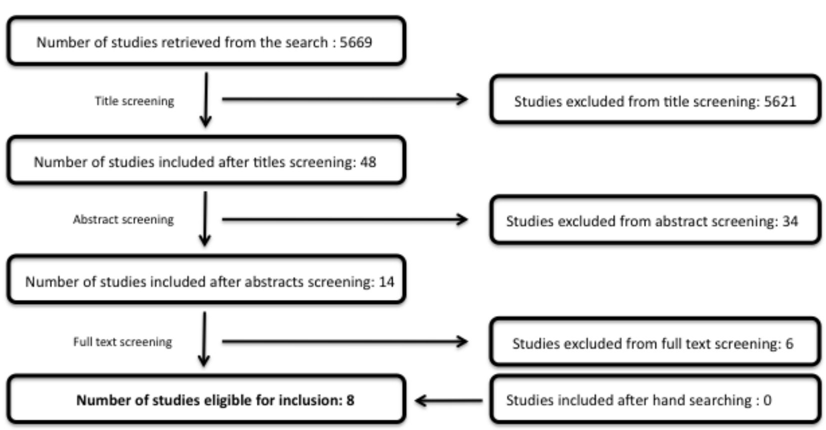
AIM: Long-standing adductor related groin pain (LSARGP) is a common entity among rotation sports disciplines such as football, rugby and hockey. Previous reviews have shown that structured rehabilitation has proven efficacy for these patients but there is little detail on which exercise approaches are most beneficial. We aimed to define the associated muscular activation changes in symptomatic patients needed to guide optimal exercise prescription in order to guide development of more specific rehabilitation approaches.

METHODS: Four databases were searched for case control, prospective and retrospective studies investigating muscle features in groin pain patients. 5669 returns were screened for inclusion and exclusion criteria with reference lists and citing articles being examined. Study quality was evaluated by two independent reviewers using a modified Downs and Black quality index. The level of evidence was established using the Van Tulder criteria. Meta-analysis was performed where possible following data requests to corresponding authors.

RESULTS: Eight studies were identified, with 7 ranked high quality and 1 ranked moderate quality (mean=12.125, SD=1.25) in modified Downs&Black Quality Index (maximum score 16). There is conflicting evidence suggesting decreased adductor muscle strength in symptomatic participants when measured with a bilateral squeeze test. No differences were found adductor muscle flexibility. Marked decreases in transversus abdominis muscle activation onset and resting thickness were found in 2 high quality studies, which constitutes a limited evidence level. There was also limited evidence indicating decreased gluteus medius to adductor longus muscle activation ratio.

CONCLUSION: Muscle strength and activation are altered in people with LSARGP compared to controls, with these alterations especially being evident in the coronal plane and affecting both the adductors and abductors of the hip, and also the abdominal musculature. Altered adductor muscle range of movement is not a therapeutic target. This review has shown that there are characteristic patterns of altered muscle function in people with LSARGP, which will be of relevance to clinicians planning treatment for such patients.

Figure 1: Flowchart showing studies inclusion and exclusion process for the review



Biomechanics 1 (Sala 4LM 9.30-11.00)

THE EFFECTS OF BODY WEIGHT UNLOADING ON ELECTROMYOGRAPHIC ACTIVITY OF THE LOWER EXTREMITY DURING OVERGROUND WALKING

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AIM**:** Body Weight Unloading (BWU) is becoming a common method of gait rehabilitation while reducing pain and restriction in range of motion in lower extremities. So far, the effects of BWU on the biomechanical gait parameters could not be determined since they were confounded by two intervening variables by the walking modality and the variability in walking speed which could not be kept constant during overground walking. By designing a device capable of maintaining a constant speed this study aimed at examining the unique effects of BWU on the knee and hip biomechanical gait parameters under conditions that approximate daily walking.
METHODS**:** The research sample included ten healthy male subjects with no gait impairments. A Biodex BWU system was used to unload levels of body weight of the subjects during overground walking. An electric winch was connected to the system to pull the system and maintain the subjects' gait speed constant. Subjects were asked to walk overground under a control condition of No Harness, and 0%, 15%, and 30% BWU.
The biomechanical parameters were recorded with an eight-camera infrared Vicon motion tracking system connected to two AMTI force plates. The electromygraphic activity (EMG) of the Tibialis Anterior (TA), Lateral Gastrocnimius (Lat GC), and Vastus Lateralis (VL) were recorded using the surface EMG ZeroWire system.
RESULTS**:** A significant inverse relationship was indicated between EMG measures and BWU levels. As the level of BWU increased the area under the curve, peak EMG activity and average EMG signal of the TA and Lat GC decreased. For VL the area under the curve significantly decreased. No significant ($p>.05$) modifications in EMG signal trajectories of the muscles examined were observed and highly significant correlations were indicated ($.79<r<.91$; $p<.01$).
CONCLUSION**:** The inverse relationship between the increased levels of BWU and the decrease in EMG activity at terminal stance suggest that BWU is an efficient method for reducing loads on the lower extremities while allowing for normal muscle activity patterns. Gait rehabilitation with BWU may be safely used with patients with neurological or musculoskeletal disorders under conditions that replicate daily walking without running the risk of impairing the propulsive force as was observed on treadmills. As gait improves and pain subsides, loading can be increased in a stepwise fashion.

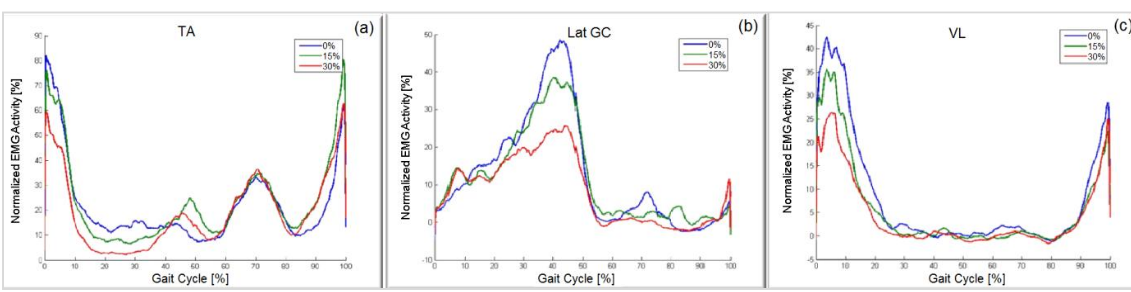

Figure 1: Curves represent the average of all the subjects over a gait cycle under the experimenatal conditions (normalized to the control condition of no harness). (a) Tibialis Anterior, (b) Lateral Gastrocnimius, (c) Vastus Lateralis.

COMPROMISING INTERMUSCULAR MECHANICAL INTERACTIONS CAN BE AN UNCONSIDERED THERAPEUTIC EFFECT OF BOTULINUM TOXIN

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AIM: Local injections of Botulinum toxin type A (BTX-A) are used commonly to reduce spasticity by causing muscle paralysis and blocking the hyper-excitable stretch reflexes. However, BTX-A also affects muscle mechanics, which is functionally very important. Previous studies showed that these effects are much more involved than a decrease in muscle tone such as length dependent force reductions and change in length range of force exertion [1]. BTX-A affects an entire muscle compartment due to diffusion from injected muscle [2].
Epimuscular myofascial force transmission (EMFT) i.e., force transmission from muscle to neighboring muscular/non-muscular structures via connective tissues continuous with its epimysium affects muscular mechanics substantially. Proximo-distal force differences are one characteristic effect. Among muscles exposed to BTX-A, EMFT effects hence, intermuscular mechanical interactions were observed to be limited [e.g., 1]. Intra-operative tests showed that spastic muscle activated alone has no abnormal muscle force-joint angle relationship, which ceases if an antagonistic muscle is co-activated [e.g., 3]. This suggests the presence of an improper coupling between muscles in spastic paresis and that the patients' joint movement disorder is ascribable to an abnormal mechanical interaction. Considering potential importance of this, we aimed at testing the following hypothesis: BTX-A causes EMFT within a muscle compartment to become diminished. METHODS: Two groups of Wistar rats were tested: Control (no BTX-A injected, n=8, body mass=300.0±6.9g) and BTX-A (0.1 units of BTX-A were injected to the mid-tibialis anterior belly, n=8, body mass=315.0±6.3g). The compartment was left intact and all muscles were activated, simultaneously. The tibialis anterior and extensor hallucis longus muscles were kept at constant length whereas; position of the extensor digitorum longus (EDL) was changed, exclusively. This eliminates muscle length effects and isolates those of EMFT. RESULTS: Control group: distally altered EDL position affected EDL distal and proximal forces (starting e.g., from 0.3±0.2N and 1.4±0.6N, these forces increased and decreased, respectively by a factor of approximately three) and proximo-distal force differences (ranged from e.g., -1.1±0.6N to 0.5±0.2N), indicating substantial EMFT. BTX-A group: Forces of all muscles decreased (up to 67%) due to BTX-A. EDL forces measured at the most proximal position did not change significantly with the muscle's position changes and proximo-distal force differences approached to zero. Histological assessments indicated a significant decrease in connective tissue content implying reduced epimuscular connections. CONCLUSION: We conclude that BTX-A does diminish EMFT within an intact muscle compartment. Due to that, mechanical interaction between the muscles becomes highly compromised. This may be clinically relevant if in future studies the relationship between EMFT and mechanics of spastic muscle can be further established. ACKNOWLEDGEMENT: The Scientific and Technological Research Council of Turkey, TÜBİTAK (grant 108M431), and the Boğazici University Research Fund (grant 6372).

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CHARACTERIZATION AND DETECTION OF LEVEL GROUND WALKING TO STAIR ASCENT AND DESCENT TRANSITION STRIDES

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AIM: Characterize the lower-limb kinematics and electromyography during level ground walking to stair ascent and stair descent locomotor transitions of able-bodied individuals.
METHODS: Lower-limb kinematic and bilateral electromyographic (EMG) data of muscles spanning the hip, knee and ankle were measured from 9 subjects as they completed 10 trials of baseline walking as well as walk to stair ascent and walk to stair-descent transitions. Significant deviations from baseline were detected if changes were outside 1 SD of the individual average baseline data. Both leading (leading foot from floor to first stair) and trailing (contralateral foot from floor to second stair) transitions strides were assessed.
RESULTS: In these transitions strides, subjects did not significantly adjust their joint kinematics prior to mid to late stance of the leading stride and early stance of the trailing stride. Increased ankle dorsiflexion in terminal stance of the leading transition strides was found for both stair ascent *and* descent. Knee flexion was initiated earlier in the leading transition to stair ascent (Fig. 1). In contrast, knee flexion was initiated later in the leading transition to stair descent. Reduced stance phase hip extension was observed in the trailing transition strides of stair ascent *and* descent. Gluteus maximus, gluteus medius, adductor magnus, and hamstring (Fig. 1) EMG activity was increased in mid to late stance of leading and trailing transition strides of stair ascent *and* descent. Rectus femoris and vasti activity were increased throughout stance in the trailing transition in stair ascent *and* descent. In addition, decreased activity of triceps surae muscles were observed throughout stance of the leading transition to stair ascent and stair descent (Fig. 1). Triceps surae activity further decreased in the trailing transition for stair descent, while it increased in the trailing transition for stair ascent.
CONCLUSION: Significant changes in these gait mechanics could be detected as early as stance phase of the leading transition prior to toe off of these transitions. Such anticipatory adjustments could be useful in the control of lower limb assistive technologies.ACKNOWLEDGEMENT: This work was supported by U.S. Army grant 81XWH-09-2-0020 and U.S. Department of Education grant H133F130034.

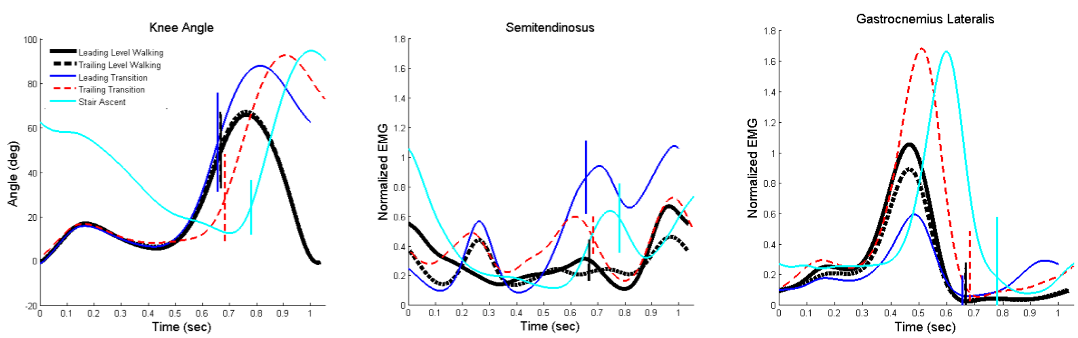

Figure 1: Group averaged knee angle and normalized electromyography of baseline walking strides as well as the leading and trailing stair ascent transitions plotted versus their respective gait cycles.

DROP-JUMP DIRECTION INFLUENCES LOWER EXTREMITY INJURY RISK

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AIM: The rate of lower extremity injury during stop-jump tasks is high, especially in anterior cruciate ligament (ACL). There were various jumping directions during stop-jump tasks in sports. The purpose of this study was to investigate the influence of jumping direction on the lower extremity injury risks during stop-jump tasks.
METHODS: Twelve male university students without lower extremity injuries during the six months prior to the experiment were recruited as subjects for this study. Two 40cm drop-jump tasks were completed by asking the subjects to perform upward jumps and forward jumps with great efforts. The Qualisys Track Manager (QTM) motion capture and analog data acquisition system with 7 infra-red Qualisys motion capture cameras (200 Hz) and two AMTI force plates (1000 Hz) was used to data collect. All of the kinematical, ground reaction force, and inverse dynamical data were calculated by The MotionMonitor software package. Statistical analysis was performed with SPSS 14.0 for Windows. Student's *t*-test was used to test for differences in dependent variables between the upward jump and forward jump tasks. The significance level was set at $\alpha = 0.05$.
RESULTS: The results in Table 1 show that the upward jump task produced a significantly greater peak posterior ground reaction force, peak vertical ground reaction force, knee stiffness, and peak knee extension moment during landing in comparison to the forward jump task (all $p < 0.05$).
CONCLUSION: We infer that a higher risk of lower extremity injury, especially in ACL, in the upward jump task could result from the fact that the upward jump exhibited greater impact forces, knee stiffness, and peak knee extension moment during the landing phase than the forward jump task.

Table 1: The variables concerning the kinetics parameters during the landing phase.

Group	**Upward jump task**	**Forward jump task**
Peak horizontal ground reaction force (BW) *	-0.50 ± 007	-0.41 ± 0.07
Peak vertical ground reaction force (BW) *	2.74 ± 0.39	2.44 ± 0.49
Stiffness of ankle ($BW \cdot BL^{-1}$)	0.39 ± 0.10	0.43 ± 0.16
Stiffness of knee ($BW \cdot BL^{-1}$) *	0.47 ± 0.10	0.33 ± 0.11
Stiffness of hip ($BW \cdot BL^{-1}$)	0.09 ± 0.48	0.06 ± 0.41
Net muscle joint moment of ankle (BW·m)	0.26 ± 0.05	0.26 ± 0.08
Net muscle joint moment of knee (BW·m)*	0.29 ± 0.04	0.23 ± 0.03
Net muscle joint moment of hip (BW·m)	0.27 ± 0.10	0.31 ± 0.06

* indicates a significant difference ($p < 0.05$) between upward jump task and forward jump task.

A NEW MUSCLE CO-ACTIVATION INDEX FOR BIOMECHANICAL LOAD EVALUATION

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AIM: Work-related Low-back disorders (LBDs), mainly caused by lifting tasks, are the most common and costly musculoskeletal problems as they account for almost 20% of all workplace injuries and illness, for almost 25% of the yearly workers' compensation expenses and for almost 25% of all lost work days with a yearly prevalence of about 18%. One of the mechanisms adopted by the central nervous system both to add protection against LBDs and to avoid or reduce pain is the concomitant activation (co-activation) of the trunk muscles in an attempt to stabilize the spine. The aim of the present study was to develop a time-varying multi-muscle co-activation function, in order to provide a tool to measure the muscle co-activation during the work task. METHODS: The time-varying multi-muscle co-activation function *TMCf(d(t),t)* was designed to range between 0 and 100 and considers rectified, low-pass filtered and 0-100 normalized *EMG* signals as input. *TMCf(d(t),t)* is calculated as follows:

$$TMCf\,(d(t),t) = C\big(d(t)\big)\cdot m\big(t\big)\cdot cc(t)$$

where N is the number of muscles considered in the analysis, *m(t)* is the mean of the N $EMG_i(t)$, *C(d(t))*, ranging between 0 and 1, is a sigmoid weight reduction coefficient that takes into account the mean of the differences between each pair of $EMG_i(t)$ and *cc(t)* is a correction coefficient introduced to adjust *TMCf(d(t),t)* behavior even in the case of N=2. We decided to apply the algorithm to data acquired in the laboratory during the execution of different manual material lifting tasks, rather than adopt a computer simulation. We enrolled 10 right-handed healthy voluntary male subject (mean age 29.3±3.65 years, height 1.74±0.03 m, BMI 23.75±0.71). RESULTS: The higher the lifting risk, the higher the value of the *TMCf*. The amount of muscle co-activation increases during the lifting task. The Friedman test revealed a significant effect of lifting condition on *TMCf* (p=0.0064). Significant differences were found between the different lifting conditions (all, p<0.001). CONCLUSION: we believe that the algorithm lends itself to the evaluation of both agonist-antagonist and synergistic multi-muscle co-activation. Although the time-varying multi-muscle co-activation function has been proposed in this paper in ergonomics and occupational medicine, it could also be used in other branches such as orthopedic and neurological rehabilitation, sport science and medicine.

COMPARATIVE STUDY OF THE LUMBAR-PELVIC MUSCLES EMG DURING CORE STABILIZATION PILATES EXERCISE

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AIM: We aimed at comparing the abdominal muscles electric activity during Core Mat Pilates exercises in individuals with non-specific LBP and controls.

METHODS: 20 sedentary subjects without any prior contact with Pilates were evaluated: 10 healthy controls (28±9yrs), and 10 (33±9yrs) with chronic non-specific LBP (LBP group), with pain above 3 in pain visual numeric scale (4.6±1.1). The EMG of internal oblique (IO), external oblique (EO), rectus abdominis (RA) and multifidus (MU) were recorded at 2kHz synchronized with a electrogoniometer at the hip, while the individuals performed exercises: single leg stretch (SLS), criss-cross (CC) and dead bug (DB). EMG signal was digitally filtered at 20-500Hz with a recursive butterworth 4th order filter. The Root Mean Square (RMS) values were calculated for eccentric and concentric phases detected by the hip kinematics, and were then normalized by the maximum voluntary contraction (MVC). Groups and exercises were compared using a 2-way ANOVA for repeated measures, followed by Newman–Keuls post hoc test ($\alpha=0.05$).

RESULTS: In concentric phase, for both groups all muscles activated more in DB exercise ($p<.01$) (table 1). The LBP group showed lower RA activity in DB exercise in comparison to controls in eccentric phase ($p<.02$). The OE muscle activated more during CC in both groups ($p<.01$) in concentric phase compared to other exercises. The OI and MU muscles showed more activation in SLS exercise in both groups ($p<.01$) in eccentric phase compared to other exercises.

CONCLUSION: The DB exercise showed the higher muscles' activity in the concentric phase regardless the studied group. This result is potentially due to arm movement going to the opposite side of the leg generating a harder situation to stabilize the pelvis and spine. The difference in the RA activity between groups shows a slight deficit in muscle activation in LBP individuals. Besides the difference in the RA muscle, the results suggests that when Mat Pilates is properly applied controls and LBP patients can take similar advantage in lumbopelvic stabilizer muscles work.

ACKNOWLEDGEMENT: This study was supported by CAPES (Brazil).

Table 1: RMS (% MVC) for both groups during Pilates exercises.

Muscle	Groups	SLS concent	CC concent	DB concent	SLS eccen	CC eccen	DB eccen
RA	Control	34.5±17.2*	13.5±6.9*	51.4±21.4*#	20.2±15.8	19.6±2.6	19.3±16.6
	LBP	45.0±25.6*	18.1±7.9*	77.8±45.8*	20.0± 11.4	15.4±5.8	24.9±22.0*
EO	Control	49.8±34.3*	15.6±9.1*	52.2±21.8*	17.7±10.8	46.7±29.7*	15.7±9.5
	LBP	39.3±23.7*	18.9±8.5*	37.8±18.6*	20.9±2.4	35.8±26.4*	14.7±5.9
IO	Control	53.1±20.5*	36.3±13.2*	77.1±35.6*	73.0±38.5*	50.2±29.4	19.5±10.7
	LBP	53.3±11.7*	35.3±18.9*	68.6±29.2*	91.4±63.9*	34.5±20.5	17.5±5.0
MU	Control	47.4±19.3	54.3±6.2	77.3±34.8*	89.6±44.7*	43.1±29.4*	24.0±11.3*
	LBP	80.3±60.1	77.8±45.8	85.7±58.8*	80.8±42.5*	35.0±22.8	22.7±9.9

* significant difference between exercises, # significant difference between groups ($p<0.05$)

VALIDITY OF ULTRASOUND IMAGING TECHNIQUE FOR SKELETAL MUSCLE ARCHITECTURE MEASUREMENT: A SYSTEMATIC REVIEW

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AIM: To identify the validity of using ultrasound (US) imaging technique as an objective measure of architectural characteristics of the muscle as compared with magnetic resonance imaging (MRI) measure.
METHOD: PubMed, CINAHL, SPORTDiscus, Web of Science, and SCOPUS were used to search relevant studies to be included from 1970 to January 2014 using combination of the terms "magnetic resonance imaging", "ultrasound, ultrasonography", "muscle", "architecture", "thickness", and "diameter". All studies were assessed with inclusion criteria and a quality assessment scale (PEDro scale). The inclusion criteria to select studies for this review were as followed: (1) the muscle architecture measured with both US and MRI, (2) human muscles regardless of body parts, (3) reporting means, standard deviations, and sample size of each group. Cohen's D effect size (ES) was calculated from selected studies.
RESULTS: Twenty one studies were identified for inclusion in this study. The average PEDro score of the studies that is included in this study was 4.2±1.1. In CSA, the ES of 24 cases were relatively moderate to low except four cases and 23 out of 24 cases demonstrated no significant difference as compared with those measured with MRI (Table 1). In addition, the ES of mass and moment arm were low and all selected cases demonstrated no significant difference as compared with those measured with MRI (Table 1). In contrast, thickness and volume result indicated that US measure demonstrated moderate to low ES throughout the cases and different from MRI measurement with low consistency (Table 1).
CONCLUSION: Based on SORT taxonomy, the strength of recommendation of this study is B and quality of evidence is 2. US can provide valid measurements of human muscle architecture such as CSA, mass, and moment arm as compared with MRI. This review came to the conclusion that US can provide valid measurements of not all skeletal muscle architecture characteristics, therefore, researchers or clinicians should selectively use US for their research and clinical practice.

<Table 1> Effect Size and Confidence Interval Result across Selected Studies (different muscles from one study were separately analyzed)

	Author	ES	CI	Author	ES	CI	Author	ES	CI
CSA	Scott	-0.16	-1.08:0.77	Scott*†	1.45	0.35:2.41	Scott‡	0.46	-0.49:1.38
	Scott‡	0.42	-0.54:1.33	Macrae‡	-0.43	-1.25:0.43	Macrae‡	-0.45	-1.28:0.41
	Walton	0.05	-0.83:0.92	Bemben‡	-0.58	-1.79:0.73	Bemben†	-0.97	-2.17:0.42
	Ahtiainen†	-0.62	-1.25:0.02	Ahtiainen†	-0.91	-1.94:0.25	Mendis	-0.11	-1.03:0.82
	Mendis	0.09	-0.84:1.01	Mendis	0.12	-0.81:1.04	Mendis	0.37	-0.58:1.29
	Mendis	0.14	-0.80:1.05	Mendis	0.14	-0.79:1.06	Hides	0.11	-0.77:0.98
	Hides	0.05	-0.83:0.92	Hides	-0.10	-0.98:0.78	Hides	-0.05	-0.92:0.83
	Hides	-0.26	-1.13:0.63	Juul-Kristensen	-0.23	-1.27:0.83	Juul-Kristensen	-0.48	-1.51:0.61
Mass	Sanada	-0.14	-0.71:0.43	Sanada	-0.04	-0.60:0.53	Sanada	-0.08	-0.65:0.48
	Sanada	0.00	-0.57:0.57						
Moment Arm	Juul-Kristensen	0.24	-0.83:1.28	Juul-Kristensen	0.33	-0.74:1.36			

* Significantly difference at α<.05 † High Effect Size ‡ Moderate Effect Size

Biomechanics 2 (Sala Cesarea 12.00-13.00)

THE EFFECT OF WALKING SPEED ON LOCAL DYNAMIC STABILITY – METHODOLOGY OF THE MAXIMUM FINITE-TIME LYAPUNOV EXPONENT

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AIM: Local dynamic stability has been proposed as predictor of the probability of falling in experimental and observational studies and in simulation models[1]. As such, this measure shows potential for identifying individuals who are more likely to fall. However, diverging trends of the effect of walking speed on local dynamic stability have been reported. We hypothesized that the different results might pertain to the different calculation methods applied. The aim of the current study was therefore to test if different methods of calculating local dynamic stability would induce different effects of walking speed on this measure.
METHODS: Local dynamic stability was measured by the short term maximum finite-time lyapunov exponent, λ_S, which quantifies the average rate of logarithmic divergence of infinitesimally close trajectories in state space and, thus, the attenuation of the naturally occurring stride-to-stride variability. Ten young healthy subjects (6 men and 4 women; 22.6±2.8 years, 70.6±6.5 kg, 1.78±0.08 m (mean±SD)) participated in the study. The subjects walked on a treadmill at five speeds (60, 80, 100, 120 and 140 % of preferred walking speed) for 3 minutes each, while upper body accelerations were sampled using a tri-axial accelerometer mounted on the sternum. From these time-series λ_S was calculated using firstly: a fixed time interval and expressed as divergence/stride (method **a**[2]); secondly: a fixed number of strides and expressed as divergence/second (method **b**[3]); and thirdly: a fixed number of strides and expressed as divergence/stride (method **c**[4]). For all methods λ_S was evaluated from 0-0.5 stride.
RESULTS: Preferred walking speed was 1.16±0.09 m/s. The three calculation methods induced different effects of walking speed on λ_S. For method **a**, the effect was modest. For method **b**, increasing walking speed increased λ_S, i.e. decreased local dynamic stability, while for method **c**, increasing walking speed decreased λ_S, i.e. increased local dynamic stability. Method **b** and **c** successfully recreated results of the studies wherein these methods have been applied. However, method **a** was not able to emulate previous findings for this method.
CONCLUSION: Based on the current study it appears that the reported different effects of walking speed on local dynamic stability in part may be explained by differences in the methodology used. Therefore, it remains that inferences of the effect of walking speed on local dynamic stability and comparisons across studies should be made with careful consideration of the methods applied.

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HIGHER KNEE ADDUCTION MOMENT IN FEMALES FOLLOWING TOTAL KNEE ARTHROPLASTY

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AIM: The focus of recent interest in improving biomechanical outcome from total knee arthroplasty (TKA) has centered around the potential need for gender-specific prostheses. Knee osteoarthritis in females is more advanced and results in greater functional deficits than males at the time of surgery. There is also emerging evidence of similar disparities in function following TKA. However, there has been no attempt to compare the knee biomechanics between genders during dynamic activities in patients with TKA. Assessment of the knee adduction moment is particularly important in this patient group as it has been associated with greater risk of TKA failure. The aim of this research was to compare peak knee biomechanics between males and females with TKA during walking and stair climbing, with reference to an unimpaired control group.

METHODS: Knee biomechanics of walking and stair ascent were assessed in 126 participants – 86 patients 12 months after surgery and 40 controls who were matched to the age (±2 years) and gender of patients. A 10 camera Vicon motion analysis system collected video data from 24 retroreflective markers placed in accordance with the modified Helen Hayes model, with additional markers to allow identification of the alternative pelvis model. Two embedded force platforms recorded ground reaction force data during level walking, and a third force platform collected data from the first elevated step in a 2-step staircase. In addition to spatiotemporal data, peak knee flexion angles and peak knee flexion and adduction moments were compared between males and females for both the patient and control groups.

RESULTS: There were no differences in age between the males and females. As expected, males in both groups were taller and heavier than females ($p<0.05$). For both groups, females ascended stairs with more knee flexion than males (Table 1). Surprisingly, despite slower walking speed and lower body mass, females had greater knee adduction moment during both walking and stair ascent.

CONCLUSION: Female patients with TKA had different biomechanics from males, which may predispose them to greater risk of complications in long-term outcome from surgery.

Table 1: Comparison of knee biomechanics between males and females

		TKA				**Controls**			
		Males		Females		Males		Females	
Walking	Speed *(m/sec)*	1.27	*(0.17)*	1.14*	*(0.26)*	1.33	*(0.21)*	1.15*	*(0.29)*
	Peak knee flexion during stance *(degrees*	13.2	*(7.3)*	13.6	*(6.4)*	20.7	*(4.9)*	14.4*	*(8.9)*
	Peak knee flexion moment *(%Bw-ht)*	2.2	*(1.2)*	2.3	*(1.3)*	3.6	2.4	1.5*	*(1.1)*
	Peak knee adduction moment *(%Bw-ht)*	2.7	*(0.6)*	3.0*	*(0.6)*	3.7	3.5	(0.8)	*(0.5)*
Stair Ascent	Time to completion *(seconds)*	1.1	*(0.2)*	1.2	*(0.2)*	1.1	*(0.1)*	1.1	*(0.2)*
	Peak knee flexion *(degrees)*	54.8	*(6.4)*	59.5*	*(6.5)*	58.8	*(3.7)*	62.8*	*(6.2)*
	Peak knee flexion moment *(%Bw-ht)*	2.1	*(1.3)*	2.6	*(1.1)*	4.1	*(1.2)*	3.9	*(1.1)*
	Peak knee adduction moment *(%Bw-ht)*	2.7	*(0.8)*	3.2*	*(0.8)*	3.8	*(0.7)*	4	*(0.7)*

USE OF DYNAMIC MOVEMENT ORTHOSES TO REDUCE GAIT INSTABILITY IN ATAXIC PATIENTS

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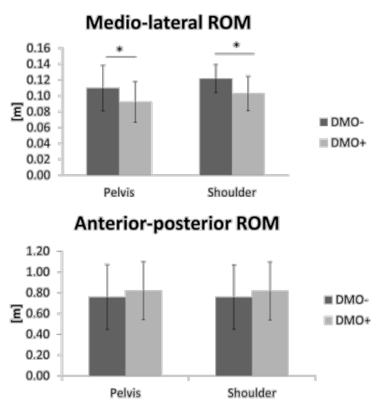
INTRODUCTION: Patients with cerebellar ataxia have an irregular and unstable gait with a high variability of all time–distance parameters, alterations known to be linked to a high falls risk. Moreover, greater upper body oscillations have long been reported in literature as a clinical feature of ataxic patients. Such wider upper body oscillations, moving the center of mass at the edges of the base of support, may induce instability. In order to reduce such instability of ataxic patients, we propose the use of dynamic movement orthoses (DMO, 7 layers Lycra suits), which may reduce the gait variability and the uncontrolled trunk oscillations, without restricting the functional movement. Thus, we aimed at quantitatively evaluating the effect of the DMO use on gait in a sample of ataxic patients.
METHODS: Gait analysis of 7 ataxic patients was performed without and with the customized DMO (after one month of continuous use). In addition to the joint kinematics, the variability of time-distance parameters, as well as shoulder-pelvis ranges of motion in the sagittal, frontal and transverse plane were investigated. The Wilkoxon test for paired samples was used to investigate differences between the two sessions in the analyzed variables. A p-value less than 0.05 was considered statistically significant.
RESULTS: With DMO, ataxic patients showed a reduction of the variability of the time-distance parameters and a reduction of shoulders and pelvis range of motion in the medio-lateral direction. Moreover, knee and ankle joint kinematics was improved by the use of DMO.
CONCLUSION: Our findings indicate that the trunk oscillations and gait variability were reduced by the use of Lycra suits. We propose to use the DMO in the neurorehabilitation of cerebellar ataxias to improve the trunk control and gait stability

Figure 1: Center of shoulder and center of pelvis displacement in the medio-lateral and anterior-posterior directions. * = $p<0.05$.



EFFECTS OF DIABETIC PERIPHERAL NEUROPATHY ON MUSCULAR ACTIVATIONS DURING STAIR ASCENT

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AIM: People with diabetic peripheral neuropathy (DPN) are more likely to fall than age-matched controls, and are particularly at risk during the physically demanding task of stair ascent. Previous studies have identified altered activation timings predominantly during level ground walking, but have failed to fully describe muscle activation patterns. The aim of this study was to investigate the effect of DPN and diabetes on muscular activations during stair ascent.
METHODS**:** 21 DPN patients, 21 diabetic patients without neuropathy (D) and 21 age and BMI-matched controls (C), ascended an 8-step force platform embedded staircase. Electromyographic (EMG) activity was recorded from the vastus lateralis (VL; representative knee extensor) and the medial gastrocnemius (MG; representative ankle platarflexor). The onset (AO), cessation (AC), duration (AD), time to peak from AO (TTP), and time of peak from foot-step contact (TOP) of activations were measured. Differences between groups were tested using a one-way ANOVA.
RESULTS: The DPN group displayed significantly later AOs for the VL and GN compared the C group, with both muscles also displaying longer TTPs (Fig. 1). AD was significantly longer in DPN patients for the VL but unchanged for the GN.

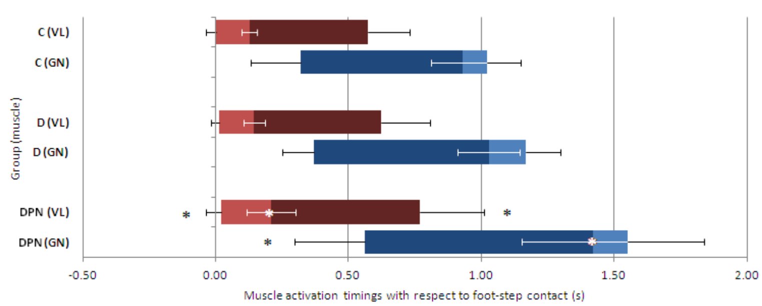

Figure 1. Muscle activation during stair ascent (foot step contact at 0s). Colour change denotes TOP. *denotes significantly different to C group, for AO (before), TTP (inside) and AD (after).

CONCLUSION: The delayed AOs and longer TTPs for the VL and GN muscles may impact upon joint stability and compromise balance during the crucial locomotor phases of weight acceptance and propulsion in DPN patients. These differences in activation may result from sensory and motor deficits, resulting in an unsteady gait pattern and subsequently increasing the risk of falling in this patient population during stair negotiation.
ACKNOWLEDGEMENTS: This study was supported by funding from the European Foundation for the Study of Diabetes (EFSD).

Clinical Neurophysiology 1 (Sala 1LM 12.00-13.00)

METHODOLOGICAL CONSIDERATIONS FOR THE QUADRICEPS H-REFLEX IN BOTH PASSIVE AND ACTIVE CONDITIONS

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AIM: H-reflex is a common tool used in neurophysiology, representing an index of spinal transmission between Ia afferents and motor neurons. However, little is known about the reliability of the quadriceps H-reflex during passive and active conditions. Therefore, this study aimed to evaluate the *vastus medialis* (VM) and *vastus lateralis* (VL) H-reflexes in passive and active conditions as well as its intra- and inter-day reliability for both conditions.
METHODS: The electromyographic activity of VL and VM muscles were recorded on the right leg of 12 healthy male subjects. Electrical stimulation of the femoral nerve (1-ms pulse duration) was used to evoke the recruitment curves of H and M waves, by gradually increasing the intensity of stimulation. The recruitment curves of VL and VM H-reflexes and M-waves were performed at rest (*i.e.,* passive condition), and during muscle contraction at 30% of the maximal voluntary contraction (*i.e.,* active condition). The recruitment curves in both conditions were repeated at 1 hour, 1 day and 1 week following the initial session to characterize the intra- and inter-day reliability of normalized H-reflex (H/M ratio).
RESULTS: The VM H-reflex was observed for a larger population in active condition (n=12) compared to passive condition (n=6). The H/M ratio was also significantly higher in active condition (0.292 ± 0.086) compared to passive condition (0.101 ± 0.116; P<0.001). Our result also revealed a greater occurrence (12 *vs.* 10 subjects) and amplitude (≈+150%) for the VM H-reflex compared to the VL H-reflex in active condition. The reliability was poor for passive VM H/M ratio in both intra- and inter-day due to high within-subject variations (*Table 1*). In active condition the VM H/M ratio was reliable, especially intra-day (ICC=0.93; CV=12%), while the reliability of VL H/M ratio was unsatisfactory in active condition (*Table 1*).
CONCLUSION: This study demonstrated that it is more appropriate to evoke VM H-reflexes during voluntary contraction of the quadriceps muscles, due to the greater occurrence, reliability and amplitude of H-reflex for this muscle compared to the VL, suggesting that *vasti* muscles behave differently.

Table 1 : Intra- and inter-day reliability of v*astus medialis* (VM) and *vastus lateralis* (VL) H/M ratios calculated for four trials in passive condition and three trials in active condition (30% of MVC) for the subjects where H-reflex was present in passive and active condition. ICC: intraclass correlation coefficient; CV: coefficient of variation.

	VM			VL		
	Mean (SD)	ICC (95% CI)	CV (%)	Mean (SD)	ICC (95% CI)	CV (%)
Passive	n=6			n=2		
Hours 1&2	0.123 (0.159) vs. 0.100 (0.106)	0.97	52.2	-	-	-
Days 1&2	0.100 (0.106) vs. 0.076 (0.068)	0.92	69.8	-	-	-
Weeks 1&2	0.076 (0.068) vs. 0.111 (0.145)	0.92	60.9	-	-	-
Active	n=12			n=10		
Hours 1&2	0.270 (0.107) vs. 0.246 (0.089)	0.93	12.0	0.189 (0.059) vs. 0.200 (0.040)	0.63	18.3
Days 1&2	0.246 (0.089) vs. 0.242 (0.063)	0.86	14.5	0.200 (0.040) vs. 0.171 (0.059)	0.31	32.0
Weeks 1&2	0.242 (0.063) vs. 0.256 (0.106)	0.79	19. 7	0.171 (0.059) vs. 0.172 (0.068)	0.64	30.8

BALLISTIC TRAINING OF THE ELBOW FLEXORS INCREASES RESPONSES TO STIMULATION OF HUMAN CORTICOSPINAL AXONS

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AIM: Plastic changes in the human motor pathway can accompany repeated movements (Bütefisch et al. 2000) and may lead to performance improvements. With ballistic training, adaptations occur in the spinal cord (Giesebrecht et al. 2012), but this has not been well studied. The aim of this study was to determine if a single session of ballistic training of the elbow flexor muscles leads to changes in the spinal cord and if the type of training is important for such changes.
METHODS: 10 subjects participated in three testing sessions. There were two training sessions for the elbow flexors (ballistic isometric training, ISO, and ballistic dynamic training, DYN), and a control session (i.e., quiet sitting). For ISO and DYN, subjects performed two blocks of training (12 sets of 8 brief elbow flexor contractions per block). Subjects received feedback on peak rate of force development during ISO and peak acceleration during DYN. Subjects were instructed to maximize these variables with every contraction. EMG was recorded from biceps brachii and responses of the motor pathway to stimulation were assessed in the relaxed muscle before, between, and after the two blocks of training. Transcranial magnetic stimulation over the contralateral motor cortex elicited motor evoked potentials (MEPs); electrical stimulation of the corticospinal tract axons at the cervicomedullary junction elicited cervicomedullary motor evoked potentials (CMEPs); and electrical stimulation of the brachial plexus elicited maximal compound muscle action potentials (M_{max}). MEPs and CMEPs were expressed relative to M_{max}. One-way repeated measures ANOVA assessed changes in performance throughout training. Two-way repeated measures ANOVA (factors: training type and time) assessed changes in CMEPs and MEPs. RESULTS: Significant improvements in peak rate of force development and peak acceleration were found during ISO (p = 0.011) and DYN (p < 0.001), respectively. For MEPs, there were significant main effects for training type (p = 0.030; ISO > control, p = 0.025) and time (p = 0.005), and a significant interaction (p < 0.001). For CMEPs, there were also significant main effects for training type (p = 0.027; ISO > control, p = 0.033) and time (p = 0.008), and a significant interaction (p < 0.001). CMEPs were significantly greater in ISO versus control five minutes after each block of training (p = 0.001). While DYN followed the same general trend as ISO, MEPs and CMEPs between DYN and control were not significantly different.
CONCLUSION: A single session of ballistic isometric training of the elbow flexors leads to increases in responses to stimulation of the motor cortex and to subcortical stimulation of corticospinal axons. Thus, changes at a spinal level occur with a ballistic training protocol and may, in part, contribute to improvements in performance.

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Giesbrecht S, van Duinen H, Todd G, Gandevia S, Taylor JL (2012). Training in a ballistic task but not a visuomotor task increases responses to stimulation of human corticospinal axons. *J Neurophysiol* 107: 2485-2492.

MUSCLES IN FUNCTION OF NEURAL PROTECTION: QUANTITATIVE PARAMETERS OF MUSCULAR ACTIVATION IN RESPONSE TO OPPOSITE SEQUENCES OF RADIAL NERVE TENSION TEST

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AIM: To investigate non-invasively quantitative parameters of muscular activation in response to elongation stress of the radial nerve with a radial nerve tension test (RNT) performed in two different sequences: proximal and distal. This was done following the notion that muscles may be activated via the common nociceptive flexion reflex (NFR) in response to painful stimuli associated with tensile or compressive loads on peripheral nerves, and that nerves tends to converge toward, and are tensioned more strongly and for a longer period of time, around the joint that is moved first. METHODS: Electromyography signals and joint angles were recorded continuously from 10 asymptomatic volunteers, using ME6000-biosignal monitor (Mega Electronics Ltd., Kuopio, Finland). Disposable Ag/AgCl-electrodes (Neuroline 720; Ambu, Ballerup, Denmark) were used in bipolar connection for surface EMG registration. Twin-axis goniometers (SG110 and SG150; Biometrics Ltd., Gwent, UK) were used for joint angle measurement. The test movements consisted of a common RNT performed until subjectively maximal tolerable painful symptoms in a proximal sequence (shoulder, elbow, wrist) and a reverse, distal sequence (wrist, elbow, shoulder). The myoelectric components were then compared with those recorded during a 20 second relaxed position (reference), and during a strong biceps brachii muscle stretch. EMG amplitude and mean frequency (MNF) were calculated for each phase of RNT. The maneuvers were performed in a random sequence. Amplitude was calculated as mean amplitude value (MAV) and it was normalized to the reference positions. MNF was calculated from the estimated Welch's averaged periodogram. Upper Trapezius, biceps brachii, brachioraldialis and extensor carpi radialis were chosen as test muscles for their capacity to decrease mechanical tension in the brachial plexus and radial nerve by i) elevating the shoulder girdle, ii) flexing the elbow, iii) extending the wrist. RESULTS: The myoelectric mean amplitude values increased continuously while the myoelectric mean frequency decreased in an opposite continuous trend during the performance of the neural tension manoeuvres, showing synchronization of motor units firing activity and mimicking pure muscular contraction. The results are highly statistically significant ($p \leq .01$) when compared to those of the relaxed reference position, and those recorded during a strong biceps brachii muscle stretch.
CONCLUSIONS: The continuous increase of MAV and the concomitant continuous decrease of MNF toward the end of each manoeuvre indicate genuine muscular contraction in response to neural mechanical loading. This activation seems to increase continuously, and motor units activation seems to synchronize, following the increase in tensile stress in the nerve in response to the RNT. These records differ significantly from those collected during strong stretch of biceps brachii, implicating that muscular stretch itself may not be responsible for the presented phenomenon. The data seem to contradict the common theory of reflex mediated muscle activation in response to mechanical loading of nerves, and support the idea that the mechanism is more complex than originally thought.
Conflict of interest disclosure: The authors have no conflicts of interest to report.

QUANTIFICATION OF MOVEMENT DISORDERS SYMPTOMS USING ATTITUDE SENSORS

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AIM: The correct diagnosis of a movement disorder is essential for a correct and early treatment of the patient. However, even the most common types of movement disorders have a high percentage of misdiagnosis. To perform the diagnosis and to quantify the severity of a disorder, subjective rating scales are typically used. To improve diagnostic accuracy we propose quantifying the observed symptoms using attitude sensors. Attitude sensors are composed of accelerometers, gyroscopes and magnetometers. If they are firmly attached to a body part it is possible to derive joint angles and distances and trajectories travelled by limbs.
METHODS: To determine the added value of the objective measurements patients with symptoms of bradykinesia, tremor and/or ataxia/dysmetria were included in addition to a similar number of healthy controls. A set of tests from clinical motor evaluation were used to evaluate different symptoms of movement disorders (as appropriate): 1) Hand extension, 2) Finger tapping, 3) Diadochokinesis, 4) Foot tapping, 5) Finger to nose test and 6) Tandem walking.
In addition, tremor episodes were automatically detected during the execution of each task. Depending on the task to be performed attitude sensors were attached to the relevant body parts. The parameters to be analyzed also depended on the selected task (such as frequency of tapping, angle of rotation, frequency of rotation, overshoot on finger to nose test and swaying of the subject in tandem walking).
RESULTS: The parameters described for each task (Fig. 1 provides an example for diadochokinesis in patients with Parkinson's disease) were compared with clinical scores on corresponding rating scales (UPDRS (Unified Parkinson's Disease Rating Scale) III for Parkinson's disease, TRS (Tremor Rating Scale) for tremor, SARA (Scale for the assessment and rating of ataxia) for ataxia).
CONCLUSION: Preliminary results indicate that objective measurements may improve diagnostic accuracy by eliminating the need to subjectively rate the severity of symptoms.

RECRUITMENT ORDER OF MOTOR UNITS IN THE QUADRICEPS: FEMORAL NERVE VS. OVER-THE-MUSCLE STIMULATION

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AIM: To investigate potential differences in the recruitment order of motor units (MUs) in the quadriceps femoris when electrical stimulation is applied over the quadriceps belly versus the femoral nerve.
METHODS: M-waves and mechanical twitches were evoked using femoral nerve stimulation and direct quadriceps stimulation of gradually-increasing intensity from 20 young, healthy subjects. Recruitment order was investigated by analyzing the time-to-peak twitch and the time interval from the stimulus artefact to the M-wave positive peak (M-wave latency) for the vastus medialis (VM) and vastus lateralis (VL) muscles.
RESULTS: During femoral nerve stimulation, time-to-peak twitch and M-wave latency decreased consistently ($P<0.05$) with increasing stimulus intensity, whereas, during graded direct quadriceps stimulation, time-to-peak twitch and VL M-wave latency did not show a clear trend ($P>0.05$) (Fig. 1). For the VM muscle, M-wave latency decreased with increasing stimulation level for both femoral nerve and direct quadriceps stimulation, whereas, for the VL muscle, the variation of M-wave latency with stimulus intensity was different for the two stimulation geometries ($P<0.05$) (Fig. 1).
CONCLUSION: Femoral nerve stimulation activated MUs according to the size principle, whereas the recruitment order during direct quadriceps stimulation was more complex, depending ultimately on the architecture of the peripheral nerve and its terminal branches below the stimulating electrodes for each muscle. For the VM, MUs were orderly recruited for both stimulation geometries, whereas, for the VL muscle, MUs were orderly recruited for femoral nerve stimulation, but followed no particular order for direct quadriceps stimulation.

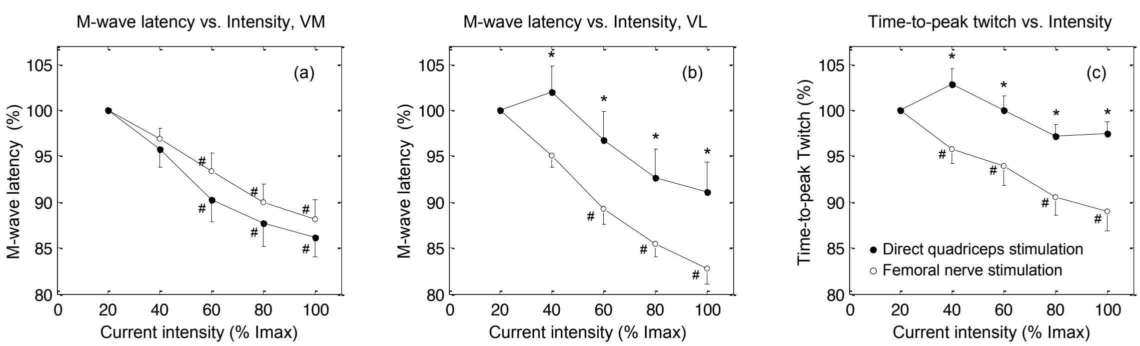

Figure 1**:** Average variation of VM M-wave latency (a), VL M-wave latency (b), and time-to-peak twitch (c) with different levels of stimulus intensity. Data are expressed as mean ± SEM (N = 20). *P < 0.05 different between muscle and nerve stimulation for the same intensity. #P < 0.05 different from the value at 20% Imax, where Imax = maximal stimulation intensity.

Multichannel EMG 1 (Sala 2LM 12.00-13.00)

Clinical Neurophysiology 1 (Sala 1LM 12.00-13.00)

MUSCLE ACTIVITY MAP RECONSTRUCTION FROM LOW-QUALITY HIGH-DENSITY SURFACE EMG SIGNALS USING IMAGE INPAINTING METHODS

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AIM: Muscle Activity Maps are obtained from High-Density surface EMG signals (HD-sEMG) to represent local muscular activity. Since the spatial resolution of 2-d electrode arrays is not high, 2-d interpolation methods are usually used for image representation. Moreover, there is a possibility that some channels have low signal to noise ratio (outliers) so that the corresponding muscle activity should be reconstructed using data from other channels. Image inpainting refers to the application of sophisticated algorithms to replace lost or corrupted parts of an image. In this work, different image inpainting methods are compared in terms of their accuracy and efficiency in reconstructing muscle activity maps obtained from HD-sEMG. METHODS: The following image inpainting methods were implemented: TV (Total Variation), FOE (Fields of Experts), and third-order optimal PDE (Partial Differential Equations). Sample frames of 13*5 electrode-array monopolar HD-sEMG signals (IED= 8 mm) recorded from the Biceps Femoris muscle during 10-s isometric low-to-moderate level contractions of healthy subjects were analyzed. The quality of the recorded channels was assessed, and the recorded signals in which the quality of all the channels was "good" were used as the gold standard. The simultaneous and average (60 ms epoch) activity maps were also calculated as the signal amplitude at each recording site. The amplitude values from randomly removed sites (with 5% to 25% rejection ratio) were then removed from the activity maps to simulate very-low quality signals. The maps were then reconstructed using the image inpainting methods. The relative error (the map reconstruction error divided by the norm of the original frame) was calculated for different inpainting methods in different scenarios ("average" or "simultaneous" activity maps). RESULTS: PDE showed the best performance for both the average and simultaneous activity map reconstruction. Its relative error (%) averaged over 10 signals in each rejection category is shown in Table 1. The C++ implementation of PDE also showed the best efficiency. Its average running times were 4.55 ms/epoch and 4.42 ms/sample for average and simultaneous activity map reconstruction, respectively. CONCLUSION: PDE image inpainting ensures continuation of level lines which is applicable in EMG activity maps on volume conduction. It is also contrast invariant and thus can be used for different levels of activation.
ACKNOWLEDGEMENT: The HD-sEMG data set used in this study was recorded at LISiN (Laboratory of Engineering of Neuromuscular System and Motor Rehabilitation), Italy. The authors are grateful to Kevin McGill for reviewing a draft of this abstract. Financial support: ERC Advanced Grant DEMOVE (No. 267888)

Table 1: Average relative reconstruction errors (μ±σ, in percent) of the PDE method for average (first scenario) or simultaneous (second scenario) activity maps at different rejection ratios (i.e., percentage of removed image frames).

Rejection / Scenario	**5%**	**10%**	**15%**	**20%**	**25%**
1	0.23±0.05	0.38±0.16	0.46±0.27	0.81±0.68	0.87±0.21
2	3.82±1.27	3.73±1.51	4.79±1.56	4.92±1.76	5.41±2.17

COMPARING THREE DIFFERENT SEGMENTATION ALGORITHMS APPLIED TO SIMULATED MONOPOLAR EMG MAPS

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AIM: Electrode grids provide a spatial distribution (a map) of muscle electrical activity. Specific regions within these maps are of interest. In this study we tested different methods currently considered in the literature for the automatic segmentation of EMG images in order to find the one providing higher accuracy in EMG map classification.
METHODS: Three segmentation algorithms K-means, watershed, and h-dome, have been tested using simulated EMG maps (a map of average rectified value (*ARV*) consisting of 8x15 electrodes; 30 motor unit populations; 2 mm and 6 mm fat thickness; 5 noise levels). We defined the parameter *h = thr*max(ARV map)*, where *thr* is the threshold level (0.05 to 0.90 in steps of 0.05), to provide a marker (*=ARV-h*) for the EMG image. In the watershed algorithm, after segmenting the ARV map, the active region was defined as the region where *ARV> thr*max(ARV in the segment)*. K-means classifies a given data set into k clusters, fixed on a priori basis. The effect of image equalization on segmentations was investigated as well.
RESULTS: For the simulated two fat thicknesses and five noise levels ([0, 5, 10, 15, 20] dB), the highest accuracy in segmentation (i.e. correct partitioning of active from in-active region) was obtained at *thr* = 70% and 30% of the max(*ARV*) with watershed and h-dome respectively. Merging all data together (threshold levels, number of clusters, fat thickness, noise level and equalization) the average accuracies (defined in the figure) and its standard deviation across all mentioned conditions and all images for watershed, h-dome and k-means segmentation were (mean(SD)) 82.2(9.48), 73.1(19.55), and 82.3(8)%, respectively. Contrary to K-means, watershed and h-dome do not need any a priori knowledge.
CONCLUSION: Watershed method is the least sensitive technique to the noise, threshold level, fat thickness, and equalization for segmenting EMG maps with no a priori knowledge.

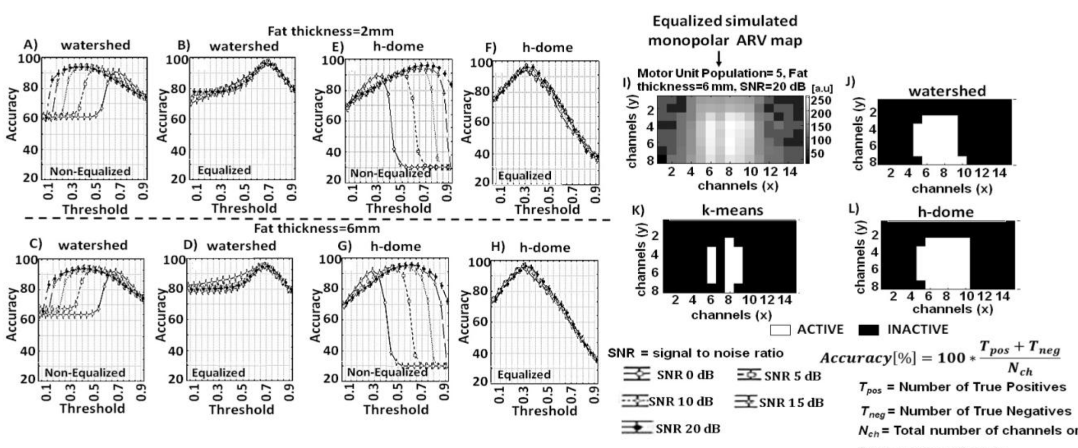

Figure 1: A, B, C, D, E, F, G, H) Average (N = 30) accuracy versus threshold applying watershed segmentation (A, B, C, D) and h-dome (E, F, G, H) methods to the simulated ARV maps (30 different MU populations) for non-equalized (A, C, E, and G), equalized (B, D, F, and H), fat thickness 2 (A, B, E, and F) and 6 mm (C, D, G, and H) in five different noise levels. I, J, K, and L) Application of segmentation algorithms to detect the active portion of a simulated EMG map of I) equalized monopolar ARV map (fat thickness = 6mm, SNR = 20dB) and the active (white) and inactive (black) regions found by J) watershed, K) k-means, and L) h-dome segmentation.

MOTOR UNIT INNERVATION ZONES OF EXTERNAL ANAL SPHINCTER FROM MULTICHANNEL SURFACE EMG USING 2D CORRELATION

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AIM: A method, to detect automatically the location of innervation zones (IZ) from 16-channel surface EMG (sEMG) recordings from the external anal sphincter (EAS) muscle, is presented in order to guide episiotomy during child delivery and to avoid damaging the IZs during surgical interventions. The new algorithm (2DCorr) is applied to individual motor unit action potential (MUAP) templates and is based on bidimensional cross correlation between the interpolated image of each MUAP template and its two mirrored images.

METHODS: The Multichannel single differential sEMG signals, recorded from EAS using an anal probe comprising an array of 16 equally spaced electrodes placed along the circumference of the probe as depicted in figure 2d, are decomposed using the Correlation Kernel Compensation (CKC) method in order to get the MUAP templates. Each MUAP template (figure 1), represented as topographic image I where x, y are dimensions in time and space and the gray level is the signal amplitude, is first correlated with its flipped upside down and inverted version I' and the maximum of the correlation matrix MCC_M is identified. The image I is then correlated with its flipped upside down then flipped left right and inverted version I'' and the maximum of this correlation matrix MCC_R is identified. It was found that in case of bidirectional MUAP propagation $MCC_M \geq 2MCC_R/(N-1)$ and the IZ corresponds to the location of MCC_M, while the opposite holds in case of unidirectional propagation and the location of the IZ is then under the channel showing the earliest signal. N is the number of channels where the MUAP propagation exists.

RESULTS: The 2DCorr method is compared with two other existing methods (Radon transform, RT and template match, TM), using 1000 simulated MUAPs generated by means of a cylindrical model of the EAS, and 2000 MUAPs detected on the EAS of 150 pregnant females. The 2DCorr showed the lowest inter quartile range (IQR) error in identifying the innervation zone of both simulated and experimental MUAPs. For simulated MUAP the IQR error for 2DCorr, RT and TM methods was 0.23, 0.42 and 2.32 inter electrode distance (IED) respectively while for experimental MUAPs it was IQR = 0.32, 0.49 and 1.19 IED respectively. The error distribution is depicted in figure 2.

CONCLUSION: A novel method for automatic IZ location was developed and tested on simulated and on experimental MUAPs detected from the EAS with a lowest error w. r. t. the two previous methods.

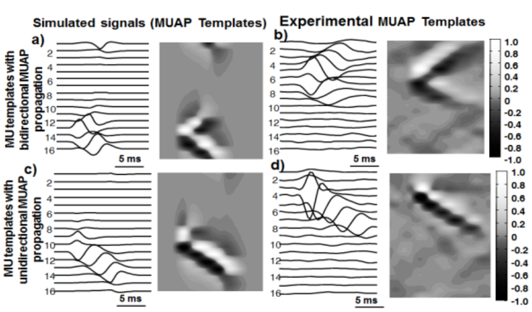

Figure1: Two simulated MUAPs in single differential mode (a, c).Two motor units identified from experimental signal using the CKC decomposition algorithm (b, d).

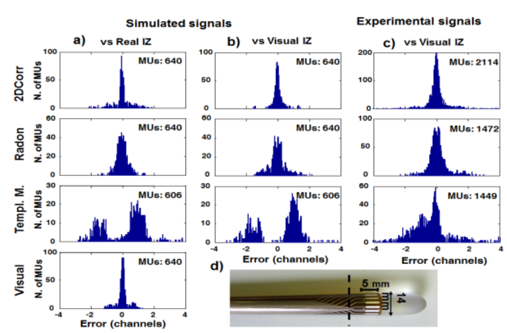

Figure 2: Distribution of the errors in the identification of the innervation zone on simulated (a) and (b) and experimental MUs (c). The anal probe (d)

OPTIMAL ELECTRODE CONFIGURATION TO ESTIMATE HAND KINEMATICS FROM SEMG

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AIM: The aim of this work was to identify the optimal electrode number and positioning on the forearm to estimate the wrist and single finger kinematics from surface EMG (sEMG) during dynamic contractions.
METHODS: Eight able bodied subjects performed free cyclic dynamic tasks involving wrist and fingers. sEMG signals were detected from the forearm muscles using a grid of 112 electrodes (14 longitudinal columns and 8 transversal rows, 15 mm interelectrode distance). The joint angles of wrist and fingers (metacarpophalangeal (MCP) and proximal interphalangeal (PIP)) were recorded using a sensorized glove. Eight perceptron artificial neural networks (one for each considered joint) were trained to estimate the angles from sEMG envelopes [1]. Different sets of EMG electrodes were evaluated: a) one ring of 14 electrodes 2 cm from the elbow crease, b) two rings (spaced 75 mm) of 14 electrodes each, c) a set with one electrode on the barycenter of each sEMG activity area, d) a set with one electrode on the center of each EMG activity area, e) a set with one electrode on the maximum of each EMG activity area. The quality of reconstruction of the joint angles was evaluated through the coefficient of determination (r^2). A repeated measure ANOVA was used to compare different sets of electrodes.
RESULTS: The results show that the quality of joint angle reconstruction depends on the electrode set ($p<0.001$, $F=8.93$). Newman-Keuls post-hoc test discovered a statistically significant difference in the reconstruction quality (r^2) between the single ring (worst performances) and all other sets of electrodes ($p<0.001$).
CONCLUSION: Taking into account the computational costs and the simplicity of the electrode positioning, two rings of electrodes provide an optimal configuration to estimate the hand kinematics during wrist and single finger movements.

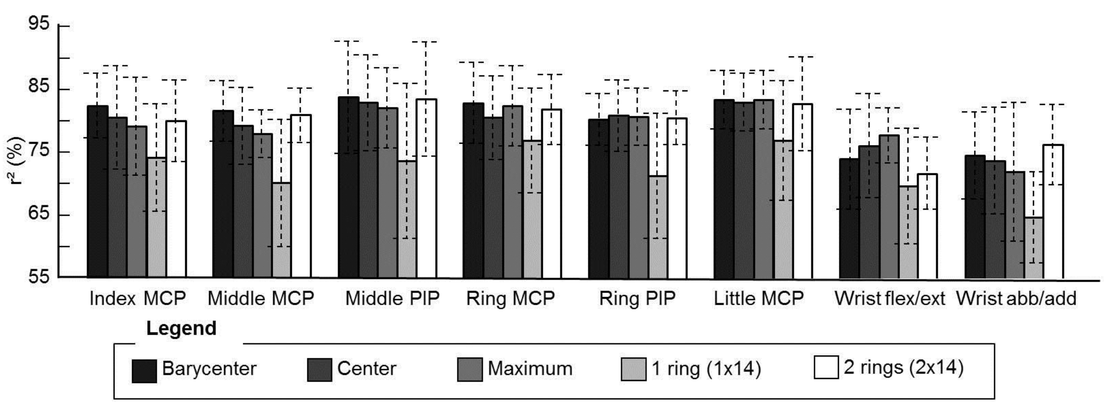

Figure 1. Mean ± standard deviation of the coefficient of determination (r2) between the measured and estimated joint angles using different electrode sets.

[1] Muceli S, Farina D, "Simultaneous and proportional estimation of hand kinematics from EMG during mirrored movements at multiple degrees-of-freedom", IEEE Trans Neural Syst Rehabil Eng. 2012 May.

HIGH-DENSITY SURFACE ELECTROMYOGRAPHY IMPROVES THE ESTIMATION OF CORTICOMUSCULAR COHERENCE

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AIM: Methods to optimize the identification of oscillatory synaptic inputs from surface EMG are currently debated. Here we investigate whether high-density surface EMG (HDsEMG) can be used to improve the estimation of corticomuscular coherence.

METHODS: Sixteen healthy subjects performed a pinch grip at low force levels, while HDsEMG of the adductor pollicis transversus and flexor and abductor pollicis brevis and whole-head magnetoencephalography (MEG) were recorded. Different configurations were constructed from the HDsEMG grid and the strength and variability of corticomuscular (MEG-EMG) coherence was compared across configurations.

RESULTS: Precision-grip resulted in significant corticomuscular coherence in the beta frequency band, i.e. 16-26 Hz. Compared to the bipolar EMG montage, all configurations obtained from the HDsEMG grid revealed a significant increase in corticomuscular coherence. The configuration based on principal component analysis (PCA) showed the largest (37%) increase (see Fig. 1). HDsEMG did not reduce the between-subject variability; rather many configurations showed an increased coefficient of variation.

CONCLUSION: HDsEMG can be used to improve the estimation of corticomuscular coherence. This increase likely reflects its ability to counteract inherent EMG signal factors that impact the detection of oscillatory inputs, such as amplitude cancellation. Reducing the effect of EMG signal factors has important consequences for the interpretation of corticomuscular coherence, allowing better comparison between conditions that are know to affect these EMG signal factors. However, the large variability in corticomuscular coherence between healthy subjects is the major drawback for clinical applications, as corticomuscular coherence cannot be used as a marker of deficiencies in the corticospinal tract.

ACKNOWLEDGEMENT: This research was financially supported by the Netherlands Organisation for Scientific Research (NWO #45110-030).

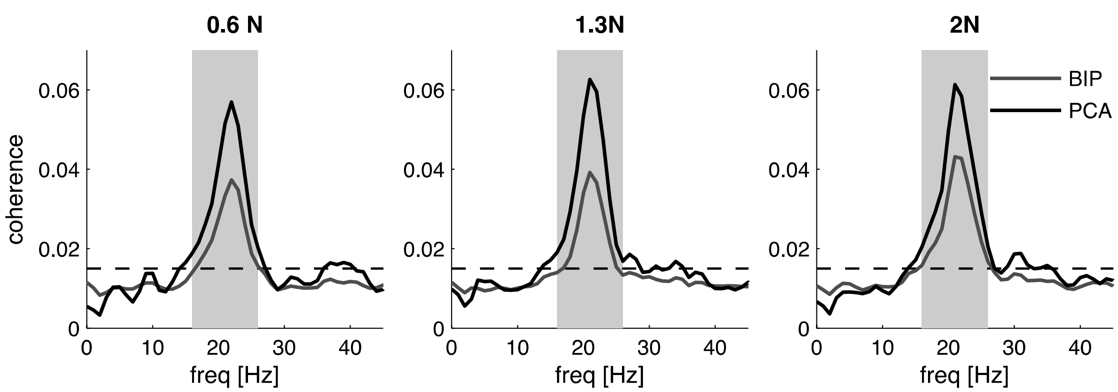

Figure 1: Corticomuscular coherence is increased for the HDsEMG configuration based on PCA compared to a bipolar configuration (BIP) irrespective of the force level (0.6, 1.3 or 2 N)

Motor Performance and Sport Science 1 (Sala 4LM 12.00-13.00)

JUMPING MECHANOGRAPHY IN MASTER RUNNERS AND CYCLISTS

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AIM: Age-related declines affect aspects of neuromuscular function to a different degree. The present study aimed to compare lower body mechanical output in relation to age and exposure to extent of elastic energy storage within stretch-shortening cycles.
METHODS: 431 master athletes (mean age 58.6±13.6y) completed counter-movement jumps (CMJ) and maximal one-legged hopping (m1LH) on a force platform. Athletes were classified as sprint or distance athletes, and cyclists or runners according to their event. Peak force, power, height and counter-movement depth for the jump, and peak force, power, height, displacement during ground contact, stiffness and energy storage for hopping were recorded. RESULTS: Sprint athletes recorded greater jump and hop performances than distance athletes in all parameters except whole body stiffness (Table 1). Peak jump power, peak hop power and whole body stiffness were greater in runners than cyclists. Jump and hop parameters except whole body stiffness decreased significantly with age – peak jump and hop power and jump height were all predicted (by MANCOVA) to be 60-70% lower at 95 years of age than at 35. CONCLUSION: Results suggest that both exercise intensity and modality affect muscular benefits accrued from exercise. Jump and hop performance outcomes are affected differently by age, likely due to the interplay between neuromuscular and tendinous factors which underly performance. Counter-movement depth greatly affects recorded CMJ force and height, but not power, and may have influenced observed age and discipline effects.
Table 1: Effects of age and athletic discipline on hop and jump parameters. Asterisks indicate significant effect of age/discipline at *P<0.05, **P<0.01, ***P<0.001. In all cases sprint group results greater than distance group, and runner results greater than cyclists - except greater body stiffness in distance athletes. Δ35_95 – Difference between values predicted by MANCOVA at age 35 and 95.

Test	Measured parameter	Age		Discipline (*P*)		R^2
		P	Δ35_95 (%)	Sprint/ Distance	Run/ Cycle	
CMJ	Peak relative force (BW)	***	-24.3	***	0.064	0.22
	Peak relative power ($W.kg^{-1}$)	***	-60.7	***	***	0.59
	Peak jump height (m)	***	-69.7	***	0.769	0.63
	Counter-movement depth (m)	***	-23.7	*	0.642	0.05
M1LH	Peak relative force (BW)	***	-31.8	**	0.987	0.28
	Peak relative power ($W.kg^{-1}$)	***	-62.7	***	**	0.39
	Peak hop height (m)	***	-43.6	***	0.695	0.22
	Ground contact displacement (m)	***	-45.3	***	0.374	0.17
	Whole Body Stiffness ($N.mm^{-1}$)	0.89	-	**	*	0.07
	Relative energy storage ($J.kg^{-1}$)	***	-48.8	***	0.364	0.25

MUSCLE SYNERGY IS RELATED TO ROWING ECONOMY

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AIM: The study of muscle synergy and its association to energy metabolism is crucial for rowing as huge muscle mass are being recruited during high intensity exercise. As a strategy of central nervous system (CNS) to improve redundancy at musculoskeletal level, we hypothesized that muscle synergy is associated to rowing economy and thus affect the rowing performance.

METHODS: Ten collegiate rowers and ten physically active males were recruited. Muscle synergies were extracted from 16 rowing specific muscles using principal component analysis with varimax rotation. Subjects covered maximum distance during 6 minutes rowing test on Concept 2 sliding ergometer with imposed stroke rate. Rowing performance, kinematic and physiological variables were analyzed.

RESULTS: Despite showing equivalent level of fitness on physiological variables ($VO_{2\ max}$ and maximal heart rate), rowers managed to cover more distance, exerted higher power output and energy expenditure with better rowing economy. Rowers utilized different rowing strategy with longer and slower strokes compared to the untrained subjects. Three functional muscle synergies with high indices of similarity were extracted in both groups. Synergy #1 which comprised of leg and back muscles and synergy #2 which consisted of upper limb muscles were activated during drive phase. Synergy #3 engaged during the transition of strokes. Significant association was found between synergy #1 and rowing economy. However, multiple linear regression revealed that rowing economy is inversely related to rowing performance for untrained subjects only.

CONCLUSION: Although rowing economy is highly associated to synergy #1 for both groups, it is not the main predictor of rowing performance. The rowers were able to achieve better rowing economy due to their longer-slower rowing strokes which is a characteristic of practice-related adaptation that decreases energy expenditure. Developing economical rowing strokes should be the focus of beginners, while the experienced rowers could achieve better rowing performance by enhancing muscles coordination.

Table 1: Rowing performance and physiological variables of untrained subjects and collegiate rowers during 6 min maximal rowing on SE.

	Untrained	**Rowers**	***p* value**
Total distance (m)	1503 (156.47)	1741.1 (47.8)	0.01
Power (Watts)	259.11 (44.2)	317.47 (38.1)	0.01
Stroke rate (spm)	35.01 (3.6)	30.9 (2.7)	0.01
Stroke length (mps)	7.23 (1.0)	9.32 (0.8)	0.01
$VO_{2\ max}$ (L/min)	5.02 (1.2)	5.78 (0.7)	0.07
$VO_{2\ max}$ (kg/L/min)	68.1 (12.9)	71.33 (12.2)	0.31
Heart rate $_{max}$ (bpm)	175.8 (5.1)	180.67 (6.9)	0.05
Energy $_{expenditure}$ (kJ/min)	73.38 (19.1)	105.9 (13.5)	0.01
Economy (%)	28.43 (5.9)	33.57 (4.02)	0.02

m, meter; spm, strokes per minute, mps, meter per stroke; VO_2, oxygen consumption; L, liter; min, minute; kg, kilogram; bpm, beats per minute; kJ, kilojoule; %, percentage

MUSCLE FIBRE CONDUCTION VELOCITY DECREASES WITH POWER OUTPUT DURING THE 3 MIN ALL-OUT CYCLING TEST

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AIM: It is well established that the bioenergetic two determinants of exercise performance in the severe intensity domain, i.e. the critical power (CP) and the total work performed above CP (W'), can be obtained from a 3 min all-out test. By measuring muscle fibre conduction velocity (MFCV) response during this test, the purpose of the present study was to give an insight into neuromuscular determinants of all-out cycling performance.

METHODS: Eight well trained competitive cyclists (22±3 yrs) performed a ramp incremental exercise test, a 3 min all-out familiarization trial and an experimental 3 min all-out test. Subjects were instructed and strongly encouraged to maintain the cadence as high as possible at all times throughout the experimental test, with the ergometer (Lode Excalibur Sport, Groningen, the Netherlands) set in the linear mode. During the test, the MFCV was estimated (OTBioLab, Turin, Italy) from the sEMG recorded with a 4-electrode linear array on the vastus lateralis muscle of the dominant limb.

RESULTS: A positive relationship between MFCV and power output was observed for all the subjects ($r = 0.89 \pm 0.1$; $P < 0.001$). The MFCV showed maximal values at the very beginning of the exercise and it markedly decreased (-14.2 ± 5.1%) until half of the trial was reached. Thereafter, a slight non significant decrease (-5 ± 3.3%) in MFCV was observed. W' and CP mean values were 14.3 ± 3.2 kJ and 359 ± 47 W, respectively. No differences in VO_2max values were found between the ramp incremental test (66 ± 10 $ml \cdot kg^{-1} \cdot min^{-1}$) and the experimental 3 min all-out test (66 ± 6 $ml \cdot kg^{-1} \cdot min^{-1}$).

CONCLUSION: Our findings link the bioenergetic two determinants of exercise performance in the severe intensity domain to neuromuscular determinants. Specifically, MFCV markedly declines until the W' has been expended and it relatively stabilizes thereafter with the attainment of the CP. The MFCV profile also suggests derecruitment of fatigued type II muscle fibres in the second part of the test.

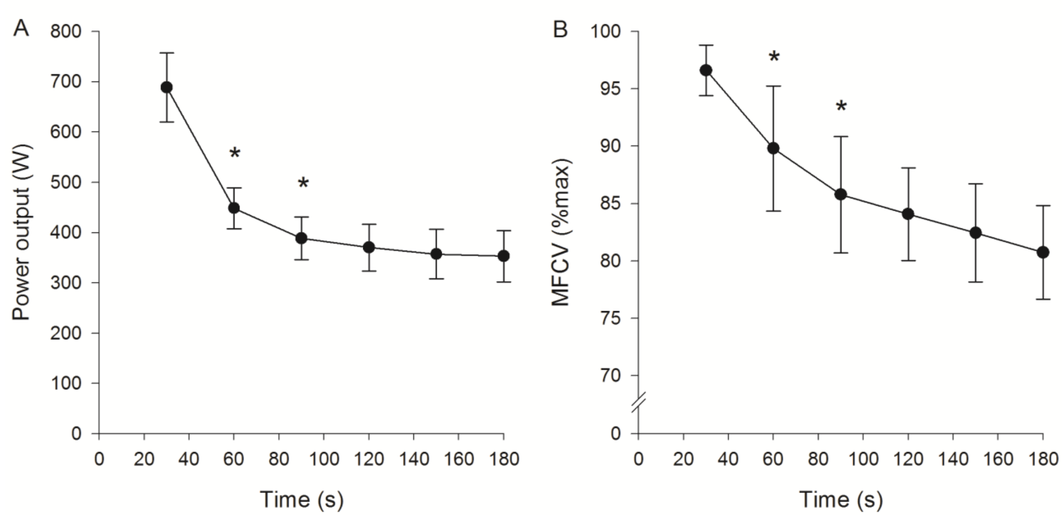

Figure 1: Power output (A) and MFCV (B) time course. Data are mean ± SD. * significantly different from the previous value.

MUSCLE FIBER CONDUCTION VELOCITY, TIME-FREQUENCY AND AMPLITUDE ANALYSIS DURING CONTINUOUS AND INTERMITTENT INCREMENTAL MAXIMAL CYCLING

Martinez-Valdes E[1,2], Guzman RA[3], Silvestre R[2,4], Macdonald JH [5], Farina D[6], Araneda OF [3]

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[3] Facultad de Medicina, Escuela de Kinesiología, Universidad de Los Andes, Santiago, Chile; [4] CIB, PhD Biomedicine Program, Universidad de los Andes, Santiago, Chile; [5] School of Sport, Health and Exercise Sciences, Bangor University, Bangor, United Kingdom;
[6] Department of Neurorehabilitation Engineering, Bernstein Focus Neurotechnology Göttingen, Bernstein Center for Computational Neuroscience, University Medical Center, Göttingen, Germany.
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AIM**:** To study the electromyographic (EMG) response during continuous and discontinuous incremental maximal cycling using muscle fiber conduction velocity (MFCV), time-frequency (instantaneous mean frequency index, iMNF) and root mean square (RMS) analysis, testing the hypothesis that rest periods influence EMG variables.

METHODS: Eight men (23±4yr, 175±8cm, 74±7kg) attended the laboratory on three occasions. On visit one, lactate threshold, peak power output, and $\dot{V}O_{2MAX}$ were obtained. On visits two and three, continuous and discontinuous incremental cycling protocols (20, 40, 60, 80 and 100% of peak power output) were performed; during both protocols surface EMG signals were recorded from the Vastus Lateralis muscle using a linear electrode array. MFCV, iMNF (Choi-Williams distribution) and RMS were analyzed at the same time-instant for each pedal cycle. Differences between and within protocols for all the EMG variables were assessed by two-way repeated measures analysis of variance followed by Bonferroni corrected t-tests when appropriate (α=0.05).

RESULTS**:** Despite similar exercise intensities, only MFCV response varied dependent upon on whether the protocol was continuous or discontinuous ($p < 0.001$). MFCV increased consistently with power output only in the discontinuous protocol, and was significantly greater than the continuous protocol at higher exercise intensities (Fig. 1a). In contrast, iMNF and RMS were statistically similar between both protocols ($p = 0.2$ and $p = 0.4$, respectively). Visually, iMNF response was greater during discontinuous cycling (Fig. 1b) but RMS response was identical to both protocols, increasing with power output linearly (Fig. 1c).

CONCLUSION**:** MFCV revealed that rest periods seem to influence motor unit recruitment strategies and myoelectric manifestations of muscle fatigue during incremental cycling. iMNF could be related to those changes, whereas RMS was not sensitive to the effect of the different protocols.

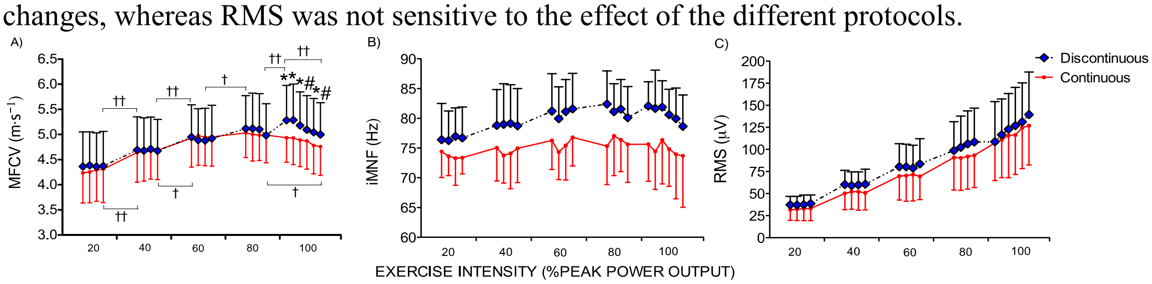

Figure 1. **MFCV (A), iMNF (B) and RMS (C) response during continuous and discontinuous incremental cycling. Values reported as means and SD. Significant differences by pairwise comparisons between continuous vs. discontinuous protocol epochs, * p<0.01, # p<0.05. Significant differences by pairwise comparisons within each protocol are displayed separately for continuous (below the figure) and discontinuous (above the figure) protocols, †† p<0.01, † p<0.05.**

Biomechanics 3 (Sala Cesarea 15.30-16.30)

MAGNETIC RESONANCE IMAGING ANALYSES CONFIRM SO FAR THEORETICALLY POSED INTERMUSCULAR INTERACTION EFFECS, IN VIVO

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AIM: Epimuscular myofascial force transmission (EMFT) i.e., force transmission from muscle to its surrounding muscular/nonmuscular structures have been previously made evident in animal experiments [1]. Coupled finite element modeling have shown occurrence of highly non-uniform muscle tissue deformations due to EMFT indicating sarcomere length non-uniformity [2]. Magnetic resonance imaging (MRI) analyses can quantify tissue deformations in human muscles, *in vivo* [3]. With such analyses we aimed at assessing local tissue deformations within the human lower leg as caused by knee angle changes. We further expected to show non-uniformity of deformations along muscle fibers of m. gastrocnemius.
METHODS: Healthy female subjects (n=5, age=27±2 years, height=159±4 cm, body mass=49±5kg) participated. Each subject was positioned prone within the MRI scanner with the ankle angle fixed at 90°. The knee was brought to flexion (142.4±4.3°) (*undeformed state*) and sets of 3D high resolution MR, and diffusion tensor (DT) images were acquired. This was repeated at the extended knee joint position (176.0±1.9°) (*deformed state*). Anatomical regions distinguished: anterior crural compartment, peroneal compartment, deep flexors, m. soleus and m. gastrocnemius. Demons non-rigid registration algorithm was applied to the MR image sets to quantify tissue deformations among the two states. Principal strains, characterizing peak local tissue lengthening/shortening were analyzed. Image sets of the undeformed state were also transformed by a representative "synthetic rigid body motion" imposed. Calculated deviations of principal strains from zero were used as estimates of strain errors in statistical tests. DT-MRI data were used to determine m. gastrocnemius muscle fiber tracts. Strain transformation was used to obtain fiber direction strains to exemplify in one-subject the EMFT effects that represent sarcomere length changes.
RESULTS: Maximal mean error strains found for lengthening and shortening (1.2% and -1.5%, respectively) were small, indicating minimal artifacts. Despite globally isometric condition of muscles other than m. gastrocnemius, significant local lengthening (except peroneal muscles) and shortening have been observed within the entire lower limb, (minimally, mean lengthening and shortening equals 5.8% and -8.8%, and peak lengthening and shortening equals 39.6% and -28.0%, respectively). In m. gastrocnemius mean lengthening and shortening are even higher (16.1% and -23.1%, respectively). Along its muscle fibers, lengthening occurred simultaneously with shortening (maximally by 35.3% and -28.2%, respectively). Within single muscle fibers, fiber direction strains showed major heterogeneity e.g., from 18.3% lengthening distally to -28.2% shortening proximally.
CONCLUSION: Knee angle changes caused substantial heterogeneous local muscle tissue deformations, and not confined to lengthened m. gastrocnemius. The findings also support our previous ideas of sarcomere length non-uniformity in human muscle, and *in vivo*.
ACKNOWLEDGEMENT: TÜBİTAK, under grant 111E084 to Can A. Yucesoy.
REFERENCES:
1. Yucesoy CA, et al. *J Biomech* **36(12)**, 1797-1811, 2003.
2. Yucesoy CA, et al. *J Electromyogr Kinesiol* **17(6)**, 664-679, 2007.
3. Yaman A, et al. *J Biomech Eng* **135(9)**, 91003, 2013.

DIRECT KINEMATICS VERSUS INVERSE KINEMATICS: KINEMATIC MODELLING APPROACH ALTERS LOWER LIMB JOINT KINEMATICS, MUSCLE MOMENT ARM AND MUSCLE-TENDON LENGTH ESTIMATES IN CHILDREN WITH CEREBRAL PALSY

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AIM: In children with cerebral palsy gait analysis is used for treatment planning and outcome assessment. Most clinical gait services use Plug-in-Gait (PiG) to directly calculate kinematic profiles from marker trajectories, a process which is known as the direct kinematics (PiG-DK) approach. On the other hand, inverse kinematics (IK) approaches adjust the joint angles of a rigid skeletal model, with predefined joint degrees-of-freedom (DoFs), to track the experimental markers trajectories. IK is employed by OpenSim, which is rapidly becoming the most commonly used suite of musculoskeletal biomechanical analysis tools and many clinical gait services are currently exploring the use of this software. To date, there have been no evaluations of whether DK and IK solutions produce the same outputs in the assessment of pathological gait. The purpose of this study was to compare joint kinematic, muscle moment arm (MMA, and muscle-tendon length (MTL) waveforms of children with cerebral palsy obtained by DK with the waveforms obtained by IK.
METHODS: Lower limb gait data of 8 children with spastic CP were collected and processed using the following two models: (1) standard Vicon Plug-in-Gait model (PiG-DK), and (2) modified OpenSim musculoskeletal model with identical joint centre locations and rotational DoFs as the widely used Vicon Plug-in-Gait model (PiG-IK). Hip, knee, and ankle joint kinematics, as well as MMAs and MTLs of lower limb muscles were calculated across the gait cycle. Similarity of waveforms from the two models was assessed using a modified version of the coefficient of multiple correlation (CMC).
RESULTS: Comparisons of waveforms obtained by DK and IK showed CMC values of 0.56-0.99 for joint kinematics, 0.58-0.91 for MMAs (Figure 1 blue solid columns), and 0.83-0.98 for MTLs (Figure 1 red striped columns). Transversal joint kinematic (CMC 0.56 for the hip, 0.66 for the knee, and 0.75 for the ankle joint), hamstring MMA (CMC 0.58-0.67), and semitendinosus (CMC 0.83) and semimembranosus (CMC 0.84) MTL had the greatest disparity.
CONCLUSION: DK and IK approaches produced different model outputs. MTLs and MMAs with the greatest disparity were the hamstrings, which is of concern because these muscles are commonly considered for surgical lengthening. Future work should assess the validity of the modelling methods by e.g. comparing repeatability and measures of dynamic consistency.

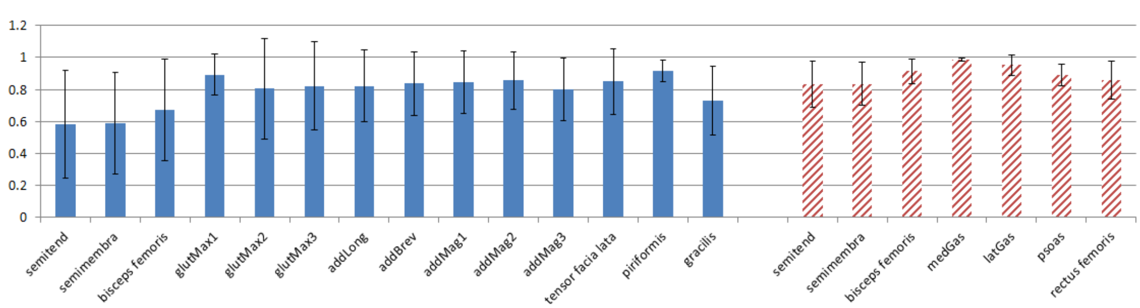

Figure 1: CMC values for all analysed MMAs (blue, solid) and MTLs (red, striped).

BIOMECHANICS OF THE SHOULDER JOINT IN REAL AND VIRTUAL ENVIRONMENTS

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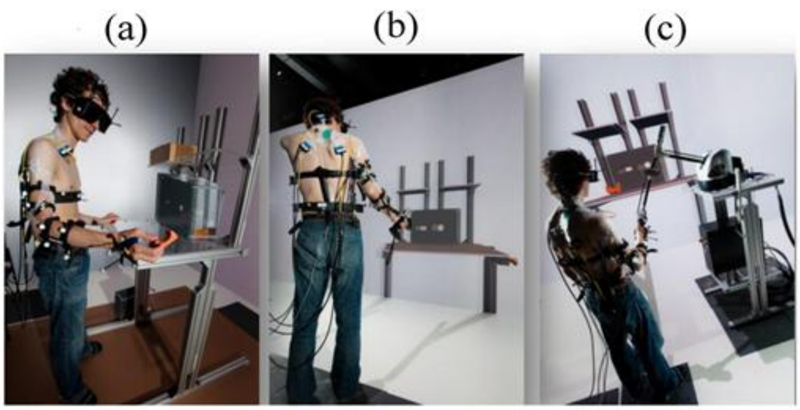
AIM: We investigated the "fidelity" of a simulated assembly task in virtual and real environments in terms of shoulder kinematics and trapezius muscle activity. The fidelity implies how well a virtual environment mimics all aspects of an equivalent real one.
METHODS: Sixteen novice volunteers performed the task within three different platforms: real (RE), virtual (VE) and virtual environment with force feedback (VEF) with two precision demands and timing regimes. The subjects repeated the task 12 times (i.e., 12 cycles). High density electromyography over upper trapezius and rotation angles of the shoulder joint were recorded and split into the cycles. The angular trajectory of the shoulder joint angles over a cycle as well as their velocities and accelerations were computed in 3D. Inter and intra-subject similarity in terms of normalized mutual information of kinematics and electromyography were investigated.
RESULTS: The task performed in VE and VEF compared with RE was characterized by lower kinematic maxima. The inter-subject similarity in RE compared with intra-subject similarity within all the platforms was lower and larger in terms of movement trajectories and trapezius muscle activation, respectively. Precision and timing regime interacted with the fidelity of the virtual platforms.
CONCLUSION: The properties of shoulder joint kinematics were better preserved within the virtual environment compared with the virtual environment with force feedback. The present study underlines the challenges inherent to the current VR platforms when assessing the biomechanics of a task.

Figure 1: Illustration of the work place within the three platforms, i.e., a) real b) virtual c) virtual with force feedback.



APPLICATION OF CIRCUIT THEORY ON MODELING OF LOWER LEG MUSCLES

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AIM: The aim of this study was to investigate if a musculoskeletal model of the human ankle joint with Hill type actuators can be represented and simulated with an equivalent electrical network.
METHODS: The force-current analogy was applied to build up a musculoskeletal model of the human ankle joint as an electrical circuit by replacing mechanical elements (springs, dampers, masses) with corresponding electrical equivalents (resistors, capacitors and inductivities). Muscles spanning the ankle joint in the model are the M. soleus, M. med. gastrocnemius, M. lat. gastrocnemius (plantarflexors) and M. tibialis anterior (dorsiflexor). All electrical simulations were done with the software LTspice IV (1630 McCarthy Blvd., Milpitas, CA) in Windows Vista. Furthermore, for comparison of mechanical and electrical models all simulations were also carried out with OpenSim (3DGaitModel 2392).
RESULTS: Figure 1 shows the resulting muscle fibre lengths over time when ankle dorsi- and plantarflexors are stimulated for both electrical simulation and simulation with OpenSim.

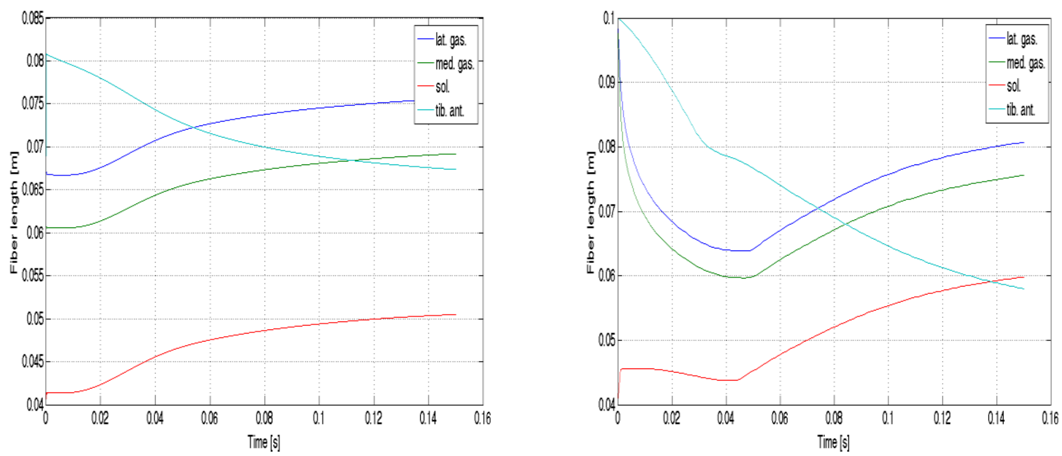

Figure 1: Length of the contractile elements of the four stimulated muscles over time. Left: OpenSim simulation. Right:Electrical simulation. The plantarflexors are stimulated with a low signal of 0.02 and the M. tibialis anterior with the maximum signal of 1.

CONCLUSION: The results of the electrical stimulation and the OpenSim-simulation show only little differences, especially at the beginning of force generation. These differences refer to different force-length characteristics and different moments of inertia in the ankle. Both models use the same activation differential equation from ZAJAC [1989]. The model based on an electrical circuit is able to accomplish forward dynamic tasks and the fact that the behaviour of electrical circuits can easily be analysed may be an advantage for biomechanical investigations on the musculoskeletal system.

MUSCLE FORCE ESTIMATED USING SUPERSONIC SHEAR IMAGING DURING HIGH INTENSITY CONTRACTIONS

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AIM: Supersonic shear imaging (SSI) is ultrasound-based technique to assess elastic properties of biological tissues by measuring the shear wave velocity. Muscle shear elastic modulus measured with this technique is linearly related to force during low-level isometric contractions (i.e., below 60% of Maximal Voluntary Contraction, MVC). The saturation limit of the current SSI device precludes measurements at high contraction intensities. The main aim of this study was to assess the accuracy and the reliability of muscle force estimation for high contraction levels using an updated version of the ultrasound scanner with a higher saturation level. We also tested the influence of saturation (by comparing the current available version of the device and the updated one) and the size of the region of interest (ROI) on muscle force estimation.
METHODS: Ten healthy males performed incremental isometric little finger abduction contractions in 2 conditions: from 0 to 70% and from 0 to 100% of MVC (two contractions per condition). The shear elastic modulus of the Abductor Digiti Minimi muscle was measured using either the SSI new package (beta version) or the current commercial sequence with a saturation limit (600 kPa). The effect of the ROI size was assessed by calculating absolute errors between a full area (1.18±0.24 cm^2), half, 1/4, 1/16 of this area.
RESULTS: Coefficient of determination (R^2) obtained using the new package were high for both ramps from 0 to 70% (0.96 ± 0.02) and 0 to 100% of MVC (0.95 ± 0.03) (Figure 1). Coefficient of variation was lower than 10% for most of the values estimated over the full range of force. R^2 values were lower (0.89 ± 0.07) if measured with saturation (i.e., current available device). Absolute error (5.0 ± 1.5% in average) increased with decreasing ROI size (e.g., 11.5% for 1/16 of ROI vs full ROI at 100% of MVC).
CONCLUSION: The new improved package with a higher saturation limit can be used to reliably estimate high levels of force. Our results show that the size of the ROI influences the accuracy of force estimation, suggesting to use a ROI as big as possible.

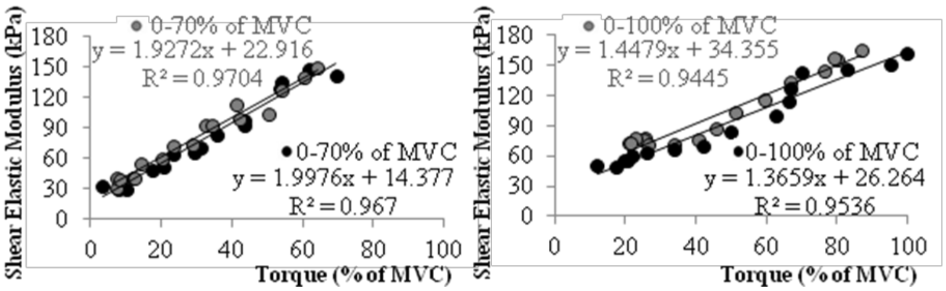

Figure 1: Typical shear elastic modulus-torque relationships obtained from one participant during two successive ramp contractions from (A) 0 to 70% and (B) 0 to 100% of MVC.

Vibrations & Neuromuscular System 1 (Sala 1LM h. 15.30-16.30)

ACHILLES TENDON VIBRATION-INDUCED CHANGES IN PLANTAR FLEXOR CORTICOSPINAL EXCITABILITY

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AIM: Daily Achilles tendon vibration has been shown to increase muscle force, likely via corticospinal neural adaptations. The aim of the present study was to determine the effects of various vibration frequencies on plantar flexor corticospinal excitability.
METHODS: Motor-evoked potentials (MEPs) were elicited in the right soleus (SOL), gastrocnemius medialis (GM) and tibialis anterior (TA) by transcranial magnetic stimulation of the corresponding motor cortical area with and without (control) Achilles tendon vibration at frequencies of 50, 80 and 110 Hz. MEPs were also recorded in the contralateral homologues. A two-way repeated measures ANOVA was performed on the MEP amplitudes with the factors condition (control, 50, 80 and 110 Hz vibration) and muscle (SOL, GM and TA in both vibrated and contralateral legs).
RESULTS: The mean MEP amplitudes are presented in Table 1. There was a significant interaction effect ($P < 0.001$) revealing that SOL and GM MEP amplitudes of the vibrated leg increased during vibration and that this occurred at all three frequencies.
CONCLUSION: Increased SOL and GM MEP amplitudes suggest increased vibration-induced corticospinal excitability that may be cortical in origin. Underlying mechanisms may be associated with vibration-induced Ia afferent drive to the cortex.

Table 1. Raw MEP amplitudes (mV) of SOL, GM and TA muscles of both legs with (50, 80 and 110 Hz) and without (Control) vibration.

		CONTROL	50 Hz	80 Hz	110 Hz
SOL	VIBRATED SIDE	0.23 ± *0.23*	0.66 ± *0.43* **	0.55 ± *0.33* ***	0.58 ± *0.42* **
	CONTRALATERAL	0.25 ± *0.16*	0.25 ± *0.17*	0.25 ± *0.16*	0.24 ± *0.17*
GM	VIBRATED SIDE	0.29 ± *0.16*	0.50 ± *0.27* *	0.48 ± *0.29* **	0.47 ± *0.28* *
	CONTRALATERAL	0.33 ± *0.26*	0.34 ± *0.28*	0.34 ± *0.28*	0.33 ± *0.27*
TA	VIBRATED SIDE	1.37 ± *0.86*	1.32 ± *0.89*	1.49 ± *0.79*	1.38 ± *0.67*
	CONTRALATERAL	1.22 ± *0.79*	1.24 ± *0.82*	1.41 ± *0.86*	1.29 ± *0.80*

Data are presented as mean ± SD. * Significantly different from control (*$P < 0.01$, and ** $P < 0.001$).

NEUROMUSCULAR INFLUENCE OF THE MECHANICAL VIBRATION DURING HAND-GRIP TASKS

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AIM: This paper is aimed to assess the effects of Mechanical Vibration (MV) on neuromuscular response of the hand-arm system by analysis of surface electromyographic (sEMG) signal of different grip forces and vibration frequencies.

METHODS: Sixteen experimental subjects have been selected between healthy volunteers: 9 females and 7 males. The experiment consisted in exposing the hand-arm system to vibration at different frequencies (at 20, 30, 33 and 40 Hz) while the subject was holding for 5 s, with a determined level of hand grip force (20%, 30%, 40% and 60% of the Maximal Voluntary Contraction-MVC), the instrumented handle (see Fig. 1). The Z axis was lined up with the shaker-forearm direction (see fig. 1). Muscular activity was assessed by surface electromyography of extensor carpi radialis longus and the flexor carpi ulnari muscles. sEMG Root Mean Square (RMS) value was evaluated on the contraction.

RESULTS: present results of the two muscles are depicted on Fig. 2. Data is shown normalized with respect of MVC.

CONCLUSION: Statistical analysis shows no difference between RMS at different MV frequencies for a given MVC percentage. Finally, present neuromuscular data showed a linear relationship with force both without and with vibrating stimulus at every MV frequency.

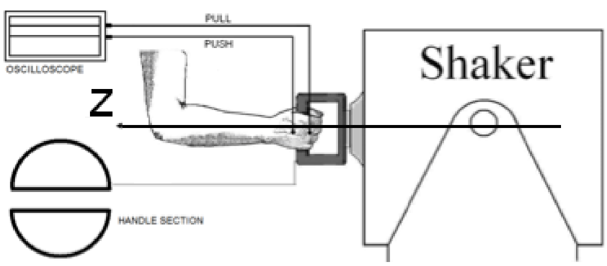
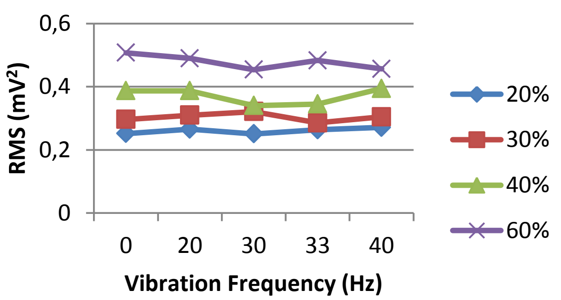
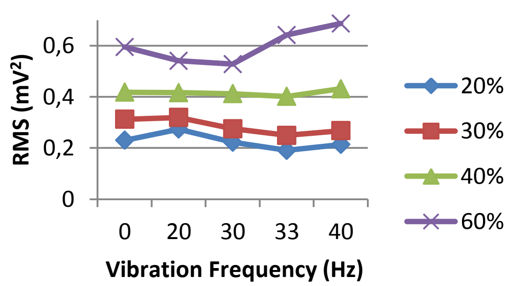


Fig.1: Experimental Setup



A



B

Fig. 2 Neuromuscular response at Mechanical Vibration. Legend refers to grip MVC percentage. Panel A extensor carpi radialis longus, panel B the flexor carpi ulnari muscles

INFLUENCE OF THE MECHANICAL VIBRATION ON FATIGUING HAND-GRIP TASKS

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AIM: This paper is aimed to evaluate the influence of the Mechanical Stimulation at several frequencies fatiguing muscular hand-grip contractions at different isometric force values.

METHODS: Sixteen experimental subjects have been selected between healthy volunteers: 9 females and 7 males. The experiment consisted in exposing the hand-arm system to vibration at different frequencies (at 20, 30, 33 and 40 Hz) while the subject was holding for 45 s, with a determined level of hand grip force (40% and 60% of the Maximal Voluntary Contraction-MVC), the instrumented handle (see Fig. 1). The Z axis was lined up with the shaker-forearm direction (see fig. 1). Muscular activity was assessed by surface electromyography of extensor carpi radialis longus and the flexor carpi ulnari muscles. sEMG Median Frequency (MDF) slope value was evaluated among the contraction.

RESULTS: present results of the two muscles are reported on Fig. 2. Statistical analysis was performed to assess difference between conditions.

CONCLUSION: Statistical analysis shows that the external vibrating stimulation induced a negative steeper MDF decline than without only at MV@33Hz. For this reason is possible to argue that 33 Hz, i.e. at the forearm resonance frequency, causes an early fatigue effect when superimposed with grip tasks.

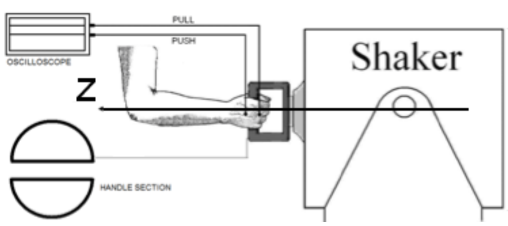

Fig. 1: Experimental Setup

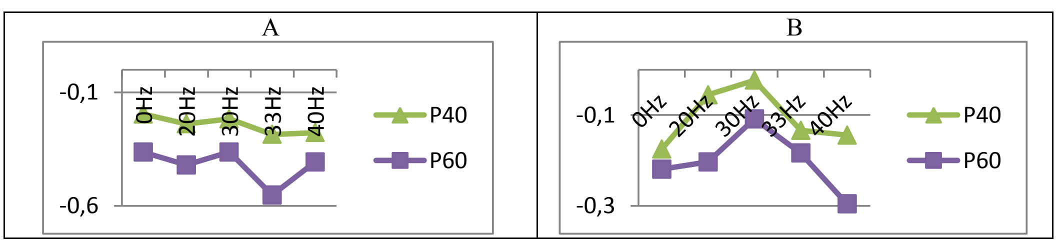

Fig. 2 MDF slope and MV frequency relationship. Legend refers to grip MVC percentage (P40 as 40% and P60 as 60%). Panel A extensor carpi radialis longus, panel B the flexor carpi ulnari muscles.

IDENTIFICATION OF TIME-VARYING JOINT VISCOELASTICITY AND STRETCH REFLEXES

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AIM: Time varying (TV) joint admittance (mechanical compliance) reveals spatial-temporal features of the neuromuscular control system. One of the drawbacks of previous approaches is the many repetitions required to identify TV admittance which made them not suited for clinical application. Aim of this study was to estimate TV admittance of the wrist from one short observation using a novel linear parameter varying (LPV) state-space model. Damping, stiffness and stretch reflex gain were estimated from the TV admittance.

METHODS: Random angular perturbations (2-20Hz, 60s) were imposed to the wrist joint using a single-axis manipulator while subjects (n=2) followed a reference torque trajectory (0.5Hz filtered noise) displayed on a screen. Angle-torque recordings were divided into 4 adjacent blocks of 15s and TV admittance was identified for each block. For the LPV model, voluntary torque (low frequency part: 0-2Hz) was used as ***scheduling variable*** while the admittance was identified from the remaining part (2-20Hz). Inertia, damping, stiffness and stretch velocity reflex gain were estimated from the admittance by least squares fitting.

RESULTS: Torque was well predicted by the LPV model (VAF > 90%, not shown). Figure 1 (Left) shows a decrease in joint admittance with torque, as expected from stiffening of muscles with force. Consistent values of joint inertia, damping, stiffness and velocity reflex gain were estimated from only 15 s of data (Figure 1: Right).

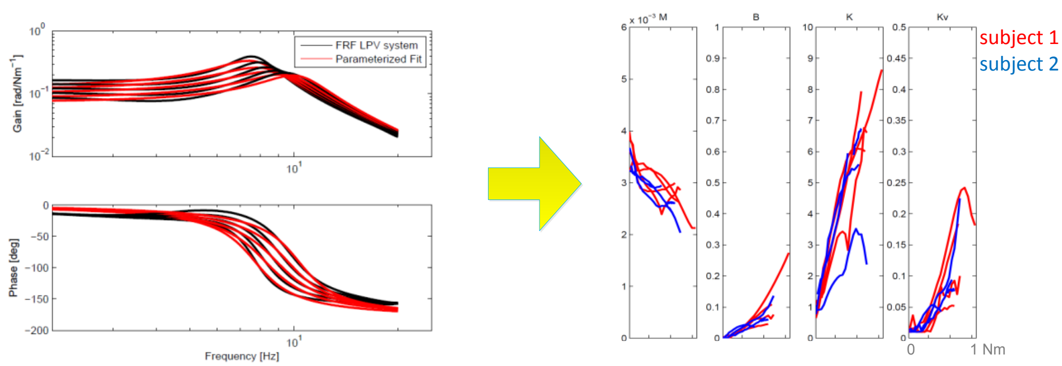

Figure 1: Left: wrist joint admittance (dynamic relationship from torque to angle). Right: Inertia (M), Damping (B), Stiffness (K) and stretch reflex gain (Kv) estimated ***during*** changes in joint torque.

CONCLUSION: The proposed LPV model provided reliable estimates of time-varying mechanical and neural control properties of the human wrist joint in short time and therefore may be a valuable tool for clinical diagnosis and treatment monitoring in neuromuscular diseases. Next steps are 1) use of EMG as additional scheduling functions to identify bi-directional stiffness (flexion-extension torque) and co-contraction, and 2) to estimate stretch reflexes during free joint motion.

Movement Disorders 1 (Sala 2LM 15.30-16.30)

RESISTANCE TRAINING IMPROVES MANUAL DEXTERITY AND FORCE TREMOR IN ESSENTIAL TREMOR PATIENTS

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AIM: Essential tremor (ET) patients can exhibit increased postural, kinetic, and intention tremors which often result in a decreased quality of life. Given that resistance training (RT) can reduce tremor amplitude and improve upper limb fine motor control in older adults, it is surprising that few studies have explored RT as a therapy for older adults with ET. This study determined if a generalised upper-limb RT program improves manual dexterity and reduces tremor in older individuals with ET.

METHODS: Ten ET patients (71± 5 yr) attended 3 supervised RT sessions per week for 6 weeks, where bicep curl, wrist flexion and wrist extension exercises were performed each session. Manual dexterity was assessed before and after the training program using the Purdue Pegboard test, Modified-Moberg Test, and Modified-Jebsen hand function test. Force tremor was quantified as the coefficient of variation in index finger abduction force during isometric contractions at 10% and 60% MVC. All tests were performed with the most and least affected limbs.

RESULTS: Bicep curl, wrist flexion and wrist extension MVC significantly increased following RT. Performance measures within the Purdue Pegboard test, Modified-Moberg Test, and Modified-Jebsen hand function test improved for both the most affected limb (~19%) and the least affected limb (~14%) following RT. Force tremor also significantly decreased during isometric finger abduction at 10% and 60% MVC for both the most affected limb (~9 %) and least affected limb (~7%).

CONCLUSION: A generalised RT program for the upper limb is capable of improving manual dexterity in individuals with ET, and to a lesser extent, reduce abduction force tremor. It also appears that the greatest benefits following RT may be gained for the limb that has been most affected due to the disorder. Overall, RT appears to be a viable therapy for improving upper limb-function in individuals with ET.

NEUROMUSCULAR ELECTRICAL STIMULATION MODULATES MOTOR CORTICAL EXCITABILITY IN HEALTHY SUBJECTS AND STROKE PATIENTS

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AIM**:** Aim of the study was to investigate, by means of Transcranial Magnetic Stimulation (TMS), whether Neuromuscular Electrical Stimulation (NMES) applied to healthy and paretic upper limb muscles functionally modulates motor cortical excitability.
METHODS**:** The study was conducted on 10 healthy subjects (HS) and, preliminarily, on 2 chronic stroke survivors (SS). Single-pulse TMS was applied to the motor cortex (dominant side for HS; affected side for SS) and motor evoked potentials (MEPs) were recorded, via electromyography, from contralateral extensor carpi radialis (ECR), extensor digitorum (ED) and first dorsal interosseus (FDI) muscles. MEPs were obtained by sequences of 12 TMS pulses, with 5 s inter-pulse intervals, delivered before (baseline) and after (post-) NMES intervention; 3 min rest was allowed between each trial. NMES was applied to forearm extensor muscles for 15 minutes (stimulation cycle: 28 s at 2 Hz + 2 s of 50 Hz tetanic contraction), evoking wrist and finger extension. MEP amplitudes were analyzed through peak-to-peak calculation on the recorded electromyographic signals.
RESULTS**:** In the HS group, increased peak-to-peak MEP amplitudes after NMES with respect to baseline were observed for ED and FDI muscles, while no change in MEP amplitude was demonstrated for ECR muscle (see Fig. 1A). Increased motor evoked responses from FDI were also evident in patients immediately after NMES (see Fig. 1B).
CONCLUSION**:** NMES of forearm skeletal muscles induces effects on the excitability of the motor cortex, which, noteworthy, is affected in a specific manner, being the distal muscles controlling hand movements the main target of the observed modulations. In particular, a strong map facilitation occurred for FDI in healthy subjects and a similar modulation was observed in the investigated patients. These preliminary findings suggest NMES as a driver of targeted neural plasticity, with a potential role in shaping functional cortical reorganization after stroke. The facilitatory effect of peripheral NMES on specific muscles would likely have relevant implications in the context of modern advanced stroke rehabilitation, which is primarily intended to recover close-to-normal motor schemes limiting the occurrence of compensatory strategies.

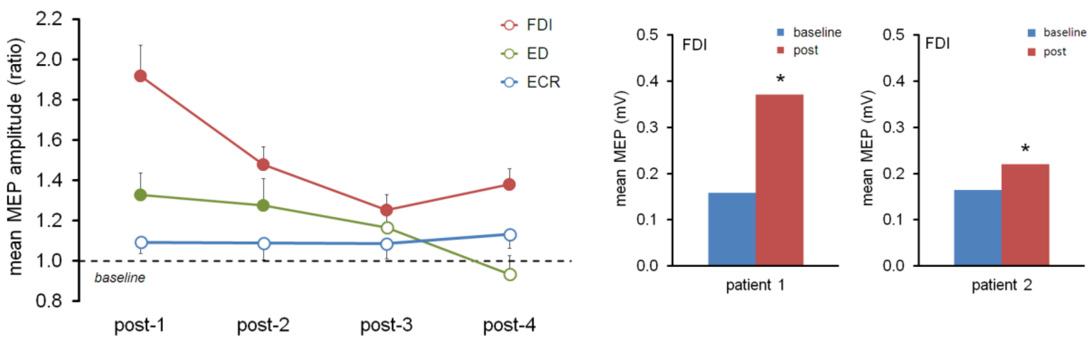

Fig. 1A (left): Healthy subjects. Filled symbols indicate a statistically significant difference with respect to baseline (paired T-test, P < 0.05). Error bars represent the SEMs.
Fig. 1B (right): Patients. * statistically significant difference from baseline (paired T-test, P < 0.05).

EMG OF DYNAMIC TENSION OF ARMS TO ASSESS THE EFFECT OF DEEP BRAIN STIMULATION TREATMENT OF ADVANCED PARKINSON'S DISEASE

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AIM: Deep brain stimulation (DBS) is an effective treatment for motor symptoms of advanced Parkinson's disease (PD). After installation the stimulator has to be reprogrammed several times to obtain optimal response. Some EMG-studies have been done to assess the effects of DBS in PD. This study is one of the first works trying to determine the effects of DBS on motor symptoms based on EMG. The aim of this study was to determine if EMG of dynamic tension of arm can sense the changes of typical DBS parameters.
METHODS: Surface EMG signal from biceps brachii muscle during dynamic tension of arm was measured from 13 patients with PD and DBS installed. The measurement was repeated with 7 different stimulator setups modifying amplitude, frequency and width of the stimulation pulse in respect to patients' optimal setting. Characteristic parameters to PD were calculated to observe the effect of the DBS: correlation dimension (D2), recurrence rate (REC), maximum wavelet coefficient (Wmax) and kurtosis (KURT). Analysis was done individually for each patient during different setups, and concluded by group level statistical analysis.
RESULTS: Table 1 shows the median of differences between the setups relative to optimal setting for the patients. The differences in the setups were the greatest in correlation dimension. Other parameters showed differences in some setups only. Lowering the amplitude of the stimulator did not have significant effect on these parameters in any setup.
CONCLUSION: EMG signal is capable of sensing the differences in stimulator setups. The EMG signal morphology, its recurrence, spikiness and correlation dimension is probably a reflection of small changes in the brain oscillation loops that manage motor control. In this study we noted that EMG parameters could sense the difference between the setups also when there were no clear clinical changes in patients' state (tremor, rigidity). This novelty study gives the first time perspective to DBS adjustment in clinical range. These results lay a solid ground on the future research of EMG based evaluation on motor symptoms in PD patients with DBS.

ACKNOWLEDGEMENT: This study was supported by the Academy of Finland under project No. 252748.

Table 1: Differences in parameters relative to optimal setup, significance *p<0.05, **p<0.01

Setup	**D2, %**	**REC, %**	**Wmax, %**	**KURT, %**
Amplitude -0.3V	-4.8	+14.8	-1.1	+1.0
Amplitude +0.3V	-6.5*	+29.9	-3.8*	+4.8
Frequency -30 Hz	-11.0**	+40.5**	-1.8	+7.5
Frequency +30 Hz	-9.6*	+35.0	-2.2	+6.3
Pulse width +30 us	-13.8*	+51.7*	-8.2*	+9.3*
DBS off	-7.1*	+45.1*	-4.3	+5.3

THE USE OF A MODIFIED FITTS' TASK TO DIFFERENTIATE BETWEEN DIFFERENT TREMORS

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AIM: To examine whether a modified Fitts' task can be used to differentiate between different tremors.
METHODS: Patients clinically diagnosed by a neurologist with Essential tremor (ET), Psychogenic tremor (PT) or Enhanced Physiological tremor (EPT) were selected from the movement disorder clinic at the department of Neurology at the University Medical Center Groningen (UMCG) in the Netherlands. Participants were instructed to perform a modified Fitts' task which consisted of 8 subtasks (small/large distance between targets and 4 different target diameters). Pen tip trajectories were recorded. The number of accurate touches per second was calculated to take into account speed/accuracy trade-off. The results of the modified Fitts' task were compared between the three groups by a MANOVA.
RESULTS: Ten ET (mean age: 60 years, 8 male), 7 PT (mean age: 63 years, 2 male) and 8 EPT (mean age: 39 years, 4 male) patients were included. The number of accurate touches per second decreased with an increase in task difficulty for all groups. The number of accurate touches per second differed significantly between the three groups on three subtasks of the task ($p < 0.05$). These tasks were: subtask 1 (small distance/smallest target diameter, subtask 5 (large distance/smallest target diameter) and subtask 6 (large distance/small target diameter). Post-hoc testing showed that the EPT group scored significantly higher on the number of accurate touches per second compared to the PT group on these subtasks of the modified Fitts' task.
CONCLUSION: Fitts' task results show a significant difference between the EPT and PT group, in which the EPT group seems to be more accurate and quicker in performing fast tapping movements between two targets compared to the PT group.
ACKNOWLEDGEMENT: This study is part of the DiPAR project for which funding was received from the EC in the FP7-SME-201001 programme (grant agreement 262291). The hardware of the measurement setup was provided by Fraunhofer IPMS (Dresden, Germany) and the data acquisition software by Fraunhofer IPA (Stuttgart, Germany), based on a concept by Manus Neurodynamica Ltd (patent WO/2011/141734).

DISCRIMINATION OF ESSENTIAL AND PARKINSONIAN TREMOR BASED ON INERTIAL MEASUREMENTS

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AIM: Although accurate differentiation between tremulous Parkinson's disease (PD) and essential tremor (ET) patients is vital for further treatment, it's very difficult due to large diversity of tremor demonstration within ET and PD groups, respectively. Moreover, ET patients can develop signs of PD at later stages. In this study, we propose an extension of recently published ET vs. PD discrimination based on accelerometric data [1].
METHODS: 17 ET (72.1 ± 5.6 years) and 18 PD (63.5 ± 10.3 years) patients were included. Tremor was accelerometrically recorded from wrists of both hands during three repetitions of the following 30 s long tasks: RE (rest), AO (arms outstretched), WE (AO with 1kg weights on each hand), PO (patient sitting, forearms supported, hands held extended against gravity), FN (finger-to-nose, performed by dominant hand only). Only the repetition with the maximum tremor amplitude was used in further analysis of each task. Powers of the tremor at its basic frequency and higher harmonics were calculated by the Welch method as proposed in [1]. In addition to [1], the values obtained in AO, WE, PO and FN tasks were normalized by the values in RE task by means of deduction. ROC curves were used to determine the optimal ET vs. PD discrimination values.
RESULTS: Mean power of all the harmonics (MPH) [1] showed the highest discriminatory power (Table 1). Highest classification accuracy was obtained in WE task (88.5 % / 85.7 % dominant/nondominant hand). FN task had the lowest accuracy (82.8 % / 54.3 %), especially in resting nondominant hand. Average value of MPH across all the tasks except FN gave a classification accuracy of 85.7% on both hands. When normalized by RE task, the discriminative power of MPH parameter improved in all the tasks (Table 1). The highest classification accuracy was obtained in the WE task (94.3 % / 85.7 %).
CONCLUSION: The power of recently proposed MPH parameter [1] in discrimination between ET and PD patients has been confirmed and further improved on average 9.3±2.7 % by normalization of every task against the RE task.
ACKNOWLEDGEMENT: This study was supported by the Commission of the European Union within 7th FP under Grant Agreement No. ICT-2011.5.1-287739 "NeuroTREMOR: A novel concept for support to diagnosis and remote management of tremor."

Table 1: No. of ET/PD patients correctly classified with MPH parameter calculated from dominant hand (left subcolumn) and nondominant hand (right subcolumn).

Task	**AO**		**WE**		**PO**		**FN**		**Average without FN**	
MPH [1]	14/12	14/14	16/15	16/14	13/14	14/13	16/13	10/9	16/14	15/15
Normalized MPH	15/15	15/15	17/16	16/14	15/16	15/15	16/16	12/11	16/16	17/16

REFERENCES:
[1] M. Muthuraman, A. Hossen, U. Heute, G. Deuschl, J. Raethjen: A new diagnostic test to distinguish tremulous Parkinson's disease from advanced essential tremor, *Movement Disorders*, 26/8, 1548-1552, 2011.

Modelling and Signal Processing 1 (Sala 4LM 15.30-16.30

PAIRWISE ATTRIBUTE NOISE DETECTION APPLIED TO SURFACE EMG

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AIM: As part of an overall study to detect contaminated surface electromyography (sEMG) recordings, this investigation looked at the Pairwise Attribute Noise Detection Algorithm (PANDA) in detecting power line (PL) interference in simulated sEMG signals. PANDA is an algorithm that provides a rank of the input signals in terms of their likelihood to be contaminated [1].
METHODS: A set of N clean sEMG signals were simulated and attributes, which characterized the sEMG, were identified. Then, noisy sEMG signals were simulated by the addition of a known noise record, and PANDA was implemented to generate a Noise Factor (F_N) for each of the clean and noisy signals. PANDA was run for 30 separate contaminations for a given signal-to-noise ratio (SNR) value. Performance of the algorithm's ability to discern between clean and noisy sEMG data was evaluated based on its ability to quantify a boundary between clean and noisy signals with precision. The clean observation base was set to N = 500 with M = 5 attributes.
RESULTS: Figure 1 displays data points, which represent the F_N of different signals experiencing contamination at the given SNR values. The solid and dashed lines represent the mean and mean-plus-three-standard-deviations (SD) of the F_N for the clean observation base, respectively. The figure indicates that bounded by 3 SD, PANDA correctly identified sEMG recordings contaminated with PL interference with a SNR $\leq$ 2 with 100% accuracy. For recordings containing PL interference with SNRs of 2.5 and 3.0, the accuracy of identification was 90% and 83.33%, respectively.
CONCLUSION: While many methods exist to detect contamination in sEMG recordings through knowledge of the noise, PANDA utilizes knowledge of the characteristics of the clean signals to detect contamination. Future work will examine PANDA's effectiveness at identifying other contaminants, including saturation and motion artifact. Other factors, including, algorithm settings, attribute selection, size of the data set, noise level and type, and homogeneity within the clean and noisy data, will also be examined.

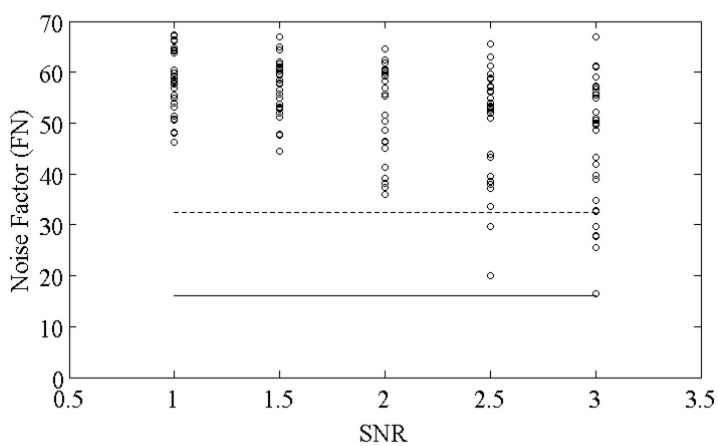

Figure 1: Noise factors of contaminated signals with increasing SNR values (N = 500, M = 5)

[1] J. Van Hulse, T.M. Khoshgoftaar, H. Huang, "The pairwise attribute noise detection algorithm," *Knowl Inf Syst*, vol. 11, no. 2, pp. 171-190, 2007.

EFFECTS OF MUSCLE FIBRE SHORTENING ON SURFACE-DETECTED MOTOR UNIT POTENTIALS

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AIM: To investigate the effects of muscle shortening on the shape, amplitude, and duration characteristics of motor unit potentials (MUPs) for different electrode positions relative to the tendon ending and for different depths of the motor unit (MU) in the muscle.
METHODS: MUPs were simulated using a convolutional model. The EMG detection system adopted was longitudinal single differential (inter-electrode distance = 10 mm). It was assumed that: (1) the muscle was contracted isometrically; (2) muscle fibres were shortened symmetrically about the innervation zone; (3) muscle fibre conduction velocity did not change; (4) there was no shift of the skin relative to the muscle. We calculated the changes in MUP characteristics corresponding to muscle shortenings of 5, 10, 15 and 20% Lrest relative to the MUP obtained at Lrest for different positions of the detection point along the MU longitudinal axis and different radial distances.
RESULTS: When the electrodes lay between the end-plate and tendon junction it was found that: (1) the MUP negative phase was not affected by muscle shortening; (2) the MUP terminal phase increased with fibre shortening; (3) the muscle-shortening effect was not important for superficial MUs. When the electrodes lay approximately over the tendon ending it was found that the MUP peak-to-peak duration decreased significantly with fibre shortening. If the detection point lay beyond the fibre-tendon junction, all phases of the MUP decreased with fibre shortening, and the sensitivity of MUP amplitude to muscle shortening decreased with MU-to-electrode distance.
CONCLUSION: Depending on the position and distance of detection electrodes relative to the fibre-tendon junction, the effect of muscle shortening on the characteristics of surface MUPs can vary enormously.

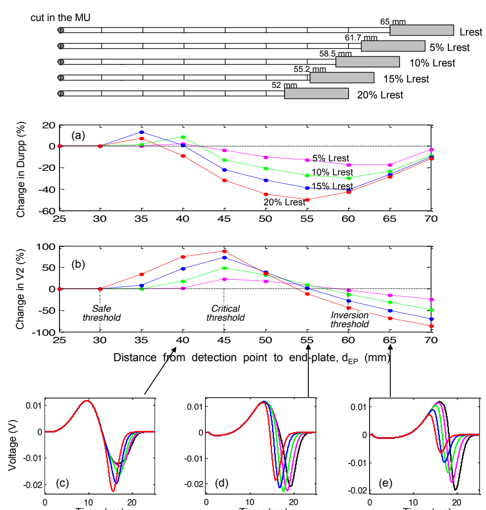

Figure 1: Simulation of changes in MUP characteristics produced by muscle shortenings of 5, 10, 15 and 20% Lrest for different positions of the detection point along the MU longitudinal axis (d_{EP}).

ONLINE NEURAL DECODING FROM THE INTRAMUSCULAR EMG SIGNAL

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AIM: The motor unit spike trains, which can be extracted real-time by decomposition of intramuscular EMG signals (iEMG), could be used in rehabilitation, sports sciences, and ergonomics. They also provide online information on the force exerted by the muscle, which makes them suitable for prosthesis control. In the past years, we have been working on the design and implementation of online iEMG decomposition algorithms. The aim of this paper is to describe two real-time iEMG decomposition programs developed in our laboratory.

METHODS: Real-time iEMG decomposition requires the following steps: 1) An online algorithm and 2) A real-time implementation. In both of the proposed algorithms, iEMG frames of 200 msec were analyzed consecutively. The noise activity was estimated at each frame, and fixed-width Active Segments (AcS's) were identified and aligned based on the maximum peaks. In the first algorithm, AcS's were de-correlated where an *incremental* Singular Value Decomposition (SVD) method was used for whitening. The assignment of a new AcS to the closest template was confirmed by the χ^2 statistics (α=0.05) and sub-sampling template shape variability (Johnson and Wichern, 2002). In the second algorithm, a new morphological feature set was defined for each AcS that not only reduced the computationally complexity, but also facilitated identification of superimposed waveforms prior to the clustering. A density-based real-time clustering was used in which the concept of potential, a measure of density in the neighborhood of the data, was used (Angelov and Filev, 2005). The procedure starts by adopting the first available data point as the first center of the cluster. As the new data point arrives, the potential of previous cluster centers are modified. If the point has a potential presented by previous centers, the procedure continues without changing the cluster structure, otherwise the new point forms a new cluster and becomes a cluster center. In both algorithms, merging clusters was performed using an expert-based system that uses firing-time and template waveform information. Robust firing time statistics were reported in moving epochs, since resolving superimposed Motor Unit Action Potentials (MUAP's) was not performed. Both algorithms were implemented in Matlab as a proof of concept, and the first algorithm was also implemented in *vectorized* Microsoft Visual Studio.

RESULTS: The developed algorithms were tested on a set of experimental (moderate isometric contractions of tibialis anterior using fine wire electrodes; McGill *et al.*, 2004) and synthetic EMG signals (Hamilton-Wright and Stashuk, 2005). The performance of the algorithms is shown in Table 1 as the worst-case analysis. All missed MUs had low SNR (< 3dB) while the erroneous MUs could be excluded using the firing-time reference intervals. ACKNOWLEDGMENT: ERC Advanced Grant DEMOVE (No. 267888).

Table 1: The performance of two proposed algorithms on a set of experimental and simulated data

Indices / Method	**Simulated EMG**			**Recorded EMG**		
	Se (%) [DI]	Pr (%)	MDR *rel* err (%)	Se (%) [DI]	Pr (%)	MDR *rel* err (%)
1	79.5±20.0 [0.56-2.77]	81.0±8.8	1.5±0.7	75.0±7.0 [0.96-2.79]	75.0±7.0	5.0±4.9
2	76.5±10.0 [1.79-2.79]	70.7±1.0	2.9±1.3	84.0±5.7 [0.85-1.37]	71.8±11.6	6.0±4.2

Se: Sensitivity; Pr: Precision; The DI (Decomposability Indices in dB) ranges were shown for the *missed* MUAPs; MDR *rel* err: the relative error of estimating MU's Mean Discharge Rate.

AUTOMATIC LOCALIZATION OF MUSCLE INNERVATION ZONES FROM MULTICHANNEL SURFACE EMG USING HOUGH TRANSFORM

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AIM: Knowledge of muscle innervation zones (IZ) is often required to optimize botulinum toxin injection in patients with spasticity (skeletal muscle) or to avoid damaging anal sphincter innervation in case of episiotomy during child delivery. In this study a method based on Hough Transform (HT) to detect automatically the location of IZs from 16-channel surface EMG recordings from the external anal sphincter (EAS) and other skeletal muscles is presented.

METHODS: Multichannel single differential sEMG signals can be represented as a topographic image, where the x dimension is time, the y dimension is space (channels) and the gray level corresponds to signal amplitude. In this representation the propagation of the motor unit action potential MUAP generates linear patterns forming a single line or a V-shape depending on the location of the IZ along the MU length. The V-shape is associated to the bidirectional propagation of MUAPs with IZ located somewhere along the MU. If the IZ is located on either end of the MU, then a line segment is formed due to the unidirectional propagation of MUAP. HT detects multiple lines in an image by transforming it from geometric space to Hough space. All the points lying on a straight line in the geometric space are transformed into sinusoids in the Hough space and are accumulated in the accumulator ***H***. The value at each location in the ***H*** matrix is a voting and if greater than a threshold, represents a line. In sEMG images, first the edges are detected along the MUAP propagation to get a binary image and then lines are detected using HT. In case of bi-directional MUAP propagation, the vertex of the V-shape is detected which corresponds to the location of the IZ and for unidirectional MUAP propagation the beginning point of the line segment corresponds to the location of the IZ.

RESULTS: An example of the simulated sEMG signals, the topographic image, the accumulator matrix ***H*** and the detected lines is shown in figure 1. The peaks in the ***H*** matrix as depicted in figure 1C give the parameters of lines. The lines obtained for the synthetic sEMG image are shown in figure 1E are used to identify the location of the IZ which is the region where these lines intersect (figure 1E). Figure 1F-H show a noisy sEMG signal, its topographic image and the detected IZs.

CONCLUSION: The HT based method detects the IZs from a sEMG epoch without prior sEMG decomposition and is also robust against noise.

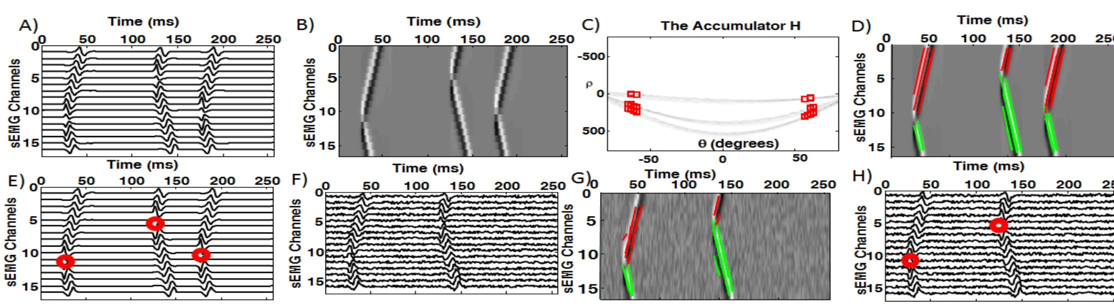

Figure 1: A) 16 channel synthetic sEMG signal. B) The topographic sEMG image in time and space. C) The accumulator matrix ***H*** for (B), the square markers at the points of intersection of curves are the peaks corresponding to all possible lines in the sEMG image. D) The detected lines drawn over the sEMG image. E) The located IZs, which are the points of intersection of these lines. F) Example of noisy sEMG signal with SNR= 7.62dB. G) The detected lines. H) The detected IZs

Vibrations and Neuromuscular System 2 (Sala Cesarea 17.30-18.30)

WHOLE BODY VIBRATION APPLIED ON UPPER EXTREMITIES: THE EMG ACTIVITY TO DETERMINE THE OPTIMAL ACCELERATION LOAD

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AIM: The purpose of the present study was to assess the optimal acceleration load by monitoring the EMG muscle activities of the subjects (including the pectoralis major [PM], triceps brachii [TB], anterior deltoid [DE] and flexor carpi radialis [FCR] muscle activities) that were mostly involved in maintaining the posture assumed on the plate during whole-body vibration superimposed to an isometric push-up.
METHODS: During the test protocol all subjects (thirty male sport sciences students [n = 30; age, 24.4.0 ± 1.16 yr; height, 178.2 ± 2.1 cm; body mass, 74.9 ± 2.8 kg; body mass index, 21.8 ± 1.3 kg/m^2]) assumed an isometric push-up position and performed several trials with different acceleration loads (from 0.12 to 5.72 g). There was a 1-min pause between trials, and each trial lasted 10 s. The trial order for each subject was randomized across the accelerations. The surface EMG root mean square (EMG_{rms}) was normalized to Maximal Isometric Voluntary Contractions (bench press and grip strength tests).
RESULTS: The PM, TB, and FCR muscle activation degrees were dependent upon the acceleration load (P = 0.0001), whereas the DE muscle was not conditioned (P = 0.063) (Figure 1). The intra-day procedure reliabilities were 0.97, 0.96, 0.95, and 0.94 for the PM, DE, TB, and FCR muscles, respectively. The inter-day reliabilities were 0.97, 0.85, 0.85, and 0.78 for the PM, DE, TB, and FCR muscles, respectively.
CONCLUSION: This study indicate that EMG monitoring during different acceleration loads can represent an appropriate method for identifying an individual's vibration of stimulation when applying whole body vibration on upper extremities. Therefore, an individualized acceleration load can be prescribed similarly to exercise prescription for progressive resistance exercise in terms of load, number of repetitions, and series.

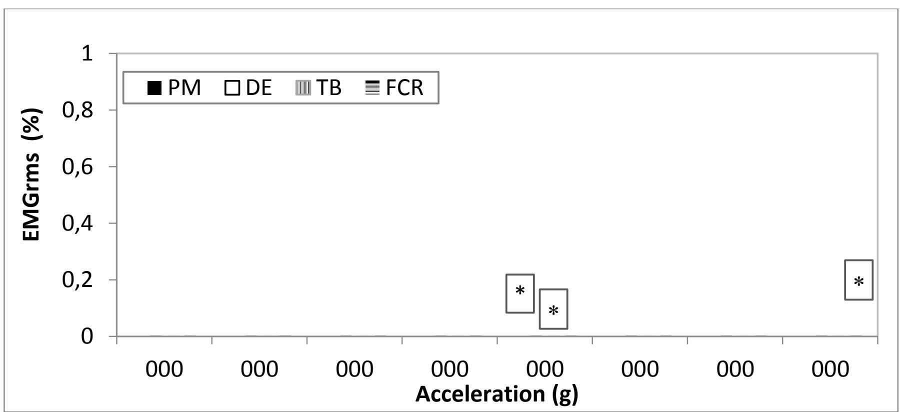

Figure 1: The normalized EMG_{rms} values (mean and SE), which were recorded during whole-body vibration at different acceleration loads . The acceleration values ranged from 0.1 to 5.7 g (expressed as a multiple of standard gravity, where 1 g is equal to 9.81 m·s^{-2}). *Significant EMG_{rms} Peaks ($P < 0.05$).

DUAL MODE WHOLE-BODY VIBRATION HAS A GREATER EFFECT ON MUSCLE ACTIVITY THAN THE SIDE-ALTERNATING MODE

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AIM: To compare muscle activity of lower limb muscles between dual mode whole-body vibration (WBV) and the commonly used side-alternating mode.
METHODS: Thirty physically active volunteers performed static squats at a knee angle of 60° (0°: knee fully extended) on the WBV platform while surface electromyography (sEMG) was measured of the vastus lateralis (VL), the biceps femoris (BF), and the soleus (SOL). The side-alternating WBV trial was induced at a frequency of 6Hz and an amplitude (displacement from baseline to peak) of 2.5mm. Dual mode WBV consisted of side-alternating vibration with additional circular vibration in the horizontal plane with frequencies of 14Hz and 43Hz. Root mean square of the sEMG signals ($sEMG_{RMS}$) was calculated after withdrawal of the excessive spikes in the sEMG spectrum via linear interpolation. Then, $sEMG_{RMS}$ was normalized to the $sEMG_{RMS}$ during maximal voluntary contractions (MVCs). Finally, $sEMG_{RMS}$ during a control trial without vibration was subtracted from the trials with WBV in order to isolate the increase in muscle activity due to the vibration.
RESULTS: Increase in $sEMG_{RMS}$ of the VL and BF was significantly greater during dual mode compared to side-alternating WBV when the dual mode trial consisted of the high circular frequency (43Hz, $P < 0.01$, Figure 1). In the SOL, the dual mode enhanced muscle activity significantly compared to the side-alternating mode for both circular vibration frequencies (14Hz and 43Hz, $P < 0.05$ and $P < 0.01$ respectively, Figure 1).
CONCLUSION: Dual mode WBV at 43 Hz resulted in significantly higher muscle activity in select lower limb muscles than the commonly used side-alternating mode. Therefore, it is recommended that dual mode platforms be considered for future WBV protocols in order to optimize the training stimulus in the lower limbs.

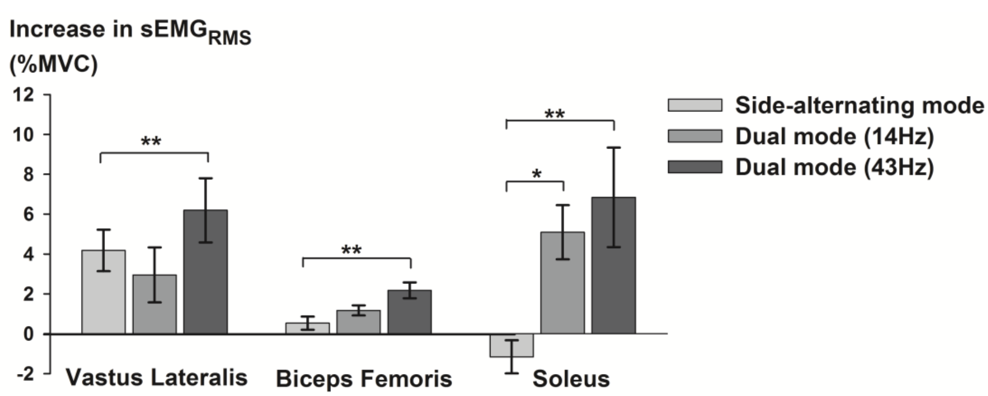

Figure 1: Increase in $sEMG_{RMS}$ during WBV for the side-alternating mode (light grey), dual mode with 14Hz circular vibration (medium grey), and dual mode with 43Hz circular vibration (dark grey) in the vastus lateralis, biceps femoris, and soleus. The horizontal bars indicate significant differences between modes (*$P < 0.05$, **$P < 0.01$, mean ± SEM).

ON THE EMG SIGNAL RECORDED DURING VIBRATION EXERCISE

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AIM: Surface electromyography (EMG) has been widely used to measure the level of neuromuscular activity during vibration exercise (VE). However, during VE, sharp peaks can be observed in the spectrum of the EMG recordings at the vibration frequency and its harmonic, whose interpretation (motion artifacts or muscle activity) remains controversial. The aim of the present study is therefore to clarify the nature of the spectral peaks observed during VE. To this end, the EMG conduction velocity (CV) is investigated.

METHODS: An actuator is adopted to generate a force consisting of a constant baseline with superimposed sinusoidal vibration. Six healthy subjects were instructed to perform 12-s isometric contractions with their elbow at 90 degrees. The applied force was a baseline force of 60% of the subject's maximum voluntary contraction (MVC) and a superimposed vibration with amplitude of 40 N. Six trials with different frequencies (0, 25, 35, 45, 55, and 65 Hz) were performed in random order, each of them followed by 5-min rest. Two bipolar EMG signals and 2-D acceleration signals were recorded from the biceps brachii (Figure. 1). The recorded EMG data was first band-pass filtered (20-450 Hz). The CV at the vibration frequency component (CV_{VF}) was estimated using the phase method while the CV of the full EMG spectrum (CV_{EMG}) was estimated using the cross-correlation method. The CV of the acceleration signal (CV_{ACC}) was also estimated to provide a reference for the mechanical vibration waves. The coherence function of the two bipolar EMG signals was calculated and only CV estimates of high coherence (>0.8) components were considered.

RESULTS: The CV estimation revealed (Table 1) average values of 6.8 ± 2.1 m/s, 6.2 ± 0.4 m/s, and 70.3 ± 100.0 m/s for CV_{VF}, CV_{EMG}, and CV_{ACC}. CV_{VF} and CV_{EMG} were comparable while CV_{VF} and CV_{ACC} were significantly different ($p<0.05$).

CONCLUSION: Our results show propagation of the EMG vibration components at average velocity CV_{VF} = 6.8 m/s, comparable (slightly higher) with CV_{EMG} and much lower than the CV of the mechanical vibration waves measured on the arm surface, CV_{ACC} = 70.3 m/s. This result suggests EMG vibration components to be primarily generated by vibration-induced muscle activity. The slight different between CV_{VF} and CV_{EMG} could possibly be explained by vibration-induced recruitment of faster motor units with higher CV.

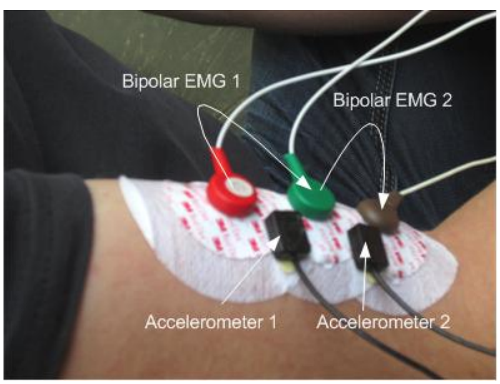

Figure 1: EMG signal recording.

Table 1: Average CV estimates (m/s).

F (Hz)	CV_{VF}	CV_{EMG}	CV_{ACC}
25	6.9±0.2	6.2±0.1	37.8±28.7
35	4.6±0.0	6.2±0.0	16.0±0.0
45	6.8±2.3	6.4±0.2	40.0±30.0
55	7.4±2.6	6.3±0.4	50.3±60.0
65	6.7±2.2	6.1±0.6	138.4±164.1
Average	6.8±2.1	6.2±0.4	70.3±100.0

H-REFLEX IN VIBRATION EXERCISE

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AIM: Vibration exercise has been suggested as an effective methodology to improve muscle strength and power performance, as well as to increase balance and bone density. These benefits make vibration exercise a suitable option for several rehabilitation programs. However, the physiological adaptation processes leading to the reported benefits, most probably associated to increased muscle activation induced by neuromuscular reflex, are not yet understood, and the potential benefit of vibration exercise cannot be fully exploited. In order to deepen our understanding of the neurophysiological mechanisms underlying the effects of vibration exercise, in this study we focus on the analysis of the Hoffmann reflex (H-reflex) as a measure of spinal excitability. Our aim is to evaluate the effect of vibration on the H-reflex measured after fatiguing exercise at different vibration frequencies.

METHODS: Twenty healthy subjects participated in this study. The subjects performed isometric contractions of the right Flexor Carpi Radialis (FCR) muscle at 80% of maximum voluntary contraction (MVC) without vibration and with superimposed vibration at 15, 30, and 45 Hz with a randomized order. The use of submaximal force (80% MVC) permitted studying vibration-induced muscle fatigue. Vibration consisted of a sinusoidal modulation of the force amplitude by 70% of its baseline value. Percutaneous electrical stimulation of the median nerve at the upper arm was used to elicit both M and H responses, measured by surface electromyography (EMG) with two electrodes in bipolar configuration. The amplitude of the H- and M-waves was assessed to estimate the H/M ratio, reflecting the percentage of motorneurons recruited by the reflex. Two different conditions were investigated: at rest (R0) and after vibration-induced fatigue (R1). Muscle fatigue was assessed by estimation of the EMG spectral compression (myoelectric fatigue) during the exercise and of the MVC decay (mechanical fatigue) induced by the exercise; the values are given as relative variations and normalized to the maximum of each subject.

RESULTS: Table 1 reports the results: the H/M decrease, i.e., the ratio (R0-R1)/R0, was lowest at 30 Hz. Also the highest level of muscle fatigue, both mechanical and myoelectric, was observed at 30 Hz.

CONCLUSION: This study shows that superimposition of vibration produces a decrease in H/M ratio. In particular, the lowest H/M decrease was observed at 30 Hz, corresponding to the highest myoelectric (EMG spectral compression) and mechanical (MVC decay) muscular fatigue. These results may suggest vibration exercise, especially at 30 Hz, to enhance peripheral fatigue, which is reflected in MVC decay and EMG spectral compression, while reducing central fatigue, which is reflected in H-reflex suppression.

Table 1: Measurement results.

Vibration frequency	**0 Hz**	**15 Hz**	**30 Hz**	**45 Hz**
H/M decrease [%]	19.43 ± 28.33	17.46 ± 30,93	16.35 ± 23,26	17.57 ± 32,00
Normalized MVC decay	-0.52 ± 0.24	-0.55 ± 0.29	-0.59 ± 0.28	-0.49 ± 0.36
Normalized EMG spectral compression	-0.75 ± 0.03	-0.82 ± 0.04	-0.84 ± 0.04	-0.68 ± 0.03

NONLINEAR ANALYSIS OF MULTI-CHANNEL MECHANOMYOGRAPHIC RECORDINGS

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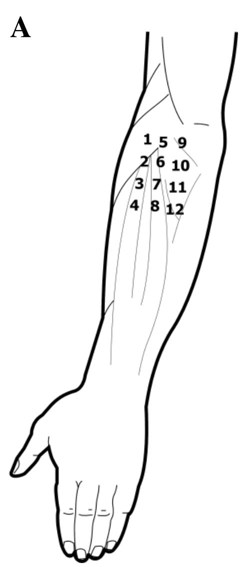
AIM: We investigated the changes in multi-channel mechanomyographic (MMG) recordings following high intensity eccentric muscle contractions by means of recurrence quantification analysis (RQA).
METHODS: Twelve iMEMS® accelerometers forming a 3×4 matrix were used to record MMG signals from the wrist extensor muscles in 12 healthy subjects (Figure 1A). Repetitive high level eccentric contractions induced muscle fatigue immediately after exercise and delayed onset muscle soreness at 24 h after exercise. The % of recurrence (%REC) and % of determinism (%DET) were extracted as indexes of periodicity from the RQA during standardized contractions at 20%max before, immediately after, and 24 h after exercise.
RESULTS: The %REC and %DET maps revealed heterogeneous changes in the periodicity of the MMGs from the wrist extensor muscles ($F=9.9$, $P<0.001$ and $F=43.6$, $P<0.001$ respectively, Figure 1B). First, the %REC and %DET decreased from before to immediately after the contractions and then increased from immediately after to 24 h after contractions ($F=27.5$, $P<0.001$ and $F=6.6$, $P<0.01$ respectively).
CONCLUSION: RQA of multi-channel MMG recordings was applied for the first time. The current findings underlined the potential of multi-channel MMG recordings combined with non-linear analysis in detecting muscular and musculo-tendinous modifications due to muscle fatigue and muscle soreness.



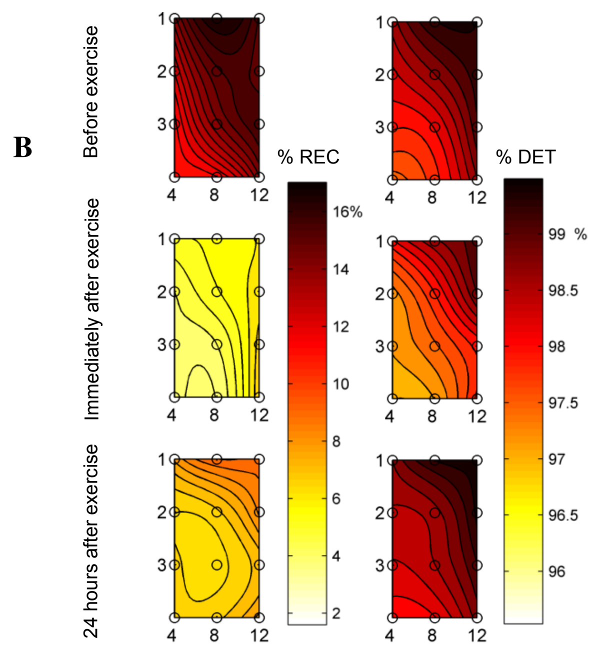


Figure 1A Numbers 1-12 represent accelerometer locations over the wrist extensor muscles (muscular and musculo-tendinous sites). **1B** Mean % of recurrence (%REC) and of determinism (% DET) of MMG maps during standardized isometric contractions performed before, immediately after, and 24 h after eccentric contractions.

Modelling and signal Processing 2 (Sala 1LM 17.30-18.30)

DECOMPOSITION OF THE TIBIALIS ANTERIOR MAXIMAL SINGLE TWITCH USING VARYING AMPLITUDE STIMULATION PULSE

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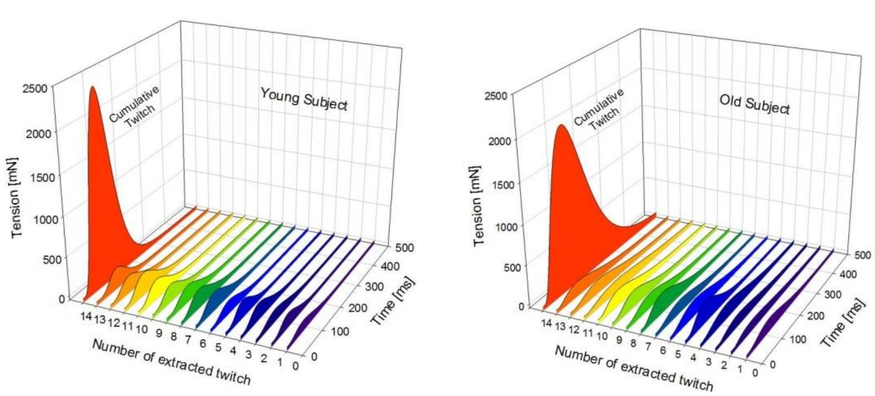
AIM: To verify: the possibility to retrieve the contribution of individual bundles of fibers recruited at different levels of stimulation amplitude to the maximal cumulative single twitch torque of human tibialis anterior (TA); the suitability of the method in describing the effect of ageing process on skeletal muscle.

METHODS: Subjects: 10 young (20-30 years old, Y) and 12 aged (65-80 years old, O). The TA was stimulated at the main motor point. Two levels of stimulation amplitude were identified: Vmin (eliciting the smallest detectable twitch) and VMax (recruiting all the motor units). The VMax-Vmin interval was divided in 60 levels of stimulation (LS). At each LS a 2 Hz train was delivered for 10 s. t-Test ($p < 0.001$) was used to verify the presence of statistically significant difference (SSD) between the mechanical responses of two adjacent LS. When SSD was verified the 20 twitches of each of the two LS were averaged and eventually subtracted one each other to extract the contribution of the bundle recruited at the higher LS. The extracted contributions were modeled according to Raikova et al (2007). For each individual modeled twitch the peak (PT), the contraction time (CT) the ratio between the area and the twitch amplitude (A/PT) as a shape factor, were calculated.

RESULTS: In the figure it is evident that the cumulative twitches come from the summation of rather homogeneous individual bundles contributions in both young and aged subjects. The extracted twitch amplitudes did not differ (Y: 227 ± 101 mN; O: 221 ± 132 mN) while the CT (Y: 69 ± 9 ms; O: 84 ± 13 ms) as well as A/PT (Y:108 ± 19 mN; O: 157 ± 33 mN) did. Given that 95% of the extracted twitches in the two groups presented A/PT below 114 (Y) and above and 138 (O) we defined the value of 126 as the limit between fast (<126) and slow (>126) responses. It resulted that Y and O subjects presented 83% and 88% fast and slow bundle twitches , respectively.

CONCLUSION: It was possible to extract and characterize the single bundle contribution to the cumulative twitch. The suggested procedure will contribute to explain the functional weight of fast and slow components in the overall mechanical response of the skeletal muscle during neuromuscular diseases, ageing process and training conditioning.

Ref. *Raikova R et al. J Electromyogr Kinesiol. 2007;1 7(2):121-30*



Modelling and signal Processing 2 (Sala 1LM 17.30-18.30)

USING EMG TO ESTIMATE FUTURE TORQUES ABOUT A JOINT

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AIM**:** It has long been known that peak EMG activity precedes peak mechanical tension by 50–100 ms or more. Hence, EMG should be able to estimate torque at future times, at least over this limited time scale. Thus, we systematically evaluated EMG-torque estimation about the elbow joint at future times ranging up to 750 ms, at a time increment of 5 ms.

METHODS**:** Previously collected EMG data from biceps and triceps muscles of 54 healthy subjects were reanalyzed. The contractions were constant-posture and force-varying. The EMG signal was optionally whitened and then related to torque via an optimized linear model or an optimized nonlinear model. Performance was assessed vs. the time advance of the torque signal.

RESULTS**:** Higher-order, whitened, nonlinear models exhibited a prediction error minimum of 5.48±2.21 %MVC_F (percent flexion MVC) over the time advance range from 0–60 ms, with error growing for larger time advances. Performance of our optimal filters was compared to the common second-order Butterworth filter approach. This filter produced a statistically inferior average error of 6.90±2.39 % MVC_F, and only at a time advance of 60 ms. Error grew on either side of this nadir.

CONCLUSION**:** Torque in the elbow could successfully be estimated up to 60 ms into the future, without change in performance, using optimized EMG-torque models. Butterworth models performed poorer and only at one specific time delay—perhaps indicating why some authors add a pure time delay to Butterworth-type models. Our optimized models performed better and do not require the cascade of a pure time delay.

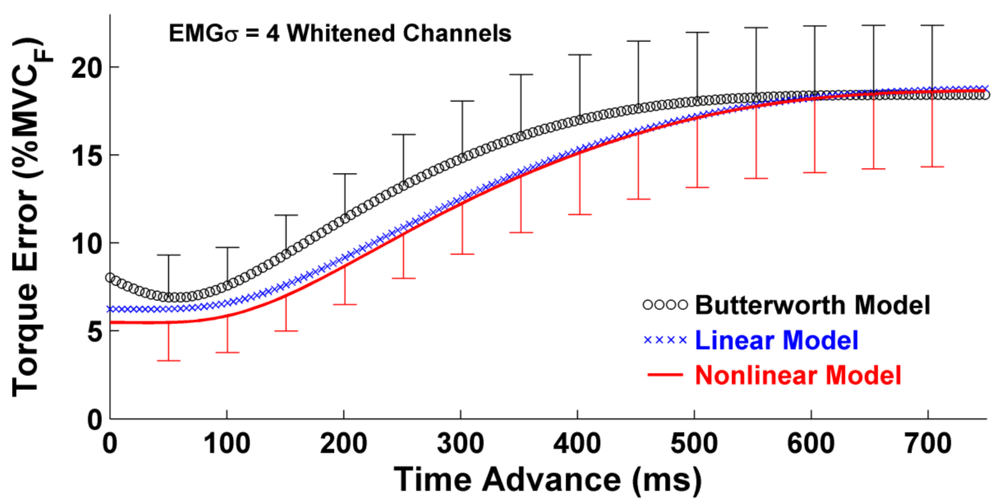

Figure 1: EMG-torque results for the optimal linear model, optimal nonlinear model and the second-order Butterworth model, averaged across 54 subjects, for time delays between 0–750 ms.

THE USE OF SURFACE ELECTROMYOGRAPHY (SEMG) TO NON-INVASIVELY MEASURE ELECTRICAL ACTIVITY FROM A DEEP CALF MUSCLE (TIBIALIS POSTERIOR)

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AIM: To investigate whether tibialis posterior muscle activity can be derived non-invasively using surface EMG and independent component analysis.

METHODS: Two concentric rings, spaced 20mm apart, with 10 EMG electrodes on each ring, were placed around the right calf of the 15 right-footed healthy participants, to record monopolar EMG. The participants performed 6 repetitions of 6 isometric movements (dorsi-flexion, plantar-flexion, eversion, inversion, toe extension and flexion), about the foot and ankle, with the knee flexed and extended. These movements selectively activated the muscles with-in the capture region of the EMG electrodes. Independent component analysis (IC) was used to un-mix the 20 monopolar EMG to form the equivalent of 20 bipolar deep and superficial muscle EMG signals. With tibialis posterior active in inversion and plantar flexion but inactive in the remaining 4 movements, a predicted EMG was created and correlated with each of 20 un-mixed EMG signals. The unmixed channel which best correlated with the un-mixed signal was labelled as tibialis posterior EMG signal.

RESULTS: Preliminary data showed a mean correlation, between the proposed tibialis posterior IC and predicted tibialis posterior activation pattern, of 0.78 (0.60 – 0.86) with knee flexed and 0.78 (0.42 - 0.87) with knee extended. However 10 of the 15 participants showed correlations above 0.75 where the mean was 0.81 (0.76 – 0.86) and 0.84 (0.75 - 0.88) in the knee flexed and extended position respectively, which was consistent over all 6 repetitions.

CONCLUSION: Preliminary results indicate that this is the first technique able to non-invasively derive tibialis posterior muscle activity using surface EMG. Additional research needs to be done to compare this technique to the gold standard of needle EMG for deep muscles.

SKELETAL MUSCLE STATES PREDICTED FROM SEQUENTIAL B-MODE ULTRASOUND IMAGES

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AIM: Ultrasonography (US) is capable of non-invasively imaging large cross-sectional areas of muscle tissue, revealing fascicle curvature/orientation, and strong indicators of activation, segment length change and tendon stiffness. Standard analysis techniques track fascicle motion and measure differentials between muscle boundaries, but these methods fail over arbitrarily long sequences (~60'') due to unavoidable tracking error. Presented here is a robust graphical model of the human Gastrocnemius Medialis (GM) which has the capacity to estimate ankle joint angle and muscle activity, directly from two sequential frames of ultrasound. A Restricted Boltzmann Machine (RBM) and a Multilayer Neural Network (MLNN) was used to model pairs of images from US recordings of muscle function from 17 participants, and was validated on a single held-out participant. Initial results show significant correlations when predicting ankle angle and activation (EMG); r=0.724 and r=0.772, respectively.

METHODS: 18 Participants were asked to stand on programmable foot pedals while strapped upright to a flat backboard. They then performed a series of ankle rotations designed to exploit skeletal muscle properties under 3 conditions: isometric contraction, passive ankle rotation, and combined contraction and ankle rotation. Ankle angle (1000*Hz*), EMG (1000*Hz*), and US (25*Hz*) of the calf were simultaneously recorded. For isometric and combined tasks, rectified filtered EMG feedback was used to guide the participants in matching their muscle activity to a pre-designed tracking target presented via oscilloscope. For passive and combined tasks, a pre-designed signal was used to drive the actuators on the foot pedals, which created a rotation about the participants' ankle joint (±10º).

An Active Shape Model was used to automatically extract images of GM from each frame of US, and a large database of image pairs (frames t and t+1) was created. Each image was down-sampled to an 80x80 matrix. Then a RBM was used to create a graphical model of the muscle from that database, leaving out a random participant's data for validation. The RBM yields a 1536 point feature vector. That feature vector was then used as an input to a MLNN, which was trained to predict ankle angle and EMG, using the Error Backpropagation algorithm.

RESULTS: Initial results from the model empirically demonstrate the capacity to estimate the current joint angle (r>0.71, p<0.001), and the current activity (filtered EMG: r>0.75, p<0.001) in all participants. The model was validated on a single, held-out participant, with r values of 0.772 and 0.724 for estimating joint angle and activity respectively, from a sequence containing combined activity and ankle joint changes.

CONCLUSION: This method is a significant departure from standard methods, which rely on tracking approximations of fascicle motion in the 2D US plane. By modeling fascicle motion directly from the data, our method has eliminated the possibility of tracking drift, and gives a good global estimate of activity and muscle length.

TOWARDS A SIMULATION-BASED EMG BENCHMARK FOR ANALYSING MOTOR UNIT FIRING STRATEGIES

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AIM: Computational-based predictions of electromyographic (EMG) signals obtained from simulating the underlying biophysical processes of motor unit firing and action potential propagation have great potential to test, verify and improve algorithms that determine the underlying motor unit recruitment and rate coding principles based on experimental EMG recordings. This way, the comprehension of EMG signals and its correct interpretation can be improved.

METHODS: This contribution presents a three-dimensional, continuum-based forward model that is able to produce virtual EMG signals based on the underlying biophysical principles of skeletal muscle fibre activation. The electrical activity of skeletal muscles from the cellular level to the body surface is hereby considered.

In detail, a three-dimensional computational model of a (part of a) skeletal muscle and a fat/skin layer is constructed. The whole domain is discretised using linear Lagrange finite elements. The action potential propagation along each muscle fibre is described by the monodomain equation using a detailed electrophysiological model as reaction term. For each time step, the obtained transmembrane potential is inserted into the extracellular bidomain equation to solve for the extracellular potential. The propagation of the potential through the volume conductor from the muscle to the surface is described by the generalised Laplace equation. The computations of the transmembrane potential and the extracellular potential are completely decoupled.

RESULTS: The model predicts virtual EMG signals for complex and realistic geometries. Interferential and rectified single-channel EMG signals taken at specific surface nodes, representing the sEMG, and at specific muscle nodes, representing the intramuscular EMG, are presented. Furthermore, the EMG data on the surface are computed while considering activation-induced contractions of the muscle tissue.

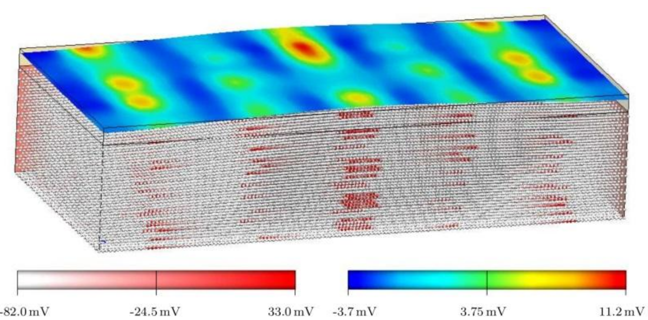

Figure 1: A virtual surface EMG signal and the corresponding transmembrane potential along each fibre of a deforming block of muscle tissue covered with a fat/skin layer.

CONCLUSION: The computed EMG signals can serve as computational benchmark for testing and improving EMG-based motor unit recruitment and rate coding algorithms, in particular under non-isometric conditions.

Motor Control 1 (Sala 2LM 17.30-18.30)

ASSESSING MUSCULAR ACTIVATION IN DYNAMIC CONDITIONS: A PROBABILISTIC APPROACH

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AIM: Due to the redundancy of the musculoskeletal system different activation strategies of agonistic muscles result in the same movement. Additionally, the amount of muscular activation might change with joint angle position, movement velocity and contraction type. As a consequence, often conflicting results are reported when investigating muscular activation during freely performed movements. The purpose of this paper is to introduce a probabilistic approach to assess the most likely muscular activation level from surface-EMG data (sEMG) of freely performed movements and to demonstrate its feasibility.

METHODS: Movements are performed repetitively while sEMG data and joint kinematics are measured synchronously. To identify the muscular activation at a certain joint position, all time segments in which the joint angle remains in a given interval are identified. Since the movement is performed repetitively, several time segments exist for the same joint angle interval. For all identified time segments the corresponding number of sEMG envelope values in a given envelope range is calculated resulting in a sEMG envelope frequency distribution (Figure 1A). The sEMG frequency distribution represents the probability that a certain sEMG envelop value can be found at the specific joint position. The statistical mean of the probability distribution characterized the most likely sEMG envelope value at the given joint angle interval and the variance indicates its confidence.

RESULTS: To demonstrate the feasibility of the approach, 20 repetitions of slow elbow flexion/extension movements have been performed. Form the probabilistic analysis of the biceps sEMG data a clear difference in muscular activation during concentric and eccentric contractions can be found. However, variance indicates significant differences for both contraction types only for elbow joint angles higher than 40° flexion (Figure 1B).

CONCLUSION: Due to the probabilistic approach the most likely activation level of a muscle can be assed from sEMG data. The way the sEMG data are analyzed allows to get defined boundary conditions like joint angle position, movement velocity or contraction type even in freely performed movements. The given example demonstrates that the method is suitable to combine different biomechanical conditions achieving more precise information about the muscular activation in freely performed movements.

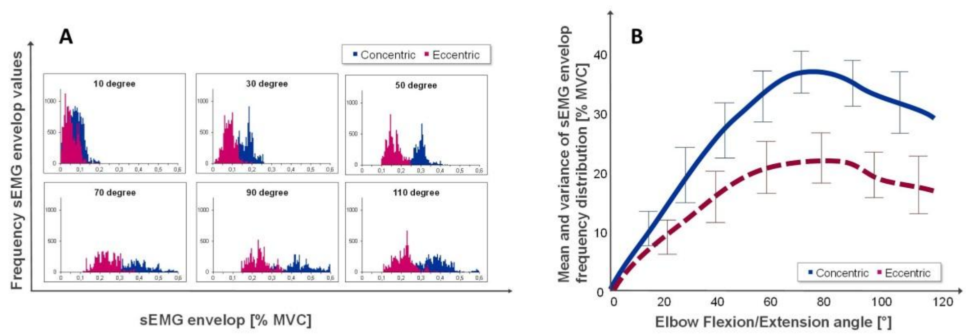

Figure 1: Differences in concentric and eccentric activation of biceps brachii in dynamic flexion / extension movements of the elbow joint.

ALTERATION IN UPPER LIMB PROPRIOCEPTION FOLLOWING NECK MUSCLE FATIGUE

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AIM**:** Limb proprioception refers to an awareness by the central nervous system (CNS) of the location of a limb in three-dimensional space and is essential for movement, postural control and position of the musculoskeletal system. For the neck, the head serves as a reference for body position, rather than the trunk. The CNS uses the position of the head and neck when interpreting the position of the upper limb segments. Therefore, altered input from cervical muscles due to fatigue is likely to affect the sensory inputs to the CNS and consequently has the potential to impair the conscious awareness of upper limb joint position. The aim of this study was to determine if fatigue of the cervical extensor muscles using a submaximal fatigue protocol (70% of maximal voluntary contraction) would alter the ability to actively recreate a previously presented angle at the elbow with the head in a neutral position.

METHODS**:** Twelve healthy participants (7 males and 5 females, 21.7 ± 4.1 years) positioned their right arm in a sling, with 90° of elbow flexion and the shoulder in 80° abduction and external rotation. For each participant, elbow joint position sense was measured as the ability to recreate a previously presented angle at the elbow during both fatigued and non-fatigued states of the cervical extensor muscles. Participants completed a total of 9 measurements, consisting of two sets of three trials each, prior to fatigue, and one set of three trials for post fatigue performance. A 3D investigator motion capture system was used to monitor changes in head motion and elbow joint angles. Surface electrodes (Meditrace^{TM} 130 electrodes) were applied bilaterally over the cervical extensors at the level of C4 and C5 (sampling rate 1024 Hz and a band pass filter of 10-500 Hz). Electromyography (EMG) was also recorded during the fatigue protocol and used to calculate the mean power frequency (MPF). The fatigue protocol consisted of an isometric neck extension task against a wall mounted force transducer at 70% of maximum until failure.

RESULTS**:** The MPF declined from the first 10 seconds to the last 10 seconds of the submaximal fatigue protocol. The average MPF of the right extensors decreased (mean ± sd.) from 70.82±7.67 Hz to 66.14±11.29 Hz and the left extensors decreased from 69.50±9.41 Hz to 62.29±9.62 Hz. A repeated measure ANOVA for the mean absolute and variable elbow joint position error (JPE) indicated that JPE increased from the second pre-fatigued to post-fatigued trials. A significant main effect of time ($F_{2, 22}$ = 27.02, $p \leq 0.0001$) was found for absolute error. No significant differences were found for time for variable and constant error.

CONCLUSION**:** These results suggest that fatigue of the cervical extensor muscles with a 70% MVC protocol reduced the accuracy of elbow joint position matching. This is one of the first studies to show that altered input from the neck due to fatigue can influence upper limb proprioception.

ACKNOWLEDGEMENT: The authors would like to acknowledge funding by the Natural Sciences and Engineering Research Council of Canada, the Canada Foundation for Innovation and the Ontario Ministry of Research and Innovation.

NECK MUSCLE RESPONSE DURING PARACHUTE OPENING SHOCK IN SKYDIVERS

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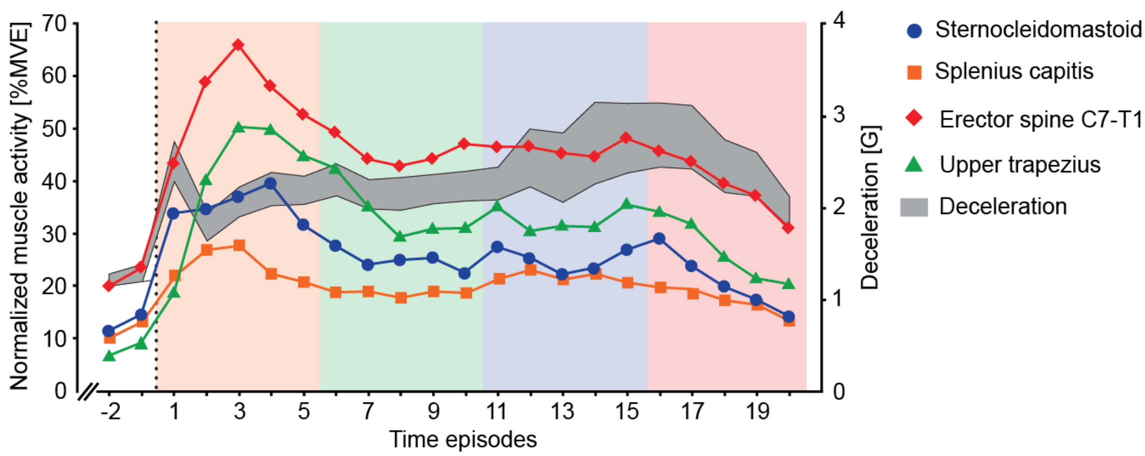
AIM: The purpose of this study was to examine neck muscle response to parachute opening shock (POS), during which the skydiver decelerates from roughly 210 km/h to 30 km/h within a few seconds. The neck muscles have a protective role for the cervical spine during external perturbations. However, high neck muscle activity in high-load environments, such as in air force pilots during multiple-G air missions, have been identified as a risk for neck pain or injury. While recent epidemiological data show POS-related neck pain prevalence to be high in skydivers, current knowledge on neck muscle load during POS is scarce. METHODS: Twenty experienced skydivers each performed two consecutive terminal velocity skydives with ram-air parachutes. During POS, muscle activity was recorded bilaterally from sternocleidomastoids (SCM), splenius capitis (SPL), cervical erector spine (ES) and trapezius descendens (TPD) with the use of a standardized surface electromyographic measuring protocol. Two triaxial accelerometers were used to quantify deceleration. Muscle activity was normalized against isometric maximum voluntary electricity contraction (%MVE), and the mean activity was analyzed in quartiles of POS duration. RESULTS: Repeated measures ANOVA revealed ES to have greater activity than the other muscles during all time quartiles of POS ($p=0.003$), reaching the highest mean level (66 %MVE) in the first quartile. TPD had greater activity than SPL during the initial three quartiles ($p=0.037$) and SCM during the second quartile ($p<0.05$), while SCM had greater activity than SPL during the first quartile ($p<0.001$). Further, muscle activity onset preceded deceleration onset for all muscles ($p=0.017$). CONCLUSION: Erector spine muscle activity was consistently higher than the other muscles during POS, suggesting it to be the main deceleration antagonist. In addition, neck muscle activity was anticipatory for all muscles in relation to deceleration onset, likely to protect and stabilize the cervical spine complex from the high load during POS.

Figure 1. Mean normalized muscle activity presented per muscle in five percentile time episodes through the duration of parachute opening shock (POS) (n=19). Colored areas denote POS time quartiles and the dotted line separate pre-POS from POS muscle activity.



MOTOR CONTROL DURING A CERVICAL EXTENSOR ENDURANCE TASK IN OFFICE WORKERS WHO DEVELOP CHRONIC NECK PAIN

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AIM: Reduced time to task failure for the prone neck extensor endurance test in healthy office workers has been shown to predict the future development of chronic neck pain. Patterns of muscle activation necessary to optimize performance on this endurance test are currently unknown. The purpose of this study was to compare cervical muscle activity during the prone neck extensor endurance test in healthy office workers who do and do not develop chronic neck pain within their first year of employment in a high risk occupation.

METHODS: One hundred and fifty six healthy participants (mean (SD) age 30(8) years, 79% women) performed an isometric prone neck extensor endurance test with a 5 kg weight. Surface electromyography (EMG) of the bilateral cervical extensors (CE), sternocleidomastoid (SCM), and upper trapezius (UT) muscles was collected. Time to task failure, median frequency (MF), root mean square (RMS) amplitude, and co-contraction ratios between synergist and antagonist muscles were quantified. Participants completed an online survey every month for 12 months to identify those who developed chronic neck pain, defined as $\geq$10% Neck Disability Index scores for 3 or more months.

RESULTS: Thirty two individuals (21%) developed neck pain during the 1 year follow up. Average time to task failure for the neck pain group was 196.8 (88) versus 257.5 (66) seconds in the healthy group. Median frequency significantly decreased over time during the prone cervical extensor test for all individuals across all muscles ($p<0.014$), excluding the non-dominant SCM. RMS amplitude of bilateral cervical extensors and dominant SCM significantly increased over time ($p<0.001$ and 0.008, respectively), whereas bilateral UT and non-dominant SCM demonstrated no change. No differences in MF or RMS amplitude over time were found between individuals who did and did not develop neck pain. Synergist and antagonist co-contraction ratios also did not significantly differ over time or between groups. Relative to the cervical extensors, co-contraction of the non-dominant UT was greater than co-contraction of the dominant UT throughout the endurance task ($p<0.001$), with this difference being more pronounced in individuals who went on to develop neck pain

CONCLUSION: The relative contribution of accessory UT muscle activity was higher on the non-dominant side, especially in individuals who went on to develop neck pain, although this demonstrated large variability. This finding may suggest abnormal contributions of accessory muscle activity to the future development of neck pain. Future research is needed to determine the mechanisms for altered motor control patterns that contribute to poor cervical extensor endurance and increased risk of neck pain.

ACKNOWLEDGEMENTS: Funding sources: NIH R01 AR056704 awarded to KSM, Foundation for Physical Therapy PODS II awarded to BS

IS REGULATION OF THE NECK MUSCULATURE OF HIERARCHICAL IMPORTANCE IN THE CONTROL OF MOVEMENT?

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AIM
Motor output is organised temporally and hierarchically. Motor output proceeds temporally along the kinematic chain from the reference-stabilising segment to the end-effector. Control of the reference segment sets boundary conditions for control of distal segments. We hypothesise that control of the neck musculature is prior to control of the head-trunk-limbs.

METHODS
Starting from a common neutral configuration with arms at the side of the body, twenty-one violinists/violists repeated six progressively demanding tasks of picking up, holding and playing their instrument (Series A). These tasks were repeated with an ultrasound probe attached to the dorsal neck (Series B, effect of wearing probe), looking at the blank side of the ultrasound monitor (Series C, effect of gaze direction), looking at the ultrasound view of the dorsal neck muscles and describing the changes in shape associated with the task (Series D, effect of visual engagement neck muscles), and finally, using visual feedback from the ultrasound monitor to minimise shape change in the neck muscles while carrying out the task (Series E, effect of minimising unnecessary neck muscle shape change). Whole-body motion was recorded (Vicon) and analysed (17 joint angles × 3 rotational degrees of freedom). We report the transition between initial and sustained configurations: (i) does fixation of gaze (C-A) change coordination? (ii) does minimisation of change in neck muscle shape (E-A) alter coordination independently of gaze fixation?

RESULTS
Participants completed all tasks in all series. Significance is reported at $p<0.05$. Multivariate, discriminant analysis of kinematic-joint rotations showed a significant difference between Series. The primary difference lay between Series {E} and {A,B,C,D}, and the secondary difference between {C,D} and {A,B}. Series E eliminated head, trunk, shoulder, arm, and leg movements not altered through fixation of gaze. Pairwise comparison showed all Series were significantly different from all others except A v B. Orthogonal discriminant functions showed: (i) a significant first function (45% variance) representing E-A (effect of visually guided inhibitory neck feedback), with a significantly smaller minority contribution to the same pattern from C-A (effect of gaze), and (ii) a significant, second orthogonal function (40% variance) representing C-A (gaze) with no contribution from E-A (neck inhibition).

CONCLUSIONS
In these tasks, fixation of the gaze changes whole-body postural and focal manual coordination. Minimisation of unnecessary change in neck muscle shape alters coordination more fundamentally and independently of gaze fixation. Independently of gaze direction, control of the neck musculature is of hierarchical importance in the control of coordination. Our interpretation is that voluntary inhibitory control of the neck musculature minimises motor output which has been selected *a priori* but which is irrelevant to the task. Exploitation of this mechanism allows the possibility of reducing mal-adapted motor control.

Posture and Balance 1 (Sala 4LM 17.30-18.30)

RECTUS ABDOMINIS ACTIVITY DECREASES RELATIVE TO ERECTOR SPINAE WITH MATURITY DESPITE SIMILAR MUSCLE VOLUMES AND LUMBAR POSTURE AT STANCE

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AIM: To compare trunk muscle volume, muscle activity and lumbar spine posture in young and mature participants without low back pain.
METHODS: Twenty-four participants were allocated to a young group (YG: age 18-25yrs, n=12) or mature group (MG: age 45-60yrs, n=12). Muscle volume of lumbar spine erector spinae (ES), multifidus (M), rectus abdominis (RA) and psoas (PS) was determined bilaterally using T1-weighted axial MRI. Flexor volume (FV) was obtained by summing RA and PS volumes and extensor volume (EV) by summing M and ES volumes. Muscle volume ratio (MVR) was defined as FV/EV. Trunk muscle activity and lumbar spine posture were evaluated from synchronously collected kinematic and EMG data at stance using 10 high speed cameras (Eagle Digital Real Time System, Motion Analysis Corp, USA) recording at 120Hz using kinematic software (Cortex 3.6) and surface electromyography (sEMG) (Delsys Trigno, Boston, USA) sampled at 1200Hz. Reflective markers were attached to the skin overlying the spinous processes of the 11th thoracic (T11), 2nd lumbar (L2), 5th lumbar (L5) vertebra and sacrum, and sagittal angles were calculated at L2 and L5. sEMG electrodes were placed over ES and RA bilaterally, data full-wave rectified and integrated EMG (iEMG) calculated. Muscle activity ratio (MAR) was defined as RA/ES. Differences between the YG and MG for all parameters were determined using an independent t-test or Mann Whitney test and Pearson's or Spearman's correlations were calculated.
RESULTS: There was a significant between-group difference for MAR (YG=1.13, MG=0.82, p=0.045). In the YG, there were significant correlations between ES activity and MAR (r=-0.689, p=0.013) and FV and EV (r=0.851, p=0.000). In the MG, there were significant correlations between FV and MVR (r=0.688, p=0.013), FV and EV (r=0.807, p=0.002), RA activity and MAR (r=0.592, p=0.043), ES activity and MAR (r=-0.736, p=0.006), and L2 and L5 angle (r=-0.579, p=0.049).
CONCLUSION: Adequate lumbar posture at natural stance does not preclude the necessity of additional abdominal training in mature people.

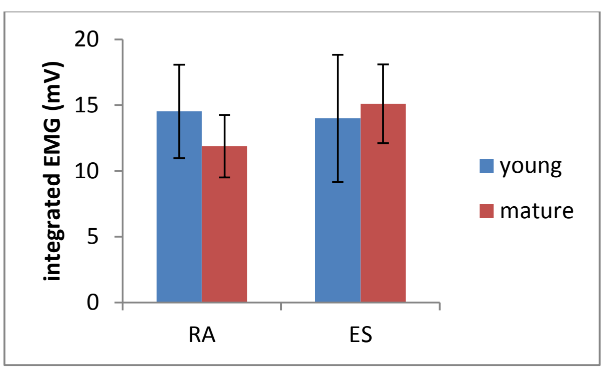

Figure1: Mean RA and ES activity in young and mature participants (error bars show stdev).

IS LUMBAR CURVATURE ANGLE IN STANDING RELATED TO LOW BACK PAIN DEVELOPMENT?

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AIMS: The aims were to (1) compare lumbar curvature angle in back-healthy participants who develop low back pain (LBP) symptoms (Pain Developers, PDs) during 2 hours of standing to those who do not develop LBP symptoms (Non Pain Developers, NPDs), and (2) examine the relationship between lumbar curvature angle and LBP symptom intensity. We hypothesized that (1) PDs would display a smaller, more lordotic lumbar curvature angle compared to NPDs, and (2) there would be a negative relationship between lumbar curvature angle and LBP symptom intensity, that is, more lordosis would be related to increased pain.
METHODS: Back-healthy participants (n=49) were recruited. Reflective markers were placed superficial to the spinous process of the 1st (L1), 3rd (L3), and 5th (L5) lumbar vertebrae. Participants stood normally while lumbar spine kinematics were recorded using a motion capture system. Participants then stood for 2 hours while performing 4 different simulated, light work tasks that were presented randomly every 15 minutes. At baseline and every 15 minutes during standing, participants rated their LBP symptom intensity on a 100 mm visual analog scale (VAS). PDs were participants that reported any symptoms following the baseline VAS measure and maintained symptoms throughout the standing test. NPDs were people who reported 0 on the VAS throughout the standing test. Lumbar curvature angle (α) was calculated by (1) finding the distance of a line (l) from L1 to L5, (2) finding the depth of the curve as a line (d) perpendicular from l to L3, (3) using the formula $\alpha = 2\arctan(0.5l/d)$. Based on this calculation, 180° represented no lumbar curvature. As the angle decreased from 180° lumbar lordosis increased. An independent samples t-test was used to test for a difference in angle between PDs and NPDs. A Pearson correlation coefficient was calculated for lumbar curvature angle and maximum VAS score during standing in PDs.
RESULTS: There were 21 (44%) PDs and 28 (56%) NPDs. Lumbar curvature angle was significantly smaller in PDs compared to NPDs (Mean difference = 4.2°; 95% CI = 0.4° to 8.0°; Cohen's d = 0.65). The correlation coefficient between lumbar curvature angle and maximum VAS during standing was -0.46 (p = 0.04).
CONCLUSION: PDs displayed significantly more lumbar lordosis in standing than NPDs. Amount of lumbar lordosis also was related to intensity of LBP symptoms during standing. These findings suggest that standing in more, compared to less lumbar lordosis may be a risk factor for LBP symptom development in back-healthy people who participate in activities that require prolonged periods of standing. The proposed mechanism for LBP symptom development is increased tissue stress concentrations in the posterior vertebral elements over time, that give rise to pain. Identifying characteristics that increase risk for developing LBP symptoms can help inform strategies for preventative interventions.

THE NEXUS BETWEEN FORWARD BENDING OF THE TRUNK AT WORK AND LOW BACK PAIN INTENSITY: A CROSS-SECTIONAL STUDY OF THE NOMAD COHORT

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AIM: Forward bending of the trunk (FBT) is one of the recognized physical risk factors leading to low back pain (LBP) intensity in blue-collar occupations (1). Previous studies investigating physical work demands through objective measurements are limited to short periods of recordings (2). The aim of this study was to investigate the relationship between FBT and intensity of LBP during work among blue collar workers.
METHODS: This investigation is based on the cross-sectional field study named New method for Objective Measurements of physical Activity in Daily living (NOMAD). One-hundred-and-eighty-five blue-collar workers (♂103; ♀82) with a mean age of 45 ± 9.6 yr (mean ± SD) were recruited from seven workplaces in Denmark. The participants answered a questionnaire about their worst LBP intensity during the last month on a 0-9 numeric rating scale. The variable was categorized into a low (≤5) and high (>5) pain intensity group. Furthermore the workers wore two three-axis digital accelerometers (ActiGraph GT3X+, ActiGraph, Florida, USA) 24 hours a day for 3 to 4 consecutive days. The degrees of FBT during work (min/day) was identified based on estimates of upper body inclinations from the accelerometer data and divided into two categories representing high (the highest tertile) and low (the remaining tertiles) amount of duration for ≥30°, ≥60° and ≥90° FBT. Data were analyzed using multiple logistic regressions.
RESULTS: The total recorded numbers of working hours was 3046 hours. The multi-adjusted odds ratios (OR) showed no positive associations between FBT and high LBP intensity. On the contrary, a strong negative association between LBP intensity and ≥30° of FBT at work was found (OR=0.35; 95% CI, 0.12 – 0.97; p<0.05).
CONCLUSION: Rather than positive associations between FBT and high LBP intensity, a negative association between ≥30° of FBT at work and LBP intensity was observed. This finding may be explained by the cross-sectional design and job crafting (the job tasks being fitted to the LBP of the worker). Future studies with more detailed measures of FBT and prospective study designs are needed.
ACKNOWLEDGEMENT: Authors would like to thank Federal Institute for Occupational Safety and Health (BAuA), Berlin, Germany for contribution and financial support to the NOMAD protocol.
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COMPENSATORY POSTURAL ADJUSTMENTS TO SUDDEN PERTURBATIONS IN INDIVIDUALS WHO UNDERWENT ACL RECONSTRUCTION

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AIM: Surgical reconstruction of the anterior cruciate ligament (ACL) with patellar tendon is recommended to restore mechanical stability of the knee joint following rupture of the ligament. However, compensatory postural adjustments (CPAs), which should help to actively stabilize limb segments in response to unexpected perturbations during voluntary movement, are altered for years after surgery. Early identification of abnormal CPAs following ACL reconstruction is paramount in order to design appropriate rehabilitation protocols and prevent re-injury. The aim of this study was to investigate CPAs to sudden perturbations of the knee joint during the early phase of rehabilitation after ACL reconstruction with patellar tendon.
METHODS: Nine male ACL reconstructed patients 2 months after surgery and 10 healthy male volunteers were enrolled in the study. Each participant was exposed to a set of 10 unpredictable perturbation trials, during which the involved limb was supported with the knee joint in full extension and unexpectedly dropped by the experimenter. The participants were instructed to resist the perturbation and restore the full extension reference position as quickly as possible. Angular displacement of the knee joint was recorded using an electrogoniometer. Surface electromyography signals were recorded from the vastus lateralis, rectus femoris and biceps femoris muscles of the involved limb. Muscle activation latencies were determined relative to the onset of the knee angular displacement. Amplitude of compensatory muscle responses were normalized to the gravitational torque of the involved limb.
RESULTS: Latency of compensatory responses were significantly higher in ACL reconstructed patients than in healthy individuals for the vastus lateralis (82.4 ± 15.5 *vs* 68.1 ± 10.5 ms, respectively; $P < 0.05$) and rectus femoris (81.6 ± 21.6 *vs* 63.0 ± 10.4 ms, respectively; $P < 0.05$) muscles. Amplitude of compensatory responses were significantly lower in ACL reconstructed patients than in healthy individuals for the vastus lateralis muscle (4.5 ± 2.4 *vs* 8.5 ± 4.7 %, respectively; $P < 0.05$).
CONCLUSION: ACL reconstructed patients 2 months after surgery showed abnormal CPAs of the knee extensor muscles to unexpected postural perturbations. The delayed latency and the reduced amplitude of muscle responses might reflect the inability of the central nervous system to quickly detect sudden changes in muscle length and/or to completely activate muscles surrounding the knee, as a result of arthrogenic muscle inhibition. Further studies are needed to evaluate whether appropriate rehabilitation protocols may help to contrast such early postoperative abnormalities in compensatory postural strategies of the lower limb muscles.

EFFECT OF TOTAL KNEE ARTHROPLASTY ON BALANCE CAPACITY AFTER SUDDEN PERTURBATION IN PATIENTS OPERATED ON BY CONVENTIONAL TECHNIQUES

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AIM: The aim of this study is to assess equilibrium ability after sudden perturbation in patients operated on by TKA using conventional methods.
METHODS: The healthy control group consisted of 22 women and 23 men. The population of the patient group consisted of 9 males and 8 females; they were operated on by a conventional technique. Prior to and 6 and 12 weeks after the surgery we conducted provocation tests using an oscillatory platform and determined the Lehr's damping ratio (D), which represented the balance capacity after sudden perturbation.
RESULTS: Prior to and after the TKA, D values determined for standing on the affected limb were significantly lower compared to the standing on both or on non-affected limb (Table 1). Prior to surgery, the D values under all three conditions were significantly lower compared to the values of healthy subjects (Table 1). 6 weeks after TKA, D values did not differ significantly from those prior to surgery (Table 1). The D values significantly increased from the 6th week postoperatively: they were significantly higher compared to the values determined prior to and 6 weeks after TKA; however, D values did not reach normal values 12 weeks after surgery (Table 1).
CONCLUSION: In patients after surgery, the unaffected leg was always the dominant leg. The results shown that the non-affected side could not compensate the decreased balance ability of the affected side, and the regeneration of the joint capsule had not finished yet. It may also indicate an increased risk of falling. It means it could be taken into account in compiling the rehabilitation protocol and in the use of different aids.
ACKNOWLEDGEMENT: This project is supported by the Hungarian Scientific Fund (K083650).

Table 1: Mean ± SD of Lehr's damping ratio (D) calculated from results of provocation test

			Standing on		
			both limbs	dominant/ non-affected limb	non-dominant/ affected limb
Control group	*male*		4.65 ± 0.33	4.47 ± 0.30	2.90 ± 0.39 [a,b]
	female		4.99 ± 0.29 [g]	4.83 ± 0.28 [g]	3.41 ± 0.31 [a,b,g]
Postoperative group	*male*	preop	3.25 ± 0.49 [c]	3.05 ± 0.42 [c]	0.84 ± 0.49 [a,b,c]
		4ws	3.21 ± 0.34 [c]	3.17 ± 0.39 [c]	1.05 ± 0.39 [a,b, c]
		12ws	3.62 ±0.37 [c,d,e]	3.57 ±0.35 [c,d,e]	1.87 ±0.35 [a,b,c,d,e]
	female	preop	3.20 ± 0.41 [c]	3.12 ± 0.49 [c]	0.88 ± 0.47 [a,b,c]
		4 ws	3.08 ± 0.37 [c]	3.04 ± 0.37 [c]	1.08 ±0.33 [a,b,c]
		12ws	3.67 ±0.35 [c,d,e]	3.60 ±0.37 [c,d,e]	1.91 ±0.33 [a,b,c,d,e]

[a] Significant difference compared to D values determined during standing on both limbs; [b] Significant difference compared to D values determined during standing on dominant/non-affected limb; [c] Significant difference compared to values of controls;[d] Significant difference compared to values determined prior to TKA; [e] Significant difference compared to values determined 6 weeks after TKA; [g] Significant difference compared to values of males and females

Poster Sessions

Poster Session 1 (Poster Area 11.00)

Poster Session 1 (Poster Area 11.00)

POTENTIAL FOR LOWER EXTREMITY INJURY BETWEEN DROP-STOP AND DROP-STOP-JUMP TASKS

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AIM: The purpose of this study was to investigate the ground reaction forces and kinematical characteristics of rapid-stop and stop-jump during the drop landing tasks. In order to understand the lower extremity injury risks of different landing tasks.

METHODS: Fourteen male university students as the subject for this study. Subjects drop from a 40cm high platform. Two drop-landing tasks were completed by asking the subjects to perform rapid-stop and stop-jump with great efforts. Kinematical parameters and ground reaction forces were recorded by using Qualisys Track Manager (QTM) motion capture with seven infra-red Qualisys motion capture cameras (200 Hz) and two AMTI force plate (1000 Hz). The MotionMonitor software was used for data processing. The data were analyzed by using the Statistical Program for Social Sciences 14.0 for Windows package program. Independent *t*-test was used to evaluate the different drop landing tasks between rapid-stop and stop-jump. The level of significance was set at $\alpha = 0.05$.

RESULTS: The ground reaction force and kinematical data during landing phase were shown in Table 1. Peak horizontal ground reaction force, peak vertical ground reaction force, and vertical loading rate were significantly greater in rapid-stop than stop-jump ($p<0.05$). The rapid-stop had a significantly smaller joint angle at initial foot contact with the ground than the stop-jump ($p < 0.05$). The rapid-stop had significantly smaller maximum joint flexion angles during landing than the stop-jump ($p < 0.05$).

CONCLUSION: The movement characteristics during landing phase were significant differences between rapid-stop and stop-jump tasks. We infer that three potential reasons for the higher risk of lower extremity injury in the rapid-stop task compared to the stop-jump task were that rapid-stop with high impact loading during the landing phase.

Table 1: The ground reaction force and kinematical variables during the landing phase.

Group	**Rapid-stop**	**Stop-jump**
Peak horizontal ground reaction force (BW) *	-0.63±0.16	-0.49±0.07
Peak vertical ground reaction force (BW) *	3.28±0.55	2.74±0.37
Vertical loading rate (BW/sec) *	80.73±35.81	59.96±13.85
Ankle angle at initial foot contact with ground (deg) *	-31.80±10.21	-24.24±8.39
Knee angle at initial foot contact with ground (deg) *	11.96±6.92	23.50±5.55
Hip angle at initial foot contact with ground (deg) *	10.29±8.35	21.68±8.40
Ankle angle at maximum dorsiflexion during landing (deg) *	6.55±3.51	11.70±2.83
Knee angle at maximum flexion during landing (deg) *	54.32±10.20	65.84±9.80
Hip angle at maximum flexion during landing (deg) *	24.78±12.77	36.77±13.44

* indicates a significant difference ($p < 0.05$) between rapid-stop and stop-jump.

WAVELET ANALYSIS OF SIGNAL OF RESPIRATORY MUSCLES IN CYCLE ERGOMETER INSTRUMENTED

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AIM: Identify the behavior of the central frequency and median frequency of the electrical activity of the external intercostal and upper trapezius muscles through the wavelet transform, front of an incremental exercise.

METHODS: It was conducted a cross-sectional observational study, in the motion analysis laboratory at the University of City of São Paulo - UNICID. Twenty-four young adults, aged 18 to 36 years of age, of both genders, who met the established inclusion criteria, were evaluated in this study. The evaluation of accessory respiratory muscles with electromyography was performed unilaterally. In the descriptive statistical analysis, quantitative variables were presented as mean and standard deviation and qualitative variables were presented as a contingency table. And calculating the confidence interval of 95% was considered significant value of $p \leq 0.05$.

RESULTS: By *wavelet* analysis of the signals, it was evident in the frequency-domain in different loads imposed against the incremental exercise, the activation of muscle fibers of the upper trapezius and external intercostal muscles. Furthermore, it was identified the activation pattern of muscle fibers in different resistive loads imposed on the instrumented cyclergometer.

CONCLUSION: Was identified the activation pattern of muscle fibers in different resistive loads imposed on the instrumented cyclergometer.

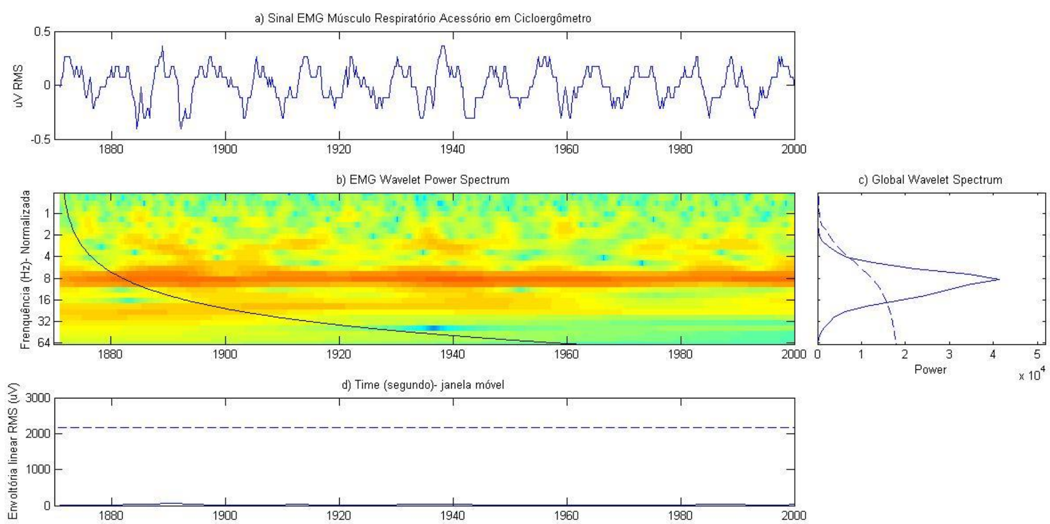

Figure 1: EMG Wavelet Frequency of Medians

BIOMECHANICAL ANALYSIS OF DIFFERENT CURVE PATTERNS OF GROUND REACTION FORCE DURING COUNTER MOVEMENT JUMP

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AIM: Force platform analysis of counter movement jump (CMJ) provides ground reaction force (GRF) information that used to study lower extremity stretch and jumping performance. To the best of our knowledge, the research concerning the patterns of the GRF curve during CMJ is limited. The purpose of this study was to investigate the biomechanical characteristics between single- and double-peak GRF curves during CMJ (Figure 1) to estimate the effect factor on the pattern of GRF curve and jumping performance.
METHODS: Sixteen collegiate physical education students volunteered as subjects in this study. The subjects were selected with respect to GRF curve pattern during CMJ. Eight subjects were classified as single-peak curve group (SG) and eight as double-peak curve group (DG). A MegaSpeed camera and an AMTI force plate was used to collect the image and the GRF during CMJ. Kinematic and force data were analyzed by using Kwon analysis software. Statistical analysis was performed with SPSS 14.0 for Windows. Variables were tested using an independent *t*-test for the differences between SG and DG during CMJ. The significance level was set at $\alpha = 0.05$.
RESULTS: The results were shown in Table 1. The DG had significantly greater impulse, jumping height, and displacement of center of gravity (CG) in comparison to SG (all $p < 0.05$). The total movement time and peak GRF were no significantly different between two groups (all $p > 0.05$).
CONCLUSION: CMJ with double-peak GRF curve may be advantageous to jumping performance. We infer that the pattern of GRF curve might be affected by the movement characteristics but not muscle stretch and movement time.

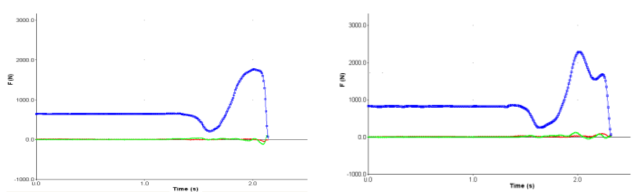

Figure 1: Single- and double-peak GRF curve during CMJ

Table 1: The variables during the CMJ of the single- and twin-peak curve groups.

Group	**SG**	**DG**
Impulse *	0.26 ± 0.03 BW·s	0.30 ± 0.03 BW·s
Jumping height *	0.12 ± 0.03 BH	0.16 ± 0.02 BH
Total movement time	0.83 ± 0.16 sec	0.87 ± 0.10 sec
Peak GRF during propulsive phase	2.55 ± 0.29 BW	2.48 ± 0.22 BW
Displacement of CG during crouch phase *	16.44 ± 1.83 BH	23.04 ± 4.31 BH
Displacement of CG during propulsive phase *	25.16 ± 1.93 BH	31.83 ± 4.64 BH

* indicates a significant difference ($p < 0.05$) between single- and twin-peak curve groups.

A PRELIMINARY STUDY OF THE EFFECT OF TRUNK POSITION ON STRATEGIES FOR LOWER LIMB FUNCTION DURING FORWARD REACHING MOVEMENTS

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AIM: This study aimed to evaluate lower limb function in different positions of the trunk during forward reaching movements.
METHODS: Seven healthy subjects (4 men and 3 women), aged 20–22 years, participated in the present study. Approval for the study was obtained from the Osaka Prefecture University research ethics committee (2013-107). Each subject performed two forward reaching tasks while sitting on a stool with both knees flexed at approximately 90°. The trunk was maintained in a neutral position (control setting) or maximally flexed position (experimental setting) during the forward reaching tasks (Fig. 1). To assess these tasks, we used 2 force plates and an electromyograph (EMG) synchronized with a motion analysis system employing 4 cameras. Surface EMG signals were recorded from four muscles of the dominant leg, namely, the vastus lateralis (VL), medial hamstrings (MH), tibialis anterior (TA), and soleus (SOL). After verifying similar total movement times for the two tasks, the percentage of ground reaction force (GRF) in the lower limbs and buttocks, and the integrated EMG was calculated. To compare these data, Wilcoxon's signed rank-sum test was used. $P < 0.05$ was considered statistically significant.
RESULTS: The percentage of GRF in the lower limbs in the experimental setting was significantly lower than that in the control setting (38.1% ± 4.5% vs. 34.2% ± 4.3%). However, the integrated EMG values for MH and TA in the experimental setting were significantly higher than those in the control setting.
CONCLUSION: Our findings suggest that trunk position would affect strategies for lower limb function during forward reach movements.
ACKNOWLEDGEMENTS: This study was supported by a Grant-in-Aid for Scientific Research (C) from the Japan Society for the Promotion of Science (1381200900).

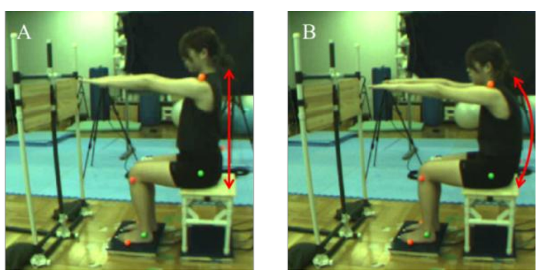

Figure 1: Two positions of the trunk in the sitting position. (A) Control setting and (B) Experimental setting.

THE EFFECTS OF AGE ON MULTISEGMENT FOOT KINEMATICS

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AIM: We currently know very little about multisegment foot mechanics or how they change as a function of age. A greater understanding of the effect of age could play an important role in identifying foot/ankle pathology in older populations. The purpose of this study was to compare multisegment foot kinematics during gait in younger and older individuals.

METHODS: Twenty-two (n=22) adult male participants were recruited between the ages of 18-30 years (young group (n=11): age=24.6±3.0 yrs; height: 178.48±5.76 cm; weight: 79.5±9.68 kg; foot size=10 ±1) and 55 years or older (old group (n=11): age=65±4.2 yrs; height: 174.6±6.3 cm; weight: 78.7±14.6 kg; foot size=10±1). An eight camera Vicon MCam motion capture system (Oxford Metrics Group), sampling at 120 Hz, was used to track the three-dimensional trajectories of reflective markers placed on the participant's skin. Two force plates (Kistler Instruments), embedded in the lab floor, were used to aid in the identification of gait cycle events. The foot model consisted of the 5 rigid segments, including the tibia, hindfoot, forefoot, hallux, and total foot. Eighteen reflective markers were placed directly on the right foot of each participant. First, a static capture of the participant during quiet standing was recorded to permit the calculation of offset values for all joint rotations. Joint offset values were subtracted from the gait cycles of each participant. Planar angles were calculated and reported without any offsets. Participants were asked to perform at least 6 gait trials. Three-dimensional coordinates were filtered with a second order low-pass Butterworth filter with a cut-off frequency of 6 Hz. Euler angles were used to represent the relative joint angles. A series of ANOVAs were used to test for significant differences in the mean values of the temporal-spatial values and joint angles between the two age groups.

RESULTS: No significant differences ($p<0.05$) in mean temporal-spatial or mean joint angle parameters were found between age groups.

CONCLUSION: This is the first study to provide a comparison of younger and older multisegment foot kinematics during gait. The results of the present study suggest that individuals aged 65.0± 4.2 years should have typical foot mechanics during gait. Therefore, deviations in motion at this age may be indicative of an underlying disease or disorder. A greater understanding of the natural changes in foot mechanics with aging will allow clinicians to more accurately identify foot pathology.

Figure 1: Picture of multisegment marker system

IMPULSE AND IMPULSIVE FORCE ON THE HEAD IN TIMING PATTERNS OF TYPICAL UKEMI IN THROWING TECHNIQUES

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AIM: In this research, eight *judo* elite athletes who are major candidates for the Japan national team were selected as participants (three athletes in the 66 kg weight category, two in 90 kg, and three in 100 kg). The aim is to examine the impulse (I) and impulsive force (F) on the faller's head during exemplary *Ukemi* techniques using kinematic analysis.

METHODS: The analysed points were twenty five body parts of each participant. Nine calibration poles were positioned within the filming range and the movements in both *O-soto-gari* and *O-uchi-gari* were videotaped with three high-speed digital cameras. The static coordinate system is oriented as follows; the direction from *Tori* to *Uke* is set as Y axis, the vertical direction as Z axis, and the horizontal direction orthogonally crossing Y axis as X axis. Filmed images were analysed evaluating two-dimensional coordinate data at measurement points with an analysis device frame-DIAS. Subsequently, three-dimensional coordinate data were calculated at each measurement point using Direct Linear Transformation Method (DLT method) with a DLT parameter given from coordinate data at control points. The timing and sequence of the *Ukemi* procedure was standardized to 100%, with the beginning of *Tori*'s throw (when *Tori* began moving his leg to perform techniques) labelled as 0% and the completion of *Ukemi* (when *Uke*'s movement completely stopped) as 100%. These data provided position and transposition of each body part in timing patterns of typical *Ukemi* techniques. The standardized sequence was then used to compute *Uke*'s vertical velocity and head's impulse (I) and the impulsive force (F) on *Uke*'s head.

RESULTS: The impulsive force (F) on *Uke*'s head in the vicinity of head's lowest point in *O-soto-gari* is greater than in *O-uchi-gari*. *Ukemi* in *O-soto-gari* as compared to other throws has been known to cause the highest damage on *Uke*'s head during upper limb contact to the ground.

CONCLUSION: To acquire the certain movement and techniques that enlarge (t) during upper limb contact to the ground is assumed to lessen (F) on *Uke*'s head. For the sake of head injury prevention.

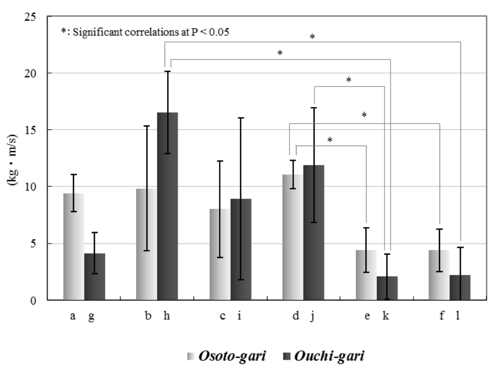

Figure 1

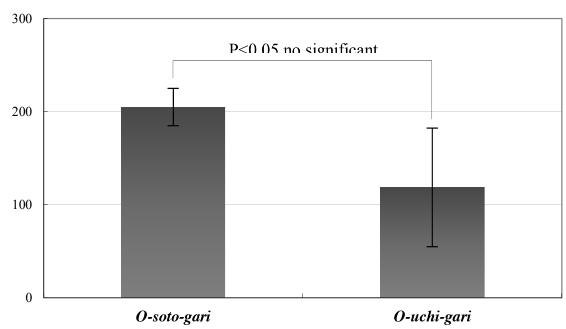

Figure 2

IMMEDIATE EFFECTS OF THORACIC SPINE MANIPULATION ON PAIN AND SCAPULOHUMERAL RHYTHM ON SHOULDER IMPINGEMENT SYNDROME

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AIM: To evaluate the immediate effects of a low-amplitude high-velocity (thrust) thoracic spine manipulation (TSM) on pain and scapulohumeral rhythm during elevation of the arm in subjects with shoulder impingement syndrome (SIS).
METHODS: Fifty-four subjects with SIS were randomly assigned to 1 of 2 interventions: manipulation (n=27; 33.2 ± 11.9 years) or sham (n=27; 30.1 ± 10.5 years). All subjects completed the Western Ontario Rotator Cuff Index to assess shoulder pain and function. Scapulohumeral rhythm was analyzed with a three-dimensional electromagnetic tracking system during elevation of the arm in the sagittal plane and a numeric pain rating scale was used to assess shoulder pain during arm movement at pre- and post- intervention. The manipulation group received a TSM and the sham group received a similar maneuver with the exception that the high-velocity thrust was not applied. All subjects performed 3 repetitions of arm elevation pre- and post-intervention.
RESULTS: Shoulder pain reduced immediately after TSM (p=0.04; F=4.1; 3.4 ± 2.5 pre-intervention; 2.5 ± 2.6 post-intervention). The 2-way analysis of variance showed no significant interaction among angle and time (manipulation: p=0.94, F=0.13; sham: p=0.11, F=2.04) and no effect of time (manipulation: p=0.36, F=0.85; sham: p=0.37, F=0.82) for scapulohumeral rhythm in both groups.
CONCLUSION: Thoracic spine manipulation seems to immediately reduce shoulder pain in subjects with SIS, however this decrease does not seem to be related with changes in scapulohumeral rhythm.
ACKNOWLEDGEMENT: FAPESP (2013/07120-1)

DIFFERENCES IN THE 3-DIMENSIONAL SCAPULAR KINEMATICS BETWEEN GENDERS IN TYPICAL CHILDREN AND HEALTHY ADULTS

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AIM: To compare the three-dimensional (Three-D) scapular kinematics between genders in typical children and healthy adults during the elevation of the arm in the scapular plane.
METHODS: Twenty-six healthy adults (14 females and 12 males, 35.34 ± 11.65 years, 1.70 ± 0.10 m, 70.00 ± 12.30 kg) and 33 typical children (15 females and 18 males, 9.12 ± 1.51 years, 1.40 ± 0.10 m, 35.40 ± 10.45 kg) participated in this study. Three-D scapular kinematics (scapular upward/downward rotation, internal/external rotation and anterior/posterior tilt) were obtained using an electromagnetic tracking device. The subjects were asked to elevate their arm in the scapular plane and the scapular kinematics were analyzed at 30°, 60°, 90° and 120° of humeral elevation. The Shapiro-Wilk test was used to check the normality of the data. A 2-way mixed ANOVA was conducted for each group (adults and children), with humeral angle (30°, 60°, 90° and 120°) as within factor and gender (male and female) as between factor.
RESULTS: Children showed no significant differences ($p > 0.05$) between genders in the scapular kinematics during the elevation of the arm. In the adults group, there was main effect of gender ($p = 0.042$) for scapular upward rotation, where men showed more upward rotation during the elevation of the arm. For scapular tilt, there was interaction between gender and angle ($p= 0.036$), where men presented more posterior tilt at 120° of humeral elevation compared with women.
CONCLUSION: There is no difference in scapular kinematics between genders in typical children. Male adults seems to present more scapular upward rotation and more posterior tilt at 120° of humeral elevation compared with female adults.

COMPARISON OF BILATERAL AND UNILATERAL CONTRACTIONS BEWTEEN FEMALE SWIMMERS AND NON-ATHLETES DURING LEG PRESS AND HAND GRIP EXERCISES

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AIM: The bilateral limb deficit (BLD) is defined as the reduction in force production during bilateral compared to summed unilateral contractions of homologous muscles. The underlying mechanism for the BLD has been elusive to determine. Furthermore, it has been shown that the BLD can be improved with targeted training. While studies of specific athletes have been conducted in order to study the BLD, no studies to date have examined swimmers and compared them to non-athletes. Swimmers are a group of interest because they are bilaterally trained and could provide evidence towards evidence towards the training theory.
The purpose of this study was to examine the presence of the BLD during maximal isometric leg press and handgrip exercises in female swimmers (n=9, mean age = 20.1 ± 1.3 years) and non-athletes (n=9, mean age = 21.7 ± 1.3 years) to determine the impact of training, compare different muscle groups and gain further insight into this phenomenon.
METHODS: Force and electromyography (EMG) measures were collected from subjects under randomized bilateral and unilateral conditions for handgrip and leg press exercises. Bilateral limb ratios (BLR) were calculated for swimmers (BLR_S) and non-athletes (BLR_{NA}) for both the leg press and handgrip using peak force data as BLR_{Force} (%) = (Peak Force BL/(Peak Force ULL+ Peak Force ULR))*100. Similarly a BLR_{EMG} was calculated using the amplitude of the resulting EMG signal. A series of one-way Analysis of Variance (ANOVAs) were used to test for mean differences in the dependent variables between swimmers and non-athletes. Student's *t*-tests were run to determine if the BLR values were significantly different than 100%, thereby identifying the presence of a BLD.
RESULTS: A deficit was found for swimmers and non-athletes in leg force (BLR_S = 79.84 and BLR_{NA} = 81.44) and leg EMG (BLR_S = 88.45 and BLR_{NA} = 94.66); however, no BLD was seen in hand force (BLR_S = 98.30 and BLR_{NA} = 95.91) and hand EMG (BLR_S = 102.42 and BLR_{NA} = 103.30). Furthermore, no significant differences were found between groups for leg force, leg EMG, hand force, and hand EMG.
CONCLUSION: A BLD (force and EMG) was detected for both groups during bilateral isometric leg press, however not during the handgrip exercise. In addition, the BLD (leg press) computed with force was greater than that computed with EMG data and suggests that while the BLD may be affected by neural influences, there may other factors involved. The results also suggest that the training status of the individual may have little influence on the BLD. However, the definition of a bilaterally trained group may need to be re-examined and more specifically defined.

Table 1 Mean values for BLR Leg force, BLR Leg EMG, BLR Hand Force and BLR Hand EMG for both swimmers and non-athletes. * Indicates that the BLR was statistically significant from the comparison mean of 100. Values are mean ± standard deviation.

Group	**BLR Leg Force**	**BLR Leg EMG**	**BLR Hand Force**	**BLR Hand EMG**
Swimmers	79.84 ± 13.09*	88.45 ± 15.41*	98.30 ± 11.21	102.42 ± 11.20
Non-athletes	81.44 ± 19.23*	94.66 ± 13.62*	95.91 ± 11.04	103.30 ± 16.50
TOTAL	80.64 ± 15.98*	91.55 ± 14.47*	97.10 ± 10.86	102.86 ± 13.69

MASTICATORY MUSCLE ACTIVITY IN PATIENTS WITH DENTOFACIAL DEFORMITY

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AIM: To evaluate the electromyographic characteristics of masticatory muscles during maximum voluntary clench (MVC) tasks in patients with dentofacial deformity and controls.
METHODS: Thirty patients with dentofacial deformity (DG) were analyzed. All were candidates for orthognathic surgery undergoing preoperative orthodontic treatment, 15 with class II (DG-II) (3 men and 12 women; mean age 25.9 years) and 15 with class III (DG-III) (6 men and 9 women; mean age 26.5 years). Fifteen healthy young adults (2 men and 13 women; mean age 25.1 years) composed the control group (CG). Surface electromyographic (sEMG) activity was recorded using a wireless device (BTS FREEEMG system, Italy). The right and left masseter and anterior temporalis muscles were examined during 5s-MVC; all signals were then standardized as percentages of the potentials obtained during 5s of MVC performed with cotton rolls interposed between the first molars/second premolars. The analyzed indexes were: POC (left and right side percentage overlapping coefficient, that assesses muscular symmetry, 100%: perfect symmetry); TORS (potential lateral displacing components due to unbalanced contractile activities of contralateral masseter and temporalis muscles, 100%: no lateral displacing force). Two more indexes linked to the previous ones were computed: the mean left-right asymmetry index (Asymmetry) and the mean momentum (Torque).
RESULTS: All participants had similar age (1-way ANOVA, p>0.05). Concerning POC indexes the DG-II differed from DG-III and from CG, while in the Asymmetry index the DG-II differed from DG-III. Significant differences were found between CG and the groups DG-II and DG-III for TORS and Torque indexes (Table 1).
CONCLUSION: The DG-II showed less symmetry between pairs of muscle, and both patient groups showed more unbalanced contractile activities of contralateral masseter and temporal muscles than GC. These differences may be determined by occlusal instability due to dentofacial deformity, but also by preoperative orthodontic treatment.
ACKNOWLEDGEMENT: Provost's Office for Research of the University of São Paulo.
*The first author received a scholarship from CNPq (Science without Borders), Brazil.

Table 1: EMG indexes in MVC, 1-way ANOVA.

Measure	CG		DG-II		DG-III		*p-value*
	Mean	***SD***	**Mean**	***SD***	**Mean**	***SD***	
POCm(%)	85.7	*4.2*	81.0	*8.1*	85.1	*2.7*	0.050#*
POCt (%)	87.3	*2.7*	82.7	*8.8*	87.1	*1.9*	0.041#*
Asymmetry (abs.) [%]	7.0	*5.5*	11.0	*10.5*	4.0	*2.5*	0.018*
TORS [%]	92.0	*0.9*	90.0	*1.9*	89.6	*2.3*	0.002#&
Torque (abs.) [%]	2.7	*1.5*	6.4	*3.4*	6.3	*4.3*	0.005#&

Abs: absolute; POCm: masseter POC; POCt: temporalis POC; *: DG-II different from DG-III; #: CG different from DG-II; &: CG different from DG-III. Bonferroni post-hoc test: POCm (p=0.024#, 0.049*); POCt (p=0.025#, 0.033*); Asymmetry (p=0.005*); TORS (p=0.005#, 0.001&); Torque (p=0.004#&).

WEARABLE ACQUISITION SYSTEM FOR MULTI-CHANNEL SURFACE EMG

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Advanced surface EMG measurement techniques (High Density EMG) require a new tool to detect EMG potential on large skin surface by means of a large number of electrodes. The presented device (patented) was designed to continuously monitor, and record signals from targeted muscles during dynamic and isometric tasks for both laboratory and field applications. The wearable tool consists of a modular solution, dynamically configurable, equipped with an optical fiber interface and powered by battery. A multi-channel (64ch to 256ch) amplifier was designed and built (see Figure 1a for the 64ch version). The acquisition system was used to study the biceps brachii muscle in dynamic conditions. Specifically, the time course of the innervation zone (IZ) of both heads of the biceps brachii was studied during repeated concentric and eccentric contractions as well as the speed of shortening/lengthening of the two heads. The wearability of the system and the lightness of the cables (7g) and connectors (see Figure 1b) made it possible to carry out EMG measurements during dynamic conditions, minimizing the effects of motion artifacts and interference with movement. Moreover, the use of the optical link for PC interfacing preserves patient safety and reduces power line interference while allowing a wide range of motion of the subject.

ACKNOWLEDGEMENTS: This work was financially supported by Bitron s.p.a. with a Ph.D. scholarship (2010-2012) assigned to U. Barone.

(a) (b) (c)

Figure 2: 64ch version of the multichannel system (a), lightweight cables (b) and kapton based modular and flexible electrode matrix (c) for High Density EMG recording.

Table 1: Device Characteristics.

Parameter	Value	Description
External dimensions	53x105x160mm	Device enclosure size for 64ch version
Weight	750 g	Total weight of the system
Power Supply	Li-Ion, 7.5V/2Ah	Internal rechargeable battery characteristics
Data link	Optical fiber (50m)	Interface for PC connection
Gain	45.7dB ± 0.05% (192V/V)	Analog Front End Voltage Gain for EMG conditioning
Bandwidth	6 - 1200 Hz	Analog Front End Bandwidth
RTI Noise	$< 1.3\ \mu V_{RMS}$	Referred-to-Input Noise Floor [10Hz – 500Hz]
CMRR	100 dB	Common Mode Rejection capability [10 – 500 Hz]
Number of Channels	64 – 256	Number of detectable EMG signals
Digital Resolution	24 bit	Detail of A/D conversion
Sampling Frequency	2.44 ksps/ch	Detail of A/D conversion

LOCALIZATION OF ELECTRODE POSITIONS FOR SURFACE EMG ON HUMAN EXTRINSIC FINGER FLEXOR AND EXTENSOR MUSCLES

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INTRODUCTION: For the flexion and extension of human fingers a very complex muscle-tendon system is responsible. The muscles are located primarily in the forearm. Here the muscles are partially superimposed in several layers. Additionally, there is the problem that the most of these muscles are multitendoned muscles. For these reasons in clinical diagnosis the needle EMG is used for selective electromyography of individual muscles or muscle areas of fingers. A simple and non-invasive surface EMG (SEMG) method would be a good alternative for the control of prostheses. Also, a control of mobility aids, alternative to the usual controls (e.g. joystick, steering wheel) is conceivable. For such applications it is necessary to validate electrode positions that are possible to record with non-invasive surface EMG methods. Besides, a high selectivity must be reached. The EMG signals must be assigned unambiguously to a defined muscle. For praxis it is important that these positions are traceable for non-experts. Amongst others, array electrodes could be used.

AIM: The aim of this study was to determine an optimal position of surface electrodes for the human extrinsic flexor and extensor muscles.

METHODS: The volunteers were examined by a monopolar 16-channel-SEMG technique while they performed different finger movements. After skin preparation (EPICONT, Marquette Hellige GmbH, Freiburg, Germany) the surface electrodes (Ag–AgCl discs, diameter of 4 mm, Zentner, Freiburg, Germany), coated with electrode cream (GE Medical Systems Inform. Techn., Freiburg, Germany), were attached to the skin by squares of flexible adhesive tape (Fixomull stretch, BSN medical GmbH, Hamburg, Germany). SEMG was amplified (gain: 1000, Biovision, Germany) using a monopolar montage. The signals were analog to digital converted at a rate of 2048/s (Tower of Measurement (ToM), DeMeTec, Germany; software: GJB, Germany). The raw SEMG signal was filtered and processed according to the root mean square (RMS) procedure. The amplitudes of the RMS for the different electrode position were compared with each other. The optimal electrode position was defined as the position with the highest RMS amplitude for the respective active finger muscle, with simultaneous consideration of the lowest amplitude for all other finger muscles.

RESULTS: For individual finger muscles optimal electrode positions for recording could be found.

CONCLUSION: With the used surface EMG technique undisturbed and reliable EMG signals from specific muscles could be recorded. With the help of these kinds of EMG signals it is possible to generate control signals for various applications.

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Thüringer Aufbaubank

THE DIFFERENCE IN THE MUSCLE ACTIVITY AT THE TIME OF A WALK WITH BAREFOOT AND HIGH HEELS

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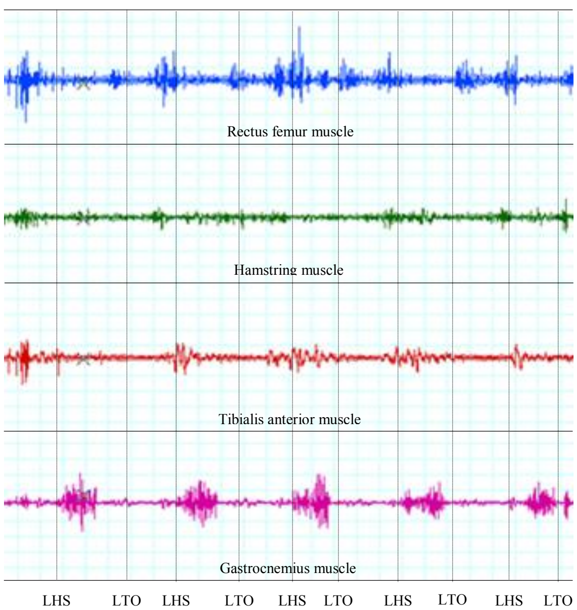
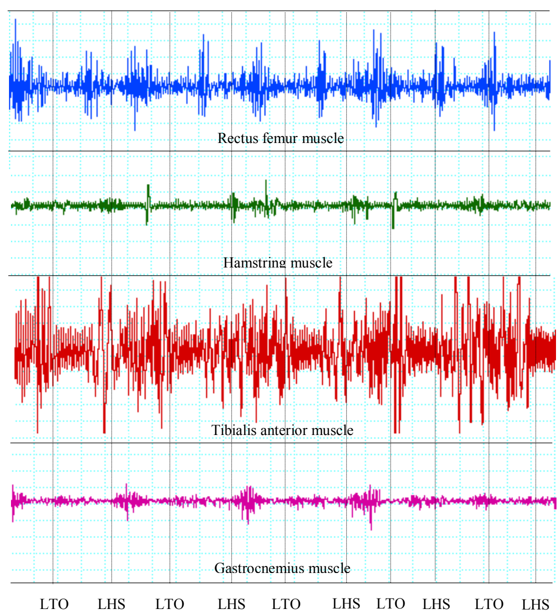
AIM: It was aimed for the kinematic analysis at the time of the walk of the high heels which many women wore. I weighed it against a barefoot about the line activity of the lower limbs at the time of the walk with high heels this time. METHODS: The subject was five healthy female college students.(average height of 159(SD=1.5)cm, average age of 20years) In a barefoot and high heels(5cm), I let you walk by the flat straight line 5m each. In the steps of the section, the time required, and a surface EMG(Rectus femur M, Hamstring M, Tibialis anterior M, Gastrocnemius M)were measured. RESULTS: The average of steps was 8.2(SD=0.4) steps with high heels 8.8(SD=0.4) steps with barefoot. The average of the time required was 4.14(SD=0.39) seconds with the high heels 3.98(SD=0.74) seconds with barefoot. Gastrocnemius M activity was seen before the tip of a foot grounding of Tibialis anterior M and Rectus femur M at the time of the heel landing of stance phase barefoot. In swing phase, Tibialis anterior M activity was seen in the whole in Hamstring M activity, the latter half. With high heels, the tendency that a similar barefoot tendency and the electric discharge of an extensor group of lower limbs particularly Tibialis anterior M came to have a big was seen. CONCLUSION: As for this barefoot result, a Gastrocnemius M electric discharge was seen in the first half of stance phase like the surface EMG of the leg at the time of the general walk in Tibialis anterior M, the latter half.In swing phase the ankle is dorsiflexion in order to prevent equines position, therefore the electric discharge was seen. In addition, it is big and often moves the arms at the time of a walk and the sports activity having difficulty in maintenance of the support bases side such as the tightrope walking, but the woman who it is big and waves an arm in high heels, and walks is not seen. It was suggested that an extensor group of lower limbs participated in the maintenance of the support base side at the time of high heels walk.





Left heel strike: LHS, Left toe off: LTO

Figure 1: The muscle activity of a walk with barefoot

Figure 2: The muscle activity of a walk with high heels

A MULTI-CHANNEL SURFACE EMG FOR CHARACTERIZING MUSCLE FUNCTION DEFICITS IN PERIPHERAL FACIAL PARESIS

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AIM: The diagnostics of facial nerve paresis include clinical examination and electrophysiological evaluation. For facial nerve paresis, the needle-EMG technique is the gold standard in clinical practice. In contrast, surface-electromyography (SEMG) is especially approved, if multichannel EMG recordings are indicated to compare activation patterns between several muscles or muscle regions. Moreover, it is a non-invasive technique. With the intent to investigate gradually different muscle functions of facial movements we developed a 44-channel surface EMG technique (Schumann et al. 2010). The aim of the presented surface EMG study is a detailed quantitative characterization of the normal facial muscle co-ordination in comparison to that occurring in patients with facial nerve paresis.
METHODS: Multi-channel surface electromyograms were monopolarly recorded (44-channel, 10-700 Hz, 3000 samples/s, resolution of 2.44 μV/bit) from the following facial muscles: frontalis-, orbicularis oculi-, zygomatic-, levator labii superioris-/-alaeque nasi-, orbicularis oris-, depressor anguli oris-, depressor labii- and mentalis muscles. At least two small disc surface electrodes were placed on each muscle symmetrically on both sides of the face (diameter 4 mm, Ag/AgCl). Subjects were instructed to perform 29 defined facial movements, e.g. pursing lips, smiling, wrinkling the nose, closing the eyelids or wrinkling the forehead. EMG curves were visually checked, quantified by power spectral analysis and normalized. 10 patients suffering from peripheral facial nerve paresis as well as 30 healthy volunteers participated in the EMG examinations.
RESULTS: The mean SEMG amplitudes increased significantly in response to facial movements - also in muscles which are not directly involved. The facial movements showed typical EMG activity profiles. These profiles express the EMG distribution between the facial muscles and thus the intermuscular co-ordination. With respect to the performed movement, there are similar (e.g. pursing lips and whistling) and significantly different EMG profiles (e.g. pursing lips, smiling or wrinkling the nose). Some intramuscular differences were found between lateral–medial and superior–inferior electrode positions. However, there was no systematical difference between the right and the left face side in healthy subjects. Patients suffering from peripheral facial paresis showed lower mean amplitudes on the disturbed side of the face in comparison to the reference of healthy subjects. In comparison between patients these functional deficits were different in extent.
CONCLUSION: The results show that the co-ordination between individual facial muscles and between intramuscular regions is more differentiated than supposed until now. The presented multi-channel SEMG technique can be used to objectively evaluate functional deficits in patients with facial paresis and to monitor both, the course of disease and treatment. Moreover, the created SEMG profiles are highly relevant for better planning of facial movement restoration in patients suffering permanently from facial paresis.

NON-UNIFORM SEMG DISTRIBUTION IN HUMAN RECTUS FEMORIS MUSCLE DURING WALKING WITH VARIOUS SPEED AND GRADES

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AIM: From anatomical properties, region-specific functional roles and neuromuscular activations has been suspected within human rectus femoris (RF) muscle. We aimed to investigate spatial distribution of surface electromyography (SEMG) within RF muscle during walking with various speed and slope.
METHODS: Eleven healthy male walked on treadmill at 4, 5, and 6 km/m with 0 deg. of grade and at 5 km/h with 0, 12.5, and 25 deg. of grade. During these tasks, SEMG was recorded from most of superficial area of RF muscle by using 2*18 surface electrodes. Central locus activation (CLA) of SEMG along with longitudinal line of the muscle was calculated at each gait phase during 20 gait cycles.
RESULTS: For all speed and grades, during stance phase and first half of swing phase CLA moves from middle to proximal part of muscle ($p < 0.05$) (Fig. 1). During swing phase, CLA shifted to proximal with an increase in speed ($p< 0.05$). At the phases after heel contact and toe off, CLA shifted from middle to distal with an increase in grades ($p < 0.05$).
CONCLUSION: During walking, region-specific neuromuscular activation was demonstrated within RF muscle. From results of the present study, we suggested that regions from proximal to distal regions of RF muscle play different functional roles during walking and are regionally regulated to changes in gait speed and grades of floor.

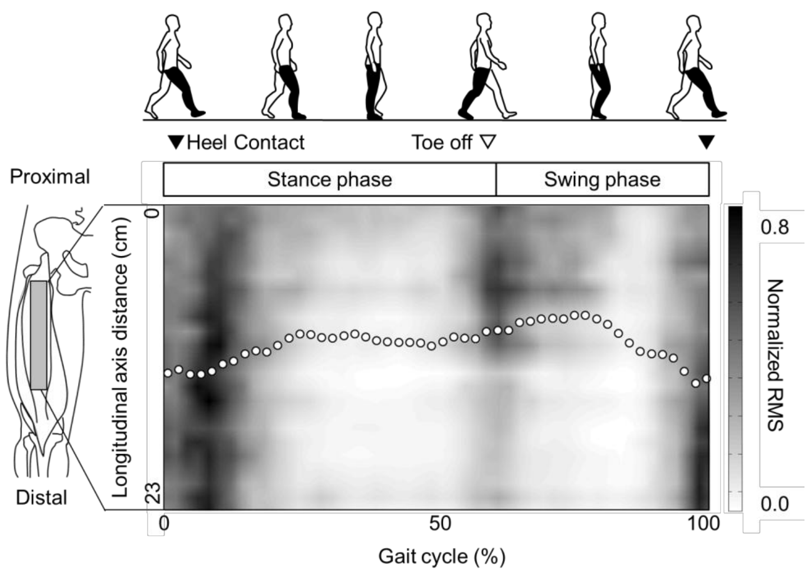

Figure 1: Mean root mean square (RMS) of surface electromyography from all subjects during a gait cycle of 5 km/h with 0 deg. of grade. RMS values are normalized by peak value at each electrode and shown in gray scale. Circles (o) indicate central locus activation (CLA) along with longitudinal line of the muscle.

VISUALIZATION OF HIGH DENSITY EMG SIGNALS WITH PROCESSING LANGUAGE

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AIM: The purpose of this study is to show the possibility of visualization for electro-biological signals with *Processing*, which is a Java based programming language mainly for designers and creators associated with arts and various media. In recent years, small size and mobile computers have been developed rapidly like Rasberry Pi, Beaglebone Black. The growth of computer technology enables us to record various types of biological and biomedical signals or various conditions of experiments like long-term and unconscious measurement. It is inevitable to visualize biological and biomedical signals for much and immediate understanding their data after their signals are recorded. Therefore, it is necessary to develop the systems with web based technology because a lot of recent instrumental devices and software systems depend on web based technology. In this paper, it is introduced that a Java applet developed on *Processing* displays and analyzes High Density (HD) EMG simultaneously and then their results will be shown.
METHODS: *Processing*, which is a kind of programming language and is developed based on Java, is used for many designers and creators to present artistic expression and activity on computer. *Processing* has not only a variety of drawing expressions, but also plenty of libraries to control sound and kinds of devices like Kinect and Auduino, etc. Moreover, *Processing* enables us to develop animating expressions with comparatively lower development cost owing to a small number of coding and simple descriptions as compared with other languages. HD-EMG has much information on neuromuscular activities like neuromuscular junction distribution and MFCV. With *Processing*, their visualization and estimation of neuromuscular junction distribution and MFCV are developed and examined. 64 channel HD-EMG signals were recorded with EMG-USB (OT Bioelettronica), which can record at most 128 sEMG channels with 2kHz, and then adhesive matrix 64 electrodes were used. The HD-EMG signals of biceps brachii muscles during remaining isometric contractions with some contraction level (0-80%MVC) for 10 seconds.
RESULTS: *Processing* can write the codes for the animation of HD-EMG signals and calculation of integrated EMG and MFCV only within a few hundred lines owing to its simple description. Decaying of EMG amplitude appears a distribution of neuromuscular junction. Therefore, it is found that integrated EMG signals can be visualized to find the position of neuromuscular junction. Then, MFCV were also calculated and estimated based on time delays of single MUAP between consecutive channels and other numerical indexes. It is also found that *Processing* lets us both parameters be calculated and visualized comparatively with ease and then their parameters can be shown and recognized online on internet browsers.
CONCLUSION: Development with *Processing* has the possibility to extend the application of electrophysiological experiments. The visualization with *Processing* lets us recognize their meanings of biological signals with the simple description and little development cost. Mostly, HD-EMG signals are recorded in laboratory environments. However, web based and small size and mobile computer technologies help us to spread a lot of experimental conditions to use HD-EMG signals, for example, in outdoor sports and exercises or in long term recording.

TRICEPS SURAE RESPONSES TO STANDING PERTURBATIONS IN PEOPLE POST-STROKE AND HEALTHY CONTROLS: A HIGH-DENSITY SURFACE EMG INVESTIGATION

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Aim: Sensorimotor deficits after stroke contribute to an increased risk of falls. Triceps surae activation is essential for maintaining postural stability in standing. The purpose of this study was to investigate the effects of stroke on triceps surae muscle responses to external perturbations of balance (across muscles and within each head of the triceps surae).

Methods: Nine people with chronic stroke (one female; 67.6 ± 8.6 yrs of age; 6.8 ± 3.8 yrs after stroke) with mild to moderately-severe levels of motor impairment and seven age-matched controls participated. Anteriorly-directed external loads were applied suddenly to the pelvis through a belt and cable-pulley system. The load, representing 2% of body mass, was applied 10 times. High-density surface electromyography (EMG) was used, resulting in 18 EMG signals across the soleus (SOL) muscle and 16 from each of the medial and lateral gastrocnemius (MG and LG) muscles of each leg. The onset of the perturbation was detected by a load cell on the cable of the pulley system. For each muscle, the latency between the onset of perturbation and the onset of the EMG burst was estimated for each channel of the grid, resulting in 16 or 18 values for each perturbation. The median and the interquartile range were considered to quantify, respectively, the average delay and the regional variation in the timing of muscle response. Both measures were then averaged across the 10 perturbations. Each measure was analyzed with a two-way ANOVA, with leg (paretic, non-paretic, right, left) and muscle (MG, LG, SOL) as factors.

Results: ANOVA tests identified a main effect of leg ($P<0.001$) and muscle ($P=0.08$, trend) on the delay (Figure). In the paretic leg, EMG responses were more delayed than in control and non-paretic legs ($P<0.01$). SOL always tended to have larger delays than MG ($P=0.06$) and LG ($P=0.1$). The regional variation of the EMG response was different across legs ($P<0.001$) but not across muscles. The interquartile range was larger in the paretic leg (16.2 ms) than non-paretic (12.3 ms, $P=0.02$) and control legs (8.6 and 9.6 ms, $P=0.001$).

Conclusions: Triceps surae activation in response to external perturbations was more delayed and had more regional variation in the paretic leg after stroke compared to controls and the non-paretic leg. Delays in EMG response tended to be greater in soleus than gastrocnemii.

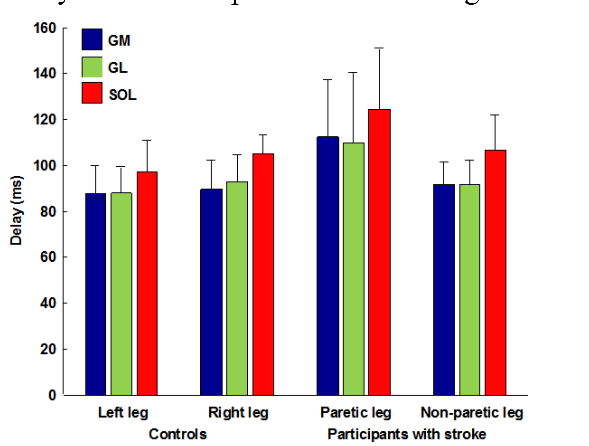

Figure: Effect of muscle (medial gastrocnemius, MG; lateral gastrocnemius, LG; soleus, SOL) and leg (left, right, paretic, non-paretic) on the delay of EMG responses to an external perturbation. The delay in the paretic leg was larger than in the non-paretic leg and in controls. Soleus tended to be activated later than gastrocnemii muscles.

INVESTIGATION OF THE RELATIONSHIP BETWEEN HIGH DENSITY EMG DATA AND PATTERN CLASSIFICATION ACCURACY FOR AMPUTEES

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AIM: Myoelectric prosthetic limbs have evolved over several decades. While these systems have improved significantly over several decades, challenges remain. Traditionally, surface electromyography (EMG) has been used to investigate muscle activation patterns to determine which areas of a residual limb would be appropriate for electrode placement and control. High-density EMG (HDEMG) systems have allowed for non-invasive collection of myoelectric signals from many closely spaced electrodes. The data obtained can be examined through the use of 'colour maps,' which provide a visual indication of the distribution and intensity of muscle activation. This technology is particularly suited for those with limited muscle physiology due to injury or loss. Recently, our research group showed that amputees are able to produce reproducible muscle contractions similar to able-bodied individuals. In order to further understand the activation patterns of amputees, this work focused on examining two types of contractions to determine the relationship, if any, between the colour maps produced from high density EMG data and classification accuracy. Understanding this relationship may help to develop better clinical training protocols for prosthesis users.

METHODS: A HDEMG system (REFA, TMS International) was used to evaluate two different hand movements ('hand open' and 'hand closed') at a self-selected medium contraction level. Four transradial amputees (2 traumatic and 2 congenital) participated in this study. Up to 32 channels of EMG were used and the electrodes were placed in a grid formation over the forearm region to collect as much data from the residual limb. The electrode placement varied slightly because each individual presented a unique case. Each amputee was asked to produce three trials of the each contraction for a total of six contractions per participant. The areas on the forearm that experienced muscle activity during given movements were illustrated in topographical (colour) maps for each trial. The colour maps were visually inspected to determine any changes in intensity (amplitude) and pattern repeatability between trials. Pattern classification accuracies were computed for both movements.

RESULTS: The classification accuracies for each subject are shown in Table 1. Upon examination of each colour map it appears as both pattern and intensity changes differ in relation to classification accuracy. For example, the differences in intensity and pattern for TR1 appeared to be minimal across trials and this subject also had strong classification accuracy for both contractions. Conversely, CG1 exhibited strong pattern changes across trials as well as strong intensity changes. Interestingly, CG1 had much lower classification accuracy than the other subjects.

Table 1: Classification accuracies for hand open (HO) and hand closed (HC) for each congenital amputee (CG) and traumatic amputee (TR). All values are %.

	CG1	CG2	TR1	TR2
HO	18.4	68.6	96.8	80.5
HC	52.7	30.3	100.0	67.2

CONCLUSION: The results suggest that classification accuracy differ according to both pattern and intensity changes, however the exact relationship remains elusive. Understanding this connection may help to determine which candidates are better suited for prostheses using pattern recognition versus those that may remain successful with traditional systems.

ON ELECTRODE CARDINALITY AND CONFIGURATION FOR SEMG HAND MOVEMENT RECOGNITION

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AIM: Literature lack of a complete study showing how many electrodes shall be used in surface EMG for the recognition of hand movements. Researchers typically employ one of two strategies: (i) few electrodes are placed by an expert on relevant muscles; or (ii) a more or less high number of electrodes are evenly spread on the forearm. This paper work in this second direction by studying and comparing 297 different electrode configurations.

METHODS: An EMG USB2 (OtBioelettronica) device was used to record 192 signals from a 24x8 electrode matrix. The matrix was placed on the forearm of 8 subjects while they were performing 11 different movements of the finger and wrist. A MATLAB® artificial neural network (ANN) was then used to compute the average recognition rate (ARR) of the different configurations. Possible configurations were obtained by spatial regular downsampling of the matrix and/or shift of the root electrode.

RESULTS: Target recognition rate was obtained with all 192 electrodes and set to 96.48%. Few of the configurations under test allowed for an ARR > 90%. The configurations allowing this result with the minimum number of electrodes are: 1 single row of 24 electrodes (~90%), 2 rows of 8 electrodes (~92%), 3 rows or 6 electrodes (~91%). For the 2 rows configuration additional studies clearly shown that the farther the electrode rows are the better the result is.

CONCLUSION: Given the compromise between hardware complexity and recognition quality we argue that two armbands placed at about 6 and 14 cm distally from the elbow joint should return the best performances for the recognition of hand movements.

Figure1. Example of the recording setup

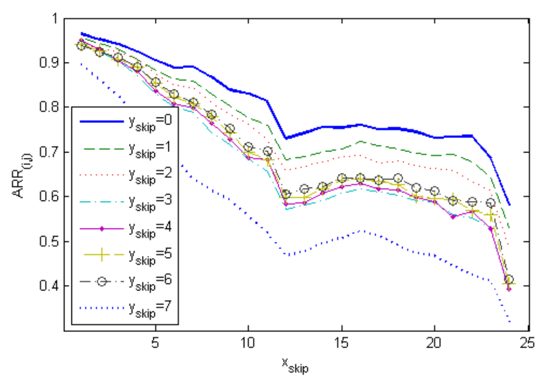

Figure2. ARR at the change of x_{skip} and y_{skip}

a)

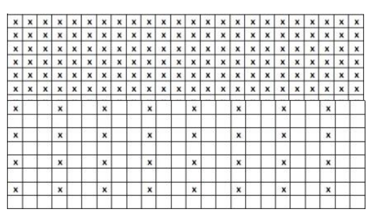

Figure 3. Complete matrix (a) and matrix obtained with $x_{skip}=2$ and $y_{skip}=1$ (b)

ELECTRODES FOR SEMG: BEYOND THE STATE OF THE ART

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AIM: In order to minimize the electrode contact impedance, the aim of this work is to evaluate different dry electrodes realized with a Direct Metal Laser Sintering (DMLS) machine. Electrodes under study are characterized by different surface micro-geometries.
METHODS: We used DMLS to produce different titanium (Ti64) electrodes with the basic shape of disks with 10mm diameter and 2 mm thickness. Electrodes are differentiated to each other for the surface texture made by additional sintering of different micro-pin arrays. In particular we analyzed three parameters: (i) the shape of the pin structures (cupolas, pyramids, or pyramid frustum); (ii) the height of such micro-pins (150, 300, or 450µm); and (iii) the distance among the pins (400, 600, or 1000µm). All feasible combinations of these three parameters were used to build a total of 18 electrodes (plus the flat references). Electrodes with different surface structuration and the same shape of the pins were placed around a central flat counter electrode (inter electrode distance of 20mm). The resulting setups (see Figure 1) were applied to the forearm of 8 subjects. Three levels of predetermined and controlled pressure were applied with a sphygmomanometer to the setup on the subject forearms to determine the effect of this parameter. Then, a CH Instrument 700D potentiostat was employed to perform impedance spectrometry on the electrode-skin system in the EMG spectrum between 10 and 1000 Hz.
RESULTS: Results show a clear impedance improvement which is inversely proportional with the height of the micro-pins. Reducing pressure increases this effect since “flatter” electrodes impedance shifts to higher values.
CONCLUSION: While showing the validity of the DMLS technology, our tests underline a clear effect of the surface texture on the skin-electrode impedance. It was shown that the micro-pins can improve the contact impedance of as much as one order of magnitude, leading to better electrodes for biopotential recording. These electrodes could benefit of the better performances at lower pressures to create more comfortable sEMG acquisition systems.

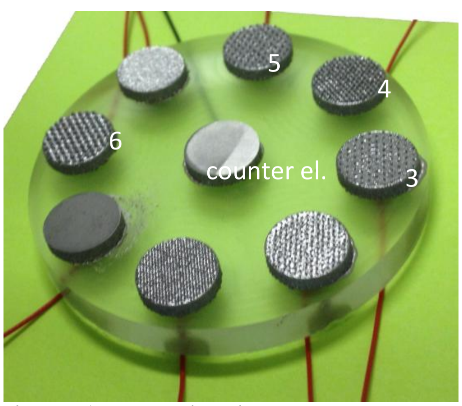

Figure 1. Pyramid-pin electrode setup

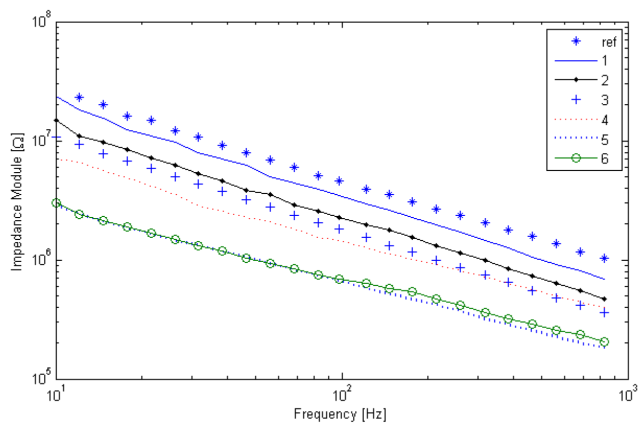

Figure 2. Impedance for the pyramid-pin electrodes at the minimum pressure (133 mBar)

AN IDENTIFICATION METHOD OF INNERVATION ZONE BY BIPOLAR SURFACE ELECTROMYOGRAM MEASUREMENT

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AIM: The aim of this study is identification of the innervation zone from surface myoelectric signals by the cross-correlation method.

METHODS: Five healthy male volunteers aged 21 to 25 years (mean ±SD: 23.2±1.3) participated in this study. Volunteer sat on a chair and maintained his right elbow joint at an angle of 90 degrees and maintained an isometric contraction level of 30% MVC for 5 seconds.

The surface myoelectric signals were detected from biceps brachii muscle by the electrode arrays which composed of 14 Ag/AgCl wires each with a diameter of 1 mm and a length of 10 mm attached on a silicon rubber plate with an inter-electrode distance of 5 mm. The amplified myoelectric signals with bandwidth of 5 Hz to 1,000 Hz and gain of 60 dB were stored into a personal computer through an A/D converter with 16-bit resolution and with the sampling frequency of 10 kHz. The cross-correlation method was used for identification of the innervation zone from surface myoelectric signals as shown in Figure 1. The correlation coefficient between the signals of the neighboring channels was calculated while carrying out the time shift of one signal.

RESULTS: For the signals of Period 1 and Period 2 in Figure 1, the maximum correlation coefficient of absolute value was shown in Table1. In Period 1, the correlation coefficient of Ch8-Ch9 that is innervation zone was -0.70 and other values were 0.74-0.98. In Period 2, the correlation coefficient near the innervation zone of Ch7-Ch9 was 0.45 and 0.47, and other values were 0.77-0.99. Therefore, a strong negative correlation was found from paired signals of polarity reversal and a weak correlation was found from poorly-characterize signals.

CONCLUSION: The possibility of identification of innervation zone was suggested from the correlation coefficient of myoelectric signals measured by electrode arrays.

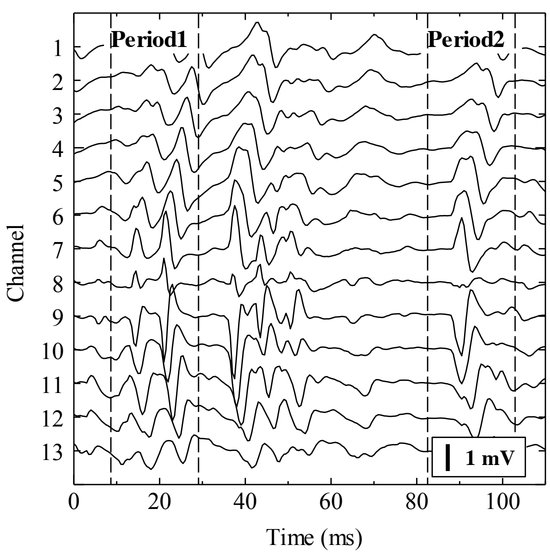

Figure 1: Example of propagation pattern for surface myoelectric signals on biceps brachii muscle.

Pair of channels	Correlation coefficient: R(T)	
	Period1	Period2
Ch1-Ch2	0.98	0.99
Ch2-Ch3	0.97	0.99
Ch3-Ch4	0.98	0.98
Ch4-Ch5	0.97	0.97
Ch5-Ch6	0.94	0.94
Ch6-Ch7	0.90	0.86
Ch7-Ch8	0.74	0.45
Ch8-Ch9	-0.70	0.47
Ch9-Ch10	0.90	0.88
Ch10-Ch11	0.96	0.85
Ch11-Ch12	0.89	0.86
Ch12-Ch13	0.93	0.77

Table 1: Maximum correlation coefficient between neighboring myoelectric signals.

EFFECTS OF GAIT TRAINING WITH NON-PARETIC KNEE IMMOBILIZATION: THREE SINGLE-CASE STUDIES

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AIM: It has been reported that stroke patients' gait and ADL improve through intensive training of their paretic lower limbs. This study examined the possibility of improving their gait by immobilizing the non-paretic knee joint on extension and promoting weight shifts towards the paretic side.
METHODS: Single-case experiments were conducted, involving 3 hemiparetic patients (Cases 1-3) who had a stroke more than 1 year previously, and required monitoring or lower levels of assistance when walking. The patients walked back and forth along a 5-m course 5 times, with their non-paretic knee joints immobilized on extension using a brace during the intervention/manipulation($B_{1,2}$) periods. Measurement items included: temporal and distance factors (measured with video cameras); and hip, knee, and ankle joint angles during gait (with electrogoniometers). The measured temporal and distance factors were analyzed, adopting the two-standard deviation band method.
RESULTS: In all cases, the stance phase was significantly prolonged on the paretic side during all experimental periods following the first baseline(A_1) period. In Cases 2 and 3, the stride length increased after the A_1 period; an increased cadence was also observed in Case 3. In Case 1, hip extension in the stance phase improved during all experimental periods following the A_1 period, and, in Cases 2 and 3, the knee hyperextension in the stance phase, which was observed during the A_1 period, was resolved during the second(A_2) and third(A_3) baseline periods.
CONCLUSION: Gait training with non-paretic knee immobilization may promote weight shifts towards the paretic side to overcome a swing limitation on the immobilized side, consequently creating a more efficient, symmetric gait pattern. It was also suggested that improved control of the paretic knee joint with appropriate weight shifts during the intervention/manipulation period may be key to preventing hyper- or limited knee extension during the subsequent baseline periods.

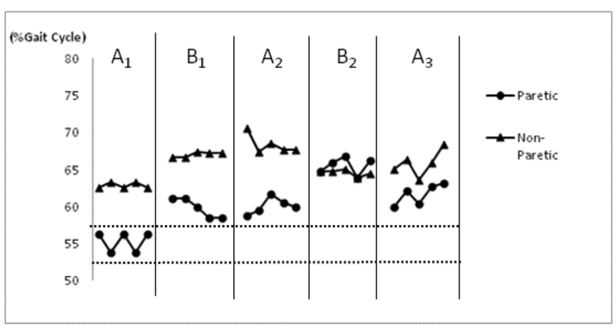

Figure 1: Changes of percentage of the stance phase in Case 1. The dotted lines represent two standard deviations from mean of the paretic side in the A_1 period.

KINESIOLOGY TAPING IMPROVES SCAPULAR PROPRIOCEPTION, KINEMATICS, AND MUSCLE ACTIVITY IN INDIVIDUALS WITH SHOULDER IMPINGEMENT SYNDROME

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AIM: The purpose of this study was to investigate the effect of kinesiology taping on the scapular proprioception, kinematics and muscle activity.
METHODS: Thirty patients with shoulder impingement syndrome were recruited and randomly assigned into the kinesiology taping or the placebo taping group. The joint position sense (JPS) was measured as the reposition errors in the direction of scapular elevation, depression, protraction and retraction. The scapular kinematics and muscle activities were measured during scaption. Liberty electromagnetic tracking system (Polhemus, Colchester, VT, USA) was used to collect the joint orientation and position and TeleMyo 2400T G2 (Noraxon USA Inc, Scottsdale, AZ) was used to collect the surface electromyography of upper trapezius (UT), lower trapezius (LT) and serratus anterior (SA). Two-way repeated measures analysis of variance (ANOVA) was used to examine taping effects and the level of significance was set at $\alpha=0.05$.
RESULTS: Compared with placebo taping, kinesiology taping significantly decreased the scapular reposition errors in upward/downward rotation ($p=0.040$) and anterior/posterior tilt ($p=0.044$) when performing scapular protraction. In addition, kinesiology taping increased the scapular upward rotation ($p=0.010$~0.045) and posterior tilt ($p=0.011$~0.049) during scaption, and improved lower trapezius muscle activity ($p=0.023$, 0.026) at 90° and 60° of arm elevation during the lowering phase of scaption.
CONCLUSION: Our results suggested that the application of kinesiology taping improved scapular proprioception, kinematics and lower trapezius muscle activity. We therefore recommended that kinesiology taping could be integrated into the treatment plan for patients with shoulder impingement syndrome.
ACKNOWLEDGEMENT: This study was funded by the National Science Council, Taiwan (NSC 101-2314-B-010-069).

THE EFFECT OF ARM POSITION ON STRETCHING OF THE INFRASPINATUS MUSCLE: EVALUATION USING SHEAR WAVE ELASTOGRAPHY

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AIM: The stretching for the infraspinatus muscle (ISP) is important to prevent shoulder injuries. Although several authors have advocated various stretching positions for the ISP, there is no agreement on the best stretching position due to the lack of quantitative analysis. In vitro study using cadavers, the effective stretching position reported for the ISP was internal rotation (IR) at maximum extension (Muraki et al., 2006). Our aim was to determine the most effective stretching position for the ISP in vivo using ultrasonic shear wave elastography (SWE).
METHODS: Fifteen healthy male subjects participated in this study (age 23.4 ± 3.1 years). The muscle shear elastic modulus of the ISP was measured using ultrasonic SWE with an 11-MHz linear array probe (Aixplorer, SuperSonic Imagine). The shear elastic modulus of the ISP was measured at eight arm positions, i.e., IR at 0° elevation (1st), IR at 90° abduction (2nd), IR at 90° flexion (3rd), IR at maximum flexion (Flex), IR at maximum extension (Ext), IR at maximum horizontal adduction (Had), IR at maximum horizontal abduction (Hab) and neutral position (Rest). As there is the linear relationship between shear elastic modulus and the degree of muscle stretching (Koo et al., 2014), we defined the greatest value of the shear elastic modulus as the most effective stretching position for the ISP. The muscle shear elastic modulus of the ISP at each position was assessed by using One-way analysis of variance followed by Games-Howell multiple comparison tests ($p < 0.05$).
RESULTS: The results of ISP shear elastic modulus at eight arm positions were shown in figure 1. The shear elastic modulus in Flex, 3rd, Hab, 2nd, Had, Ext were significantly greater than those in Rest. Ext was significantly greater than Flex, 3rd, Hab and 2nd, though there was no significant difference in shear elastic modulus between Ext and Had.
CONCLUSION: The results suggested that effective stretching position for the ISP is IR at maximum extension in vivo.

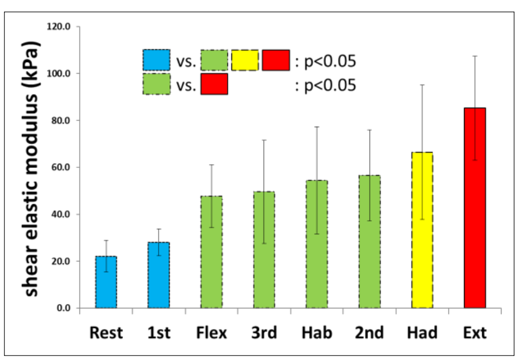

Figure 1: Shear elastic modulus of the ISP at each position. The values are mean ± standard deviation.

ESTIMATION OF SHEAR ELASTIC MODULUS OF THE MEDIAL AND LATERAL HAMSTRINGS WITH AND WITHOUT VOLUNTARY CONTRACTION IN AN EXTENDED POSITION USING SHEAR WAVE ELASTOGRAPHY

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AIM: The aims of this study were to estimate shear elastic modulus of biceps femoris long head (BF), semitendinosus (ST) and semimembranosus (SM) in an extended position, and to investigate the effect of voluntary muscle contraction on change in shear elastic modulus of the three muscles.
METHODS: Ten healthy young men participated in this study (age: 23.4±2.4). The subjects lied in a supine position with one leg at 45° knee flexion and 90° hip flexion (extended position) so that the hamstrings are extended. Measurement was performed in two conditions, without any voluntary muscle contraction ("NON"), and with 30% of maximum voluntary contraction of the hamstrings muscles ("CON"). Shear elastic modulus of BF, ST and SM was measured using ultrasonic Shear Wave Elastography with an 11-MHz linear array probe (Aixplorer, SuperSonic Imagine) on "NON" or "CON". The Student paired t-test with Bonferroni adjustment was used to test differences in shear elastic modulus among BF, ST and SM on "NON" and "CON" respectively. Statistical significance was set at $p<0.05$.
RESULTS: The results of shear elastic modulus on "NON" and "CON" were shown in Fig 1. On "NON", shear elastic modulus of SM (104.8±31.7kPa) was significantly higher than those of BF (76.3±27.3kPa) and ST (59.6±22.1kPa). In addition, that of BF was significantly higher than that of ST. On "CON", there was no significant difference between shear elastic modulus among three muscles (BF:126.9±26.8kPa, ST:124.1±36.8kPa, SM:135.9±25.2kPa).
CONCLUSION: Among the hamstrings muscles in an extended position, tension was most applied to SM. However, when voluntary contraction was added in the same position, the tension applied to BF, ST and SM were equal. These results suggested that muscle contraction could change the relation of tension among hamstring muscles in an extended position.

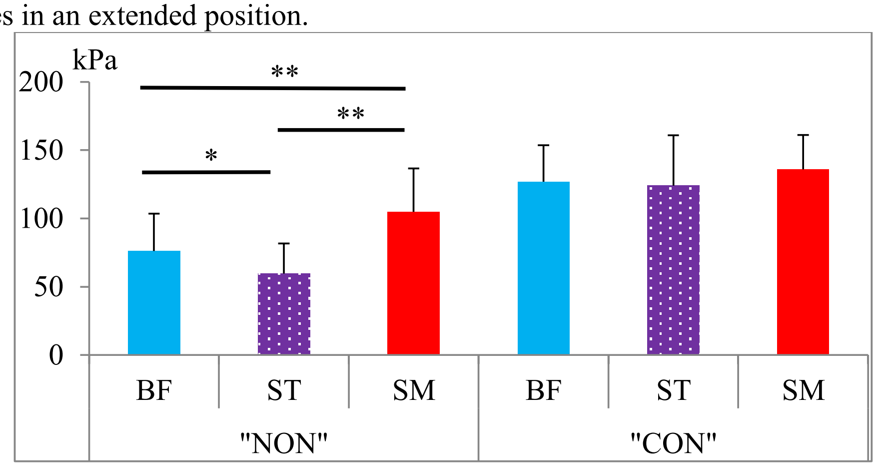

Fig 1: The shear elastic modulus of BF, ST and SM on NON and CON
*:p<0.05, **:p<0.01

CASE REPORT: ELECTROMYOGRAPHICAL FINDINGS OF THE PARAVERTEBRAL MUSCULATURE AFTER MINIMALLY INVASIVE SPINE SURGERY DURING STATIC LOAD

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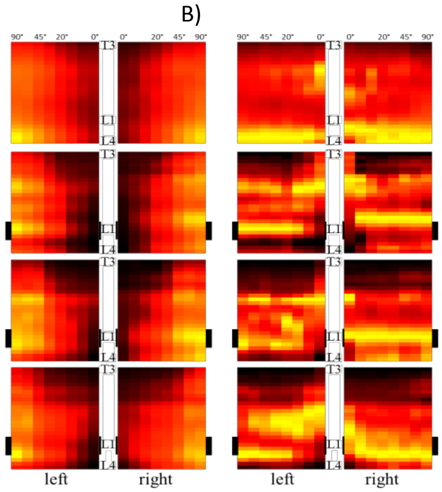
AIM: Any surgical treatment of fractured lumbar vertebrae is inevitably associated with damage of surrounding tissues. Therefore, denervation of different degrees occurs in the operated and, depending on the applied technique (minimally invasive *vs*. open), also in adjacent segments. The aim was to investigate, whether, and if so, how minimally invasive surgery affects the activity of the paraspinal muscles in the lumbar and thoracic regions.
METHODS: Follow-ups at 6 weeks, 12 weeks and 6 months of a male patient (46 years, BMI: 27) after minimally invasive dorso-ventral surgery (MIS) of a fractured vertebra (L1) were compared with a control group (29 healthy males, age: 37 ± 13 years, BMI: 24 ± 3). Surface EMG was applied using a monopolar montage along the paraspinal muscles starting at L5 spinous process. Static loads were utilized by tilting the subjects forward from upright up towards a horizontal position. The tilt angles were 5°, 10°, 20°, 30°, 45°, 60° und 90°, respectively. Subjects' lower body was fixed up to their hips, leaving the upper body freely movable. The control of accurate remaining in the upright body position was facilitated by a video controlled biofeedback system.
RESULTS: The patient successfully performed all applied loads but showed variations of the amplitude-force-relationship (Figure 1A) and spatial coordination (Figure 1B) at all follow-up examinations.
CONCLUSION: Despite reduced surgical damage MIS appears to affect a larger area of the spine muscles than expected. However, since this is a case report, general conclusions cannot be drawn, but further patients have to be investigated.

A) B)

healthy

MIS

6 weeks



ACKNOWLEDGEMENT: This study was supported by the German Statutory Accident Insurance (DGUV – FF-FR0194). The sole responsibility for the content of this publication lies with the authors.

Figure 1: A) Amplitude-force-relationship of the paraspinal muscles between L4 and T3 vertebral levels. The applied tilt angles are displayed above the maps. The injured vertebra is marked by black bars. SEMG amplitude levels are coded by colors (black = Minimum; yellow = Maximum), normalized for both sides and all tilt angles. B) Spatial coordination patterns: amplitude levels of each column (i.e., tilt angle) are normalized separately.

12 weeks

6 months

COMPARISON OF THE ELECTROMYOGRAPHIC ACTIVITY OF THE ANTERIOR TRUNK DURING THE EXECUTION OF TWO PILATES EXERCISES – TEASER AND LONGSPINE – FOR HEALTHY PEOPLE

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AIM: The purpose of this study was to compare abdominal electromyographic activity during the performance of two Pilates' exercises, the longspine and the teaser, on different of apparatus and on a mat.
METHODS: Sixteen females, aged between 20-31 years, participated in the study. To collect the data the subjects performed a warm-up and subsequently, the abdominal muscles (rectus abdominis (RA) and external oblique(EO)) activation was recorded while subjects performed two traditional Pilates´ exercises, the longspine exercise on mat, Cadillac and Reformer, and the teaser exercise performed on mat, Cadillac and Combo-chair. Each subject repeated four times with an interval of five minutes between exercises. Video analysis was used to identify concentric and eccentric phases. An eight channel electromyography system (MP150; BIOPAC Systems Inc., Aero Camino Goleta, CA), consisting of a signal conditioner with a band pass filter with cut-off frequencies at 20–450 Hz, active bipolar electrodes were connected to a high impedance preamplifier gain of 2000x and a common mode rejection ratio > 120 dB was used to obtain the biological signals. All data were collected using AcqKnowledge software 4.1 for acquisition and analysis. Analog-to-digital conversion (16 bits) was set up with an anti-aliasing filter and a sampling frequency of 2 kHz for each channel and an input range of 10 mV. The electrodes were positioned bilaterally on the RA and EO muscles, as follows: 3 cm lateral to the umbilicus for the RA and 15 cm lateral to the umbilicus at the transverse point of the umbilicus for the EO muscle, taking muscle fiber direction into account. The interelectrode (center-to-center) distance was 2 cm and the reference electrode was placed on the nondominant wrist. All EMG data were analyzed using Matlab sub-routines (Version 7.0; The MathWorks Inc., 3 Apple Hill Dr, Natick, MA, USA) and presented in RMS normalized by the peak activation.
RESULTS: The longspine exercise on the mat increased EO activity, more than on the Reformer and the Cadillac in the concentric phase (P = .04). Differences favor to the mat compared to Reformer for RA was found in the eccentric phase (P = .02). Regarding the teaser exercise, significant differences were found in eccentric phase between the mat and the Cadillac (P = .001) and the mat and the combo-chair (P = .001) for the RA. The EO muscle presented higher activation in the Cadillac (P = .001) and Combo-chair (P = .02) and in the concentric phase of the teaser exercise.
CONCLUSION: The performance of Pilates' exercises in different conditions changes the activation of the RA and EO muscles. It was found that the mat exercises required greater activity.

AMPLITUDE-FORCE RELATIONSHIP OF TRUNK MUSCLES – DATA UPDATE INCLUDING MVC NORMALIZATION

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AIM: The aim of this study was the re-evaluation of the known amplitude-force relationship of trunk muscles [1], here including the normalization of amplitudes based on Surface EMG (SEMG) values during static maximal voluntary contraction (MVC) tasks. Thus it can be identified whether actually measured data comply with the known MVC-based estimation of SEMG amplitude-force relationship.
METHODS: Using SEMG the following muscles of 50 subjects aged between 20 and 40 years (25 women, 25 men), were investigated: rectus abdominis muscle (RA), obliquus internus abdominis muscle (OI), obliquus externus abdominis muscle (OE), multifidus muscle (lumbar part, MF) and erector spinae muscle (longissimus, LO). All subjects were free of back pain and had no history of any back injury. The investigation was performed using a device for trunk muscle diagnosis and training (CTT Centaur, BfMC, Germany). In the device subjects are fixed at thighs and hips while the trunk remains unsupported. Forces are applied on the trunk by tilting the whole body from neutral upright position while subjects stabilize the upper body along body axis against gravity. Forward and backward tilts applied 9 %, 17 %, 34 %, 50 %, 71 %, 87 %, 100 % of upper body mass (UBM). For analysis of subject-perceived strain level subjects performed MVC-tests in upright body position in sagittal plane. UBM was measured at 90° forward tilt. MVC and UBM were both determined in the CTT Centaur. Considering the MVC to UBM ratio expected SEMG amplitudes for all applied force levels were estimated according to the common procedure assuming a linear amplitude-force relationship. These estimated values were then compared with actual experimental data, separately for both sexes.
RESULTS: For all abdominal muscles the known non-linear amplitude-force relationship was confirmed. Compared to the linearly interpolated estimation, at low load levels measured data of RA and OE show lower, but with increasing load levels finally higher values than expected: for women the measured values exceed the linearly estimated level at load levels > 70 % UBM, for men at load levels > 85 % UBM. At 100 % UBM (i.e. horizontal position) women's SEMG levels of RA exceeded even those measured during MVC testing. All back muscles confirmed the known linear amplitude-force relationship. For LO the measured amplitude values are virtually always well below the estimated levels, even more-so in men.
CONCLUSION: Depending on the applied load level resulting from gravitational forces, actual strain levels on abdominal muscles are always unlike linearly interpolated strain levels: starting at overestimated strain levels at low loads with increasing loads these levels are underestimated considerably due to their non-linear amplitude-force relationship. Strain levels on back muscles seem to be generally overestimated.
ACKNOWLEDGEMENT: The study was supported by the Central Innovation Program of the German Federal Ministry of Economics and Technology, grant KF2150501WD8.

1 Anders C, Brose G, Hofmann GO, Scholle HC. Evaluation of the EMG-force relationship of trunk muscles during whole body tilt. Journal of Biomechanics. 2008;41:333-9.

ELECTROMYOGRAPHIC ANALYSIS OF THE SCAPULAR MUSCLES DURING PUSH-UPS ON STABLE AND UNSTABLE BASES OF SUPPORT IN SUBJECTS WITH SCAPULAR DYSKINESIS

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AIM: To assess the electromyographic activity of the scapular muscles during push-ups on a stable and unstable surface, in subjects with scapular dyskinesis.
METHODS: Absolute (upper trapezius [UT]; lower trapezius [LT]; upper serratus anterior [USA]; lower serratus anterior [LSA]) and relative (UT/LT; UT/USA; UT/LSA) muscle activation levels were determined by electromyography in 30 asymptomatic men with scapular dyskinesis, during push-up performed on a stable and unstable surface. Data were analyzed using a multivariate analysis of variance with repeated measures.
RESULTS: The unstable surface caused a decrease in the EMG activity of the serratus anterior and an increase in EMG activity of the trapezius (p = 0.001) (Table 1). UT/USA and UT/LSA ratios were higher during unstable push-ups (p = 0.001) (Table 2).
CONCLUSION: The results suggest that in individuals with scapular dyskinesis, there is increased EMG activity of the trapezius and decreased EMG activity of the serratus anterior in response to an unstable surface. These results support the use of stable push-ups for the training of subjects with scapular dyskinesis and suggest that the use of unstable push-ups does not seem to be a beneficial strategy for these subjects.
ACKNOWLEDGEMENT: This work was funded through grants from the Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

Table 1. Descriptive statistics of normalized EMG data of the four muscles during push-up variations with 2-base of supports.

Muscle	Mean (SD)		*p*-value
	Stable surface	Unstable surface	
Upper Trapezius	36.40 (22.01)	47.90 (26.57)	0.001*
Lower Trapezius	73.01 (55.16)	84.88 (51.36)	0.034*
Upper Serratus Anterior	70.81 (34.45)	58.21 (30.63)	0.001*
Lower Serratus Anterior	81.86 (33.19)	65.21 (28.12)	0.001*

Table 2. Descriptive statistics of normalized EMG data of the three ratios during push-up variations with 2-base of supports.

Ratio	Mean (SD)		*p*-value
	Stable surface	Unstable surface	
UT/LT	0.90 (0.79)	0.89 (0.75)	0.829
UT/USA	0.66 (0.46)	1.01 (0.60)	0.001*
UT/LSA	0.52 (0.35)	0.87 (0.59)	0.001*

RELATIONSHIP BETWEEN KNEE JOINT LOAD AND MUSCLE ACTIVITY OF THE LOWER EXTREMITY IN PATIENTS WITH MEDIAL KNEE OSTEOARTHRITIS.

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AIM: External knee adduction moment (KAM) represents medial joint loads, which is closely related to symptoms and disease progression of medial knee osteoarthritis (knee OA). It is assumed that higher external loads would require larger muscle activity to reduce joint stress. However, relationship between muscle activity in lower extremity and KAM value remains unclear. The purpose of this study was to clarify the relationships between muscle activity and KAM value during gait in patients with knee OA.

METHODS: Nineteen individuals with physician-diagnosed medial knee OA were recruited. All patients performed three walking trials along a 6-meter walkway at self-selected speed.

Kinematic and kinetic data were obtained using three dimensional motion analysis system (Vicon Nexus; Vicon Motion Systems Ltd., Oxford, England) and two force platforms (Kistler Japan Co., Ltd. Tokyo, Japan). Peak value of external KAM in early stance was calculated for each trial. Electromyography (EMG) data was simultaneously collected using a surface EMG system (Telemyo2400; Noraxon USA Inc., Scottsdale, AZ, USA) at following muscles of the affected limb; gluteus maximus (Gmax), gluteus medius (Gmed), rectus femoris (RF), vastus lateralis (VL), lateral hamstrings (LH), and lateral gastrocnemius (LG). RMS EMG was determined by using a 50-ms smoothing window and normalized to amplitude of maximum voluntary isometric contraction. Mean muscle activation value from heal strike to the time when the peak KAM occurred was calculated in each muscle. In addition, Co-contraction Index (CCI) were calculated for LH and VL (LH/VL) and LG and VL (LG/VL). Partial correlation coefficients between peak KAM and each muscle activation and CCI adjusted for gait speed were calculated.

RESULTS: There was significant positive relationships between peak KAM and LH activation ($r = 0.808$, $p<0.01$) (Figure1). No other muscle activation was correlated with peak KAM. There was also positive correlation in LH /VL and peak KAM ($r = 0.625$, $p<0.01$) while LG/VL was not correlated.

CONCLUSION: Previous studies mentioned increased activities in some muscles were observed in knee OA patients. However, it was unknown which muscle activity contributed to response to medial knee load. This study suggested that high relationship was found between KAM and LH activity which is considered to be a response to counteract the increased varus stress.

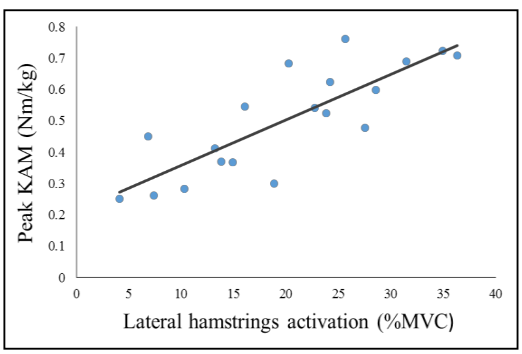

Figure 1: Relationship between LH activation and peak KAM.

INFLUENCE OF ISOMETRIC HIP ABDUCTION DURING SQUAT EXERCISES IN WOMEN WITH PATELLOFEMORAL PAIN SYNDROME

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AIM: to verify the influence of isometric hip abduction on the electrical activity of the stabilizers muscles of the hip and patella during squat exercises in women with patellofemoral pain syndrome (PPS).
METHODS: It was evaluated 24 women, mean age 24±3.9 years, with anterior knee pain. The electrical activities of the vastus medialis oblique (VMO), vastus lateralis longus (VLL), vastus lateralis oblique (VLO) and gluteus medius (GMed) were studied during maximum voluntary isometric contraction (MVIC) in conventional squat (CSQ) and squat with isometric hip abduction exercises, with knee flexion at 60^{o}. Each exercise was repeated three times and MVIC was maintained for six seconds, with a two minutes interval between the repetitions. Raw electromyography (EMG) signals were collected at a sampling frequency of 4 KHz and digitally filtered at 20 to 1K Hz. EMG activities of the muscles were normalized by the RMS of the knee extension MVIC and the GMed muscular function test with knee flexion at 90^{o}. EMG signals were processed by SuiteMyo 1 version 3.00 software. Comparisons between exercises were performed using Student's t-test for dependent variables, while one-way ANOVA and the Bonferroni post-hoc test were used to compare the patellar stabilizers muscles, considering a significance level of 5% and using SPSS version 17.0. RESULTS: greater activity of GMed musculature was observed during the squat with hip abduction (33.37±18.19) compared to the conventional squat (10.54±4.73) $p<0.05$; however, the VMO, VLO and VLL muscles did not presented difference in the EMG activity between exercises (Table 1). CONCLUSION: our results showed that squat exercises with hip abduction promote an increase in GMed muscle activity and a balance between the patellar stabilizers muscles simultaneously, hence being recommended for rehabilitation programs of patients with PPS, particularly when related to proximal causal factors, such as a weakness pelvic muscle.
ACKNOWLEDGEMENT: The authors thank FAPERJ (process number: E-26/112.472/2012) for financial support.

Table 1: Mean, standard deviation and [minimum and maximum] electrical activity of VMO, VLO, VLL and GMed in Squat and Squat-ABD exercises (n=24)

	Squat	**Squat-ABD**
VMO	39.79± 14.9 [9.94; 73.62]	38.16± 17.8 [9.4; 85.17]
VLO	44.26± 18.43 [20.47; 76.14]	42.94± 18.15 [15.52; 89.31]
VLL	42.64± 14.73 [15.8; 85.84]	47.48± 20.24 [16.29; 101.78]
GMed	10.54± 4.73 [2.54; 20.88]	33.37± 18.19 [10.95; 99.84]*

Comparison between exercises: Student's t-test for dependent variables, *p< .05
Comparison between patellar stabilizers muscles – One-way ANOVA and Bonferroni post-hoc test ^{a}p< .05

INVESTIGATION OF M-MODE DIAPHRAGM IMAGING IN COMPARISON TO LUNG VOLUME OUTPUT

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AIM**:** Spirometers are regularly employed for the measurement of exhalation and inhalation rates, and are often used for basic pulmonary function tests. There are numerous different types of spirometer, most commonly used spirometers require patients to have direct mouth contact with a mouthpiece for measurement. This inhibits the ability of patients to vocalise during measurement, preventing use in many vocal physiotherapy and rehabilitation tasks. The use of m-mode ultrasound (US) for the investigation of diaphragmatic excursion (DE) is well established, but we wish to establish whether this may be used as a reliable estimate of changes in lung volume. We aim to compare three possible US viewing strategies to ascertain whether they provide a clear, repeatable view of the diaphragm. Where repeatable views were identified, the relative changes in diaphragm depth were compared to synchronously collected spirometer data. This establishes to what degree these measurements correlate with changes in lung volume.

METHODS**:** The three anatomically defined US views of the right hemi-diaphragm were chosen; subcostal placement with sagittal alignment (SS), subcostal placement with transverse alignment (ST), and intercostal placement with transverse alignment (IT). Data were collected synchronously using a convex US probe (25 Hz), collecting both b-mode and m-mode video, and a Spirometer (1 KHz), under normal breathing conditions. B-mode data were analysed qualitatively by two independent operators, in order to assess whether the diaphragm was imaged at all times, and m-mode data were analysed quantitatively, where manual mark-up of diaphragm movement was tested against spirometer output to measure their correlation. Data were collected from 10 participants (5 female, 5 male), of different heights ($\bar{x}$ = 173cm, σ = 7cm), weights ($\bar{x}$ = 70.9Kg, σ = 11.6Kg) and ages ($\bar{x}$ = 29.2, σ = 11.4).

RESULTS**:** Overall, the subcostal transverse view could image full DE in 8 out of 10 trials, however in remaining trials the m-mode tracking of the diaphragm resulted in a strong correlation with the spirometer output ($\bar{R}$ = 0.817, σ = 0.073, ρ << 0.01). The subcostal transverse view allowed for imaging of full DE in all subjects, and also showed a strong correlation with the spirometer ($\bar{R}$ = 0.852, σ = 0.05, ρ << 0.01). The intercostal transverse view was also viewable in all subjects, in contrast however, a weaker, less consistent correlation with the spirometer readings was achieved ($\bar{R}$ = 0.756, σ = 0.113, ρ << 0.01).

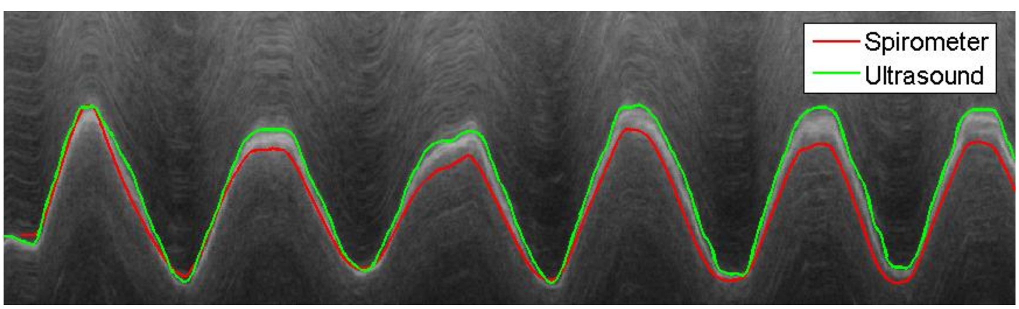

Fig 3*- An m-mode trace of DE. The green line shows a manually marked trace of DE, whilst the red line shows the output from the spirometer. Signals are in arbitrary (linear) units.*

CONCLUSION**:** Despite the full diaphragmatic excursion being viewable throughout two of the three possible viewing strategies tested, the correlation with spirometer readings was highest when taking the subcostal transverse approach.

THE CONDITION OF BONE METABOLISM AND THERAPEUTIC EXERCISE IN ELDERLY MALE HEMODIALYSIS PATIENTS

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AIM: The hemodialysis (HD) patients have multiple complaints, and their motor functions drop to about 60% of healthy persons at the same age. However, it is difficult to say that there is a solid system that HD patients can receive a good therapeutic treatment by physical therapist (PT) in Japan yet. The purpose of this study was to investigate a relevancy of bone metabolism abnormality with HD patients and therapeutic exercise currently held by PT, and finally consider a necessity of therapeutic exercise with HD patients.
METHODS: The subjects were 11 male outpatients receiving maintenance HD three times per week (mean age, 67.7years), who agreed to participate in this study. Bone metabolism was evaluated by serum level of intact-PTH and TRACP-5b. ADL was evaluated by functional independence measure (FIM); five items in capability of mobility. The patients received instructions by PT twice per month and also performed home exercises as much as possible.
RESULTS: The mean value was 152.5+-80.0pg/ml (37-283pg/ml) in intact-PTH and 466.0+-280.5mU/dl (11-1038mU/dl) in TRACP-5b. The ADL score was 33.5 points in FIM (fully independent was 35 points). There was not a statistical correlation between FIM points and the value in marker of bone metabolism. Therapeutic exercise, such as strength exercise for lower extremity, showed positive reaction to six HD patients, who have complaints due to HD muscle cramp, peripheral arterial disease (PAD), and drop in blood pressure at the end of HD sessions, after continuing six months of work out. Moreover, five HD patients required only couple exercise sessions with PT to get better; they stay in good condition by working out on their own.
CONCLUSION: Elderly male patients with HD maintained high level of independence in ADL. However, there may be gradual decline in motor functions and physical abilities due to the tendency of rise in bone resorption based on TRACP-5b and multiple complaints that HD patients deal with. Not only an effect of therapeutic exercises for HD patients was accepted in previous studies but also it obtained good results in this study, an intervention of PT may be necessary for them.

THE EFFECTS OF LUMBAR SPINE MOBILISATIONS ON KNEE FLEXOR NEUROMUSCULAR PERFORMANCE

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AIM: The aim of this study was to investigate the effects of spinal manipulative therapy (SMT) on the neuromuscular performance of the knee flexors.

METHODS: Indices of peak force (PF) and electromechanical delay (EMD) were assessed in the knee flexors of 7 healthy males (age: 19.4 ± 0.8 yrs; height: 177.7 ± 7.6 cm; mass: 74.2 ± 7.1 kg) during SMT and SHAM conditions. SMT consisted of Grade III lumbar spine mobilisation (applied manually by physiotherapist) at a frequency of 2Hz over the L5 spinous process using a 1:1 minute treatment:rest ratio; SHAM consisted of a light sustained pressure over the same area. Both treatments lasted 5 minutes. Measures of PF and EMD were obtained at 'pre', immediately post and 1-hour following both treatment conditions in a prone position at functional joint ankle of 30° knee flexion (0° = full extension). Participants completed both conditions at the same time of day, separated by 7 days. The order of treatment condition and muscle group testing was randomly assigned.

RESULTS: Peak force appeared to decrease to a greater extent vs. baseline performance in the SMT condition (6.2% vs. 1.3%, respectively) and remained so at 1-hr post treatment (4.4% vs. 9.0%, respectively) (Table 1), however, analyses revealed only a significant main effect for time ($p < 0.05$). A similar pattern of performance was observed for EMD whereby a performance was impaired by 16.1% immediately following SMT vs. 1.6% following SHAM (Figure 1); analyses revealed a significant main effect for condition only ($p<0.05$).

CONCLUSION: These preliminary data are the first to report on neuromuscular performance in the knee flexors following SMT and present potentially contrary findings to those reported in the knee extensors. Whilst no significant interaction effects were found in this small sample, there is a need for further research given the possible negative effects of this therapy on muscle performance at a functional and vulnerable joint angle.

Table 1: Group mean (±SD) knee flexor peak force (N) .

Condition	Pre	Post	1-hr Post
SHAM	326.1 (53.0)	321.9 (44.6)	311.6 (44.7)
SMT	340.6 (50.5)	319.5 (57.5)	309.5 (47.9)

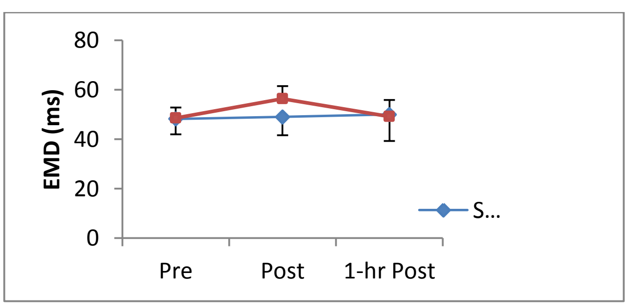

Figure 1: Group mean (±SD) knee flexor electromechanical delay (ms).

THREE-DIMENSIONAL UPPER EXTREMITY KINEMATICS IN A YOUNG ADULT AND PEDIATRIC POPULATION DURING AN EATING TASK

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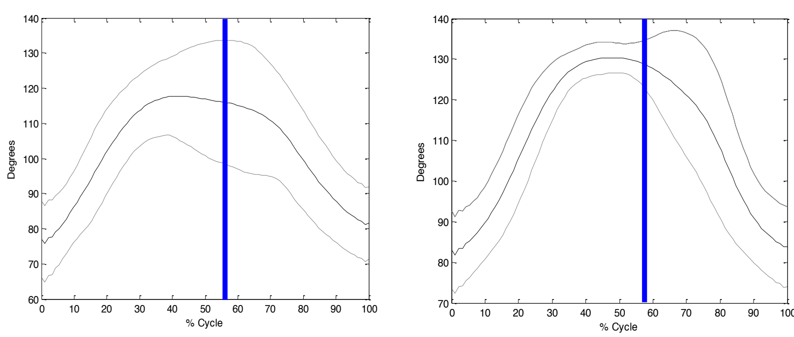
AIM: Few researchers have examined age-related differences in upper extremity (UE) kinematics during activities of daily living. Knowledge of typical UE movements would aid in the identification of movement deviations in clinical populations of the same age. The purpose of this research was to quantify and compare age-related differences in three-dimensional UE kinematics between a young adult and pediatric group during an eating task.
METHODS: Fifteen young adults (5 male, 10 female), aged 18-24 years (mean age: 20.2 years), and fifteen paediatric participants (5 male, 10 female) aged 7-9 years (mean age: 8.3 years) participated in the study. An eight-camera Vicon MX motion capture system (Oxford Metrics Ltd.) was employed to track the three-dimensional trajectories of eighteen (n=18) reflective markers placed on the participants' skin at a sampling frequency of 60 Hz. Rigid body segments included the head, trunk, and the left and right upper arm, forearm, and hand. Each participant was asked to perform a standardized eating task, which involved scooping pudding from a bowl with a spoon. Joint angles were then computed from the relative orientations of embedded coordinate systems using Euler angles. Two-way ANOVAs were used to test for significant (p<0.05) differences in joint angle data across age groups and dominant/non-dominant arms.
RESULTS: Significant differences (p<0.05) in mean joint angle parameters (max, min, range) were found between age groups for the eating task. No significant differences were found between the dominant and non-dominant arms. The young adult had a significantly larger mean maximum elbow flexion (Figure 1) than the paediatric group during phase 1 of the eating task (lift spoon to mouth). The young adult group also had a significantly larger mean maximum elbow flexion angle than the paediatric group during phase 2 of the eating task (return spoon from mouth to bowl). The paediatric group showed significantly greater shoulder abduction throughout the task.
CONCLUSION: Differences in UE kinematics between pediatric and young adult age groups demonstrate the importance of using age-matched control groups in clinical studies. Differences in anthropometry, task experience, and movement efficiency likely contributed to movement differences. Future work will focus on increasing sample sizes and establishing a control database for clinical applications.

A

Figure 1: Mean ± 1 SD for elbow flexion (A) Paediatric Group, (B) Young Adult Group (blue vertical line is end of phase 1)



THE ACUTE EFFECTS OF LOW-INTENSITY SLOW TRAINING ON MUSCLE PROPERTIES IN VIVO

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AIM: The aims of this study were to investigate the effect of a single bout of slow training (ST) on muscle properties and to determine the minimum intensity of ST required to cause damage to the quadriceps.
METHODS: Thirteen healthy males (23.1±2.1 years of age) each performed four sessions of ST, which consisted of slow knee extensions (5 s for the concentric and 5 s for the eccentric phase), at four different intensities [0, 10, 20, and 30% of one repetition maximum (1RM)]. During each ST session, three sets of 10 repetitions each were performed, with a rest period of 60 sec between sets. The sessions were performed in random order and were separated by intervals of more than 48 hours. Muscle thickness (MT) and echo-intensity (EI) of the vastus lateralis (VL) were measured before (pre) and immediately after (post) ST; these were used to evaluate muscle damage. Increases in MT and EI immediately after training were considered to indicate muscle swelling and inflammation, respectively. Electromyographic (EMG) activity of the VL was recorded during the training sessions. EMG activity was calculated using the root mean square (RMS) with a window interval of 50 ms, and was expressed as a percentage of an isometric maximum voluntary contraction (MVC). A paired t-test was used to compare pre- and post-training values.
RESULTS: The mean 1RM was 31.8±4.7 kg. The average EMG activities of the VL during the ST sessions were 5.4±1.8% for 0% 1RM, 8.5±2.7% for 10% 1RM, 10.2±3.3% for 20% 1RM, and 13.9±3.9% for 30% 1RM. There were significant differences between the pre- and post-training MT at 20 and 30% 1RM, but not at 0 and 10% 1RM. There was no significant difference between pre- and post-training EI at any intensity (Table 1).
CONCLUSION: These findings suggest that a ST intensity of at least 20% 1RM is needed to cause damage to the quadriceps.

Table 1: Changes in muscle thickness (MT) and echo intensity (EI) pre- and post-training

intensity	property	pre-training	post-training
0%1RM	MT (cm)	2.27±0.46	2.25±0.49
	EI	83.4±15.4	83.1±16.2
10%1RM	MT (cm)	2.41±0.42	2.39±0.36
	EI	84.5±9.0	87.8±11.1
20%1RM	MT (cm)	2.41±0.32	2.48±0.30*
	EI	79.8±16.7	81.2±14.9
30%1RM	MT (cm)	2.24±0.36	2.40±0.37**
	EI	73.3±14.1	74.9±16.5

Values are means ± standard deviation (SD)
*: P<0.05, **: P<0.01; Significantly different from pre-training value

Poster Session 2 – (Poster Area 16.00)

THE EFFECT OF WALKING WHILE TYPING ON NECK/SHOULDER PATTERNS

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AIM: This project was designed to quantify the effects of modifying the work posture on neck/shoulder patterns during a prolonged computer work task. In turn, this would serve to provide objective data on a popular computer work intervention: walk-and-work.

METHODS: Thirteen healthy, adult participants completed a 90-minute computer typing task in the two postures of sitting and walking on a treadmill, at 2.25 km/h. Electromyography (EMG) was recorded from 8 muscle sites of the upper right side of the body. EMG amplitude (RMS) and variability (CoV) were computed over time and across the two postures. Upper limb discomfort and computer performance (speed, errors) were also recorded. Repeated measures ANOVAs with factors of Time and Posture were applied on the data ($p < 0.05$).

RESULTS: There were significant interaction effects for wrist extensor (Wext) and lumbar erector spinae (LES) EMG RMS, both muscles showing increased activity with time during sitting, and conversely a decrease with time during walking ($p < 0.001$). Wext and external oblique (EO) EMG RMS were significantly higher during walking ($p = 0.004$, $p = 0.018$), and anterior deltoid (AD) EMG RMS was significantly higher during sitting ($p = 0.028$). CoV of LES, EO and lower trapezius (LT) were higher during walking, although LT CoV decreased with time during walking. There were no effects on typing performance. Upper limb (UL) discomfort increased with time and was higher during sitting.

CONCLUSION: Previous studies have found that increases in muscle activation over time may be associated with low-force, slow-developing fatigue and increased risk to develop musculoskeletal disorders (MSD). Notably, lower AD EMG RMS and UL discomfort as well as higher variability (hypothesized to reflect an effective injury prevention mechanism) during walking suggest a benefit of this alternative posture; however, higher Wext EMG RMS may indicate an attempt to stabilize the hands so as to be able to continue the typing task. Acclimatization to walking and working may be necessary to obtain its full benefits.

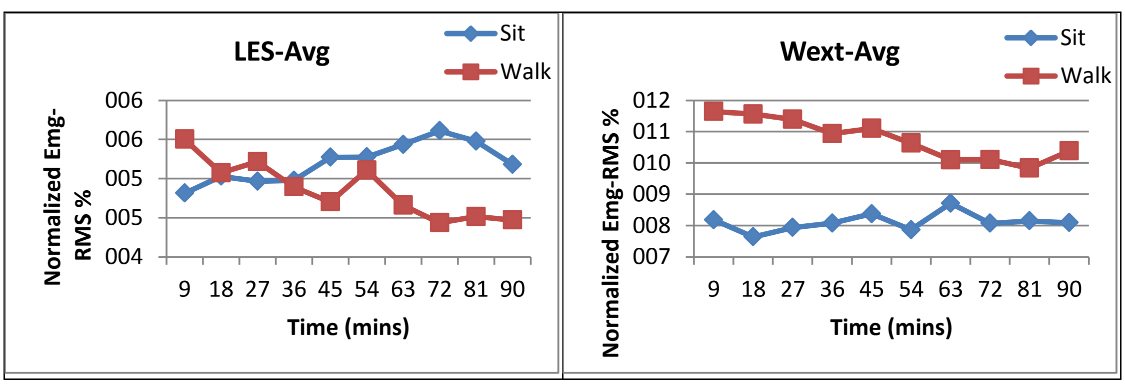

Figure 1: EMG-RMS of the LES (group average values), normalized to corresponding maximum isometric voluntary contraction (MIVC) (left); EMG-RMS of the Wext (group average values), normalized to the corresponding MIVC (right)

REAL-TIME ELASTOGRAPHY USING AN EXTERNAL REFERENCE MATERIAL: PRELIMINARY RESULTS OF ACHILLES TENDON ELASTICITY PATTERN

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AIM: The aim of this study was to describe elasticity pattern of normal Achilles tendon using real-time elastography (RTE) with an external reference material.
METHODS: Six healthy subjects were recruited. Longitudinal RTE ultrasound (MyLab™ ClassC) images of left and right Achilles tendon were acquired. An external reference material (Zerdine®, CIRS, Inc., Norfolk), with known elastic properties (first layer 93 kPa, second layer 10.5 kPa), was placed on the subject's tendon and included in the b-mode scans (Fig. 1). The reference material was used to normalize colour scale among subjects. Two region of interest (ROI) were drawn in the reference material and in the tendon. The range between soft and hard (from red to blue) (Fig. 1A) was divided in 256 steps (0-255), according to the ultrasound image colour depth. The median and interquartile range of the distribution color were computed. Index ratio between the reference material and the tendon median values were calculated.
RESULTS: The mean ± (SD) color index for the tendon was 199 ± (8.42) and for the reference material (93kPa) was 79 ± (9.64). The color index ratio between reference and tendon was 0.397 ± (0.04).
CONCLUSION: Preliminary results show that healthy subject have similar color index ratios for the Achilles tendon. Color index ratios of pathological Achilles tendon should be investigated in future research.
ACKNOWLEDGEMENT: The study was supported by Thim van der Laan Foundation.

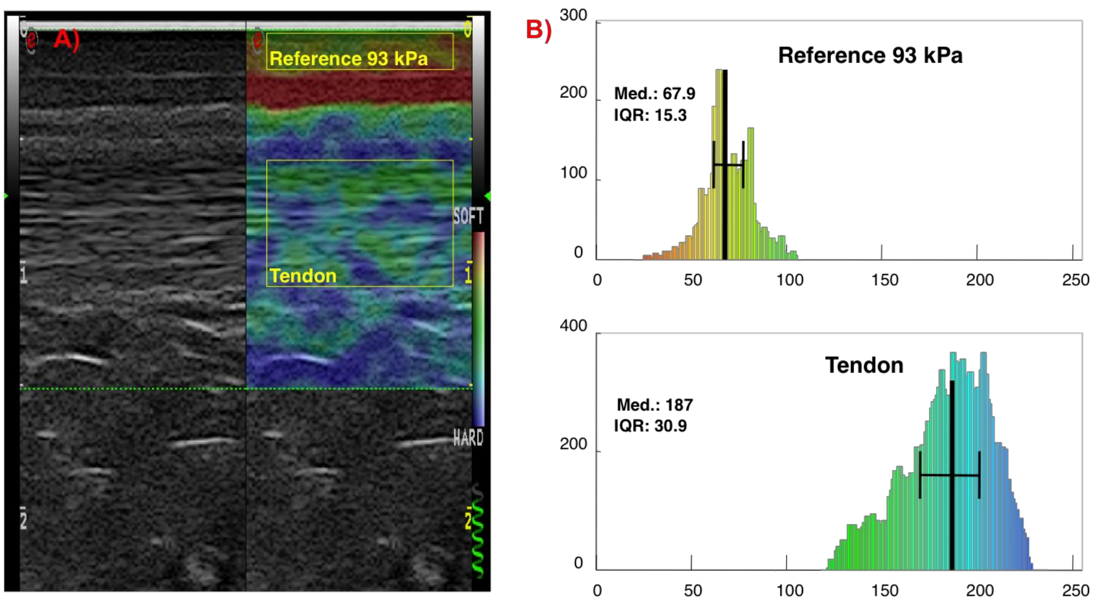

Figure 1: A) Elasto-Dual image, yellow boxes contain the two tissues examinated. B) Color-histogram for the reference material and for the tendon.

COMPARISON BETWEEN ULTRAFAST ULTRASOUND BASED AND ALPHA METHODS TO ASSESS MUSCLE AND TENDON STIFFNESS DURING SHORT RANGE EXPERIMENTS

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AIM: The stiffness of musculo-articular system is an important parameter in understanding of the skeletal muscle performance. Currently, only two methods enable to dissociate the passive (i.e, tendinous tissues) and active (i.e., fascicles) part of the musculo-articular stiffness during short-range experiments. The first method implies to perform stretches on activated musculo-articular system and apply the alpha method. The second method uses ultrafast ultrasound to track muscle fascicle length. The aim of the current study was to compare both methods.

METHODS: Ten healthy males performed a short-range stiffness experiment, which consisted to sustain a constant voluntary isometric plantarflexion at 7 submaximal torque levels. During isometric contraction, the dynamometer applied a fast dorsiflexion on a range of motion of 20°. Based on assumptions about the muscle fascicles and tendinous tissues behaviors, the mathematical model of the alpha method allowed us to estimate the compliance of the musculo-articular system due to either active or passive part. Then, using the ultrafast ultrasound measurements performed on the *gastrocnemius medialis* muscle belly during the stretch, the contribution of both parts to the global compliance was calculated.

RESULTS: Considering the two-way ANOVA (method × torque level), no main effect of "method" factor was found (P>0.05) inferring the similar shape of the muscle fascicles contribution – joint torque relationships between both methods (Figure 1). Interaction between "method" and "torque level" factors was observed (P<0.05). For the three highest torque levels, the muscle contribution estimated by the Ultrasound Model was significantly lower than the Mathematical Model.

CONCLUSION: The present study validates the use of the alpha method at low torque levels. Further analyses are required to better understand the differences observed between methods at high torque levels. Since the alpha method can be applied using a commercial isokinetic device, these results can lead to several interesting applications.

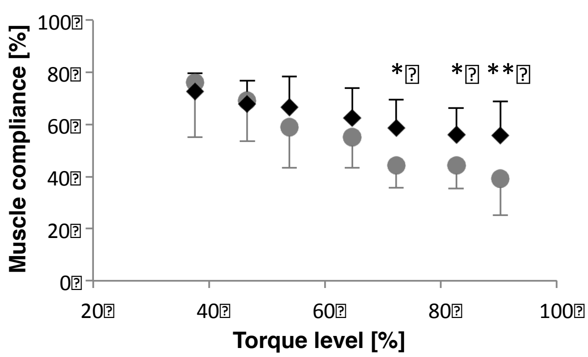

Figure 1: Muscle fascicles contribution to the isometric torque level (black diamonds: alpha model; gray circles: ultrafast ultrasound measurements). Significant difference between the models used are denoted by * (P<0.05) and **(P<0.01).

NEUROMUSCULAR RESPONSES OF THE GLIDE EFFECT IN BREASTSTROKE TECHNIQUE: A CASE OF STUDY

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AIM**:** The aim of this study was to examine the capability of a trained breaststroke swimmer to adapt his muscular responses to different glide and speed conditions. In other words, we explored which parts of the muscular responses were kept stable and which parts varied.
METHODS**:** A 18-y-old male swimmer performed 9 x 25m breaststroke trials of increasing velocity. Each trial required an individually imposed swim pace corresponding to 70, 80 and 90% over the best time of 25 m and to a specific glide condition: non-glide, normal glide and extra-glide.
Using a wireless signal acquisition system (bioPlux research, Portugal), surface electromyogram was collected in eight muscles *gastrocnemius medialis(GM)*, *tibialis anterior(TA)*, *rectus femoris(RF)* *biceps femoris*(*BF*) *bíceps brachii(BB)*, *deltoid anterior(DA)*, *pectoralis major(PM)*, *tríceps brachii(TB)*.
All EMG analysis was conducted with a MATLAB routine (Mathworks, Inc.,Natick MA,USA). Starting from the raw signal, DC components were removed and thereafter filtered with a fifth-order Butterworth band pass filter where the lower and upper cut-off frequencies were set to 10 and 500Hz respectively. The temporal evolution of the active and nonactive phases average durations during stroke were calculated for each muscle for all the trials. Linear regression curves were fitted to the data and the durations of the fitted curves at the beginning and completion of the swim were compared. The average amplitude of EMG of each active phase was estimated using the average rectified value (ARV) and plotted as a function of time. As a measure of the central tendency of PSD we used the mean frequency of the PSD (MNF).
RESULTS**:** The long duration of neuromuscular active phase was shown in the TB (1.47 s) and TA (0.97 s) in the normal condition or 70% of swim pace, GM (1.99 s) in the no-glide condition for 80% of the swim pace and TB (3.37 s) in the no-glide condition for 90% of the swim pace. The EMG average rectified value (ARV) showed the highest values in the extra-glide condition for the BB and DA and in the no-glide condition for the DA. The lowest ARV values were shown in the BF muscle in all the conditions and swim paces. The mean frequency of the power spectral density (MNF) showed the highest frequency in the 80% (155.2 ± 2.3 Hz) and 90% (156.4 ± 7.3 Hz) for the TA muscle for all the swimming conditions and the lowest frequency for TB.
CONCLUSION**:** It can be concluded that the neuromuscular responses of the muscles *tibialis anterior* and *gastrocnemius medialis* for the lower limbs, and the *bíceps brachii*, *deltoid anterior*, *tríceps brachii* for the upper limbs may play a strong and meaningful role on the glide effect and speed effect. These results might be useful to develop specific training and enhance swimming performance in breaststroke swimmers.

PARAMETERISATION AND RELIABILITY OF THE FUNCTIONAL REACH TEST IN PEOPLE WHO SUFFER STROKE

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AIM: The aim of this study is to analyse the reliability, sensitivity and specificity of the parameterisation of FRT using inertial sensors to record kinematic variables in subjects who have had a stroke. Our hypothesis is that the IS will be reliable instruments for kinematic study of the FRT.

METHODS: This is a cross-sectional study of 5 subjects over 65 years who suffer of stroke. During the execution of Funtional Reach Test the subjects carried two inertial sensors, one was placed in the lumbar and the other in the trunk. After analysing the data obtained in the kinematic registration by inertial sensors a number of direct and indirect variables were obtained. The variables extracted directly from FRT through the IS were distance, maximun angular lumbosacral/thoracic displacement, time maximun angular lumbosacral/thoracic displacement, time return starting position and total time. Using this data the speed and the acceleration of each one of them were calculated. A descriptive analysis of all kinematic outcomes recorded by the two inertial sensors was developed (trunk and lumbar) and the average range achieved in the FRT. Reliability measures were calculated by analysing the internal consistency the measures with 95% confidence interval of each outcome variable. The reliability was calculated in the functional reach and the outcomes measured by the IS.

RESULTS: The values in the the Functional Reach Test obtained in the present study (2.06 ± 12.75cm) are similar to those obtained in other studies with this population and in the same age range. Intrasubject reliability values observed in the use of inertial sensors are all located above 0.820, ranging from 0.829 (time B_C lumbar area) and 0.891 (A_B displacement of the trunk). Likewise, the observed intersubject values range from 0.821 (Time B_C lumbar area) and 0.883 (B_C trunk displacement). On the other hand, the reliability of the FRT was 0.987 (0.983-0.992) and 0.983 (0.979-0.989) intersubject and intrasubject respectively.

CONCLUSION: The main conclusion that can be reached is that the inertial sensors are a tool with excellent reliability, validity, sensitivity and specificity in the parameterisation of the Functional Reach Test in people who have had a stroke.

Table 4: Intra-observer and inter-observer reliability of variables measured directly during functional reach test.

Variable			INTRA-OBSERVER ICC	IC (95%) Min.	IC (95%) Max.	INTER-OBSERVER ICC	IC (95%) Min	IC (95%) Max
Trunk	Time	A_B	**0.855**	0.833	0.872	**0.851**	0.828	0.869
		B_C	**0.835**	0.822	0.852	**0.831**	0.824	0.848
		A_C	**0.847**	0.839	0.868	**0.840**	0.839	0.868
	Displ	A_B	**0.891**	0.879	0.913	**0.883**	0.877	0.913
		B_C	**0.863**	0.843	0.878	**0.858**	0.845	0.871
		A_C	**0.877**	0.861	0.895	**0.870**	0.859	0.888
Lumbar	Time	A_B	**0.867**	0.844	0.880	**0.858**	0.841	0.879
		B_C	**0.829**	0.806	0.855	**0.821**	0.804	0.852
		A_C	**0.851**	0.837	0.869	**0.839**	0.832	0.860
	Displ	A_B	**0.878**	0.850	0.896	**0.875**	0.852	0.893
		B_C	**0.868**	0.849	0.883	**0.863**	0.846	0.870
		A_C	**0.872**	0.853	0.889	**0.868**	0.850	0.877
Functional Reach Test			**0.987**	0.983	0.992	**0.983**	0.979	0.989

STUDYING UPPER-LIMB KINEMATICS USING INERTIAL SENSORS

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AIM: The aim of this study was to analyze scapulohumeral rhythm through nine physical properties that correspond to angular mobility, angular velocity, and acceleration in the three axes of space, obtained by inertial sensors.
METHODS: This cross-sectional study recruited healthy young adult subjects. Descriptive and anthropometric independent variables related to age, gender, weight, size, and BMI were included. Nine physical properties were included corresponding to three dependent variables for each of three special axes: mobility angle (degrees), angular speed (degrees/second), and lineal acceleration (meters/seconds^2), which were obtained thought the inertial measurement sensors with four inertial sensors (*InertiaCube3™ Intersense Inc., Billerica, Massachusetts*). Inertial sensors were placed in the right half of the body of each subject located in the middle third of the humerus slightly posterior, in the middle third of the upper spine of the scapula, in the flat part of the sternum, and the distal surface of the ulna and radius.
RESULTS: Descriptive graphics of analytical tasks performed were obtained (figure 1). The main difference in mobility between the scapula and humerus was found in pitch axis for abduction ($\bar{X}$ = 107.6°, SD = 9.3°) and flexion ($\bar{X}$= 113.1°, SD = 9.3°).
CONCLUSION: This study shows how much each body segment contributes to upper-limb motion, and allows us to obtain grades of mobility provided by the scapula. Also, this study identified movement patterns, and supports inertial sensors as a useful device to analyze upper-limb kinematics. However, further studies with subjects with shoulder pathology should be carried out.

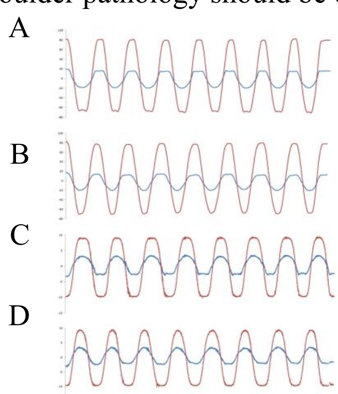

Figure 1: Four examples of kinematic patterns through reptitions were showed for angular mobility during flexion (A) and abduction (B), and the linear acceleration during flexion (C) and abduction (D) in pitch axis.

Humerus ___________
Scapula____________

RELIABILITY AND PARAMETERIZATION OF ROMBERG TEST IN PEOPLE WHO HAVE SUFFERED A STROKE.

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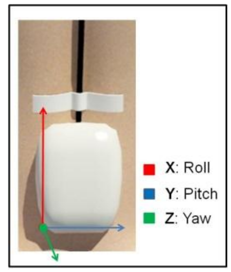
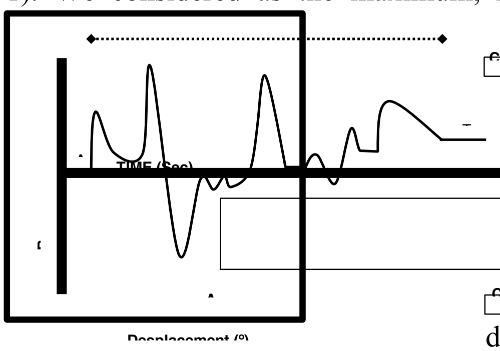


Figure 1: Axis

AIM: To analyze the reliability and describe the parameterization with inertial sensors, of Romberg test in people who have had a stroke.
METHODS: Romberg's Test was performed during 20 seconds in four different setting, depending from supporting leg and position of the eyes (opened eyes / dominant leg; closed eyes / dominant leg; opened eyes / non-dominant leg; closed eyes / non-dominant leg) in people who have suffered a stroke over a year ago. Two inertial sensors (sampling frequency 180Hz) were placed in lumbar (L_5-S_1) and in the trunk (T_7). The test was performed three times for the four different settings. The outcome variables were extracted in each of the axes (X, Y, Z) (figure 1). We considered as the maximum, minimum and mean velocity and the magnitude of the angular displacement for each of the sensors (Figure 2 shows an example of direct extraction of variables). Statistical Analysis: descriptive analysis of all outcome variables for each axis and sensor. Further analysis of the internal consistency of the measure was performed by analysis interclass correlation (ICC) with a confidence interval of 95%.



RESULTS: Values obtained after statistical analysis show levels of reliability ranging from 0.61 (Z axis speed - eyes closed / non-dominant leg) and 0.92 (Y axis offset - opened eyes / dominant leg). The descriptive results of all outcome variables are shown in Table 1.
CONCLUSION: Making inertial sensors in trunk and / or lumbar, inertial sensors are reliable tools for parameterizing Romberg test in different settings in people who have suffered stroke over a year ago.

		L1	T1	L2	T2	L3	T3	L4	T4
Displacement (º)	MAX_x	4,88	5,92	11,54	7,52	24,7	12,56	22,66	25,19
	Min_x	-5,64	-2,36	-12,25	-13,24	1,07	-2,75	-24,39	-18,55
	Mean_x	7.02	3,05	5,49	-2,08	13,61	9,89	-2,71	3,58
	Max_y	2,46	2,06	3,72	5,65	10,21	11,56	6,36	12,56
	Min_y	0,07	-3,14	-3,96	-1,85	1,73	0,58	-6,38	-5,47
	Mean_y	2.06	-1,28	-0,49	0,06	4,32	5,29	1,1	2,87
	Max_z	4,84	8,12	14,92	8,46	3,42	1,98	19,28	15,73
	Min_z	-6,62	-2,25	-3,86	-0,45	-13,52	-10,36	-18,22	-22,63
	Mean_z	-0,71	1,67	7,02	2,17	-5,01	-7,19	3,55	-4,96
Velocity(º/s)	MAX_x	44,17	37,25	41,65	38,22	45,57	50,93	49,42	48,19
	Min_x	-44,46	-36,06	-45,81	-41,13	-34,8	-36,69	-41,78	-55,82
	Max_y	30,85	32,56	30,69	41,72	23,89	40,81	23,5	32,19
	Min_y	-31,78	-36,72	-21,86	-34,74	-40,49	-43,52	-37,32	-62,29
	Max_z	37,75	36,52	25.07	41,06	41,01	50,44	24,26	20,91
	Min_z	-30,2	-27,43	-41,62	-61,69	-23,61	-29,42	-47,28	-30,81
	R_pos	66.37	63,13	60,21	77,77	51,92	111,04	60,84	62,15
	R_neg	62,28	61,71	69,67	88,76	61,13	66.63	76,66	93,22

L1: Lumbar inertial sensor (opened eyes / dominant leg); T1: trunk inertial sensor (opened eyes / dominant leg); L2: Lumbar inertial sensor (opened eyes / non-dominant leg); T2: trunk inertial sensor (opened eyes / non-dominant leg); L3: Lumbar inertial sensor (closed eyes / dominant leg); T3: trunk inertial sensor (closed eyes / dominant leg); L4: Lumbar inertial sensor (closed eyes / non-dominant leg); T4: trunk inertial sensor (closed eyes / non-dominant leg); R_pos: positive resulting vector; R_neg: negative resulting vector

THE EFFECTS OF WALKING SPEED ON MULTISEGMENT FOOT KINEMATICS

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AIM: Previous research has shown that walking speed influences biomechanical variables. However, little is known about the effects of speed on the multisegment foot. Such information is critical for increasing our understanding of foot mechanics in typical and atypical populations. The purpose of this study was to examine the effects of walking speed on multisegment foot kinematics.
METHODS: Twenty-one (n=21) adult participants (male, female) were recruited between the ages of 18-30 years (age=23.0±2.6 yrs; height: 1.73±0.1 m; weight: 72.1±10.1 kg). A 12 camera T160 Vicon motion capture system (Oxford Metrics Group), sampling at 100 Hz, was used to track the three-dimensional trajectories of 32 reflective markers placed on the participant's skin. Six force plates (Kistler Instruments), embedded in the lab floor, were used to aid in the identification of gait cycle events. The foot model consisted of the 6 rigid segments, including the tibia, hindfoot, midfoot, forefoot, hallux, and total foot. First, a static capture of the participant during quiet standing was recorded to permit the calculation of offset values for all joint rotations. Joint offset values were subtracted from the gait cycles of each participant. Planar angles were calculated and reported without any offsets. Participants were asked to perform at least 6 gait trials. Three-dimensional coordinates were filtered with a second order low-pass Butterworth filter with a cut-off frequency of 6 Hz. Euler angles were used to represent the relative joint angles. Repeated measures ANOVAs were used to test for significant differences in the mean values of the temporal-spatial values and joint angles across the 5 walking speeds.
RESULTS: Significant differences ($p<0.002$) in multisegment foot kinematics were found as walking speed changed (Figure 1). Significant differences ($p<0.002$) were found for all of the absolute angles, 6 of 9 relative angles of the foot (all sagittal), 11 of 13 time to maximum angles, and all of the temporal-spatial variables analysed.
CONCLUSION: Very few studies have examined the effects of speed on multisegment foot kinematics. Such data is important for distinguishing between pathological gait patterns and speed-mediated effects. The results of this study suggest that clinical gait analyses that use multisegment foot models should compare patient data to speed-matched control data.
ACKNOWLEDGEMENT: We wish to thank the New Brunswick Innovation Foundation for their support.

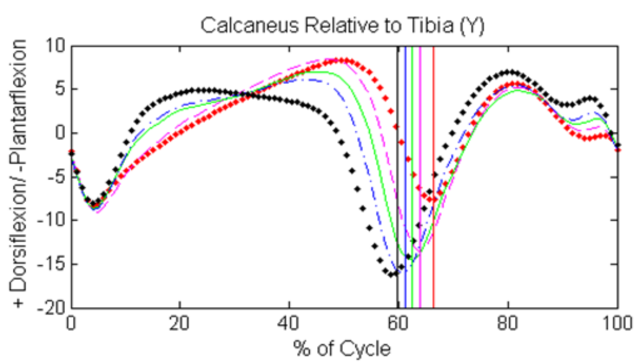

Figure 1: a) Picture of multisegment marker system, b) Example of changes in multisegment angles as a function of speed (black = very fast; red = very slow)

EFFECTS OF ACUPUNCTURE TREATMENT THROUGH ELECTROMYOGRAPHIC ANALYSIS IN THE SEQUELAE OF PERIPHERAL FACIAL PALSY: A CLINICAL CASE

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AIM: Evaluate the effects of acupuncture through electromyographic analysis in the sequelae of peripheral facial palsy.
METHODS: Participated in this study a female patient, age 44, with a sequelae resulting from 20 years of peripheral facial paralysis on the right side, showing synkinesis in the left eye. Electromyography was performed according to the Seniam protocol, the motor points of the orbicularis muscles of the mouth and eyes to establish myofunctional feedback before and after the process of rehabilitation through acupuncture, which consisted of 10 sessions of 25 minutes once a week at the following points: F3, VB21, VC17, E2, E3, E6, E7, VB2, ID19, with manual stimulation, E4 and EXT7 (Tou-Kuang-Ming) with electrostimulation at 4 Hz, pulsed current and subjective intensity of the patient.
RESULTS: By electromyographic comparative analysis of root mean square (RMS) was possible to observe in facial movements greater activation and recruitment of muscle fibers on the right and the left lower overhead, providing the functional evolution of motion and producing a positive response in the stomatognathic system where it was possible to note the absence of synkinesis left eye (Image 1), and formation of the nasolabial fold (Image 2), demonstrating a clinically symmetrical face.
CONCLUSION: The combination of acupuncture points associated with electrostimulation provided the reversal of peripheral facial paralysis frame in a short period and the serious sequelae were minimized due to the balance of muscle activation in response to stimulus of acupuncture needles.

Table 1: Analysis using the root mean square (RMS) before and after acupuncture with electrostimulation treatment**.**

Orbicularis mouth and eyes	Open eyes R	Open eyes L	Close eyes R	Close eyes L	Pouting R	Pouting L
Before µV	13,70	32,11	11,69	50,20	239,69	432,20
After µV	15,80	29,18	18,58	31,86	404,87	384,10

Right (R), Left (L

Before **After**
Image1 - Synkinesis left eye.

Before **After**
Image2 - Formation of the nasolabial fold.

THE ESTABLISHMENT OF CLINICAL THRESHOLD FOR CLASSIFICATION OF LOW BACK PAIN PATIENTS WHO RESPOND TO EXERCISE THERAPY

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BACKGROUND: Exercise therapy has been proposed as one of the treatments of chronic low back pain. However, the successful rate is not high due to the presence of heterogeneous subgroups of patients in low back pain. Through classifying the subgroups by establishing a clinical threshold, successful rate of exercise therapy for low back pain patients would be improved.
AIM: To establish a clinical threshold to classify the subgroup of low back pain patients who are responsive to exercise therapy.
METHODS: 51 chronic low back pain patients and 43 healthy subjects were enrolled in the study. The patients were classified as “responders” or “non-responders” to exercise therapy based on the changes in Oswestry Disability Questionnaire (ODQ) scores and Visual Analogue Scores (VAS) after a 12-week rehabilitation programme. Subjects performed sagittal trunk flexion and extension while surface EMG signals were recorded from the L3-L5 lumbar region before the rehabilitation programme. The EMG signals were processed by sEMG topography analysis. The corresponsive Root-Mean-Square Difference (RMSD) of patients respective to healthy subjects was calculated. 6 RMSD combinations were proposed. Each combination was tested by ROC for the discriminatory ability to classify the exercise therapy responders from non-responders. An optimal threshold of each combination was found by Maximum Youden Index. Accuracy statistics of combinations were evaluated and the optimal combination was chosen based on the accuracy statistics.
RESULTS: 18 patients were classified as responders to exercise therapy and 33 patients as non-responders. 6 RMSD combinations were proposed for establishing the clinical threshold: Sum, Geometric, Relative Area, Relative Width, Flexion and Extension. Geometric was found to be the optimal combination among the six with the strongest discriminatory ability and accuracy statistics at significant level ($p<0.05$). Area under curve of ROC = 0.83, sensitivity= 0.72, specificity= 0.9. The proposed threshold of Geometric combination was 0.2. Patients with Geometric RMSD measurement below 0.2 were classified as responder to exercise therapy. The probability of successful outcome increased from 35% to 81% when patients classified as responders to exercise therapy according to the proposed threshold.
CONCLUSION: Response of chronic low back pain patients towards exercise therapy can be classified by sEMG topography analysis with Geometric RMSD measurement. Patients with Geometric RMSD measurement below 0.2 were classified as responder towards exercise therapy. The established threshold may be beneficial in clinical decision making for implementing exercise therapy to the targeted responsive LBP patients.

INTER-SESSION RELIABILITY OF TRAPEZIUS MUSCLE H-REFLEX

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AIM: The aim of this study was to investigate inter-session reliability of trapezius muscle H-reflex and the corresponding M-wave.
METHODS: The maximum H-reflex (H_{max}) was recorded from the middle part of the trapezius muscle by electrical stimulation of the C3/4 cervical nerves in 10 healthy young volunteers. The maximum M-wave (M_{max}) was measured by electrical stimulation of the accessory nerve. The maximum H-reflex, M-wave, and their ratios were obtained in two sessions separated by ~5 weeks. Inter-session reliability was estimated by intra-class correlation coefficients ($ICC_{2,1}$, for absolute agreement), standard error of measurement (SEM), and minimum detectable change (MDC). Paired t-test was performed in order to assess any difference between sessions. Bland-Altman plots were constructed and inspected visually for consistency of agreement through the range of measurements.
RESULTS: No statistically significant difference was observed between sessions ($p > 0.05$) and the H-reflex parameters showed substantial to almost perfect reliability (ICC = 0.63 – 0.85) (Table 1). For Hmax, all mean differences were close to zero (Figure 1).
CONCLUSION: This study indicates that the trapezius muscle H-reflex elicited by stimulation of the C3/4 cervical nerve is reliable between sessions separated by weeks. This is useful for investigations of the effects of strength training and rehabilitation on monosynaptic reflexes in the neck-shoulder region.
ACKNOWLEDGEMENT: This study was partly supported by grants from The Ministry of Culture Committee on Sports Research in Denmark, The Danish Rheumatism Association, and the Danish Council for Independent Research - Technology and Production Sciences.

Table 1: Inter-session reliability indicators of trapezius muscle H-reflex parameters.

Measure	$ICC_{2,1}$ (95% CI)	SEM	MDC	Sig.
H_{max}	0.85 (0.55-0.96)	0.6 mV	1.4 mV	$p = 0.45$
M_{max}	0.63 (0.05-0.89)	1.5 mV	3.5 mV	$p = 0.08$
H_{max}/M_{max}	0.80 (0.38-0.95)	0.07	0.16	$p = 0.86$

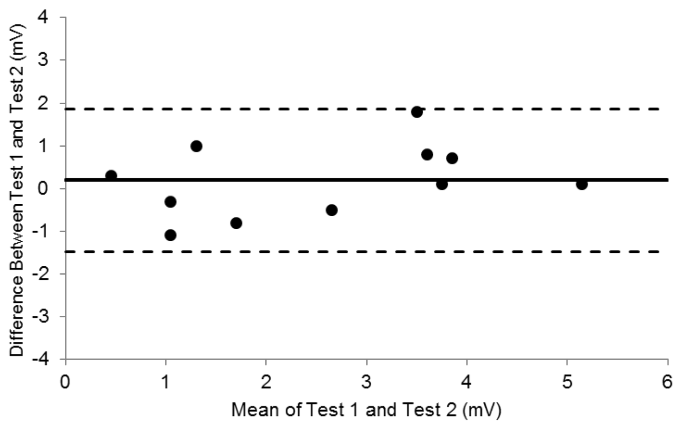

Figure 1: Bland-Altman plot for inter-session agreement for Hmax.

MUSCLE-FIBER CONDUCTION VELOCITY ESTIMATED FROM SURFACE EMG SIGNALS DURING STARTLE REFLEX EVOCATION

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INTRODUCTION: The startle reflex is a physiological phenomenon elicited by an unexpected stimuli and is characterized by an automatic bilateral bursts of muscular contraction. Acoustic startle reflex is a sensitive and noninvasive measure of central nervous system activity that is used in a large variety of research and clinical settings. Surface electromyography (sEMG) has become the most widely used method for the study of that phenomenon but the muscle fiber conduction velocity (CV) has not been previously estimated in such contractions.

AIM: The aim of this study is to assess of the possibility of estimating muscle fibers CV in the startle reflex with multi-channel sEMG.

METHODS: Ten healthy subjects (six females, four males), age (mean ± standard deviation) age) 28 ± 5 years participated in this study. Startle reflex were elicited by randomly presented auditory stimuli (4 stimuli in 30 minutes). Unexpected acoustic stimulation was presented at an intensity of 108 dB with the subjects seated and relaxed. sEMG signals were detected from the sternal and clavicular heads of the sternocleidomastoid (SCM) muscle bilaterally using linear electrodes arrays (8 electrodes, 5mm interelectrode distance) in single differential configuration. CV was estimated using algorithm which allows the computation from short EMG signal epochs (burst).

RESULTS: Reflex EMG activity was recorded in SCM muscles, in at least one stimulus, in nine subjects out of ten while in one subject was not detected. At the first acoustic startle reflex evocation it was possible to estimate muscle fiber CV in SCM muscles in 86% of cases. CV estimates were found in physiological range (2.4 - 5.0 m/s). Absolute values (mean and standard deviation) of the muscle fiber CV estimates were (left and right side respectively): 3.6 ± 0.6 m/s and 3.5 ± 0.5 m/s for the clavicular heads of the SCM; 3.6 ± 0.7 m/s and 3.7 ± 0.5 m/s for the sternal heads of the SCM.

CONCLUSIONS: Muscle fiber CV can be estimated during very short automatic muscular contractions elicited by the acoustic startle reflex. CV is an important physiological variable that could provide indications on motor unit recruitment strategies due to the relation between conduction velocity and fiber diameter. Hence the possibility of estimating muscle fibers CV in the startle reflex elicited contractions can be useful in the neurophysiological research setting to determine contraction intensity and neuromuscular recruitment strategy.

THE CHARACTERIZATION OF DEEP TENDON REFLEX OF BICEPS BRACHII USING HIGH DENSITY SURFACE EMG

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AIM: The aim of the study was to characterize the deep tendon reflex of biceps brachii using high-density surface EMG.
METHODS: Ten healthy volunteers were enrolled in the study, deep tendon reflex elicited by 8 consecutive standardized taps on the biceps brachii tendon using a reflex hammer. The force of the hammer as well as the time of impact was estimated using the signals of a linear uniaxial accelerometer embedded in the hammer handle. Surface EMG signals were detected in monopolar configuration using a 16x8 adhesive array of electrodes with 10mm inter-electrode distance (OT-Bioelettronica) positioned on the biceps brachii with the longer axis aligned to the muscle fibers. The instants of contact between the hammer and the tendon were identified from the acceleration signal using a simple threshold technique. The EMG signals evoked by the tendon reflex were aligned using the spike triggered averaging technique, with the acceleration signal as trigger.
EMG parameters of interest were: muscle fiber conduction velocity (CV), reflex latency between the hammer hit and the sEMG signal onset, width of the evoked action potential, and the peak-to-peak amplitude of the potential.
RESULTS: the mean CV was 4,06 m/s, the mean latency 14.7 m/s, the mean width was 25.2 m/s and mean peak-to-peak was amplitude 32 mV.
CONCLUSION: Deep tendon reflex was characterized with a novel technique including electrophysiological variables acquired using high-density surface EMG.

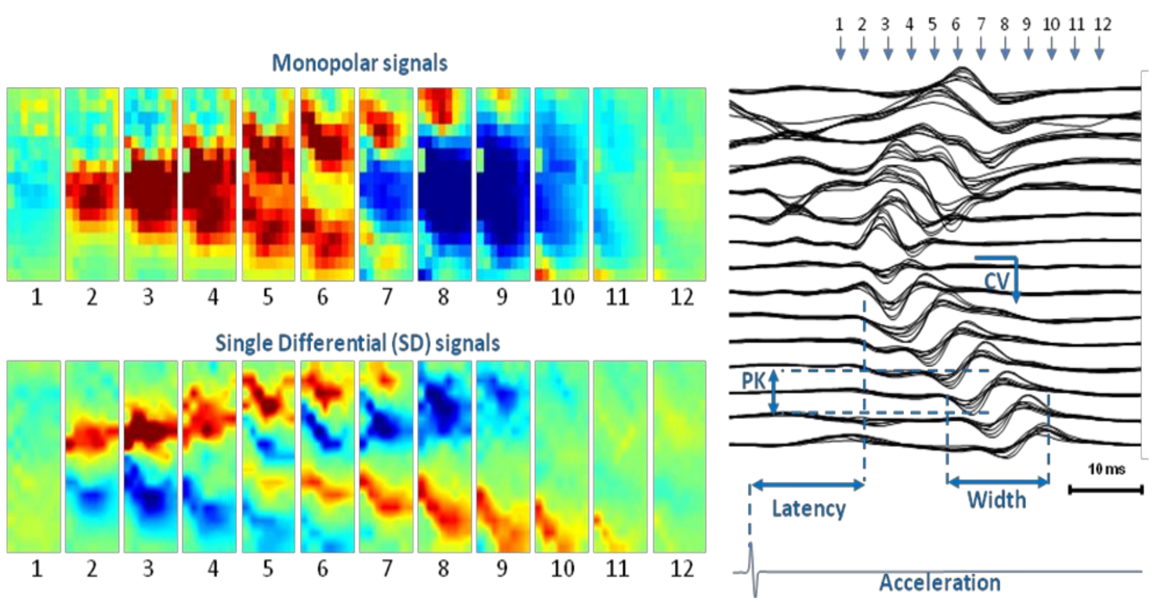

Figure 1: In the left side surface EMG maps of instantaneous amplitude. An example of surface EMG signals from one array together with the proposed electrophysiological variables.

SPATIAL DISTRIBUTION OF ACTION POTENTIALS OF GASTROCNEMIUS MOTOR UNITS IN STROKE SURVIORS

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AIM: In this study we compare the surface distribution of motor unit action potentials detected from healthy and paretic, medial gastrocnemius (MG) muscles.
METHODS: While seven stroke survivors stood upright, 15 surface electromyograms (EMGs) were recorded from their healthy and paretic MG muscle with an array of electrodes (1 cm interelectrode distance). EMGs were triggered with the firing patterns of individual motor units, identified through decomposition of intramuscular EMGs. The root mean square (RMS) amplitude of surface potentials was then computed for each channel. Finally, the standard deviation of Gaussian curves adjusted to RMS distributions (Figure) was considered to compare the spatial distribution of motor unit action potentials between limbs.
RESULTS: Thirty four MG motor units were identified, of which 13 in the paretic limb. The number of firings per second of all motor units was significantly correlated to changes in centre of pressure position in the sagittal plane (Pearson $R>0.56$; $P<0.05$ for all 34 cases). The surface distribution of motor units action potentials was represented equally locally in the EMGs collected for both limbs (Figure). Specifically, Gaussian curves were statistically similar for the paretic and healthy limbs (Mann-Whitney test; $P=0.51$; $N=7$ subjects).
CONCLUSION: Although we could not estimate the recruitment threshold of MG motor units analysed, all were associated to postural sways. The spatial distribution of surface potentials did not depend on the limb condition, paretic or healthy. These later results must however be carefully analysed in relation to MG architectural changes following stroke; architectural changes were quantified though not reported in the current study.
ACKNOWLEDGEMENT: Rede DOr são Luiz , Faperj e CNPq

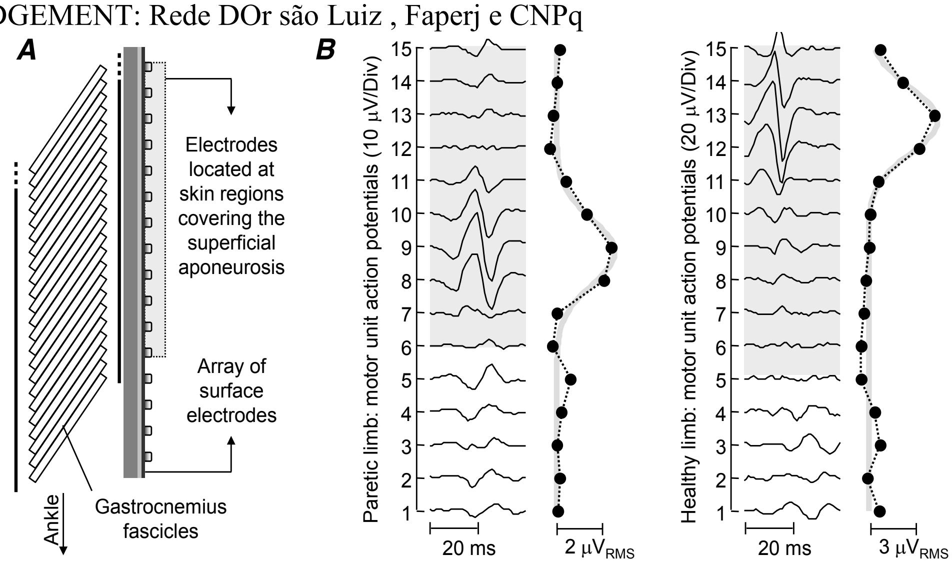

Figure: Electrode positioning (*A*) and representation of MG motor units in the surface EMGs (*B*).

EEG MONITORING OF ALFA ACTIVITY OCCURENCE DURING QI GONG PRACTICE

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AIM: Traditionally, electroencephalographic research describes the occurrence of alpha activity only in a relaxed state and with closed eyes. However, some recent studies have detected alpha activity during motor tasks such as cyclical repetitive movement. The aim of our study was to monitor the occurrence, frequency and distribution of scalp alpha activity during qi gong practice both with open and closed eyes.
METHODS: Five volunteers were tested (three men, two women), all with more than twelve month experience with qi gong practice. Basic, simple movements were selected which all volunteers were familiar with. They were asked to perform given movements first for ten minutes with open eyes and subsequently for ten minutes with closed eyes. Simultaneously, electroencephalographic activity was recorded with the telemetric 32-channel Nicolet EEG Wireless Amplifier by Natus Neurology Inc. The record of subjects performing movements was then compared with the native EEG recording recorded before qi gong practice.
RESULTS: During native EEG testing before qi gong practice (in a relaxed resting state with closed eyes) alpha activity was registered with four subjects. In the same fours subjects, alpha activity was also recorded during qi gong practice with closed eyes, and in three subjects also during qi gong practice movements with open eyes. Only with one subject there was beta activity both in the resting and exercising mode (both with open or closed eyes).
CONCLUSION: Many studies have looked into the correlation of brain activity and alpha activity. To sum up, it can be said that there is negative correlation between alpha activity and cerebral neocortex activity, and positive correlation between alpha activity and the deeper structures of the brain (thalamus, amygdala and insula, anterior cingulum and cerebellum). The results of this pilot study indicate that there is a subcortical stearing process for acquired movement stereotypes which are accompanied with a decrease in cerebral neocortex activity and an increase in the activity of certain limbic structures.
This article was written with support from the GAČR 13-07776P grant project.

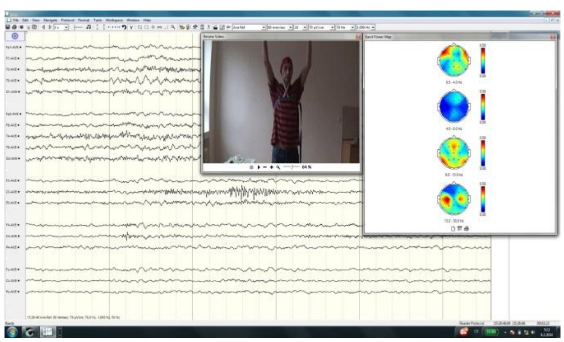

Figure 1: This graph illustrates an EEG record with video monitoring and brain mapping.

INTER-SESSION RELIABILITY OF TRAPEZIUS MUSCLE H-REFLEX

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AIM: The aim of this study was to investigate inter-session reliability of trapezius muscle H-reflex and the corresponding M-wave.
METHODS: The maximum H-reflex (H_{max}) was recorded from the middle part of the trapezius muscle by electrical stimulation of the C3/4 cervical nerves in 10 healthy young volunteers. The maximum M-wave (M_{max}) was measured by electrical stimulation of the accessory nerve. The maximum H-reflex, M-wave, and their ratios were obtained in two sessions separated by ~5 weeks. Inter-session reliability was estimated by intra-class correlation coefficients ($ICC_{2,1}$, for absolute agreement), standard error of measurement (SEM), and minimum detectable change (MDC). Paired t-test was performed in order to assess any difference between sessions. Bland-Altman plots were constructed and inspected visually for consistency of agreement through the range of measurements.
RESULTS: No statistically significant difference was observed between sessions ($p > 0.05$) and the H-reflex parameters showed substantial to almost perfect reliability (ICC = 0.63 – 0.85) (Table 1). For Hmax, all mean differences were close to zero (Figure 1).
CONCLUSION: This study indicates that the trapezius muscle H-reflex elicited by stimulation of the C3/4 cervical nerve is reliable between sessions separated by weeks. This is useful for investigations of the effects of strength training and rehabilitation on monosynaptic reflexes in the neck-shoulder region.
ACKNOWLEDGEMENT: This study was partly supported by grants from The Ministry of Culture Committee on Sports Research in Denmark, The Danish Rheumatism Association, and the Danish Council for Independent Research - Technology and Production Sciences.

Table 1: Inter-session reliability indicators of trapezius muscle H-reflex parameters.

Measure	$ICC_{2,1}$	SEM	MDC	Sig.
H_{max}	0.85	0.6 mV	1.4 mV	$p = 0.45$
M_{max}	0.63	1.5 mV	3.5 mV	$p = 0.08$
H_{max}/M_{max}	0.80	0.07	0.16	$p = 0.86$

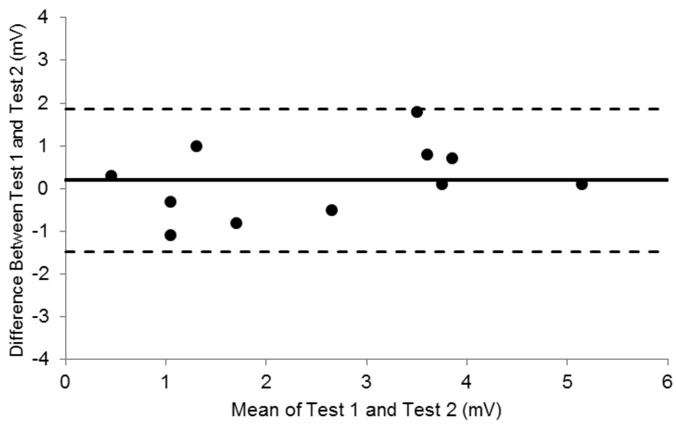

Figure 1: Bland-Altman plot for inter-session agreement for Hmax.

CORTICOMOTOR RESPONSES DURING A MENTAL ROTATION TASK PERFORMANCE

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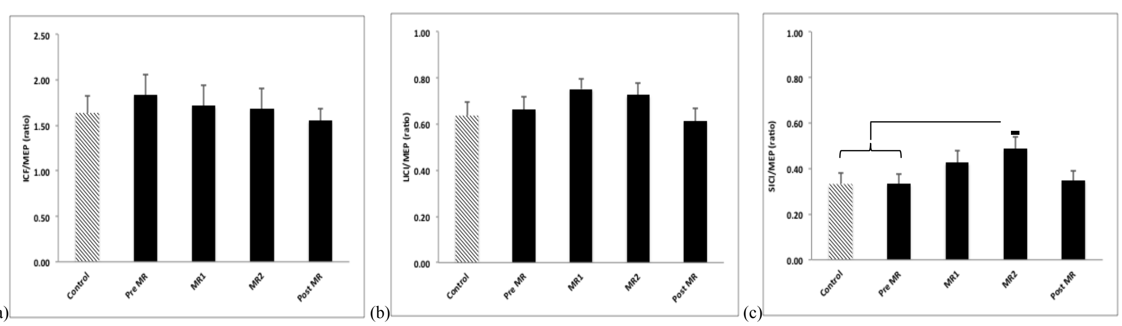
AIM: This study aimed to measure corticomotor excitability and intracortical inhibition using paired-pulse transcranial magnetic stimulation (TMS) during the performance of a mental rotation (MR) task.
METHODS: Twelve participants (20 - 45 years; 4 male), completed symbol MR (number) and control tasks during 3 TMS paired-pulse stimulation conditions: 1). Intracortical Facilitation (ICF, 12ms), 2). Long-Interval Cortical Inhibition (LICI, 100ms), 3). Short-Interval Cortical Inhibition (SICI, 2ms). Symbol MR tasks required the participant to respond to the computer as quickly as possible by identifying if the symbol (either the number ‘2’ or ‘7’) that was rotated (between 90° and 270°) on the computer monitor was conventional or mirrored. The control task required the participant to respond as quickly as possible to a neutral symbol (filled green box) that appeared on the screen. Two Magstim 200^2 TMS units, linked with a Bi-Stim adapter (Magstim, UK) delivered the stimuli via a 70 mm figure of eight coil over the M1 from which TMS elicited greatest motor evoked potential amplitude (MEP) of the first dorsal interosseous muscle in the contralateral hand during rest while the participant used their dominant hand to press responses to the symbols presented on the computer. MEP data for ICF, LICI and SICI were expressed as the ratio of their respective MEP amplitudes to the single pulse MEP amplitude, so that the data reflects their respective inhibitory or facilitatory effects. Mean data (± SE) was compared using repeated measures ANOVA. Alpha was set a p>.05.
RESULTS: During the mental rotation condition, no significant effects for either the ICF (Figure 1a) or the LICI (Figure 1b) conditions were observed (p>.05). In the SICI condition (Figure 1c), cortical inhibition significantly reduced (as observed as an increase in evoked potential amplitude) during the MR task relative to control and baseline (p=.01) and returned to baseline measures post MR task.
CONCLUSION: The data from this study demonstrates that during MR tasks, motor cortex excitability changes are modulated via the γ-amino-butyric acid type B ($GABA_B$) pathway, as observed in the change in SICI. These findings of *decreased* inhibitory activity might account for the lack of previous imaging evidence of motor cortex involvement in MR of abstract forms.



(a) (b) (c)

Figure 1 (a-c): Control and MR time course data for ICF (a), LICI (b), and SICI (c).
* Indicates significant difference to control and pre MR data (p>.05).

THE EFFECT OF ACUTE SPORTS CONCUSSION ON CORTICOMOTOR EXCITABILITY IN AUSTRALIAN FOOTBALL PLAYERS

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AIM: The aim of this study was to measure the neurophysiological, neurocognitive and functional changes, during the acute phase (24 hours to 10 days post), following a sports-related concussion in Australian football players.

METHODS: Forty male players (mean age 25.7 ± 4.5 years) from one Australian football club volunteered to participate in the study. Prior to the start of the football season, all participants completed measures of fine dexterity, visuomotor reaction time (time from stimulus presentation to onset of movement) and movement time (time from initiation of movement to target stimulus), and neurocognitive assessments (implicit learning and attentional focus). Transcranial magnetic stimulation (TMS) was used to measure motor cortex excitability (motor evoked potential 125% of active motor threshold, normalised to maximal M-wave), and intracortical inhibition (cortical silent period [cSP], short-interval intracortical inhibition [SICI] normalised to resting MEP at 125% of resting motor threshold). Throughout the season, as participants were identified having sustained a game-related concussion they were tested at 24 hours, 96 hours and 10 days post concussion. At the end of the season, players who did not receive a concussion injury returned to the laboratory for comparative testing at similar time points. Mixed-design repeated measures ANOVA (with post-hoc pair-wise analyses) was used to compare differences across groups and time.

RESULTS: Ten players were excluded prior to testing due to sustaining a sports-related concussion in the previous 12 months. During the course of the season 8 players (mean age 25.0 ± 4.6 years) were diagnosed having sustained a concussion, compared to 15 non-injured players (mean age 25.3 ± 4.4 years). Concussed players showed changes in fine dexterity over time ($F_{2.3,\ 46.7}$=26.82; p<.001) but not between groups ($F_{1,20}$=.22; p=.64). Visuomotor reaction time was found to have slowed in the concussion players ($F_{2,\ 40.2}$=12.2; p<.001) at 24 hours post concussion (44.8 ms; p<.001) and 96 hours (15 ms; p<.02). Similarly, visuomotor movement time was observed to be slower in concussed players ($F_{2.8,57.5}$=3.27; p=.04) at 24 hours (29.33 ms; p<.04) post concussion. No differences were observed between groups for implicit learning ($F_{3,\ 59.8}$=1.57; p=.21), however concussed players performed significantly worse in the attentional focusing task ($F_{2.4,\ 49.4}$=12.57; p=<.001) at all time points post concussion (24 hr p<.02; 96 hr p<.01; 10 d p<.04). No differences between groups were found in MEP/M-wave measures ($F_{1.6,\ 33.5}$=.61; p=.52) or SICI ratio ($F_{1.7,\ 34}$=1.81; p=.18); however cortical silent period duration was found to have significantly increased in the concussed group ($F_{2.7,\ 54}$=5.99; p=.002), showing a mean lengthening of 13 ms (p=.04) and 15 ms (p=.02) at 24 and 96 hours respectively.

CONCLUSION: This is the first study to measure the neurophysiological responses in the motor cortex of athletes sustaining a sports-related concussion during the acute phase post-concussion. In summary, the data demonstrate that following a concussion injury, intracortical inhibition is increased in the acute phase as well as observable reductions in visuomotor reaction and movement time performance and attention ability.

ACKNOWLEDGEMENT: This study was funded in part by Smart Head Play foundation.

EFFECT OF REPETITIVE ROTATOR EXERCISE ON THE CORTICOSPINAL EXCITABILITY OF THE INFRASPINATUS MUSCLE DURING SHOULDER JOINT ABDUCTION

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AIM: Repetitive rotator exercise is frequently performed as therapy for patients with impaired abduction of the shoulder joint. This exercise aims to increase an acute corticospinal plasticity to recruit external rotator muscles during the shoulder joint abduction, rather than to strengthen muscles. However, it is unclear whether repeated rotator exercise has the intended effect. This study aimed to clarify the effect of repetitive rotator exercise on corticospinal tract excitability, which controls the external rotator muscles during shoulder joint abduction.

METHODS: Eleven healthy young subjects (11 men; age 21.9±1.0 years, height 171.9±4.1cm, weight 69.1±8.6kg) participated in this experiment. We examined the corticospinal excitability before and after the rotator exercise by using transcranial magnetic stimulation (TMS). The interventional exercise in the scapular plane was external rotation of the right shoulder with a load of 500 g. The exercise was repeated 100 times every 15 minutes, for a total of 300 repetitions. The corticospinal excitability during shoulder joint abduction was measured by using motor-evoked potential (MEP). TMS was applied to induce MEP in the infraspinatus, middle deltoid, posterior deltoid, and lower trapezius muscles during the isometric shoulder joint abduction. The abduction was performed with 20° abduction in the scapular plane. MEP was measured twice before exercise (pre1, pre2), immediately after each exercise (post0, post15, post30), further, and 60 minutes and 90 minutes after the first exercise ended (post60, post90). As an index of muscle fatigue, integrated electromyogram (iEMG) and median power frequency (MDF) were calculated from the background electromyogram for 500 ms just before TMS. One-way repeated ANOVA with Dunnett's post-hoc test was used to assess the effect on the MEP amplitude of the time factors. The significance level was $p = 0.05$.

RESULTS: The MEP amplitude of the infraspinatus muscle was significantly increased until 90 minutes after post0 in comparison with pre1 (Fig. 1), whereas there was no significant difference in MEP amplitudes of other muscles. The iEMG and MDF did not change significantly in all muscles.

CONCLUSION: The present study demonstrated that the corticospinal excitability of the infraspinatus muscle selectively increased during shoulder joint abduction after the intervention exercise. The iEMG and MDF results indicated no muscle fatigue. This finding suggests that the repetitive shoulder joint external rotation can enhance recruitment of the external rotator muscles in the unconsciously during shoulder abduction.

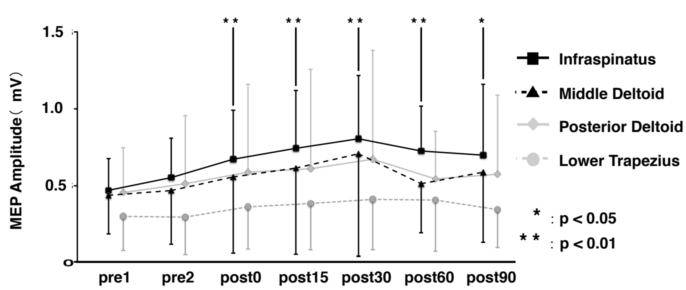

Fig. 1: The average of MEP amplitude.

NEUROMUSCULAR ASYMMETRIES IN ANTERIOR CRUCIATE LIGAMENT PATIENTS AND IN HEALTHY SUBJECTS USING THE TWITCH INTERPOLATION TECHNIQUE

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AIM: The objective of this methodological study was to examine the validity of the twitch interpolation technique for evaluating neuromuscular quadriceps asymmetries.

METHODS: Fifty-seven subjects participated in the study (19 healthy, 24 with unilaterally- and 14 with bilaterally-reconstructed anterior cruciate ligament). Supramaximal electrical paired stimuli were delivered to the quadriceps muscle during and after maximal voluntary contractions (MVC). The main outcomes were left and right MVC torque, activation level (AL) and resting doublet (DB) torque. Percent asymmetries between the left and the right side were computed for each parameter and MVC asymmetry (representing strength asymmetry) was plotted against AL (“neural”) asymmetry and DB (“contractile”) asymmetry.

RESULTS: Significant positive correlations were observed between AL asymmetry and MVC asymmetry ($r=0.404$; $p=0.004$) and between DB asymmetry and MVC asymmetry ($r=0.506$; $p<0.001$). An index of global neuromuscular asymmetry was then computed by summing up AL and DB asymmetries. This neuromuscular asymmetry index was strongly correlated with MVC asymmetry ($r=0.649$; $p<0.001$).

CONCLUSION: These results establish the validity of the twitch interpolation technique, which is based on the simple analysis of voluntary and evoked torque traces, for the evaluation of neuromuscular quadriceps asymmetries. Our present findings also provide new insights into the contribution of neural (activation level) and muscular (contractility) mechanisms to voluntary force-generation capacity of the quadriceps femoris muscle.

ACKNOWLEDGEMENT: The study was supported by the Yellow P-Sport Foundation.

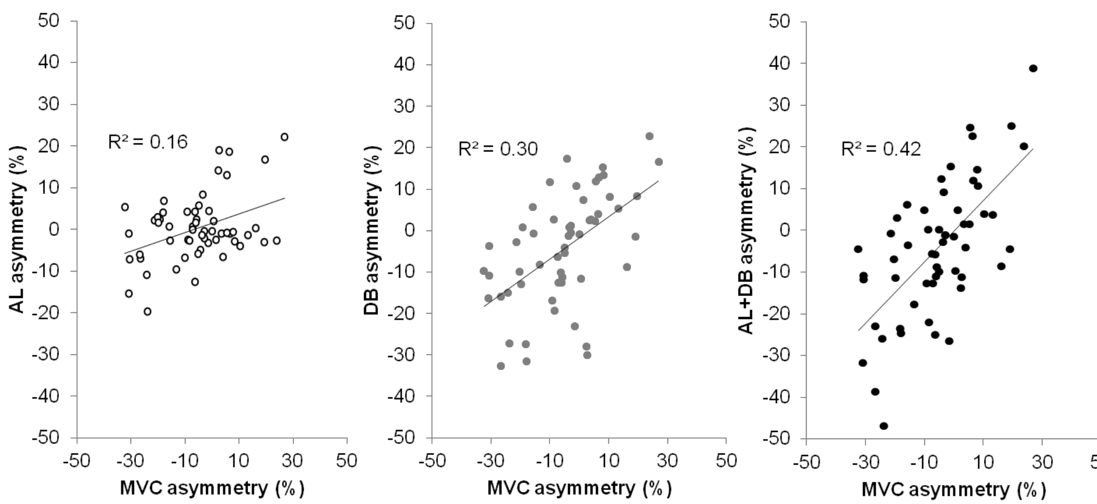

Figure 1: Correlations between MVC asymmetry and neuromuscular asymmetries.

CAN TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION AFFECT THE CORTICAL EXCITABILITY IN THE PRIMARY MOTOR CORTEX?

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AIM: Transcutaneous electrical nerve stimulation (TENS) is widely used for pain control, muscle re-education and nerve stimulation. Cochrane review had confirmed that TENS can be applied on head to improve cognition, which indicated that TENS should be classified as one kind of the non-invasive brain stimulation (NIBS) techniques. NIBS techniques such as transcranial magnetic stimulation (TMS), transcranial direct current and alternative current stimulation (tDCS, tACS) can modulate the cortical excitability in human brain and improve motor performance. TENS is cost-effective and convenient in clinical use, but the effects of TENS application on cortical cortex remains unknown. This study aims to investigate whether TENS could change the cortical excitability in primary motor cortex (M1).
METHODS: Twenty-four healthy adults (mean age: 22.45 y/o) received 15 Hz, 120 Hz TENS and sham stimulation in randomized order over the M1. Each stimulation last for twenty minutes and were applied in different days. TMS was used to evaluate the cortical excitability of M1, including the motor-evoked potential (MEP), short-interval intracortical inhibition (SICI) and intracortical facilitation (ICF). Finger pinch task was used to assess motor performance. Both TMS and finger pinch task were assessed at baseline, immediately after stimulation, and at 30 and 60 minutes follow up.
RESULTS: MEP, normalized MEP, SICI and ICF were significant increased immediately after 15 Hz stimulation (p=0.029, 0.002, 0.002, <0.001, respectively). Normalized MEP was significant increased immediately after 120 Hz stimulation (p=0.007). No significant change of cortical excitability was found after sham stimulation. There was no significant change of motor performance in all groups.
CONCLUSION: Application of TENS could significantly change the cortical excitability of M1. TENS stimulation with 15 Hz was more effective than stimulation with 120 Hz. The findings may inform further research on TENS application as NIBS.

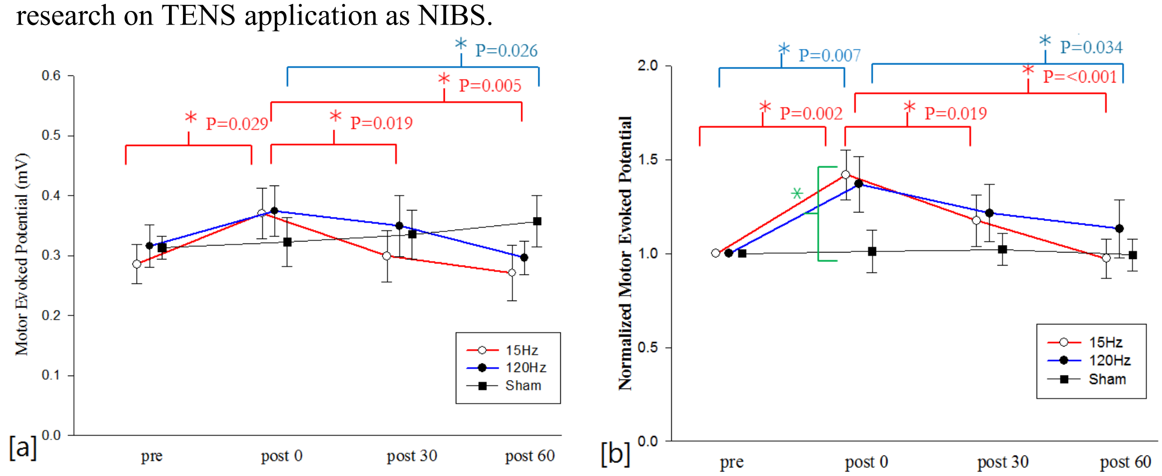

Figure 1: [a] MEP and [b] normalized MEP changes before and after 20 minutes application of TENS, and follow up 30 and 60 minutes under 3 conditions, 15Hz, 120 Hz and sham stimulation.

TEMPORAL CORRELATION BETWEEN INTRA-ABDOMINAL PRESSURE AND LOW-FREQUENCY RECTIFIED EMG OF TRUNK MUSCLES DURING ABDOMINAL BRACING

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AIM: Early electromyographic (EMG) studies have revealed that stable intra-abdominal pressure (IAP) by the co-contraction in the trunk muscles (bracing) plays a functional role to stabilize the spine. However, it is unknown which muscle predominantly acts for making stable IAP during steady bracing task. The purpose of this study was to examine the role of individual trunk muscles for stable IAP during steady bracing tasks at different IAP levels. METHODS: Six healthy young adults (20-23 yrs) were instructed to increase IAP without any trunk flexion/extension forces by voluntary co-contractions of the trunk muscles (bracing) at the supine position. IPA was measured by a pressure transducer placed in the rectum. Subjects matched the IAP to the target level with visual guidance as an IAP matching task (20, 40, and 60% of maximal IAP) for ~12 s. In addition to IAP, surface EMGs from the rectus abdominis (RA), oblique external (OE), oblique internal (OI), and rector spine (RS) muscles (bipolar configuration with a 2-cm inter-electrode distance) were simultaneously recorded at 2000 samples/s. Surface EMG was band-pass filtered (5-1000 Hz), full-wave rectified, and then low-pass filtered < 5 Hz (rEMG). Cross correlation function (CCF) between IAP and each of rEMGs for individual muscles was determined for the middle 8.192 s

RESULTS: At all IAP levels, a clear peak was observed in the CCF between rEMG of OI and IAP ($r = 0.17$-0.46) in all subjects, and this peak was significantly larger compared with that between IAP and rEMGs of other muscles ($P < 0.001$). The peak in CCF between IAP and rEMGs except for OI was sometimes not present especially at lower IAP level.

CONCLUSION: The results suggest that the oblique internal muscle is predominantly important for achieving stable IAP and would be recruited in a coordinated manner to stabilize the spine during steady bracing task.

ACKNOWLEDGEMENT: Supported in part by Grant-in-Aid for Scientific Research (B) in Japan to YY.

METHODOLOGICAL STUDY OF SCIATIC NERVE STIMULATION BY USING A MAGNETIC AUGMENTED TRANSLUMBOSACRAL STIMULATION COIL

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AIM: Transcutaneous magnetic stimulation can be used to induce peripheral nerve stimulation, similar to electrical stimulation. However, it is anatomically difficult to stimulate the sciatic nerve using electrical stimulation. We previously reported the findings of our methodological study on sciatic nerve stimulation by using transcutaneous magnetic stimulation at ISEK 2012. We reported that the evoked electromyographic activity induced by magnetic stimulation did not attain the supramaximal level. Here, we aimed to investigate whether transcutaneous magnetic stimulation by using a magnetic augmented translumbosacral stimulation coil can induce compound muscle action potentials (CMAP) of the semitendinosus muscle via the sciatic nerve.

METHODS: Fifteen healthy males participated in this study. Each subject knelt on a bed, with the stomach placed in a prone position on a box. Transcutaneous magnetic stimulation was produced by a magnetic stimulator that was connected to a magnetic augmented translumbosacral stimulation coil. The stimulation spots were defined as a 49-point grid above the line connecting the greater trochanter of the femur and ischial tuberosity. Each spot was stimulated at 100% intensity of the magnetic stimulator, with 3 stimuli. The map of each subject was calculated on the basis of the center of gravity and normalized by the maximal amplitude. At the hotspot of the semitendinosus muscle, stimulation of 10–100% of the intensity of the magnetic stimulator was induced. We recorded the twitch force and the CMAP from the semitendinosus muscle.

RESULTS: By using transcutaneous magnetic stimulation of the sciatic nerve, we could assess the map of CMAP from the semitendinosus muscle. Twitch force depended on the intensity of magnetic stimulation, and reached a plateau.

CONCLUSION: Thus, transcutaneous magnetic stimulation by using a magnetic augmented translumbosacral stimulation coil can stimulate the sciatic nerve. The CMAP from the semitendinosus muscle and twitch force induced by magnetic stimulation achieved supramaximal or constant stimulation of the sciatic nerve. Transcutaneous magnetic stimulation by using a magnetic augmented translumbosacral stimulation coil is useful to record CMAP of the semitendinosus muscle and twitch force induced by the sciatic nerve.

ACKNOWLEDGEMENT: This work was supported by JSPS KAKENHI Grant Number 2575210.

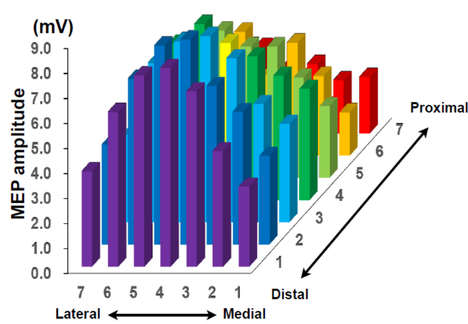

Figure 1: Typical map of CMAP from the semitendinosus muscle in 1 subject.

PLANTAR FLEXOR STRENGTH GAIN INDEPENDENTLY INCREASED FROM MUSCLE ACTIVATION AND H-REFLEX AFTER SHORT-TERM CALF-RAISE TRAINING IN HUMANS

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INTRODUCTION: Proprioceptive inputs during dynamic resistance training affect resting muscle via spinal and/or supraspinal pathways.
AIM: The purpose of the study was to examine maximum voluntary isometric contraction (MVIC) torque of plantar flexors, voluntary activation (VA) assessed by twitch interpolation technique and spinal reflex assessed by Hoffmann (H) reflex before and after 5 days calf-raise training in healthy subjects.
METHODS: Twelve volunteers were randomly allocated into a resistance training group (RT, n=6) or control group (CONT, n=6). The training consisted of 4 sets of right leg calf-raise in standing position with fifteen 5-sec isometric contractions for 5 days.
They were seated supine position with the ankle joint at 0 degree, knee flexion at 60 degrees, and hip flexion at 60 degrees in Biodex System 3. Ankle was securely fixed on footplate and maintain 0 degree during experiment. Muscle activation was recorded by supramaximum doublet stimulation of tibial nerve of the ipsilateral leg during 3 seconds MVIC plateau (superimposed twitch) and after MVIC at rest (potentiated twitch). %VA was calculated by Allen's formula. Soleus H-reflex was electrically elicited by tibial nerve stimulation at rest. Peak to peak amplitudes of maximum H-reflex (Hmax) and M-wave (Mmax) were recorded and calculated Hmax/Mmax (HM) ratio. Repeated multivariate analysis of variance (rmANOVA) was used to determine overall interaction [group (training vs control) x trial (pre-post)] in dependent variables (torque, %VA, HM ratio). Correlation analysis was used to determine relation among these variables.
RESULTS: There were no overall interaction (Wilk's Lambda = 0.805, $F(3, 8) = 0.646$, $P = 0.607$). MVIC torque significantly increased from 90.4 Nm to 109.6 Nm ($P < 0.01$) whereas %VA ($P = 0.45$) and HM ratio ($P = 0.64$) did not change after training in pooled analysis. Changes in MVIC torque was not correlated to MVIC torque ($r = 0.05$, $P = 0.88$), %VA ($r = 0.09$, $P = 0.78$) and HM ratio ($r = 0.21$, $P = 0.51$) before training.
CONCLUSION: The result shows plantar flexor strength gain independently increased from muscle activation and H-reflex after short-term calf-raise training in healthy humans.
ACKNOWLEDGEMENT: Part of the study was funded by Meiji Yasuda Life Foundation of Health and Welfare.

PROPORTIONAL ACTIVATION CHANGES IN TRICEPS SURAE DURING PRE, INITIAL AND PROPULSION PHASES OF A DROP JUMP

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AIM: To show the variation in proportional muscle activation contribution of the triceps surae across the time course of a drop jump.

METHODS: Subjects (n=15) performed 6 drop jumps. EMG electrodes were attached to the medial and lateral gastrocnemius (MG; LG) and the soleus (SOL) of the dominant limb. EMG was synchronized with a force plate to provide time dependent variables. Mean EMG (mV) was calculated for each time phase. Mean EMG of each individual muscle was represented as a portion of the pooled muscle activation (SOL mV + MG mV + LG mV). Definition of the phases were as follows; Pre- 100ms prior to contact, Initial contact to 40ms post contact; Post- post 40ms to end of contact time. One way ANOVA with bonferroni post hocs were used to assess between phase differences ($p<0.05$).

RESULTS: The MG contributed more pooled activation than SOL (P=0.0001; ES: 1.55) and LG (P=0.0001; ES: 1.85) in the Pre phase. The SOL contributed a larger proportion than the MG (P=0.0001; ES: 1.59) and LG (P=0.0001; ES: 0.76) in the Initial Phase. No diffs occurred in the propulsion phase (Figure 1). Initial and Post phase total muscle activation was greater than the Pre phase (P=0.0001).

CONCLUSION: This study has indicated that proportional contributions to pooled muscle activation vary according to the phase of the jump. The larger proportion of activity by the MG in the pre- phase indicates that prior to contact the ankle is stiffened which would minimize ankle rotation velocity[1]. The increased contribution of the soleus in the initial contact phase suggests it plays a more important role in controlling ankle stiffness on impact with the ground which agrees with prior research[2]. Peak EMG values have been shown to occur during amortization phases where there is an initial shortening of the muscle and tendinous release [3,4]. This indicates that in the phase of the DJ where maximal force and activation occurs, there is an even contribution of all triceps surae to producing the movement.

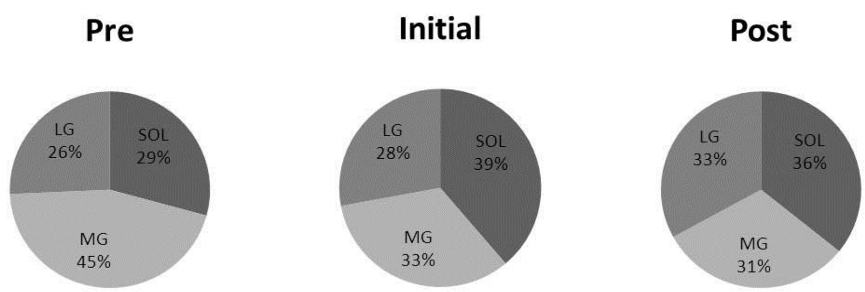

Figure 1: Proportional contribution of the triceps surae during a drop jump.

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MEASUREMENT OF CEREBRAL BLOOD FLOWS AT THE TIME OF THE DASH START USING NIRS

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AIM: In track and field, the reaction to the sound at the time of a start is an important index which influences game results. In this research, in order to investigate the difference for a reaction about the experienced person and an inexperienced person in track and field.
METHODS: We measured the cerebral blood flow at the prefrontal area and hearing field, when the subject was hearing the sound of "On your mark", "Get set", "Go", using NIRS
RESULTS: As the result of the experiment, while the cerebral blood flow changed temporally in the experienced person, in an inexperienced person, it hardly changed. Especially, while the blood flow of the prefrontal area fell from immediately after the signal of "Get set", the blood flow of a hearing field increases as shown in figure 1. This phenomenon was not found in an inexperienced person as shown in figure 2. We consider that this phenomenon means that the experienced person gained concentration by training.
CONCLUSION: We measured cerebral blood flow in order to investigate the difference of reaction for sound between experienced person and inexperienced person in track field. The result of the experienced shows that we are able to diagnose the concentration from cerebral blood flow using NIRS.

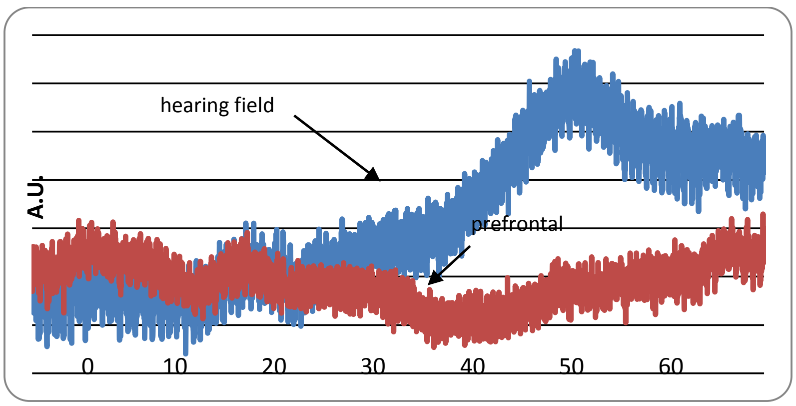

Figure 1: Blood flow of the experienced person

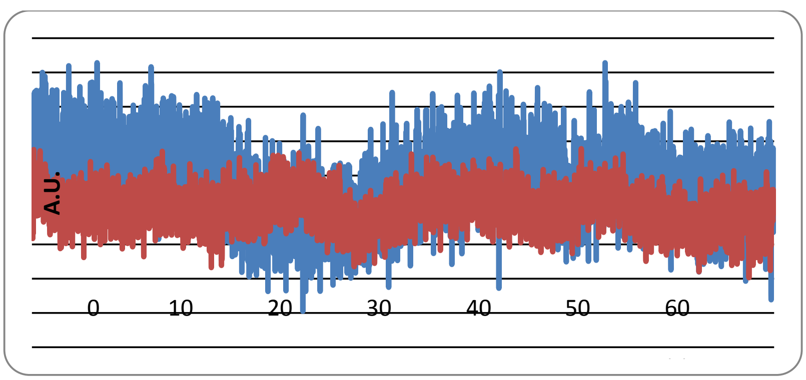

Figure 2: Blood flow of the inexperienced person

TEST-RETEST RELIABILITY OF MECHANICAL MEASUREMENTS OF VASTUS LATERALIS MUSCLE IN YOUNG ADULTS

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AIMS: This pilot study aimed to examine the test-retest reliability of muscle mechanical properties in young adults by comparing over two days muscle architecture (MA), skeletal muscle stiffness (MS) and musculo-articular stiffness (MAS) measurements.
METHODS: Twelve healthy young volunteers (5 males and 7 females, age 22.3 $\pm$ 2.4) were tested on two separate days. Firstly, knee-extensor maximal voluntary isometric contraction (MVIC) was tested. MA parameters of the vastus lateralis (VL) were obtained by ultrasonography, with measurements taken at 60% of the distance from the lateral femoral epicondyle to the greater trochanter, with the participant positioned in supine lying with the knee joint fully extended. MS of the VL was measured via myotonometry at 2/3 of the distance between the anterior superior iliac spine and the lateral border of the patella both at rest and during muscle contraction (20% MVIC). MAS was measured with free-oscillation technique, using sub-maximal loads (20% MVIC). Intraclass correlation coefficients (ICCs) with 95% confidence intervals (CI) and minimum detectable change (MDC) expressed as absolute and percentage values were calculated to determine inter-session reliability.
RESULTS: all parameters including: VL muscle thickness, pennation angle, fascicle length, MAS supported load of 20% MVIC, MS at relax and during muscle contraction (20% MVIC) showed excellent reliability. No significant difference was observed between two days (paired samples t-test).
CONCLUSION: This pilot study suggests that the measurements of VL MA, MS and MAS are all reliable procedures. Therefore, this study suggests that B-mode ultrasonography, Myotonometry and free-oscillation technique can be used with confidence to investigate changes in muscle mechanics in groups of young adults.

Table 1:

	Mean (SD) Day 1	Mean (SD) Day 2	ICC (95% CI)	MDC	MDC%
Muscle Thickness (cm)	2.248 (0.271)	2.260 (0.232)	0.967 (0.884-0.990)	0.124	5.51%
Pennation Angle (degree)	12.85 (2.11)	12.96 (1.79)	0.964 (0.874-0.990)	1.006	7.80%
Fascicle Length (cm)	9.709 (0.672)	9.887 (0.671)	0.827 (0.400-0.950)	0.764	7.80%
MAS (20% MVIC) (Nm^{-1})	976.44 (346.89)	965.48 (437.23)	0.910 (0.687-0.974)	321.000	33.06%
MS (relaxed) (Nm^{-1})	364.52 (50.38)	358.12 (35.35)	0.817 (0.363-0.947)	50.616	14.01%
MS (20% MVIC) (Nm^{-1})	427.63 (72.14)	417.62 (73.85)	0.886 (0.604-0.967)	66.990	15.85%

STUDY OF MUSCLE FATIGUE CHARACTERIZATION METHOD USING THE SURFACE EMG IN TABLE TENNIS

With a focus on upper arm muscle groups of repeat forehand drive strokes–

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In this study, to clarify the characteristics of the upper arm muscles fatigue trend during forehand drive strokes repeatedly. For performing many matches throughout the day in the Table Tennis competition, players need muscular endurance. In addition, the accumulation of fatigue will also lead injury. The purpose of study was also discussion of the possibility by using the surface EMGs to evaluate the muscle fatigue in the actual motion (forehand drive strokes) of the table tennis.

The measurement system was composed of the 16 channels wireless unit with the two-bar active electrodes (Myomonitor IV and DE-2.1, Delsys) for the EMG signals and Goniometer to measure changes in the elbow joint angle. Signals were sampled at 1000 Hz at a 16-bit resolution using the attachment software (EMGWorks 3.5, Delsys). The target muscles were triceps and biceps of racket hand side. Subjects were 6 advanced players and 11 intermediate players. Subjects were performed one stroke per second, the strokes of the forehand drive were total of 180 times for 3 minutes. The ARV (Averaged Rectified Value) and MPF (Mean Power Frequency) were calculated from EMG signals extracted per each stroke by using Goniometer signals.

The results and conclusion are followed.

Since the downward trend of MPF and increasing tendency of ARV by muscle fatigue is clearly seen, the muscle fatigue evaluation of upper limb in table tennis is possible by this method.

As shown in the figure, there is a difference in the decline of MPF both of biceps and triceps between the Intermediate players group and Advanced players group, it was found that the tendency of muscle fatigue is different depending on the competition level.

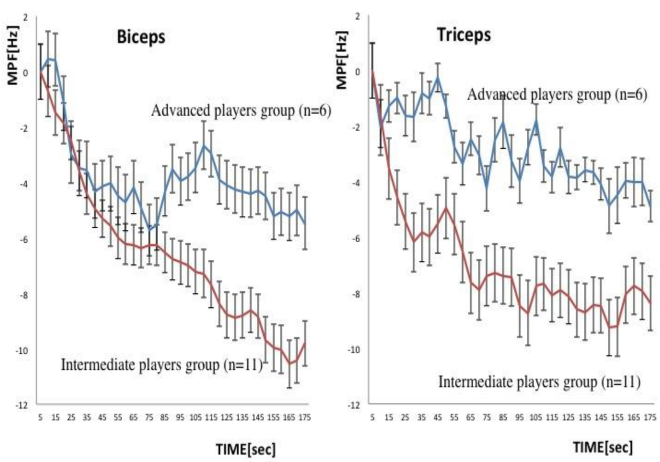

Fig. MPF changes in competition by levels

0 as the initial value of measurement start time, and shows the subsequent changes.

STUDY OF DYNAMIC POSTURE CONTROL ON THE INSTABILITY SITUATION

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We studied the relevance of static posture control and dynamic posture control from trajectory of body sway. It is substantiated about dynamic posture control being more important when thinking from a viewpoint of overturn-preventive. Although hip Joint-strategy and Ankle-strategy are used in dynamic posture control, By Functional Reach Test which is one of the measurement of dynamic posture control, it thinks it more effective to use ankle-strategy. Moreover, while it fixes and arthro is stabilized, correction when posture is broken down is difficult for carrying out co-contraction made to constrictive both flexor muscle and extensor muscle of arthro. By this research, co-contraction of ankle muscle examines whether it is related to dynamic posture control using EMG and stabilometer paying attention to ankle muscle. The subject considered it as 11 healthy male colleges, and measured four places of anterior tibialis of both legs, and gastrocnemius.
body sway to order was imposed on stabilometer as measurement of dynamic posture control, and relation nature with co-contraction was tried.

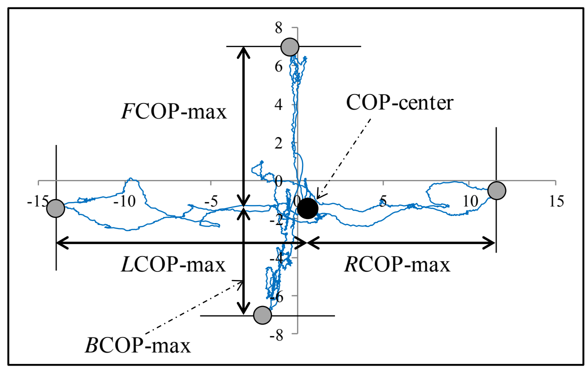

Table 1: Mean ± standard deviation of Cross Test（%COP）

	%FCOP		%BCOP	
	front	rear	front	rear
Rest	29.7±6.8	32.0±8.2	24.5±4.6	23.5±5.9
Intervention	33.0±7.5	31.2±8.7	23.7±5.3	25.8±4.8

%LCOP		%RCOP	
front	rear	front	Rear
111.7±22.8	114.9±25.8	110.6±18.5	110.4±18.7
119.6±23.9	119.2±27.7	121.8±17.9	119.3±20.4

Poster Session 2 – (Poster Area 16.00)

DELAYED EFFECTS OF SHORT TIME STATIC STRETCHING

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AIM: To determinate the duration of the effects caused by Intermittent Static Stretching (ISS) on muscle elongation within a range of time of 3 minutes and 7 days after the last performed stretching exercise.
METHODS: Eighteen fitness active subjects aged 20-30 years (age 24±3 years, weight 69±10 height 172±10) were divided in two group: 9 subjects were randomly assigned to the Experimental Group (EG) and the remaining 9 people formed the Control Group (CG). Both groups were tested using the sit and reach test. The experimental group used the sit and reach protocol also as experimental exercise. The EG performed 12 set of 1 maximal stretching, maintaining the static position 2±1 seconds with a 30 seconds rest among the sets. The CG performed just a set to register its basal condition and did not practice the entire protocol. Test were taken for both groups at 3, 6, 9, 12, 15, 30, 45, 60, 60, 120 minutes, after 4, 24, 48, 72 hours and the end 7 days after the last stretching set (EG) or basal condition measurement (CG).
RESULTS: Friedman and Dunn's Post Hoc tests were used for statistical analysis. Results showed (Figure 1) in EG increasing in basal R.O.M. ($p< 0,001$, +21%). In addition, this result is maintained for 48 hours. In the same group statistically significant decrease of gained ROM was identified at 72 hours ($p<0,001$, -8%) and 7 days ($p<0,001$, 10%) after the last ISS set Instead, no significant differences were found in CG.
CONCLUSION: The results of this study showed the duration of ISS stretching effects, giving the possibility to plan weekly the flexibility training during a microcycle .

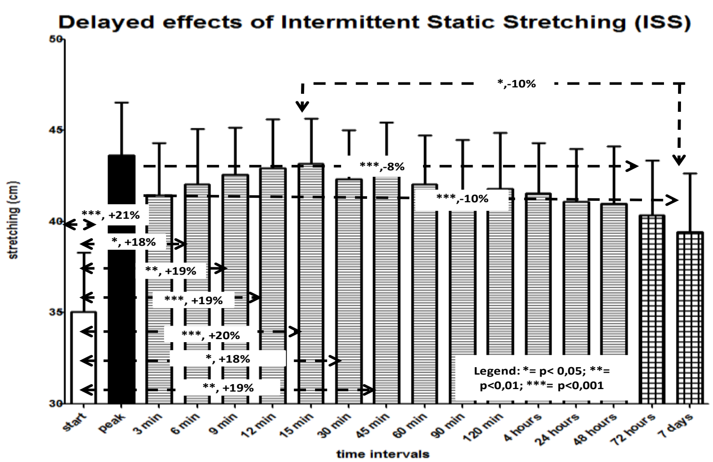

Figure 1: The graph shows the delayed effects of a short duration stretching session.

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STRENGTH TRAINING AND WHEELCHAIR TENNIS: A LONGITUDINAL STUDY

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AIM
To investigate the variation of isomeric maximal voluntary contraction (MVC) without (NR) and with racquets (R) in relation to specific weightlifting training on the trunk and upper limb muscles in a group of wheelchair tennis athletes.
METHODS
Twelve wheelchair tennis (WT) athletes, with different levels of disability, were studied. The subjects were divided into two groups of six athletes: 1) the experimental group (EG) in addiction of tennis training on field, following eight weeks (WKs) of weightlifting training; 2) the control group (CG) do not change their tennis training habits. At the beginning of the research EG performed four WKs of weightlifting training to avoid that the learning effect worse the technique of exercises used in training protocols. At the end of four weeks of training, the weightlifting training protocol began. All groups were evaluated before and after two months of training to verify the effects of weightlifting and tennis training. The isometric MVC was measured using the TESYS system (Total Evaluation System, Globus, Treviso, Italy) which was connected to a load cell (ESYCC300, Globus Italy, Treviso, Italy).
RESULTS
Data analysis (Wilcoxon test) showed a significant increase in MVC in EG in the NR ($p<0.05$, +16%) and R conditions ($p<0.05$, +11%). No significant changes were observed in CG (Figure 1).
CONCLUSION
The weightlifting training increases the isometric MVC of NR and R, while playing only tennis is sufficient to maintain strength performance. The results highlight that training with overloads can significantly contribute to improve physical efficiency on upper body in wheelchair tennis athletes and so facilitate them to become more dangerous to opponents.

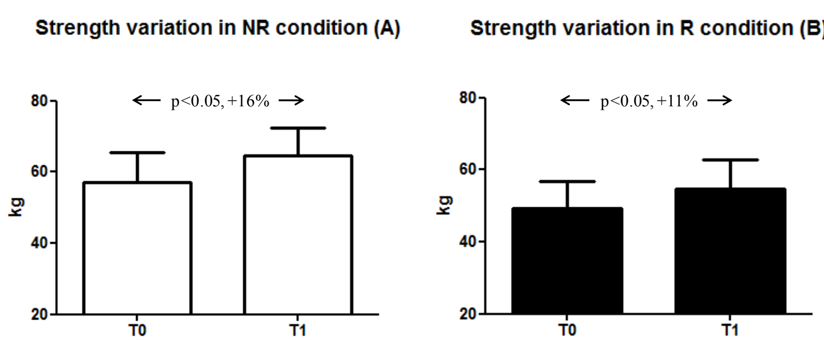

Figure 1: Isometric MVC in EG: NR (A) and R conditions (B).

SUB THRESHOLD TRAINING EFFECTS ON OXYGEN UPTAKE KINETICS AND MUSCLE ACTIVITY

Onarici Gungor E[1], Yilmaz I[1], Kurdak S[2], Soylu R[3], Ertan H[1]

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AIM: The purpose of this study was to determine the effects of sub threshold effects on oxygen uptake kinetics and electromyographic activity of vastus lateralis muscle.
METHODS: Twelve male subjects undertook 6 week of sub threshold training 4 days per week for 30 min per session. Before and after the training program, the subjects performed an incremental bicycle test ($20W.dk^{-1}$) to exhaustion for the determination of the LT and the VO_{2maks} and 6 min square wave transitions from a 3 min baseline to a workload equivalent to %80 lactate threshold. Oxygen uptake (breath by breath) and muscle activation of vastus lateralis were measured continuously throughout baseline and exercise transition.
RESULTS: $VO_{2\ max}$ and LT was increased significantly after sub threshold training. VO_2gain and time constant was reduced after 6 week training period ($P<0.05$). But there is no statistically significant difference vastus lateralis iEMG before and after exercise period.
CONCLUSION: In conclusion, this study resulted in the increase of the rate of adaptation of oxidative phosphorylation at exercise onset after 6 week of sub threshold training. Training program and measurement protocol was at sub threshold level and there was no slow component rise in oxygen uptake. So vastus lateralis iEMG was not change after the training.

Table 1: Results of Oxygen Uptake Kinetics Before and After the Six week Exercise Period

VO_2 gain (ml/dk/W)		Time Constant (s)	
Pre Test M	**Post Test**	**Pre Test**	**Post Test**
12.41	11.55	31.1	27.6

A STUDY OF NECK AND SHOULDER MUSCLE ACTIVITY WHEN USING PORTABLE TOUCHSCREEN DEVICES

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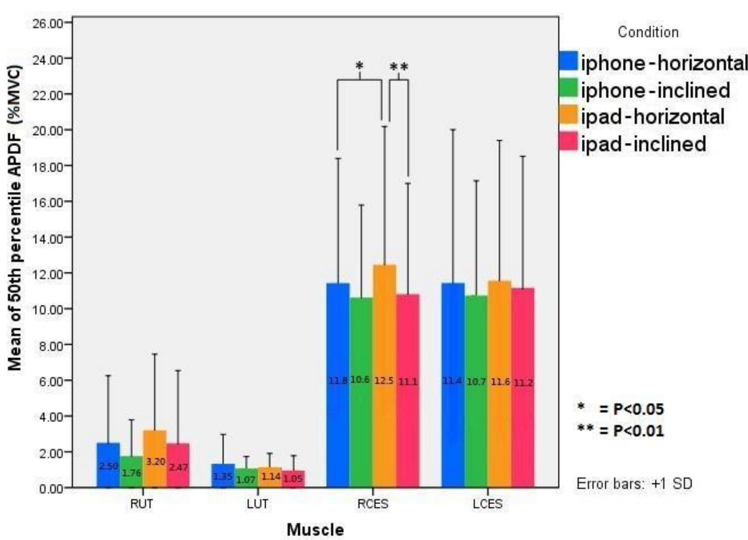
AIM: In recent years, portable touchscreen devices such as smartphones and tablet computers are extremely popular. This study aimed to compare the cervical muscle activity when using these devices in a horizontal and an inclined position.

METHODS: 20 healthy university students (10 males and 10 females) without any neck and shoulder symptoms participated in the study. Surface electromyography (sEMG) of bilateral cervical erector spinae (CES) and upper trapezius (UT) muscles was recorded continuously in 10-minute game session in using a smartphone and a tablet computer, each positioned in a horizontal position and an inclined position. The inclined position involves placing a support behind the device so that the display screen is at about 60 degrees from the horizontal. The 4 experimental tasks were performed in a random order, with a 5-minute rest period in between. The same game was played in all conditions and the same desk and adjustable chair were used for all subjects. Median muscle activity expressed as 50^{th} percentile of the Amplitude Probability Distribution Function of each muscle was compared among the 4 experimental conditions, and the task muscle activity was normalized to the maximum sEMG recorded during 3 trials of maximum voluntary contraction of each muscle.

RESULTS: The right cervical erector spinae (RCES) showed statistically significant differences in muscle activity, with the highest activity in the "tablet horizontal" condition, followed by "phone horizontal", then "tablet inclined" and "phone inclined". Similar patterns were found in the other muscles namely the left CES and bilateral UT muscles, but these were not statistically significant.

CONCLUSION: The results suggest that placing the touchscreen devices in a horizontal position seemed to be associated with the highest demands in the cervical muscle activity compared to inclined position. The use of tablet computers was generally found to be associated with higher muscle activity compared to the use of the smartphone device with the smaller screen. These findings may have important implications on the effects of prolonged or intensive use of portable touchscreen devices contributing to musculoskeletal disorders.



Poster Session 2 – (Poster Area 16.00)

Poster Session 3 – (Poster Area 18.30)

ISOKINETIC TESTING OF EVERTOR AND INVERTOR MUSCLES IN PATIENT WITH CHRONIC ANKLE INSTABILITY

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AIM: Ankle sprains are among the most common sport-related injuries and can lead to chronic ankle instability. Impaired sensorimotor function of the ankle musculature is often suggested as a cause. The present study sought to assess and compare the isokinetic performance and electromyographic patterns of evertor and invertor muscles in patients with chronic ankle instability and in a control group.

METHODS: Twelve patients with chronic ankle instability and twelve healthy subjects were included. Isokinetic eccentric and concentric testing at various angular velocities was performed for eversion and inversion movements. The corresponding myoelectric activities of the fibularis longus and tibialis anterior muscles were quantified from surface electromyographic recordings by computing average root mean square values.

RESULTS: Patients had lower myoelectric activity of the evertor and invertor muscles than controls did; this difference could account for the eccentric weakness associated with ankle instability (Figure 1). Functional strength ratios revealed a dynamic strength imbalance in unstable ankle patients and that may contribute to recurrent injury.

CONCLUSION: Our findings suggest that ankle instability is linked to neural drive rather than muscle impairment and thus rehabilitation programs for unstable ankle patients must be focused on the motor control of eccentric contractions of the ankle evertors and invertors, in order to boost these muscles' contribution to ankle stabilization.

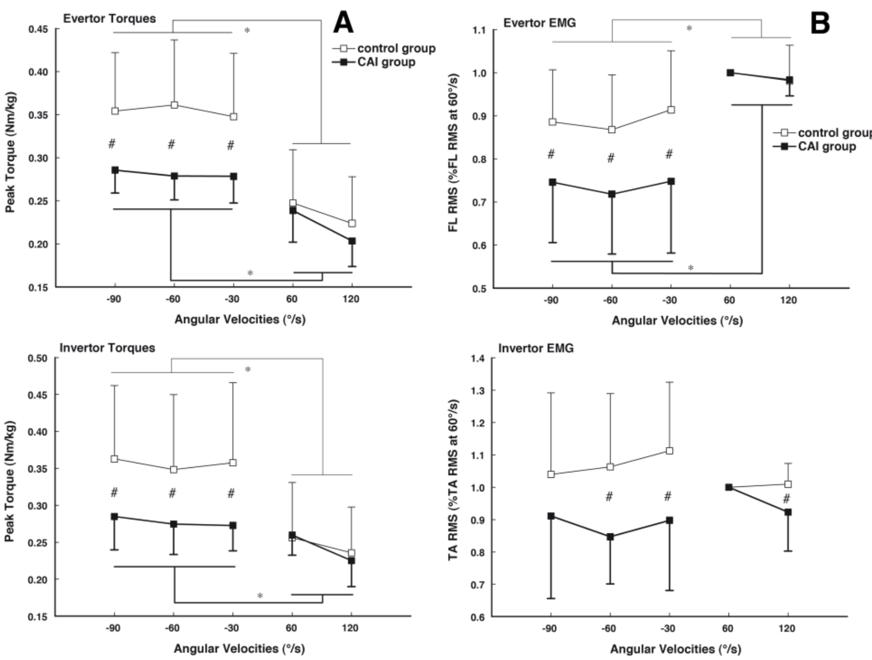

Figure 1: Normalized torque values (A) and EMG activities (B) measured during eccentric contraction (negative angular velocities) and concentric contraction (positive angular velocities). Mean value and one standard deviation are shown. * and # denote significant differences with P<0.001 and P<0.05, respectively.

ACUTE EFFECTS OF STATIC STRETCH IN WRIST RANGE OF MOTION

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AIM: Although stretching has been used in studies recording movement in order to minimize possible muscle strains and source of bias during registration, there is no consensus about its effect. Thus, the aim of this study was to analyze the acute effects of static stretch in wrist range of wrist motion in healthy subjects.
METHOD**:** 24 healthy men (age 24.6±4.8 years; weight 78.2±12.72 kg and height 1.78±0.04 m) took part of this study. From this sample, 12 workers were randomly assigned to control group (CG), whom did not perform wrist muscles stretching, and 12 were assigned to stretching group (SG), whom performed wrist muscles stretching. Electrogoniometer sensor was attached to the right wrist of each subject following the manufacturer recommendations. Each subject performed actively three maximum flexion/extension and ulnar/radial deviation. The series of movements were repeated twice with one minute interval between the series. During the one minute interval, SG performed flexors and extensors stretching during 60 seconds for each muscular group while the CG rested. Subjects remained sat during the test, with the shoulder at 0° of flexion and abduction, elbow at 90° of flexion and the forearm was supported by a table at 90° of pronation. The movements order was randomized. The data were analyzed descriptively and statistically by repeated measures ANOVA.
RESULTS: Similar values of mean flexion, extension, radial and ulnar deviation were found before and after one minute static stretches for control and stretching group (Table 1). No interaction was identified between groups and the series ($P>0.4$).
CONCLUSION: The static muscle stretching did not increase maximum range of motion of wrist flexion/extension and ulnar/radial deviation in healthy subjects. The present study did not corroborate results from others reporting immediate effects on range of motion of joints after stretching. This may be due to different stretching technique used, duration of stretching and muscle groups tested. Moreover, no studies evaluating the immediate effect of stretching on range of motion of the wrist in healthy individuals were found in the literature. Thus, further studies are needed to investigate the acute effect of other techniques of stretching on range of motion of the wrist. ACKNOWLEDGEMENT: This work had the financial support of Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

Table 1: Mean and standard deviation (SD) values (in degrees) for wrist movements presented by CG and SG

		Extension Mean±SD	Flexion Mean±SD	Radial deviation Mean±SD	Ulnar Deviation Mean±SD
SG	after	92.0±12.5	50.4±8.2	23.1±6.3	30.8±7.3
	before	92.5±10.2	51.9±8.3	23.4±6.1	30.5±7.9
CG	after	95.5±8.7	51.9±6.6	20.4±6.9	35.6±7.4
	before	95.2±10.1	52.4±7.2	21.0±5.3	34.0±6.8

EMG SIDE DIFFERENCES OF ERECTOR SPINAE DURING ISOKINETIC TRUNK EXTENSION – A PILOT STUDY

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AIM: Imbalanced neuromuscular activity of the lumbar erector spinae (LES) is supposed to be one contributing factor for chronic low back pain (CLBP). Most studies investigated these imbalances only under isometric conditions and found side differences in CLBP patients as well as in healthy controls. For dynamic situations it is still unclear whether side differences are present at all. Therefore the aim of this pilot study was to evaluate side differences in muscle activity of the lumbar erector spinae during submaximal isokinetic trunk extension in healthy subjects.
METHODS: In 42 healthy subjects (21 males/21 females, 27±3 years, 69±12 kg, 1.74±0.09 m) muscular activity of the LES at L3 level was measured bilaterally via 2-lead-EMG (myon RFTD-32, myon AG, Suisse) during concentric isokinetic back extension at 45 °/s and a ROM of 45° flexion to 10° extension (Con-trex MJ, TP module, Physiomed AG, Germany). Warm-up was followed by 5 maximum voluntary contractions (MVC). Afterwards each 5 isokinetic contractions were performed with 20, 40, 60 and 80% of the peak torque. Root mean square (RMS) of all 5 repetitions was averaged for each condition and normalized to MVC. RMS was calculated for the isokinetic phase of trunk extension. Left and right LES activity were compared with a paired t-test (α=0.05). Data is presented as mean difference±SD of normalized RMS values.
RESULTS: Average peak torque for MVC was 263±79 Nm. Mean difference (22±76 µV) of raw RMS values of the MVC measurement was not statistically significant (p=0.062). Mean differences for the conditions 20, 40, 60 and 80% were 0±6, 1±8, 1±8, 0±7 and 4±13%, respectively. Neither of these differences was statistically significant.
CONCLUSION: In contrast to isometric exercises there are obviously no side differences in normalized EMG activity in healthy subjects under dynamic back extension load. It has to be discussed if this is due to the linear test situation. In addition, CLBP patients have to be evaluated to clarify if side differences could be evaluated in patients.

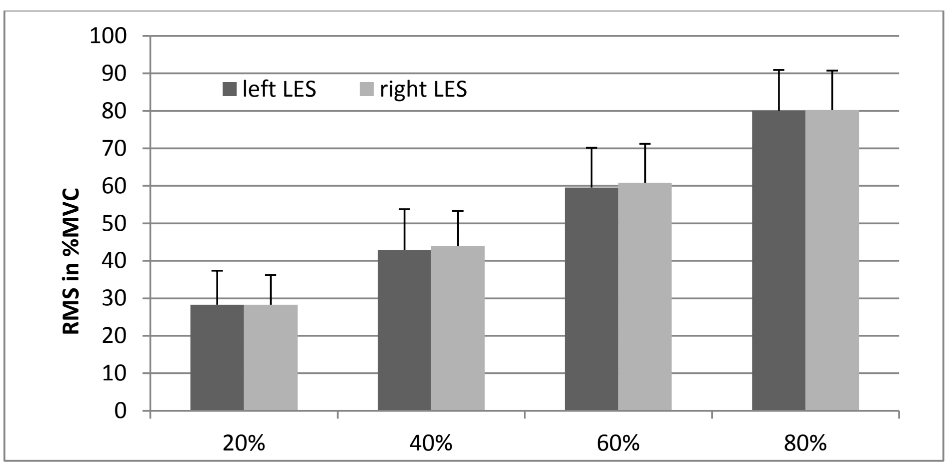

Figure 4: Normalized RMS of lumbar erector spinae (LES) for both sides and each condition (mean+SD).

TOTAL BODY MOVEMENT MONITORING USING A REGULAR SMARTPHONE TO DETECT BICYCLE ACCIDENTS

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AIM: Today's high-end smartphones are typically equipped with both GPS –functionality and movement sensors such as accelerometers and gyroscopes. The aim of this study was to explore to what extent inherent smartphone sensors can be used to monitor non-trivial total body movement. A specific aim was to test if a smartphone can be used to automatically detect when a bicyclist fall or is involved in an accident.
METHODS: First an inventory was made to sort out possible smartphone candidates based on sensor dynamics and system characteristics that provide enough amplitude and time resolution of the sensor signals for total body movement evaluation. Next was to use the selected smartphone to record movements during bicycling to create a pool of "normal" data and use this to learn what acceleration and orientation levels typically occur in bicycling. The approach used to detect a possible fall or accident is to detect when the recorded signals deviate significantly from what is found in normal bicycling. The suggested algorithm where verified during regular bicycling and in modeled falls/accidents using a simple custom built crash test dummy.
RESULTS: A Google Nexus 4 smartphone was chosen for the study. This device is equipped with a combined accelerometer and gyroscope chip (MPU-6050, Invensense) allowing the sensor signals to be recorded with a sampling frequency up to 1 kHz. In order to allow the smartphone to be easily carried, i.e. not fixed to the body and not distinguishing "true" x, y, z –directions, an integrated accelerometer signal measure was created based on the sum of the square of each direction. In normal use this acceleration measure was found to be as high as 4 g. These levels could be from simple handling of the smartphone or e.g. from road bumps during cycling. This prompted that high acceleration measures alone are not appropriate to be used to indicate a fall or accident. Based on the pool of recorded "normal" data and Matlab simulations an adequate crash detection algorithm could be designed based on a combination of a high accelerometer measure, changes in orientation, and zero velocity inside a certain time window. The algorithm was evaluated in over 20 hours of normal bicycling without any false positive alarms and successfully in 10 simulated accidents using the crash test dummy. Contrary to what was expected, the algorithm did not demand any special arrangement for carrying the smartphone tightly fixed to the body.
CONCLUSION: This study shows that non-trivial total body movements can be monitored and used in real-time evaluation based on the inherent sensors of today's high end smartphones. This opens up for inexpensive and easy access to long term monitoring of total body movements to be used e.g. in rehabilitation to inform or warn about specific activities or activity patte ACKNOWLEDGEMENT: This work was carried out in association with SAFER – Vehicle and Traffic Safety Centre at Chalmers, Gothenburg, Sweden rns.

NEUROMUSCULAR ADAPTATIONS DURING ISOMETRIC FORCE CONTROL IN INDIVIDUALS WITH KNEE-OSTEOARTHRITIS

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AIM: Use a weight-bearing isometric target matching protocol to i. Investigate neuromuscular control in adults with knee-osteoarthritis (OA) compared to healthy controls (HC); ii. Examine differences in absolute ground reaction forces (GRF) and maximum torque produced.

METHODS: A force matching protocol [1] evaluated 16 OA (64.8±6.2) and 18 HC (59.5±4.8). Participants stood in a staggered stance with their foot secured to a force platform and their test hip and knee joints at 30° flexion. Participants modified GRF to match 12 targets displayed onscreen and scaled to 30% maximum force Fx and Fy directions and 50% Fz.

EMG of 8 knee joint muscles, maximum torque produced during maximum voluntary isometric contractions (MVIC), kinematics, kinetics were recorded. Mean resultant magnitude (X_{EMG}), activation direction (Φ), and specificity index (SI) were calculated for each muscle. GRF (Fx, Fy) were calculated for each target. Group differences were tested with mixed ANOVAs followed by independent T-tests for significant variables at $p<0.05$.

RESULTS: OA produced significantly less knee extension torque during MVIC. Despite similar GRF produced between groups (Fig 1f), OA had significantly greater X_{EMG} in rectus femoris, vastus lateralis, vastus medials, biceps femoris, and tensor fascia latae (Fig 1a-e). SI was greatest in biceps femoris, semitendinosus, and medial gastrocnemius in both groups. However, specificity of the medial gastrocnemius was significantly less in OA than HC. Similar muscle activation patterns were observed in both groups.

CONCLUSION: While GRF were similar between groups, the OA group had increased muscle activation, and decreased specificity. The lesser maximum knee extension torque in OA may relate to the increase in isometric quadriceps activation used to stabilize the knee joint. This suggests OA's neuromuscular system adapts intrinsically without producing significant external GRF differences to achieve task-demands during isometric force modulation. These adaptations may compensate for decreased muscle strength and joint degradation commonly associated with OA [2].

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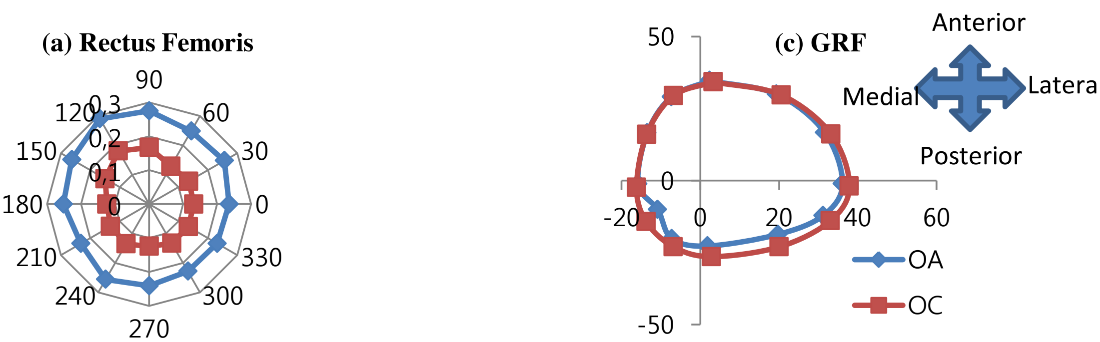

Figure 1: (a,b) Normalized EMG polar plots; (c) Absolute GRF (N); at 12 target locations (°)

PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION - PNF INFLUENCE IN THE CHANGE OF RECTUS FEMORIS FIBER VIEW THROUGH SURFACE ELECTROMYOGRAPHY AND ANALOGIC DYNAMOMETRY

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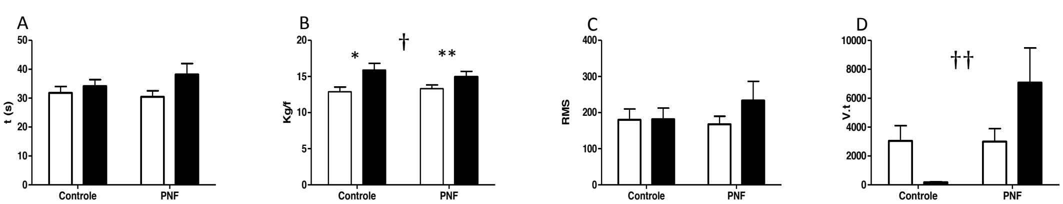
AIM: The PNF - Proprioceptive Neuromuscular Facilitation - is a technique that is increasingly being used in muscle training of healthy people and athletes. Studies have shown that resistance exercises, including PNF, are able to convert the trained muscle fiber type. This research aimed to verify the effectiveness of PNF in increased muscle strength and check for non-invasive methods would be indicative of conversion of muscle fiber type after training.
METHODS: A sample group of 22 young, female university students aged between 18 and 25 years, physically active, was divided into a control group (CG n = 10) and experimental group (EG n = 12). It was collected first the Maximum Volunteer Contraction (MVC) of Quadriceps muscle for analogic dynamometry and root mean square - RMS by surface electromyography (EMG) of all subjects. After the first data collecting EG conducted PNF based training in the dominant lower limb to 15 sessions in 5 weeks. Before the training sessions, new MVC and RMS data were collected of all samples.
RESULTS: Regarding MVC muscular strength (Smax), there was an increase in both groups, significant in CG ($p< 0.01$) and EG ($p <0.05$) for RMS and MVC time (MVC t), there wasn't significant increase in EG, but the interaction Vxt was significantly increased for this group. The results corroborate the literature by showing that muscles with a predominance of resistant fibers (fiber I / IIA) have greater contraction time with more electrical activation and that the PNF is able to type IIB fibers II A.
CONCLUSION: the training sample was efficient to increase muscle strength and EMG data presented show strong evidence of the conversion of muscle fibers trained.
ACKNOWLEDGEMENT: UFAM – Federal University of Amazonas, FAPEAM

Table 1: Changes in the rectus femoris muscle pre and post experiment (M±SD).

		MVC t (s)	Smax (Kg/f)	RMS (mV)	V x t area
GE	Pre	30.43±6.72	13.3± 1.72	167.56±70.78	2993.08±2828.58
	Post	38.18±11.83	14.95± 2.35*'	233.48±167.58	7067.24±7606.64†
GC	Pre	31.83±6.24	12.88± 1.83	180.04±85.15	3039.45±2992.01
	Post	34.14±6.37	15.88± 2.63**'	181.54±88.04	4924.57±88.03†

** - p<0,05 ** - p<0,01 ' – p<0,01 ANOVA † - p<0,05 ANOVA*



** - p<0,05 ** - p<0,01 † – p<0,01 ANOVA †† - p<0,05 ANOVA*

Figure 1: Changes in CG (Controle) and EG (PNF): A – MVC t; B – Smax; C – RMS; D – V x t area.

THE DIFFERENCE IN THE MUSCLE ACTIVITY AT THE TIME OF A WALK WITH BAREFOOT AND HIGH HEELS

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AIM: In recent years, rotation jump landing was included for a part of anterior cruciate ligament (ACL) injury prevention training programs. And the effect of rotation jump landing has been evaluated on the electromyography of the quadriceps and hamstrings in female. Our aim was to examine the relationships between the peak vertical ground reaction forces and the muscle activities of knee joint during 180 degrees rotation jump landing.
METHODS: The subjects were eight healthy females. The task was bidirectional 180 degrees rotation jump landing. The EMG activity was recorded bilaterally for vastus medialis, rectus femoris, vastus lateralis, semimembranosus and biceps femoris. We measured the integrated EMG from initial contact to 100ms. The peak vertical ground reaction forces generated at landing were recorded using the force platforms. The initial ground contact was defined as the time when the vertical ground reaction force exceeded 10N. Pearson product-moment correlation coefficient were used to determine whether there were any significant differences between the peak vertical ground reaction forces and the 10 muscle activity.
RESULTS: As for the right leg during left-handed rotation jump and the left leg during right-handed rotation jump landing, the peak vertical ground reaction forces were positively correlated with the quadriceps muscle activity, however, the peak vertical ground reaction forces were negatively correlated with the hamstrings muscle activity.
CONCLUSION: Our results found that the participants landed with their support legs during right-handed rotation or left-handed rotation jump landing. Generally, the non-dominant leg was selected as the support leg. However, our results found that there were left-right asymmetry patterns during bidirectional rotation jump lading. Our results suggest that it may be made distinction of right or left-handed rotation jump as training to prevent anterior cruciate ligament injury.

DEVELOPMENT A TRAINING DEVICE FOR RELIEVING SPASTICITY IN UPPER LIMBS

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AIM: After receiving primary emergency care for stroke, patients may begin to experience spasticity, which may cause them difficulties in managing daily activities. A new training device was developed to enable the safe and easy movement of an immobile upper limb.
SUBJECT: Subject A is a male. He is 44 years old, and his medical history includes cerebral apoplexy that is 2 years and 6 months past onset. Subject B is also a male. He is 63 years old, and his medical history includes cerebral apoplexy that is 4 years and 3 months past onset.
METHODS: We used the Myoresearch system developed. To perform the EMG measurements, the immobile hand was placed on the device. The subjects were then asked to move the device over the table. They drew a circle for 2 second in one cycle; the cycles were controlled using a metronome. The first training session lasted 5 min, following which the subjects were rested for 2 min. Similarly, two more rounds of training and rest were conducted. The EMG measurements were taken 2 min after the start of every training and rest period. The study was explained to the subjects in detail, and their informed written consent was obtained. Analysis was carried out using raw data and integral calculus.
CONCLUSION: Subject A: At the beginning of the training session, the electrical potential in flexor carpi radialis decreased rapidly. During the rest period, the electrical potential of flexor carpi radialis recovered to the levels prior to the beginning of the training session (Figure 1). Subject B: In the integrated EMG (1 second) for the training sessions, the values of electrical potential in the cases of pectoralis major, triceps brachii, and flexor carpi radialis were lower in the second session than those in the first session.

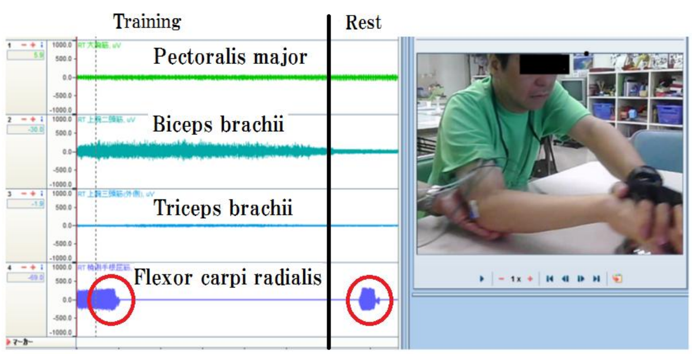

Figure 1: Right: Photo of measurement, Left: Sample of low EMG data

RESIDUAL FORCE ENHANCEMENT DURING MULTI-JOINT LEG EXTENSIONS AT JOINT-ANGLE CONFIGURATIONS CLOSE TO NATURAL HUMAN MOTION

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AIM: When an active muscle is stretched a) the resulting post-eccentric steady-state force is known to be greater than the isometric force or b) a given force requires less muscle activation than producing the same force under isometric conditions at the corresponding muscle length. This so called residual force enhancement (RFE) was recently shown to be present in submaximal multi-joint leg extension. The aim of this research was to clarify the relevance of RFE during a close to everyday life experimental setup, based on joint-angle configurations comparable to human walking or running. Therefore we chose a submaximal multi-joint leg extension design with knee angle range of motion of 30 to 50 degree knee flexion.
METHODS: 14 subjects performed 12 submaximal leg extensions (6 isometric and 6 isometric-eccentric-isometric trials, 30°-50° knee flexion, $\omega = 60°s^{-1}$) lasting 30 seconds on a motor-driven leg-press dynamometer while measuring external reaction forces (F_{ext}) as well as activity of 9 lower extremity muscles. In addition, in combination with a 6-camera 3d motion-tracking system, ankle (M_a) and knee (M_k) joint torque were calculated using inverse dynamics. To control and standardize level of intensity (i.e. 30%MVC) visual feedback from either the EMG signal of the m. vastus lateralis or reaction force was given.
RESULTS: We found no residual force enhancement independent from the analyzed time interval or the way of giving visual feedback to the subjects. There was no enhanced F_{ext} ($p > 0.05$) or enhanced M_a, M_k ($p > 0.05$) nor a significantly reduced EMG level ($p > 0.05$). CONCLUSION: In this work we could not show a clear indication for RFE to be present in a close to everyday life multi-joint setup. These findings are not in accordance with previous published papers. Reasons for the varying results might be the disparity in the angular position and the associated differences according to the force-length characteristics since RFE *"in vivo"* predominately occurs on the descending limb of the force-length relationship. Although mean values showed enhanced forces and lowered EMG data, statistical analyze revealed no significant differences.
ACKNOWLEDGEMENT: This work was funded by the German Research Foundation.

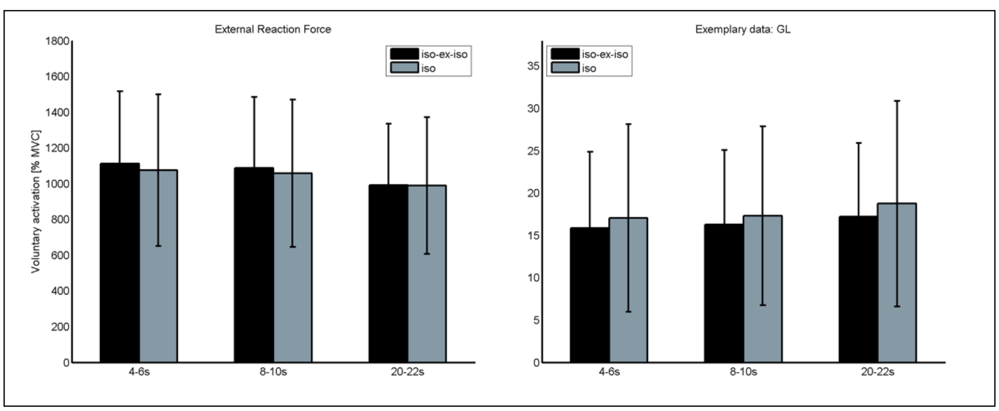

Figure 5: External reaction force of the right foot (left graph) and exemplary EMG data of the gastrocnemius lateralis (right graph). The black bar represents the isometric-eccentric-isometric and the grey bar the pure isometric trial. There is a trend towards higher F_{ext} data and lower EMG data exemplary shown for the GL across the 3 analyzed time intervals.

EFFECT OF PROFICIENCY IN STREET DANCE ON FUNCTION OF BIARTICULAR MUSCLE

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Previous research investigated level of co-contraction during rhythmic repetitive knee-bending movement in street dance, and demonstrated that skilled street dancers exhibited lower level of co-contraction of leg muscles such as the rectus femoris (RF) and the biceps femoris (BF) than did non-dancers [1]. Both groups activated the RF at around the time when the knee and hip joints were maximally flexed (immediately before knee and hip started to extend). On the other hand, while non-dancers activated the BF at the same time as the RF, skilled street dancers activated BF at around the time when the knee and hip joints were maximally extended (immediately before knee and hip started to flex). Because the BF is biarticular muscle that flexes the knee joint and extends the hip joint, different timing of the BF activation between both groups would affect mechanical work at joint differently: Positive work at the knee joint during flexion would be greater in skilled dancers because the BF started to activate immediately before knee and hip flexed. In order to test this, we calculated positive mechanical work at the knee joint during the flexion phase. Eight skilled street dancers including 6 winners of celebrated street dance competitions, and non-dancers performed rhythmic knee bending movement to metronome beat over wide range of movement frequencies from 60 to 180 beats per minute. Reflective markers were attached to the right side of the greater trochanter, rotation axis of the knee joint, and lateral malleolus, which were recorded by high-speed camera. By using Lagrange method, we calculated the knee joint torque. The torque was normalized to body mass. Knee joint power was obtained by multiplying knee angular velocity with the torque. Then, the positive power during the knee flexion phase was integrated, in order to obtain the positive work at the knee joint during flexion phase. A two-way analysis of variance (within-subject factor: movement frequency, and between-subject factor: group) was performed on the positive work during knee flexion phase, and revealed significant main effect of group ($p < .05$). This indicates that the positive work at the knee joint during flexion phase is greater in dancers than in non-dancers. Along with the previous findings that the BF started to activate immediately before knee and hip flexed in skilled dancers, this result suggests that the BF activation would contribute knee flexion more in dancers than in non-dancers.

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RELATIONSHIP AMONG EMG (ELECTROMYOGRAM), MMG (MECHANOMYOGRAM), AND MUSCLE FORCE FOR M. QUADRICEPS FEMORIS IN THE MAXIMUM VOLUNTARY CONTRACTION

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AIM: The total system from occurrence of electric potential to that of muscular force for m. quadriceps femoris is studied with use of EMG(electromyogram), MMG (mechanomyogram), and muscle force. The behavior of mechanical vibration of muscles during muscular contraction known as MMG is studied to make the ability of muscular contraction clear.
METHODS: The maximum voluntary isometric contraction(MVC) of m. quadriceps femoris is carried out. EMG for surface three muscles (i.e., m. vastus medialis (mvm), m. rectus femoris (mrf), m. vastus lateralis (mvl)) are detected with electric sensors. MMG for surface three muscles, which is the muscular mechanical vibration, are detected with use of three-dimensional acceleration sensors. The muscle force is measured, and weight bearing index (WBI) is obtained as the muscle force divided by body weight of subject. The WBI is proved to show physical strength. EMG and MMG are evaluated by sum of the power spectrum (total power) in the frequency ranges from 1Hz to 100Hz and from 1 Hz to 50Hz, respectively. The normal subjects of 46 males and 37 females from 20 to 30 ages attend.
RESULTS: EMG evaluated by total power for male in Figure 1 show that the value of m. rectus feroris is the maximum, and the tendency is the same for female. The value of male is larger than that of female by twice. MMG evaluated by total power for compose of three dimensions in Figure 2 denotes different results for male and female subjects. The mean value of WBI for male and female are 120 (level of sport) and 100 (level of living), respectively.
CONCLUSION: The mechanical vibration for surface three muscles in m. quadriceps femoris denotes a difference based on sex by the evaluation of MMG in MVC. The MMGs of m. vastus medialis and m. rectus femoris for male are more active than that of m. vastus lateralis, while MMG of m. rectus femoris for female are most active. The cause is difference of muscular quality and muscular size for male and female muscles.

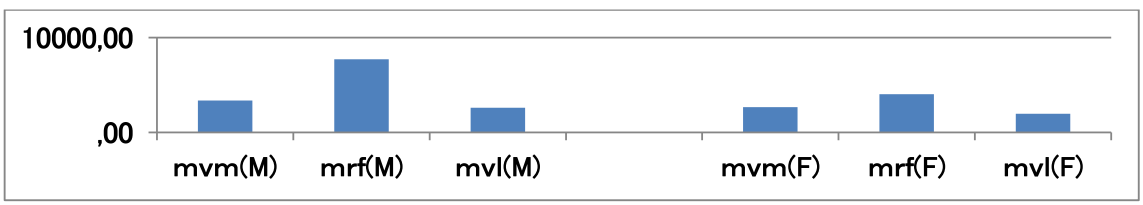

Figure 1: EMG(Electromyogram) in three muscles (mvm, mrf, mvl) for Male(M) and Female(F). Total powers of EMG are shown with unit of mV^2.

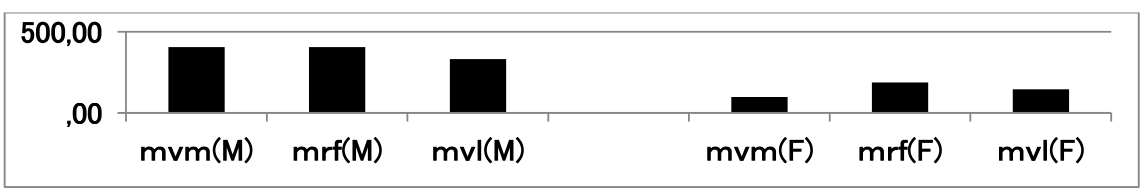

Figure 2: MMG(Mechanomyogram) in three muscles (mvm, mrf, mvl) for Male (M) and Female (F). Total powers of three dimensional MMG are shown with unit of G^2.

ANALYTICAL METHODS FOR MYOELECTRIC CONTROL

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AIM: In order to optimize simultaneous myoelectric prostheses control of multiple degrees of freedom (DOFs), this work conducts an analysis of electromyogram (EMG) feature set, feature projection, and force estimation.

METHODS: Ten able-bodied subjects participated in this study, in which wrist flexion-extension, abduction-adduction, and pronation-supination were investigated. Single and combined contractions were used. The EMG from the right forearm, and the wrist force from the opposite (contralateral) limb were recorded, concurrently, during mirrored bilateral contractions.

RESULTS: Myoelectric force estimation accuracies (R^2) using several feature sets including time domain (TD), and the TD combined with wavelet coefficients, autoregressive coefficients, Willison amplitude, and median frequency were calculated. No significant difference was found between the performances of these feature sets. The R^2 values using feature projection methods including principal component analysis (PCA), non-negative matrix factorization (NNMF), and canonical correlation analysis (CCA), are plotted in Fig. 1. Also, the estimation accuracies using polynomial estimators (the first to fourth order) and the baseline ANNs are plotted in Fig. 2.

CONCLUSION: The TD feature set demonstrated high performance and had fewer numbers of features than other sets. The CCA outperformed the PCA and NNMF for dimensionality reduction. Also, the ANNs outperformed the polynomial estimators.

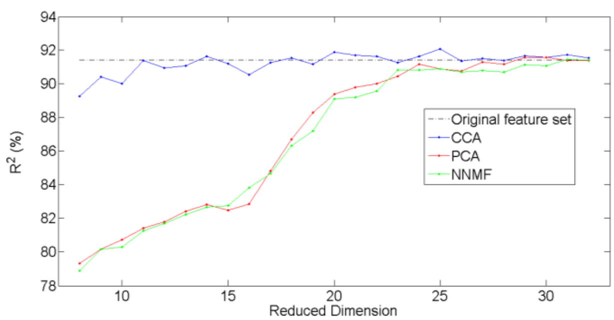

Figure 1: The R^2 values using dimensionality reduction methods including PCA, NNMF, and CCA.

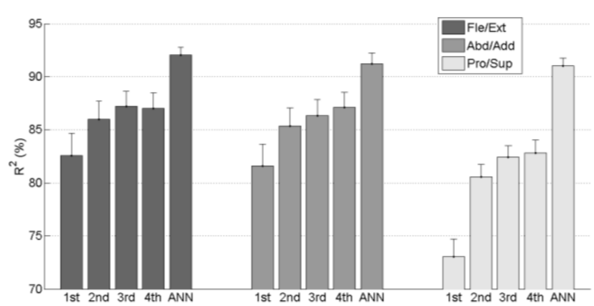

Figure 2: The R^2 values using the first to fourth order polynomial estimators, and the ANNs.

USER-FRIENDLY TOOL FOR S-EMG AND HD-EMG SIGNAL PROCESSING

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AIM: Available tools for surface electromyography signals (S-EMG) processing are proprietary. A free software tool that is usable even by those unfamiliar with signal processing would certainly be an important contribution to the field. This paper presents the development of a Matlab tool for processing of S-EMG, including multichannel (electrode-array) S-EMG, and high-density (electrode-matrix) S-EMG (HD-EMG). The proposed tool implements a graphical user interface (GUI), which allows users without computer programming or signal processing experience to perform S-EMG and HD-EMG analysis.
METHODS: The proposed tool is capable of displaying the multichannel waveforms of a one- or two-dimensional electrode array in both time and frequency domains. It also implements the most widely-used S-EMG estimators — linear regression angular coefficients of the root mean square (RMS) value, average rectified value (ARV), mean frequency (MNF), median frequency (MDF), and conduction velocity (CV).
RESULTS: Figure 1 shows the main window of the tool. Estimator values and regression lines are graphically displayed, and saved onto an Excel spreadsheet. In preliminary tests, users unfamiliar with signal processing or Matlab learned how to use the tool after 10-minute instructions. This tool is a work in progress, as we aim to implement (and freely-distribute) a general-purpose tool that meets the needs of electromyography users in the fields of rehabilitation or physical training.
CONCLUSION: A Matlab-based GUI for multichannel S-EMG signal processing was presented. Preliminary tests show that new users unfamiliar with computer programing or signal processing learned how to use the tool after 10-minute instructions. Tools such as the one presented in this work could help in popularizing S-EMG analysis in the fields of rehabilitation and physical training.

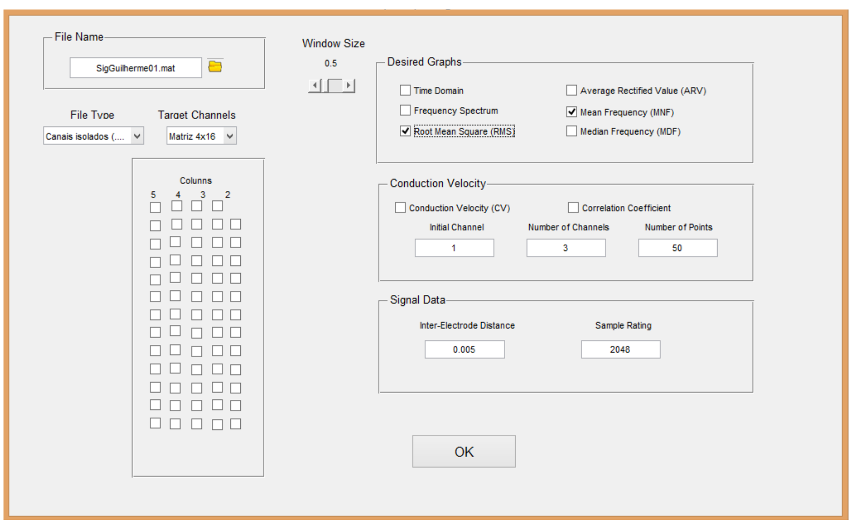

Figure 1: Main window of the proposed tool: selection of signal and channels (left), and signal processing options (right).

REFERENCE CONTRATIONS FOR ELECTROMYOGRAPHY DATA NORMALIZATION OF TYPING TASK

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AIM: To compare maximal voluntary contraction (MVC) and a submaximal voluntary contraction (sMVC), holding 1kg halter, for normalization of surface electromyography (sEMG) of upper trapezius (UT), deltoideus anterior (DA) and extensor carpi radialis brevi (ECR) muscles recorded during typing task without arm support.

METHODS: Muscle activity of UT, DA and ECR were bilaterally recorded by sEMG (bipolar Ag/AgCl electrodes, 1cm inter-electrode distance, at 1000Hz, bandwidth of 20-450Hz, Myomonitor System, Delsys) in 9 healthy computer user females (23.6±3.8 years, 1.6±0.1m, 61±9kg). Two types of isometric reference contractions were recorded while the participants were seated: sMVC (one repetition of 15s) and MVC (three repetitions of 5s, 90s interval). For UT and DA sMVCs, subjects were measured with upper arms at 90° of abduction holding a 1kg halter; for UT and DA MVCs, subjects were at same posture and performed maximal abduction against straps. For ECR sMVC, subjects held 1kg halter, wrist at full-extension; for ECR MVC, wrists were at neutral position maintained by straps. Participants performed a 5min of copy typing task using an ordinary desktop with chair and table individually adjusted. There was no space between keyboard and table board to support upper arms. EMG data were band-pass filtered in the frequency range of 20-450Hz, and the root mean square (RMS) of raw data was calculated for each 100ms window. Peak of muscle load (90th percentile) during task performance was determined by amplitude probability distribution function (APDF) and normalized by CVM and sCVM. Data from these two normalization conditions were compared by dependent *t* test.

RESULTS: Mean of sMVC corresponded to 44±18% of MVC. Statistical significant differences were found for muscle activity during typing task when normalized by the two types of reference contraction ($p<0.002$). Figure 1 shows higher values of muscle activity obtained by normalization using sMVC (grey box) as reference contraction.

CONCLUSION: Since sedentary tasks such as typing presented low physical demands, the normalization by sMVC could improve EMG responsiveness due its lower muscle activity level. Beyond that, considering sMVC feasibility in occupational settings, sMVC parameter for normalization must be encouraged for ergonomics studies among sedentary tasks.

ACKNOWLEDGEMENT: CAPES PNPD Proc.23038006938/2011-72; CNPq Proc.301772-2010-0

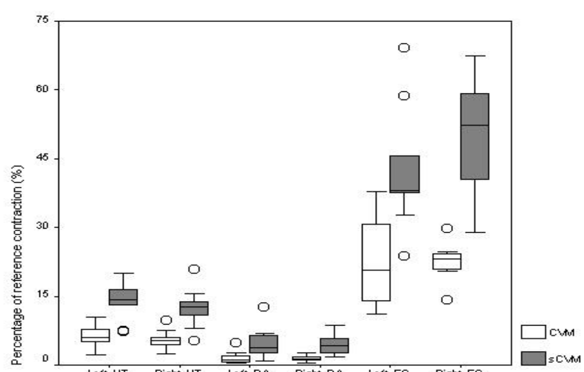

Figure 1: Peak of muscle activity during typing task normalized by CVM (white) and sCVM (grey).

A FINITE ELEMENT MODEL TO STUDY THE EFFECT OF BIPOLARSURFACE ELECTRODE ORIENTATION ON EMG MEASUREMENTS

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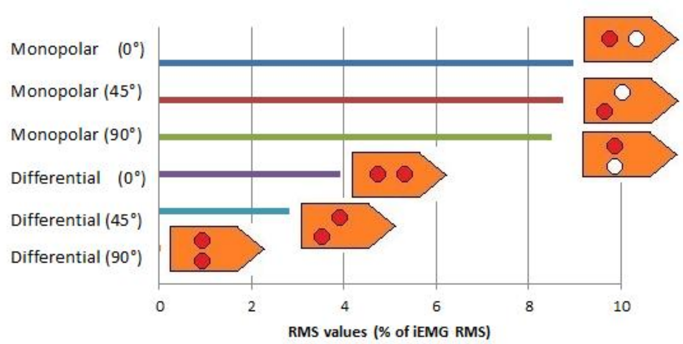
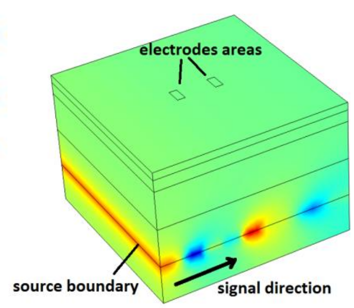
AIM:To quantify the effect of the orientation of bi-polar electrodes relative to the muscle fiber architecture on the electric potential measured using surface electromyography(EMG) electrodes.
METHODS:A planar three layer resistive finite element model was constructed representing the skin, the fat and the muscle tissue of parallel fibers using COMSOL multiphysics software. A travelling source potential was generated in the interface between the deep muscle level and the middle level (2 cm away from the surface, figure 1b) and the resulting surface potentials were measured in two areas representing electrode surfaces with a bipolar configuration. The electric potential source is an experimentally recorded intramuscular electromyography (iEMG)from approximately 25mm depth of the short head of a biceps brachial. To simulate different electrodes directions with respect to the fiber, the detecting areas were rotated at three different angles (0°, 45°&90°) to the simulated muscle fiber direction. The surface EMG signals were analyzed in the time and frequency domain using Matlab (version noR2013a).
RESULTS:RMS values for monopolar electrodes showed little variation as would be expected. RMS values of bipolar surface electrode readings showed a range of measurement variation from 4% to 0.03% for 0° to 90° respectively (figure 1a).
CONCLUSION:The results of the present study show the importance of electrode alignment with respect to muscle fibre orientation when using muscle surface emg signals to estimate muscle activity. Further work is ongoing to analyse the frequency component and other electrode parameters such as electrode size and the depth of activation within the muscle.
ACKNOWLEDGEMENT: This research was funded by the EPSRC Bridging the Gaps program (NanoInfoBio) and the Faculty of Science & Engineering, MMU.



a)



b)

Figure 1:a) Root Mean Square values of the detected surface signal with different configurations. The arrow indicates the fiber direction and the verse of the travelling signal.b) Finite element model of the muscle tissue. The source signal is applied at the interface between the middle and the deep level and the dynamic is simulated as a travelling signal at an estimated velocity of 4 m/s. The potential is detected at the two area on the top, representing the electrodes.

HD-EMG FATIGUE MAPS FOR ASSESSMENT OF SPATIAL VARIATIONS OF S-EMG VARIABLES

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AIM: Fatigue plots are graphs which show the temporal behavior of surface electro-myography (S-EMG) variables, such as the root mean square (RMS), average rectified value (ARV), mean frequency (MNF), median frequency (MDF), and conduction velocity. A first-order approximation of the time-varying curve of each of these variables is typically calculated, and the normalized angular coefficient is used as an indicator of fatigability. A limitation of this approach is that it provides limited spatial information, especially if the signal from only one channel of the electrode array is considered. We propose the use of fatigue maps, which graphically display (in two spatial dimensions) the angular coefficient from every channel of a high-density electromyography (HD-EMG) electrode matrix, allowing the evaluation of spatial characteristics of the muscle fatigue process.
METHODS: Ten male subjects performed a 30-second contraction of the biceps at 60% maximum voluntary contraction. The elbow was positioned at a 90º angle. S-EMG signals were recorded using a 5×13 HD-EMG electrode matrix. The signal from each individual single differential channel was segmented into three 10-second windows, which were then further segmented into ten 1-second segments. For each segment, RMS, ARV, MDF and MNF variables were calculated. Then, for each window, a first-order approximation was calculated for each variable. Finally, for each variable, the angular coefficient from each window was normalized by the linear coefficient of the first window (i.e., the initial value of the variable), and arranged onto a 5×12 matrix, in which each coefficient is associated with one electrode of the array. The coefficient values were then mapped onto gray-scale colormaps, and the matrices were displayed as images (Figure 1).
RESULTS: Statistical tests were performed, and showed that fatigue manifestation varies significantly along the direction perpendicular to the motor fibers (vertical axis). Spatial variations parallel to the motor fibers (horizontal axis) were not statistically significant.
CONCLUSION: The concept of fatigue map was presented. Statistical tests based on results from 10 male subjects showed that the manifestation of fatigue is not spatially uniform. These results suggest that spatial information may be relevant in studies on muscle fatigue.

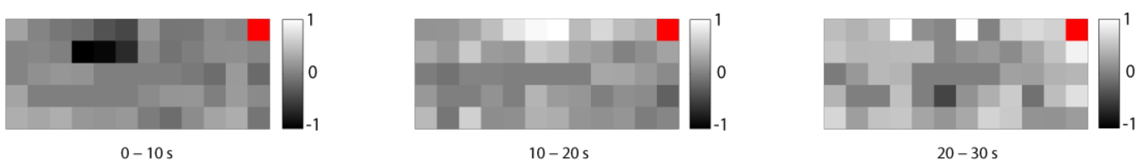

Figure 1: Representative example of MDF fatigue map for a 30-second contraction of the biceps. Red pixel indicates a non-existent channel. The 1st pixel on the up-right corner (red pixel) is the origin (0 mm) the inter-channel distance is 8 mm for both directions. On color map we have the normalized minimum and maximum values of the angular coefficient of the regression lines.

A DECONVOLUTION TECHNIQUE TO ESTIMATE THE NEURAL DRIVE TO MUSCLE FROM SINGLE CHANNEL SURFACE EMG

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INTRODUCTION: During voluntary movements, each muscle receives a neural drive from the pool of innervating motor neurons [1]. The estimation of this neural signal is important for understanding the type of synaptic input received by the motor neurons. Commonly, this has been performed using the rectified surface EMG signal [2]. Rectification of the EMG is believed to enhance the identification of the oscillatory synaptic inputs to motor neurons since it compresses the surface EMG power spectrum toward low frequencies [3]. However, it has been recently shown that the nonlinear operation of signal rectification generates a spectral distortion that is not easily predictable since it depends on the degree of amplitude cancellation in the surface EMG [4]. AIM: We developed an innovative method to estimate the neural drive to muscles from a single EMG recording site. The method is based on deconvolution of the raw EMG signal to extract the cumulative spike trains of the innervating motor neurons. We evaluated the proposed method with a computational model. METHODS: The technique consisted in three steps: first, an estimation of the average motor unit action potential shape was performed by applying a threshold to the raw EMG corresponding to three times the baseline noise standard deviation and averaging the signal with the threshold crossing points as triggers; second, the Tikhonov regularization method [5] was performed with the estimated shape of the average action potential as kernel; third, the minimization problem was solved imposing the constraint of non-negative solution (Landweber method [6]). For the evaluation of this method, we used a model that incorporated two muscles innervated by 300 motoneurons each [7] and an advanced surface EMG model [8]. The synaptic input was modeled as a band-pass Gaussian noise to all motor neurons (common noise component, CN) and an independent component (IN) unique for each motor neuron. The CN was chosen to have a narrow band centered at a frequency (that was varied in the simulations) with 1 Hz of side band. The frequency was varied in the range 0-20 Hz across the set of simulations. The IN was modeled in the frequency range 0-100 Hz for all simulations. The total variance of the synaptic input (CN+IN) was selected to determine a coefficient of variation for the interspike interval (ISI) of ∼15% in all simulations. The mean value of the input was set to both a low excitation level (low cancellation (LC), ~ 34 %) and a higher cancellation level (high cancellation (HC), ~ 64 %). All simulations had 100 s duration. The coherence spectra between the two muscles were calculated using the output of the proposed method and, for comparison, the rectified EMGs. The ratio between the magnitude of the coherence calculated using the proposed method and the one calculated using the rectified EMGs was used as an indicator of the efficacy of the proposed method. RESULTS: The correlation between the discharge pattern estimated with the proposed method and the simulated composite spike train CST, averaged across all simulation, was 65 ± 8 %. The coherence ratios calculated for the LC case were 1.1 at 0 Hz and 1.5 at 20 Hz. In the HC case, the ratios were 1.6 at both at 0 and 20 Hz, showing a substantial enhancement of the coherence peaks for the high excitation level. CONCLUSION: Our results demonstrated that deconvolution is a useful pre-processing to estimate the neural drive to muscle from the surface EMG signals. ACKNOWLEDGEMENTS: European Research Council Advanced Grant DEMOVE No. 267888

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ERD- VS BP-BASED MOVEMENT ONSET DETECTORS IN STROKE PATIENTS

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AIM: To compare the most well-known volitional movement-related electrophysiological phenomena for voluntary movements in stroke patients, as source of information for online movement classifiers.
METHODS: Six stroke patients (4 men, age 60.17±9.49, Fügl-Meyer 85.5±30.05) were recruited. They were asked to perform consecutive, self-initiated reaching movements with the affected upper limb. EEG was recorded using active Ag/AgCl electrodes and a 32-channel EEG amplifier amplified the signal and sampled it at 256Hz. Signals were recorded from parietal, centroparietal, central, frontocentral and frontal channels symmetrically distributed. Data from gyroscopic sensors placed on the limb were used to detect movement events. For the BP classifier, the EEG signal was filtered using a linear-phase band-pass filter [0.05Hz-1Hz]. Large laplacian filtering was applied to channels C1, Cz and C2. The average potential of the best channel in the target time window [-1.5s, movement onset], was used to design a matched filter. For the ERD classifier, the ten pairs (channel, 1Hz frequency band) with the most pronounced frequency decay in the same target window with respect to base level window [-3,5s, 1.5s] were selected as input to a Naïve Bayes classifier. The classifiers were independently built and tested by leave-one-out cross validation for each subject.
RESULTS: Figure 1 presents a summary of the results obtained. The classifier using BP features performs better than the ERD-based classifier for four out of the six patients. Average percentages of good trials (trials with movement correctly identified and no false positives), are 53.1% (± 24.2) and 53.8% (± 26.0) for the BP-based and the ERD-based classifiers, respectively. Average true positive rates reach 71.0% (± 16.0) and 73.1% (± 22.0), respectively. The latency of the correctly identified movements is closer to the movement onset for the BP-based classifier (+136 ms, ±16), presenting the ERD-based classifier an average longer delay (+394 ms, ±350).
CONCLUSION: Online detection of volitional movements has become a complex problem for BCI-based real-time rehabilitation. EEG phenomena related to movement preparation, such as BP and ERD, has shown to be arbitrarily absent or distorted in healthy subjects. The present work has revealed certain features of these phenomena that seem to be also dependent on the patient but complementary. Therefore, an intelligent combination of the both could lead to a more homogeneous solution.

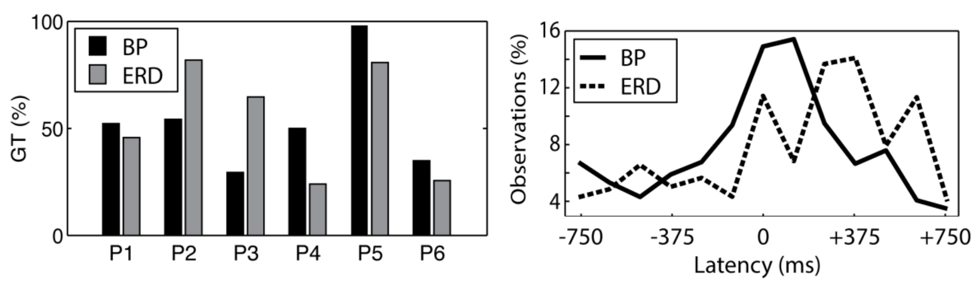

Figure 1: Left: percentage of good trials (GT), i.e. trials with movements correctly identified and no false positives, for the six patients using BP and ERD features. Right: distribution of the latency (0 ms = movement onset), of the movements correctly identified using BP and ERD features.

DETECTION OF EMG ELECTRODE LIFTOFF FOR POWERED PROSTHESES

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AIM**:** EMG signals have been shown to improve intent recognition in lower limb prostheses but have yet to be clinically implemented because EMG signal quality degrades over time. A method for detecting EMG signal changes will provide a viable method for implementing EMG in the control of leg prostheses. The aim of this study is to develop and test a metric that can detect EMG signal quality degradation in an effort to improve EMG-based pattern recognition algorithm accuracies for powered prostheses. For this study, we specifically investigate the problem of EMG electrode liftoff (i.e., a loss of electrode-skin contact).

METHODS**:** We propose a method for detecting electrode liftoff that can be used in real-time with a powered prosthesis by using the log likelihood. EMG signals with lower log likelihoods are considered dissimilar from desired EMG signals. Thus, EMG signals with electrode liftoff should have lower log likelihoods that can be detected with a threshold. This metric was evaluated offline using EMG data that was collected from eight transfemoral amputees. Subjects were fitted with a powered knee-ankle prosthesis and a custom socket that recorded EMG from nine leg muscles while the subjects completed 20 repetitions of a circuit that included level walking, ramps, and stairs. EMG data were partitioned into training and testing datasets. Two versions of the testing dataset were used: a "clean" set with normal EMG, and a "noisy" set where one channel of EMG data was replaced with 60Hz, 2-volt peak-to-peak sinusoids to simulate liftoff. Liftoff was detected if the log likelihood of the testing sample was significantly lower ($>3\sigma$) than the average log likelihood of the training set. The number of false positives and false negatives of liftoff detection was also determined.

RESULTS**:** Table 1 shows the average log likelihood of each dataset. That of the training dataset is the highest, and that of the testing data with no simulated liftoff is close to it ($<1\sigma$). The average log likelihood of the testing data with simulated liftoff is much lower than that of the other two datasets ($>3\sigma$). There were few false positives and no false negatives when the threshold was used to detect liftoff; the threshold detected 100% of the testing data with simulated liftoff and 5.19% of testing data with no liftoff were detected as having liftoff.

CONCLUSION**:** The use of a log likelihood threshold could be used in real-time to reliably detect when surface EMG signals have been corrupted by electrode liftoff. The threshold rarely detected liftoff in data where there was none, and detected all instances of liftoff when it was simulated. This metric could determine whether EMG should be used to make locomotion mode predictions in a pattern recognition controller for a powered leg prosthesis, and ensure that only EMG that is not noisy is incorporated into the prediction. Moreover, this metric could be used to detect EMG signal variations that are caused by factors besides that of electrode liftoff, such as electrode shift, fatigue, or variations in electrode/skin impedances.

Table 1: Average Log Likelihood of the Training and Testing Datasets

Dataset	**Average Log Likelihood (1σ)**
Training	–14.88 (22.37)
Testing (no simulated electrode liftoff)	–23.65 (48.85)
Testing (simulated electrode liftoff)	–1.40e4 (1.04e3)

NORMALIZATION OF SURFACE ELECTROMYOGRAPHY: ASPECTS OF TEST-RETEST-RELIABILITY AND THE INFLUENCE ON DATA INTERPRETATION.

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AIM: The interpretation of the surface electromyography (sEMG) amplitude is ambitious due to high inter- and intraindividual variability. To enable objective comparisons among subjects and muscles sEMG amplitude has to be normalized to a certain reference-value. Two criteria help to choose an appropriate reference-value for sEMG normalization. One is the test-retest-reliability of a reference-value. Another one is the influence of the applied reference-value on sEMG data interpretation. Therefore, the first aim of this study was to investigate the test-rest-reliability of different reference-values commonly used for sEMG normalization. The second aim was to examine the influence of the used reference-value on data interpretation when comparing a) two groups with different physical capacity (men and women) during repetitive work and b) two groups performing repetitive work under different ergonomic conditions.
METHODS: 57 subjects (w = 30; m = 27; median age = 28; median BMI = 23) performed one hour of repetitive work on three different days (2-5 days apart). The electrical activity (eA) as the root mean square value of sEMG has been measured for the extensor digitorum and biceps brachii muscles of the dominant arm. Further, three types of reference-values have been determined on each day. The first type is the reference electrical activation with absolute forces (RVEabs). Therefore subjects contracted each muscle isometrically with given forces (extensor: 30 and 60 N; biceps 50 and 110 N). The second type is the reference voluntary activation with individual relative forces (RVErel) using forces corresponding to 20% and 40% of the muscles' maximum capacity. The third type of reference value is the maximal voluntary electrical activation (MVE) which is determined during an isometric maximal voluntary contraction. Test-retest-reliability has been quantified using the standard error of measurement (SEM) of the variable „eA/force“. The influence on data interpretation has been investigated by comparing the normalized eA during repetitive work between men and women and by comparing a group of subjects that performed repetitive work in an ergonomic posture with a group of subjects performing repetitive work in an unergonomic posture.
RESULTS: SEM of eA/force was low for the biceps in comparison to the extensor muscle (biceps: 0.27 – 0.48; extensor: 0.7 – 1.1). For the biceps the SEM of RVErel and RVEabs have been smaller than for MVE. The lowest SEM of the extensor muscle has been found during MVE. Differences of the eA between men and women during repetitive work were more evident using RVErel and MVE normalization. The difference in muscular activity due to the ergonomic condition during repetitive work was more significant by applying RVEabs normalization.
CONCLUSION: Test-retest-reproducibility from the eA of different reference-values differs between muscles. This may be caused by anatomical and physiological differences. Based on our results, the discrimination between groups with different physical capability should be done by using RVErel or MVE normalization. To show differences in the work induced muscular activity due to the ergonomic condition in groups with inhomogeneous physiological capability, RVEabs reference-values should be used for normalization.

DECOMPOSITION OF ELECTROMYOGRAPHIC SIGNALS OF THE PARASPINAL IN LUMBAR DISC HERNIATION AND HEALTHY SUBJECT

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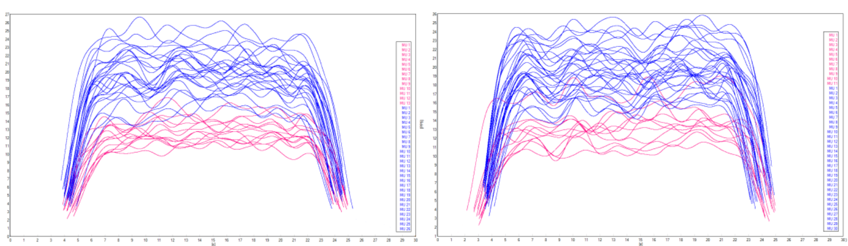
AIM: The aim of this study was to compare the motor unit firing patterns of the lumbar paraspinal muscles through dEMG in the dominant and non-dominant sides in a lumbar disc herniation patient and a healthy subject.
METHODS: Electromyographic signals were recorded through five cylindrical pin electrodes (0.5 mm diameter each) placed on the paraspinal muscles at level L3 (3 cm of the spinal process) on both sides of the spine using a Bagnoli EMG System (Delsys, Boston, MA), with an input at ±5 Volts, high-pass filter of 20 and low-pass filter of 450 Hz and sampling rate of 20 KHz using EMGWorks®. One healthy female (aged 25 years, BMI 21.91 kg/m²) and one female patient, diagnosed as having a lumbar disc herniation (aged 29 years, BMI 22.4 kg/m²), were evaluated during a 30 second isometric extension hold in the prone position against rigid straps at 40% of MVIC. The signal was decomposed and analyzed for its accuracy by means of an artificial intelligence algorithm. The average of firing rate was found by applying a Hanning window of 3 seconds.
RESULTS: The accuracy ranged from 88.5% to 92.6%. The healthy subject presented 26 motor unit action potential trains (MUAPTs) and 30 MUAPTs, while the patient presented 13 MUAPTs and 11 MUAPTs on the right and left sides respectively. The baseline noise was low and similar for all data analyzed of healthy subject and patient. The healthy subject showed a range of firing rates of 18.07 to 21.69 pulses per second and 17.69 to 22.77, whereas the lumbar disc hernia patient showed a range from 9.58 to 13.74 and 9.89 to 15.08 for the right and left sides respectively (FIG 1).
CONCLUSION: The subject with a lumbar disc hernia appears to show reduced firing rate compared with the health subjects.
ACKNOWLEDGMENTS: CNPq grants # 014/2010 and Delsys EMG System.



Right **Left**

Figure 1: Differences on average of firing rates between normal (blue) and lumbar disc hernia (pink) subjects.

SPATIAL DISTRIBUTION OF THE GASTROCNEMIUS MEDIALIS EMG ACTIVITY WITH CHANGES IN KNEE JOINT ANGLE

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AIM: To characterize the amplitude distribution of surface electromyograms (EMGs) along the gastrocnemius medialis (GM) muscle for two knee joint angles.
METHODS: Surface EMGs were detected from the GM muscle of 16 healthy participants with a linear array of 16, silver bar electrodes (1 cm inter-electrode distance). With the assistance of ultrasound imaging, this array was positioned so as to cover as much as possible the muscle longitudinal axis. Subjects were asked to exert isometric plantar flexions at 60% of their maximal voluntary contraction (MVC) for 5 seconds, with the ankle joint at 90º. Submaximal efforts were performed with the knee fully extended (180º) and flexed at 90º. The root mean square (RMS) amplitude of surface EMGs was computed separately for each channel. The number of channels detecting RMS amplitudes greater than 70% of the maximal amplitude and their respective mean RMS amplitudes were considered to estimate the effect of the knee position on the spatial distribution of GM activity.
RESULTS: Significant differences were observed in both RMS amplitude and distribution with changes in knee position. A representative example is illustrated in the Figure. Average RMS values obtained for knee extended were statistically greater than for knee flexed ($p<0.001$). The number of active channels (i.e., channels providing 70% of maximal RMS values), however, showed an opposite result with knee position. More channels detected relatively larger surface EMGs with knee flexed than extended ($p<0.001$).
CONCLUSION: Changes in knee angle, from full extension to 90° flexion, led to surface EMGs with, on average, smaller amplitude though distributed across a larger skin region. This raises the question as to whether the degree of GM activity can be exclusively defined in terms of RMS amplitude.

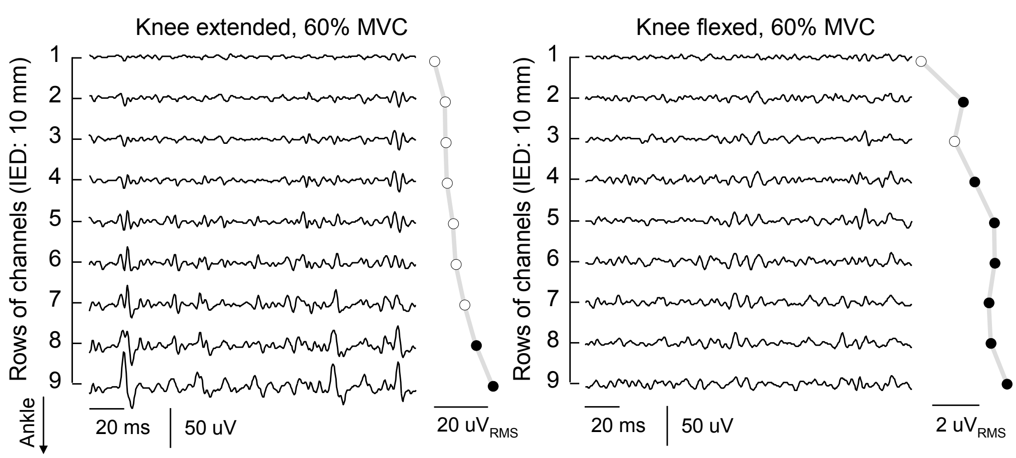

Figure 1: Surface EMGs and their RMS amplitude distribution for a single subject. Black circles denote channels providing RMS values greater than 70% of the maximal value.

FOREARM MUSCLE ACTIVITY DURING WRIST AND FINGER MOVEMENTS

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AIM: The aim of this work was to quantify 1) whether it is possible to localize the surface electromyographic (sEMG) activity of forearm muscles during free movements of the wrist and single fingers and 2) the effect of hand position on the sEMG activity distribution.

METHODS: Eight male healthy subjects participated in the study. The subjects performed cyclic dynamic single DOF tasks involving the wrist (flexion/extension and adduction/abduction) and the fingers (hand opening/closing, flexion/extension of the metacarpophalangeal (MCP) and of the proximal interphalangeal (PIP) joint of a single finger). The wrist tasks and the hand opening/closing task were performed with the hand in prone and neutral positions. A sensorized glove was used to record the kinematics of the hand and of the fingers. Monopolar sEMG signals were acquired from the left forearm muscles using a grid of 112 silver electrodes integrated into a stretchable textile sleeve (Figure). The centre of gravity (COG) of the sEMG activity areas have been identified by applying a segmentation technique to the weight matrices obtained from the Non Negative Matrix Factorization applied to sEMG envelopes.

RESULTS: The Wilcoxon test disclosed a statistical difference ($p<0.01$) in the position of COG in ulnar-radial direction between the neutral and prone hand positions (shift: median (25%-75%)): 0.8 IED (0.7-1.1) for wrist flexion/ extension, 1.2 IED (0.1-1.4) for wrist adduction/ abduction). Moreover, sEMG activity level was influenced by the hand position highlighting the influence of gravity. The results for single finger movements showed that distinct areas of sEMG activity can be identified in the forearm for different fingers.

CONCLUSION: This work gives new quantitative information about sEMG activity distribution on the forearm during hand and finger movements and provides a basis for future works on the identification of optimal electrode number and positioning for sEMG based prosthesis control.

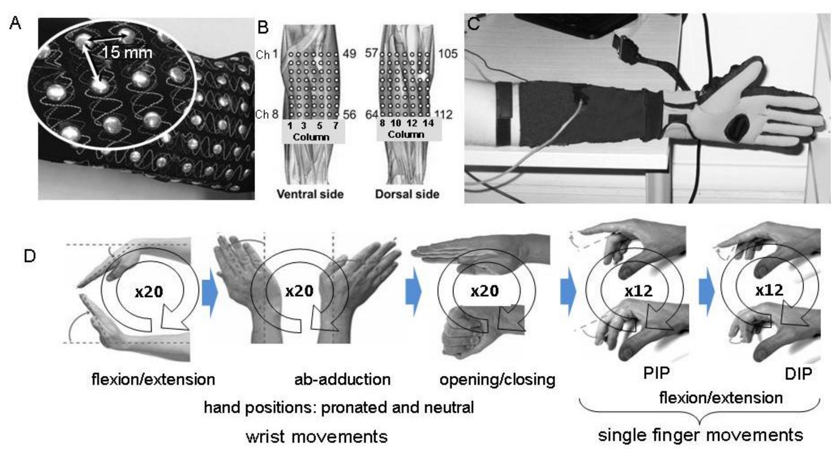

Figure 1: Experimental setup. A) Wearable detection system. B) Approximate position of the electrode matrix on the forearm. C) Sensorized hand and forearm. D) Studied dynamic tasks.

INFLUENCE OF HEEL CUSHIONING ELEMENTS IN SAFETY SHOES ON MUSCLE-PHYSIOLOGICAL PARAMETERS

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AIM: Musculo-skeletal disorders play an important role in socio-economics of modern industrialized countries. In addition to widespread muscular deconditioning due to reduced physical demands overloading is still an important factor as well. Since active protection of the bony structures is ensured through muscles, the prevention of muscular fatigue or at least its detention could essentially contribute to an improvement of this important active protection function. The purpose of this study was therefore to examine whether such a contribution could be achieved through the application of cushioning elements in the heel area of safety shoes.
METHODS: Six trunk and 7 hip and leg muscles of 10 healthy men, aged 25-48 (median = 38.5) years were analyzed with surface electromyography (SEMG). The subjects completed three different walking speeds (slow, preferred, and fast) on a walkway. During the initial investigation they wore the safety shoes they regularly used during their working hours, which were then replaced by the test shoes (VX 5 Perbunan, Steitz Secura®, Class 2 safety shoes). The latter were equipped with exchangeable heel inserts. Three different degrees of heel cushioning were used: 'no' (i.e. dummy insert), 'optimal', and 'too soft' (based on the individual body weight). The investigation took place after at least two days of habituation and was always carried out at the end of the working shift. Time independent parameters of gait economy (integral, cost of transport (COT)) and grand averaged amplitude curves were analyzed.
RESULTS: The comparison of gait economy parameters (integral, COT) revealed a clear amplitude drop if the values of the test shoes were compared with the subject's own safety shoes, indicating reduced muscular effort while wearing the test shoes. Furthermore, differences between the damping situations within the test shoes could be detected whose effects vary between muscle groups and walking speed, respectively. In addition, for the grand averaged curves the heel strike associated amplitude peak of the back muscles occurs earlier within the time normalized stride if the test shoes are considered. If the different damping qualities are to be compared, the heel strike associated amplitude peak of the back muscles could be reduced by wearing the cushioning elements in comparison with the dummy element.
CONCLUSION: By wearing the test shoes with its optimal cushioning inserts an earlier occurrence of the heel strike associated amplitude peaks of the back muscles and a decrease in overall muscular effort could be detected, which represents a potentially protective mechanism for the spine.
ACKNOWLEDGEMENT: The study was supported by Steitz Secura Corp. The sole responsibility for the content of this publication lies with the authors.

THE INFLUENCE OF LOCOMOTOR ABILITY ON LOWER-LIMB MUSCLE ATROPHY IN INSTITUTIONALIZED ELDERLY WOMEN: A LONGITUDINAL STUDY

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AIM: Many studies have investigated age-related muscle atrophy using ultrasonographic measurement of muscle thickness of lower limb muscles. Previously, we reported that the degree of age-related muscle atrophy of the lower limbs in elderly women was closely associated with their walking ability in a cross-sectional study (Eur J Appl Physiol, 2011). However, no studies have focused on the influence of disability among elderly people on lower-limb muscle atrophy in longitudinal studies.

This longitudinal study investigated the relationship of locomotor ability with the decline in muscle thickness of the lower extremities among institutionalized elderly women.

METHODS: Subjects comprised 21 elderly women residing in a nursing home (mean age 82.4±6.5 years). Subjects were able to ambulate independently or with an assistive device, and did not have an unstable physical condition. The subjects were divided into two groups according to their locomotor ability: the high-mobility group (n = 10), who were able to perform the timed “Up & Go” (TUG) test at a maximum speed of < 8.5s, which has been considered a reference value in elderly women (Isles et al., 2004); and the low-mobility group (n = 11), who performed the TUG test at a maximum speed of > 8.5s. No significant differences were found between the groups in age and BMI.

The thickness of the following 11 lower limb muscles was measured using B-mode ultrasound: the psoas major, gluteus maximus, gluteus medius, gluteus minimus, rectus femoris, vastus lateralis, vastus intermedius, biceps femoris, gastrocnemius, soleus, and tibialis anterior muscles. Muscle thickness was assessed before and after a 12-month period.

Differences in muscle thickness between baseline and after 12 months were examined using paired t-tests. Differences in the magnitude of decline in muscle thickness (%) compared with baseline between the groups were examined using the Mann–Whitney U test.

RESULTS: No significant differences were found between the groups in muscle thickness at baseline. In the low-mobility group, muscle thickness of the rectus femoris, vastus lateralis, vastus intermedius, and tibialis anterior muscles decreased significantly after 12 months, whereas that of the psoas major, gluteus maximus, gluteus medius, gluteus minimus, biceps femoris, gastrocnemius, and soleus muscles showed no change. In the high-mobility group, only muscle thickness of the rectus femoris decreased significantly among lower-limb muscles.

The magnitude of decline in muscle thickness compared with baseline in the vastus lateralis muscle in the low-mobility group (−24.9±18.7%) was significantly greater than that in the high-mobility group (−7.8±17.9%). The magnitude of decline in muscle thickness was highest for the vastus lateralis muscle in the low-mobility group.

CONCLUSION: Loss of skeletal muscle mass is part of the aging process and is exacerbated by inactivity, which is in turn closely associated with locomotor ability. This longitudinal study suggests that the degree of locomotor ability influences age-related muscle atrophy in the lower limbs, especially in the vastus lateralis muscle, among frail elderly women.

AN ELECTROMYOGRAPHIC STUDY TO DETERMINE MUSCLE ACTIVITY WHILE WALKING ON LAND AND IN WATER

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AIM: Walking in water is the most frequently performed aquatic exercise. Recently, stride walking in water, which includes the wide swing of the lower extremities with increased hip flexion and knee extension, has also been described. Although walking in water is commonly performed during both training and rehabilitation, there is little evidence on its potential advantages compared with those of walking on land. Then, we aimed to clarify whether activities of the trunk and lower extremity muscles during walking and stride walking in water were different from those while during walking and stride walking on land.
METHODS: Six men participated in this study. Electromyographic (EMG) and motion analysis data were synchronously obtained during walking and stride walking on land and in water (water depth, 1.3 m). Participants walked at self-selected comfortable speeds. The step length was prescribed to be 0.35 times the height for the walking task and was to be half of the height for stride walking. EMG data were obtained for 7 muscles on the right side: rectus abdominis (RA), internal obliques (IO), erector spinae (ES), gluteus medius (GMED), rectus femoris (RF), biceps femoris (BF), and gastrocnemius medialis (GM). The experimental task was divided into the prior stance phase, middle stance phase, late stance phase, double stance phase 1, prior swing phase, middle swing phase, late swing phase, and double stance phase 2 for the right lower extremity. 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: The GMED showed significant interaction while walking on land compared to that while walking in water. The GMED showed significantly high activation during prior stance phases (on land, 22.0 ± 11.2 %MVC; in water, 4.6 ± 2.5 %MVC) and double stance phase 2 (on land, 14.7 ± 8.9 %MVC; in water, 6.1 ± 3.6 %MVC). The main effect for tasks was significant in the activity of the IO. When averaged across all phases, IO activity during walking on land was significantly greater than that during walking in water. Significant interaction was observed in RA, ES, BF, and GM activities during stride walking on land compared to that during stride walking in water. The main effect for tasks was significant in the activity of the IO, GMED, and RF. The activities of all muscles during stride walking on land were significantly greater than those during stride walking in water.
DISCUSSION: For the same tasks, EMG activity of the trunk and lower extremity muscles decreased while walking and stride walking in water compared with that while walking and stride walking on land. On the other hands, a previous study (Shono et al., 2007) reported that walking in water at the xiphoid process level increased lower extremity muscle activity. Our results might be influenced by differences in the depth of water. This study indicated that walking in deep water decreases loading and stress to the muscles compared to that observed while walking on land.

THE EFFECT OF DIFFERENT LUMBAR BELT DESIGNS ON THE LUMBOPELVIC RHYTHM IN HEALTHY SUBJECTS

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AIM**:** The aim of this study was to determine the effect of different lumbar belts (LB) designs (flexible, comfortable) on range of motion (ROM) and lumbopelvic rhythm.
METHODS**:** Healthy subjects (10 males; 10 females) performed 5 standing lumbar flexion/extension cycles, with knees straight, during a control (no belt) and four LB experimental conditions (extensible, with and without back and front panels; non-extensible). The tension of the LBs was standardized with the use of a pressure sensor (70 mmHg). Motion of the pelvis and lumbar spine was measured with 3D angular inertial sensors (X-Sens Motion Technologies, Enschede, The Netherlands) positioned on a plastic plate overlying the sacrum (Figure 1) and just above the LBs (~ T7 – T9 levels). ROM of the lumbar spine as well as the relative contribution of the lumbar spine to the total trunk ROM ($\%ROM_{LU}$ variable) were computed, the later being further divided into 4 intervals (0-25; 25-50; 50-75; 75-100% of total trunk ROM). ANOVAs for repeated measures were applied.
RESULTS**:** Wearing any LB significantly reduced lumbar ROM by an amount ranging from 9 to 15º, adding back and front panels to an extensible LB producing the largest restrictions. It also significantly changed the lumbopelvic rhythm, as revealed by different coordination variables such as $\%ROM_{LU}$ (Figure 2). A secondary comparison also revealed a SEX × CONDITION interaction that just failed to reach statistical significance.
CONCLUSION**:** These findings provide direct evidence of the biomechanical effects of LB use during trunk flexion/extension.

Figure 1: Positioning of the sensors to allow the monitoring of the pelvis and lumbar spine without interference from the lumbar belts

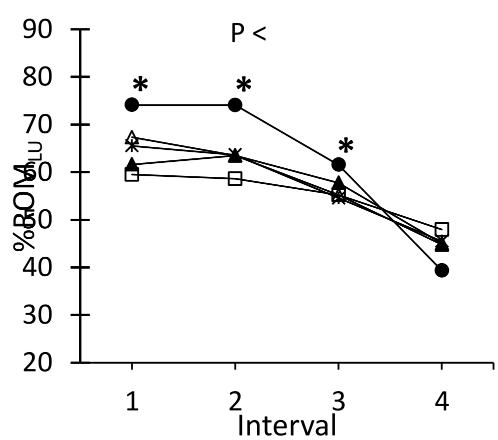

Figure 2: $\%ROM_{LU}$ across intervals for each condition (CONDITION × INTERVAL interaction; $P < 0.001$):
●**:** control; ∆**:** extensible without panels; extensible with back panel; □: extensible with back and front panels; ×: non-extensible. *Significant CONDITION effect for a given interval. Standard deviations were not shown for clarity.

CARDIORESPIRATORY RESPONSE AND MUSCLE ACTIVITY DURING BACKWARD WALKING AT LOW SPEED

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AIM: This study determined differences of cardiorespiratory response and muscle activity between those of forward walking (Fw) and backward walking (Bw) on a treadmill at low speed.
METHODS: In this study approved by the Tohoku Bunka Gakuen University Human Subjects Ethics Committee, 12 young healthy men (21.8 ± 2.2 years old, 58.8 ± 4.6 kg body mass, and 172.5 ± 5.9 cm height) who volunteered to participate were informed of the experiment purpose. They gave their written consent to participate. All participants were asked to perform Fw and then Bw respectively for three consecutive minutes at walking speeds of 20, 40, 60, and 80 m/min. The EMG activity was recorded with surface electrodes from the gluteus maximus (GM), gluteus medius (Gmed), biceps femoris (BF), rectus femoris (RF), vastus medialis (VM), tibialis anterior (TA), lateral head of gastrocnemius (GA), and soleus muscles (SO) of the left leg during Fw and Bw. The analog EMG signal and a foot-switch data were passed through the 16 bit A/D board. All signals were sampled at 1 kHz. EMG data were filtered with a 10 Hz high-pass IIR digital filter and a zero-phase filtering approach was adopted. After the signal was full-wave rectified, the moving average was calculated for 75 ms windows. Furthermore, EMG data were standardized by each walking cycle. After calculating the arithmetic mean, the integrated EMG (IEMG) value was detected for each participant. The cardiorespiratory response parameters including oxygen uptake (VO_2, ml/kg/min) and heart rate (HR, beats/min), were adopted for 30 s from the end of each walking speed condition. Moreover, we calculated the oxygen cost (ml/kg/m) by dividing walking speed into VO_2.
RESULTS: The IEMG of Gmed, BF, RF, VM, and TA were significantly larger for Bw than for Fw at walking speed. They increased concomitantly with walking speed. The mean VO_2 and mean HR for all participants were higher for Bw than for Fw, and increased concomitantly with the increment in walking speed. Furthermore, the mean oxygen cost at 60 m/min was lower than at any other speed in Bw.
CONCLUSION: In previous works, Bw was investigated at higher speeds (over 50 m/min). However, Bw is performed at lower speeds during rehabilitation. Results of this study show that VO_2 and HR were higher in Bw than in FW at low speed, and that IEMG shows a similar tendency.

Table 1: Cardiorespiratory response parameters and integrated EMG of rectus femoris.

		Rest	20 m/min	40 m/min	60 m/min	80 m/min
oxygen uptake (ml/kg/min)	Fw	5.0 ± 1.3	9.3 ± 2.9	10.4 ± 3.0	12.2 ± 3.9	14.6 ± 3.5
	Bw	4.9 ± 0.7	10.0 ± 1.5	13.3 ± 2.0	16.8 ± 1.9	24.5 ± 2.9
heart rate (beats/min)	Fw	103.7 ± 17.2	105.9 ± 16.6	107.1 ± 16.3	112.5 ± 16.4	115.5 ± 16.6
	Bw	108.8 ± 16.9	111.1 ± 17.6	118.6 ± 22.6	130.9 ± 23.6	152.2 ± 16.6
oxygen cost (ml/kg/m)	Fw	-	0.46 ± 0.15	0.26 ± 0.07	0.20 ± 0.07	0.18 ± 0.04
	Bw	-	0.50 ± 0.07	0.33 ± 0.05	0.28 ± 0.03	0.31 ± 0.04
IEMG of RF (mV・s)	Fw	-	57.5 ± 9.0	84.4 ± 22.5	129.6 ± 40.3	155.8 ± 53.6
	Bw	-	74.7 ± 21.6	113.4 ± 34.0	235.3 ± 35.1	340.0 ± 57.7

Fw: Forward walking, Bw: Backward walking. IEMG of RF: Integrated EMG of rectus femoris. (mean ± SD)

EARLY SLOWDOWN OF SKELETAL MUSCLE DEOXYGENATION DURING INCREMENTAL CYCLING EXERCISE IN TYPE 2 DIABETES

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AIM: The aim of this study was to determine whether changes in deoxygenated Hb (Deoxy-Hb) of skeletal muscle during incremental cycle ergometer exercise detected by Near-Infrared Spectroscopy (NIRS) are altered in individuals with type 2 diabetes (T2DM) compared with age matched healthy subjects. We hypothesized that patients with T2DM had an earlier slowdown of muscle doxygenation compared with healthy subjects because of an early onset of anaerobic metabolism.
METHODS: Ten elderly men with T2DM and eleven age-matched healthy men participated in this study. The subjects performed the incremental exercise test using a cycling ergometer. The experimental protocol consisted of 2 min of rest, 4 min of warming up period, a progressively increasing in work rate (10 W/min) exercise, and 6 min of cooling down period. During experimental period, NIRS probe was placed on the right vastus lateralis muscle to assess skeletal muscle deoxygenation. Also, respiratory gas exchange and ECG were continuously monitored and recorded. The ventilatory threshold (VT) was detected from gas exchange data using the V-slope method. %Heart Rate Reserve (HRR) was calculated as followed; heart rate / predicted maximum heart rate. $\dot{V}O_2$ and %HRR at VT were compared between groups using independent student's t-test. Also ANOVA was used to test to compare Deoxy-Hb among at each relative intensity in both groups. The level of statistical significance was set at $p < 0.05$. All procedures used in this study were in accordance with the Declaration of Helsinki and were approved by the Committee for Human Experimentation at the Graduate School of Human and Environmental Studies, Kyoto University and for Kyoto Teishin Hospital.
RESULTS: $\dot{V}O_2$ and %HRR at VT was significantly lower in the patients with T2DM when compared with healthy subjects ($p < 0.05$). In both groups, the Deoxy-Hb temporarily decreased in warming up period, and then most of the patient with T2DM showed nonlinear increase in Deoxy-Hb, whereas most of the healthy subjects displayed a linear increase. In the patients with T2DM, there were significant changes in Deoxy-Hb at 20 and 30 %HRR compared with the value at 70 %HRR ($p < 0.05$). On the other hand, significant differences were found at 20, 30, 40 and 50 %HRR compared with 70 %HRR in healthy subjects ($p < 0.05$).
CONCLUSION: We observed an early slowdown or plateau of muscle deoxygenation mainly in T2DM during incremental cycling exercise. This suggests that exercise intolerance in T2DM may depend on not only an insufficient supply of oxygen to muscle but also poor capacity for usage of oxygen in the muscle. Since exercise intolerance in T2DM has been considered to contribute to mortality, it is clinically important to elucidate the mechanism of the reduced exercise tolerance. Therefore, this study would further explain the potential mechanisms of exercise limitation and intolerance in patients with T2DM as related to the ability of O2 extraction of skeletal muscle.

DESCRIPTION OF THE ELECTROMYOGRAPHIC VARIABLES DURING VOLUNTARY COUGH IN HUMANS – A SYSTEMATIC REVIEW

DESCRIPTION OF THE ELECTROMYOGRAPHIC VARIABLES DURING VOLUNTARY COUGH IN HUMANS – A SYSTEMATIC REVIEW

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INTRODUCTION

Voluntary couch is the main physiologic mechanism of bronchial hygiene. It occurs through the activation of expiratory muscles [1], and clinical conditions such as spinal cord injury (SCI) reduce the peak cough flow (PCF) due to the partial or total paralysis of these muscles [2]. However, cough remains as an active process in spite of the lesion. There is evidence of electromyographic (EMG) activity in the clavicular portion of the pectoralis major during expiration, in patients with traumatic SCI below the fifth cervical segment (C5) [3]. Even when the expiratory muscles have no functional contraction, EMG signals can be detected during cough, and this signal can be used to trigger the contraction of these muscles in the explosion phase, through functional electrical assistance [4]. The characterization of EMG signals during voluntary cough in humans can make the synchronization between electrical stimulation and functional cough feasible. The goal of this systematic review of the literature (SRL) was to describe the EMG variables during voluntary cough in subjects with and without SCI.

METHODS

A SRL has been made, based on the PRISMA declaration (Figure 1) [5], through a qualitative and methodological analysis of the results. The goal was to answer the following question: "which electromyographic variables can be used to detect cough in subjects with and without spinal cord injury?". The search included scientific articles in English, Portuguese, and Spanish languages, using the combination of the following descriptors: electromyography *OR* eletromyogram *OR* EMG *AND* cough *OR* bronquial hygiene *OR* defensive pulmonary reflex.

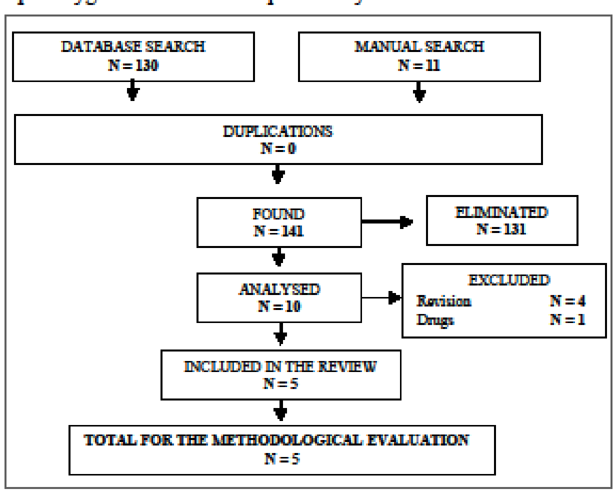

Figure 1 – Flowchart of the stages of the systematic review

EFFECTIVENESS OF ISOSTRETCHING TECHNICAL IN GERIATRIC PATIENTS

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AIM: Aging is a physiological process that has positive and negative bodily changes. In the aging process, there is reduction in physical, cognitive and behavioral aspects that develop senile individual a reduced functional capacity. Isostretching is a technique that allows the body work seamlessly from self-stretching in certain muscle and isometric contractions chains. The objective of this study is identifying and to quantify the effects of the technique isostretching in senile patients.

METHODS: Participated in this study 10 subjects of both genders, aged 60 to 70 years that did not have any musculoskeletal disease, neurological or respiratory diseases. All subjects underwent physical therapy evaluation by tests: Borg, Manuvacuometria of inspiratory muscles, Manuvacuometria of the expiratory muscles, the multifidus muscle testing, test the transverse muscle of the abdomen, and EVA time up and go to evaluate the effectiveness of isostreching in geriatric patients . The technique isostretching performed in this study was standardized twice a week for 10 sessions of 50 minutes each. The final values for each test performed was evaluated statistically by test t ($p < 0.05$) using the SPSS 21.0 program.

RESULTS: In this study it was found significant differences for tests: Borg, Manovacuometry to the expiration muscles and Time up and go.

CONCLUSION: The technique isostretching the group evaluated was effective for the treatment of functional capacity and strength of respiratory muscles, these important aspects for geriatric patients present progressive loss of functional capacity.

ACKNOWLEDGEMENT: Departamento de Geriatria do Centro Universitário UNIFAFIBE.

USE OF VIRTUAL REALITY IN GERIATRIC PATIENTS IN TERMS INSTITUTIONALIZED AND NOT INSTITUTIONALIZED

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AIM: The Brazilian population is composed of approximately 2 million elderly, accounting for 10% of the total population of Brazil. During the aging process limiting factors in daily life activities are frequent and need for physiotherapy intervention becomes indispensable to prevent further bodily impairments. Aware of demotivation caused to patients during long-term treatment, some hospitals bind the playful work with physical therapy to improve patient adherence to therapeutic proposals. In these respects, the use of virtual reality, it has become a trend to conventional treatments, allowing greater stimulation during treatment. This study aims to assess the effectiveness of the Kinect device to aid physical therapy in institutionalized and non-institutionalized geriatric patients.
METHODS: We analyzed 10 geriatric patients aged 60-90 years of both sexes were divided into two groups matched for 6 women and 4 men. These groups were: G1 - Institutionalized consisting of 5 elderly residents over 5 years in a geriatric center. G2 - Do not institutionalized, composed of 5 elderly community Trough - SP. Patients were submitted to physiotherapy assessment by the SF-36 questionnaire, Time up and Go, the Berg Scale and the six-minute walk test. The treatments with virtual reality occurred during 10 50-minute sessions focusing on balance, muscle strength and functional exercises. The final values of each dimension assessed by the SF-36 and the balance and functional tests were compared to assess the outcome of patients with treatment of virtual reality using T ($p < 0.05$) by using SPSS 21 program.
RESULTS: This study found improvement in all dimensions assessed by the SF-36, Team Up and Go, the Berg Scale Test and six-minute walk, however the results were not statistically significant ($p < 0.05$).
CONCLUSION: The virtual reality device showed improved quality of life, balance and functional ability of geriatric patients undergoing treatment in this study, given that the patient's experience with virtual reality platform creates new opportunities and challenges that facilitate the action physiotherapy during rehabilitation of these patients. ACKNOWLEDGEMENT: Departamento de Geriatria do Centro Universitário UNIFAFIBE.

THE EFFECTS OF KINESIO TAPING ON SUBJECTS WITH UPPER TRAPEZIUS TRIGGER POINT PARTICIPATING IN A RANDOMIZED CONTROLLED TRIAL

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AIM: The aims are (1) to investigate the effects of manual pressure release and manual therapy plus kinesio taping in subjects with upper trapezius trigger point; (2) to examine the relationship between outcomes following treatments.

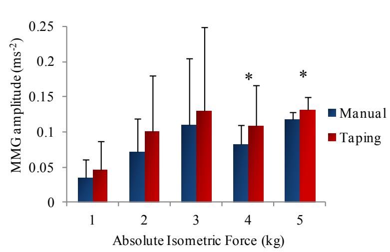
METHODS: Thirty one subjects with upper trapezius trigger point were randomly allocated to one of the following group: manual pressure release (MPR) and manual pressure release plus kinesio taping (MKT). Subjects in both groups received one session of manual pressure release, but subjects in the MKT group also received taping two times applied for 3 days and re-applied for other 4 days. Main outcome measures were pain intensity, pressure pain threshold (PPT), mechanomyographic (MMG) signal, and muscle stiffness. Subjects were assessed at baseline, immediately after intervention and 7 days follow up.

RESULTS: Subjects in both groups improved their pain sensitivity from baseline to intervention and follow-up (d=5.57, $p<0.005$; d=4.01, $p<0.005$). A significant improvement on tissue displacement was found in the MKT group compared to MPR group (27% difference, $p<0.05$). Subjects in the MKT group showed significant higher MMG amplitude than that of MPR group after intervention and follow up (at 4 and/or 5kg force level, $p<0.05$). However, no significant difference was found for the MMG frequency between groups ($p>0.05$). Poor to fair relationships were found between MMG amplitude and other outcomes in both groups. Fair to excellent relationships (r= -0.30 - -0.95) were found between MMG frequency and PPT in baseline and immediately after intervention for both groups.

CONCLUSION: Manual pressure release and manual pressure release plus taping are effective in reducing pain in subjects with upper trapezius trigger point. Kinesio taping has an additional effect on muscle characteristics like tissue displacement and muscle contraction amplitude. The good to excellent relationships between MMG frequency and PPT in MKT also support that trigger point muscle characteristics may be changed by taping. Long-term follow-up study is needed to validate this assumption.

Table 1: Data at post treatment and 1 week follow-up of both groups.

Group	**MPR group (n=15)**		**MKT group (n=16)**	
Time	**Post**	**Follow-up**	**Post**	**Follow-up**
PPT (Kg)	3.55 ± 0.39	3.14 ± 0.29	3.75 ± 0.47	2.75 ± 0.48
VAS	2.13 ± 1.64*	0.73 ± 0.88*	3.56 ± 0.81*	0.37 ± 0.81*



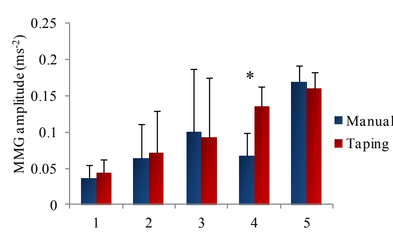


Figure 1: Mean mechanomyographic (MMG) amplitude across absolute isometric force at post intervention (left) and follow up (right) for both groups. The error bars represent standard deviation. *Significant difference between groups ($p<0.05$)

AN ELECTROMYOGRAHIC COMPARISON OF SHOULDER MUSCLE ACTIVATION LEVELS AND RECRUITMENT PATTERNS DURING THE SHOULDER PRESS AND SCAPULAR PLANE ABDUCTION EXERCISES.

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AIM: The shoulder press and scapular plane shoulder abduction are exercises commonly used in rehabilitation and the prescription of exercises to improve shoulder muscle function. Although the shoulder press has been referred to as an abduction exercise it is not known if muscle activation patterns and levels are similar in both exercises. Therefore, the aim of this study was to compare the activation patterns and levels during the shoulder press exercise with scapular plane abduction to determine if they are similar exercises.
METHODS: Eight shoulder muscles (deltoid, pectoralis major, serratus anterior, upper trapezius, lower trapezius, supraspinatus, infraspinatus, subscapularis) were investigated using surface and indwelling electromyographic recordings during the shoulder press exercise in 15 subjects and shoulder abduction in 14 subjects at low, medium and high load.
RESULTS: Higher average muscle activation levels were recorded during shoulder abduction performed in the scapular plane than during the shoulder press, with subscapularis activity higher at all loads, upper trapezius at medium and high loads and infraspinatus and lower trapezius activity higher at high load ($p<0.05$). The only muscle to have a similar activation pattern between exercises was middle deltoid ($r \geq 0.65, p<0.05$). All other muscles tested had inconsistent, low or negative correlations between exercises.
CONCLUSIONS: The shoulder press and scapular plane abduction are complex exercises requiring the coordinated activity of shoulder torque producing muscles, axioscapular and rotator cuff muscles. The shoulder press exercise with a shorter lever arm requires less average muscle activity to perform than scapular plane abduction and therefore may be a more suitable exercise earlier in rehabilitation. The different pattern of muscle activation between exercises indicates that the shoulder press and scapular plane abduction represent two distinctly different exercises.

AMBULATORY ASSESSMENT OF SHOULDER ABDUCTION FORCE-ANGLE CURVE USING A SINGLE WEARABLE INERTIAL SENSOR

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AIM: Due to muscle fibers (sarcomere length) and joint (muscle force moment arm) mechanics, the capacity of a contractile entity to produce force varies as a function of joint angle. When coping with an injured joint, knowledge of force production patterns throughout the range of motion (ROM) becomes, thus, essential for assessing damages, monitoring functional recovery and addressing therapeutic interventions avoiding overloads imposed on the muscle-tendon structure during the rehabilitation phase. In a laboratory setting, force-angle curves can be assessed using isometric dynamometry by measuring force produced statically at any given joint angle [Kulig et al, 1984] or using isokinetic dynamometry [Toledo et al, 2007]. Limitations of these methodologies are both functional (human movements are neither performed with fixed joint angles nor at constant angular velocities) and practical (expensive and cumbersome setup). Alternatively, strength of an injured joint while rotating against a isoinertial resistance (i.e., elbow flexion or shoulder abduction holding a dumbbell) can be assessed using a single inertial measurement unit (IMU), consisting of a three-axes accelerometer and gyroscope: if fixed to the external resistance, IMU can be used to measure at the same time the angular displacement of the external resistance (which is equal to the ROM of the joint) and the linear acceleration of the external resistance (which corresponds to the force applied to the external resistance). Aim of the present paper is to assess the reliability (accuracy and repeatability) of force-angle curves as determined from signals measured by a single IMU during a shoulder abduction movements.

METHODS: 60 subjects (30 males and 30 female, age: 25 ± 7 yrs) without any past shoulder complication where asked to perform four trials consisting of one consecutive maximal shoulder abduction-adduction movement holding a 1 kg dumbbell in the hand. Force-angle curve relative to the shoulder abduction movement was assessed using a wireless IMU (FreeRehab, Sensorize, Italy) fixed to the dumbbell. Within-subject (inter-trials) repeatability of the determined force-angle curves was assessed by means of intra-class correlation coefficient (ICC) performed using force values averaged throughout the ROM. Accuracy of the estimated ROM was assessed using an isokinetic dynamometer (Kin Com, Isokinetic International, USA): one subjects performed three consecutive shoulder abduction-adduction movements at five different angular velocities (30, 60, 90, 120, 240 °/s) with 90° of imposed ROM.

RESULTS: No differences in force-angle curves were found between trials (ICC=0.98, 95% CI=0.96 to 0.99, p=0.001). Mean error of the current method in estimating ROM was always less than 1° (p=0.37) in any of the 3x5 repetitions performed at the isokinetic dynamometer. Neither the number of repetitions (p=0.21) nor the angular velocities (p=0.62) were found influencing the estimated ROM. The latter did not result correlated with the increasing angular velocities used in the experiments (r=0.32).

CONCLUSIONS: This study showed the effectiveness of using an IMU for the assessment of force-angle curves of a joint. This opens up new perspectives in the field of rehabilitation: angle-specific force curves may help doctors in identifying pathologies and monitoring their recovery through the rehabilitation program, in a manner that fully complies with the needs of clinicians of an ambulatory setting of measurements.

ACKNOWLEDGEMENT: Authors would like to thank the Exercise Physiology Lab of University of "Foro Italico" for its cooperation in providing and supporting experiments with isokinetic dynamometer.

MOTOR UNIT SYNCHRONIZATION AS A MEASURE TO IDENTIFY AGE-RELATED CHANGES

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AIM: The purpose of this study was to investigate the impact of age on muscle activity recorded from multiple channels of surface electromyogram (sEMG). This research hypothesis that with ageing, there is a net increase in the motor unit density and reduction in number of motor units, which would indicate that there is a reduction in the independence between multiple channels of the muscle activity.

METHODS: Surface Electromyogram (SEMG) of biceps brachii (four channels) was recorded from 98 subjects (age range 20-70) while performing sustained isometric contraction at maximum voluntary contraction. A new measure, Increase in synchronisation (IIS) was computed to identify the dependency factor due to motor unit synchronisation. IIS index was computed using sub-band ICA technique and Frobenius norm to measure the independency factor.

RESULTS: From the results (Figure 1), it is conferred that a) there is clear trend of decrease in IIS measure as age increases, b) with ageing, there is a net increase in the motor unit density and reduction in number of motor units, which would indicate that there is a reduction in the independence between multiple channels of the muscle activity.

CONCLUSION: This research study has observed that with ageing there is an increase in the motor unit synchronization which can be computed by measuring the independence between multiple channels of the muscle activity. This increase in synchronization is due to the net increase in the motor unit density and reduction in number of motor units in muscle physiology. The findings of this study can be used for the assessment of subjects suffering with neuromuscular disorders or for the rehabilitation programs for monitoring the elderly generation.

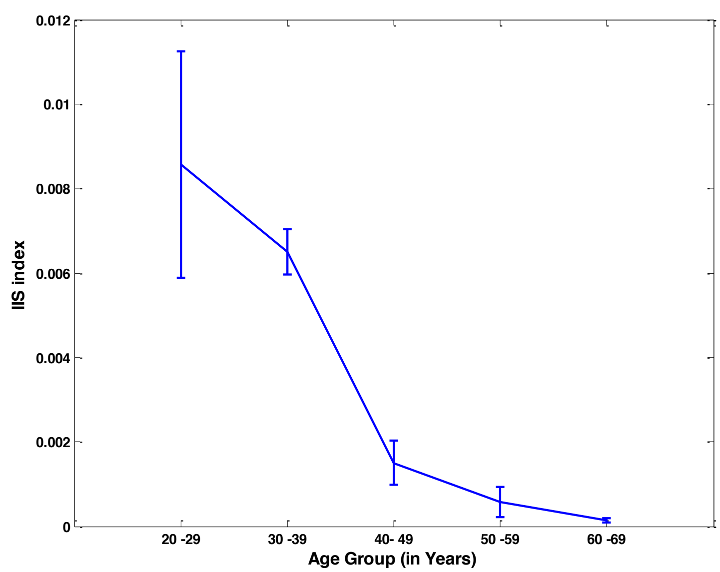

Figure 1: Increase in Synchronisation (IIS) Index vs. Age

THE EFFECTS OF A LOW-INTENSITY VIBRATION EXERCISE TRAINING PROGRAM OF 8 WEEKS ON THE BICEPS BRACHII: A PILOT STUDY

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AIM: A novel vibration exercise (VE) instrument, characterized by sinusoidal force applications has been developed and tested for proof of concept in a previous study. The aim of the present study was to evaluate the effects of such force-modulated VE training on muscle strength and neuromuscular activity.
METHODS: Nine subjects were randomly assigned to an intervention or control group. They underwent a unilateral arm flexion training program twice a week for 8 weeks. Two sets of ten repetitions were carried out in each training session. For the control group, the applied load was a ramp-up function applied to the subject's range of motion with the maximum value equal to the subject's 10-repetition maximum (Fig.1). For the intervention group, a 30-Hz vibration (sinusoidal force) was superimposed on the rump-up load. The vibration amplitude corresponded to 60% of the baseline force.
The isometric maximum voluntary contraction (MVC) of the subject's dominant arm was assessed before and after the 8-week training period. The EMG activity was recorded from the biceps brachii during isometric contraction with the elbow at 90 degrees at a fixed force level, corresponding to 60% of the MVC measured before the training program. The EMG signals were acquired with a Mobi8 system (TMSi, Enschede, NL) and sampled at 2 kHz. The recorded EMG data were band-pass filtered (20-450 Hz) and the root mean square (RMS) value of the filtered data between 2 and 8 s was derived and analyzed.
RESULTS: After the 8-week training program, no significant MVC increase was found, with no significant difference between the two groups (Table 1). This may be due to the low intensity of the training program. EMG RMS measurements showed an increase by 8.49% for the control group and a larger decrease by -15.08% for the intervention group. However, due to the small statistical sample, the difference between the groups was not significant.
CONCLUSION: Our results show low-intensity force-modulated VE to produce negligible MVC increase and larger EMG RMS decrease as compared to control. The EMG RMS decrease may reflect an improvement in the motor unit recruitment strategy, leading to increased force-production efficiency and making this training modality a suitable option for rehabilitation programs. These preliminary results and conclusions need however confirmation through extended validation. According to power analysis (single-tail t-test) on the EMG measurements, achievement of statistical significance requires group sizes of at least 12-subjects.

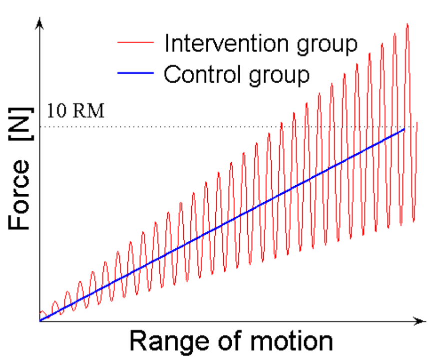

Table 1: MVC and EMG (RMS) variation.

	MVC	EMG
Intervention group	1.61±10.71%	-15.08±24.02%
Control group	-0.15±12.69%	8.49±14.72%

Figure 1: Loading function for the control group and the intervention group.

Poster Session 3 – (Poster Area 18.30)

CONCENTRIC AND ECCENTRIC MUSCLE ACTIVITY OF ERECTOR SPINAE ARE NOT CORRELATED DURING FULL RANGE FLEXION-EXTENSION

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AIM: To investigate erector spinae muscle activity in healthy young and mature females relative to trunk movement in forward flexion at stance
METHODS: In ten female participants (young 18-25yrs, n=5; mature 45-60yrs, n=5) left and right erector spinae (ES) muscle activity and thoracolumbar spine motion were evaluated from synchronously collected kinematic and EMG data during forward flexion and return to neutral. Ten high speed cameras (Eagle Digital Real Time System, Motion Analysis Corp, USA) recording at 120Hz using kinematic software (Cortex 3.6) and surface electromyography (sEMG) (Delsys Trigno, Boston, USA) sampling at 1200Hz were used. A reflective marker attached to the skin over the 11th thoracic (T11) vertebra was used to determine craniocaudal trunk motion. sEMG electrodes were placed over ES bilaterally at the thoracolumbar junction and data were full-wave rectified and a 6Hz low pass Butterworth filter was applied to obtain a linear envelope. Range of T11 displacement, maximal concentric activity (MCA) and minimal activity during the flexion relaxation phenomenon (minFRP), as well as maximal eccentric activity (MEA) were further analysed. Also, the time delay between the occurrence of maximal T11 displacement (MDispl) and minFRP (MDispl - FRP) was noted. Parameters were compared between age groups (using the independent t-test), as well as between left and right sided values (using the paired t-test), resulting in no differences. Pearson's correlation between the MEA peak (difference of MEA and min FRP) and the remaining MCA peak (difference of MCA and MEA) was calculated of the combined data set.
RESULTS: Both groups showed a similar range of MDispl (young: 305.56 ± 85.79 mm; mature: 333.25 ± 45.37mm; p=0.547), also a clear minFRP was identified in all participants, and in the majority of participants minFRP occurred just after maximal T11 displacement was reached. Standard deviation of muscle activity values was larger in the young, whereas standard deviation of the timing delay was larger in the mature. There was no correlation between the MEA and MCA peaks (r=0.112; p=0.758), even though MEA was smaller than MCA in all participants.
CONCLUSION: In females with no clinical signs or symptoms of back pain, FRP is clearly identifiable in a continuous flexion/extension movement independent of age. However, in such healthy females the magnitudes of concentric and eccentric erector spinae activity appear to be independent, raising the question whether these different activities should both be evaluated in clinical studies.

		differences			
		MCA – minFRP [mV]	MEA – minFRP [mV]	MCA – MEA [mV]	MDispl - minFRP [s]
young	ESL	3.77 (1.00)	1.54 (1.20)	2.23 (0.39)	-0.01 (0.43)
	ESR	3.39 (1.21)	1.44 (0.74)	1.98 (1.10)	-0.20 (0.16)
mature	ESL	3.60 (0.85)	0.97 (0.47)	2.63 (0.89)	-0.15 (0.75)
	ESR	3.46 (0.99)	1.14 (0.37)	2.32 (0.65)	-0.18 (0.71)

Table 1: Mean and standard devation (±) values for erector spinae (ES) left (L) and right (R)

Thursday July 17th 2014

Oral Sessions

Special Session: Ultrasound Methodology (Sala Cesarea 9.00-11.00)

Session Organizers:
E Hodson-Tole
Ian Loram
Nicholas Costen

Title	Speaker
Welcome and Introduction to the session	Emma Hodson-Tole
THE CONTRIBUTION OF ULTRASOUND FOR UNDERSTANDING HUMAN MOTOR CONTROL	Ian Loram
COMPUTER VISION TECHNIQUES FOR THE ANALYSIS ULTRASOUND VIDEO IMAGES OF MUSCLES	Nicholas Costen
COMPUTATIONAL ANALYSIS OF ULTRASOUND IMAGES TO INVESTIGATE REGIONAL VARIATION IN MUSCLE MOVEMENT	Emma Hodson-Tole
DYNAMIC RECONSTRUCTION OF THREE-DIMENSIONAL MUSCLE ARCHITECTURE USING ULTRASONOGRAPHY	Robert Herbert
ULTRAFAST ULTRASOUND FOR THE STUDY OF FASCICLES-TENDON INTERACTIONS	Antoine Nordez
Flash presentations – including	
BIOMECHANICAL FEATURES ARE INVOLVED IN MUSCLE FASCICLE VELOCITY DURING PLANTAR FLEXIONS	Hugo Hauraix
IS HUMAN MEDIAL GASTROCNEMIUS SHAPE INFLUENCED BY ACTIVATION OF ITS SYNERGISTS?	Elisabetta Ferrari
Final Questions and Closing remarks	Emma Hodson-Tole

THE CONTRIBUTION OF ULTRASOUND FOR UNDERSTANDING HUMAN MOTOR CONTROL

Loram ID [1], Harding P[1], Cunningham R[1], Costen N[1], Hodson-Tole E[1]

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Human motor control combines processes of sensory analysis, selection and motor output within a continually operating feedback loop[1]. Muscle provides the actuation of movement, the most significant sensory input to the sensory analysis of kinematic configuration[2] and provides a peripheral measure of motor effort which contributes directly to the estimation of configuration[2]. Surface electromyography, limited by its superficial view is unable to record deep muscles and indwelling electromyography is limited by recording volume and its invasive nature. Inference of muscle contraction from kinematic analysis is unable to resolve the higher dimensional content of muscle behavior including co-activations and sub-optimal contraction patterns. Ultrasound provides a low cost, non-invasive view of large sections of deep and superficial muscle tissue allowing direct analysis of muscle shape.

In a triangle of factors muscle shape reflects two primary inputs, kinematic joint angle(s) and neural activation. The relationship between factors is complex and intrinsically muscle images are information rich. Ultrasound provides relatively low quality images and two dimensional images sample a three dimensional reality. Hence automated analysis through tracking, segmentation and modeling is a challenging prospect. Knowledge of two factors enables prediction of the third and more recently the question of whether or not active contraction can be extracted solely from ultrasound is being investigated[3]. The motivation for developing this technology lays in the fact that ultrasound can provide information of physiological importance unavailable through motion analysis and electromyography.

Analysis of muscle shape informs understanding of proprioceptive input to the nervous system and transmission of motor output[4]. Analysis of deep muscles (e.g. abdomen and neck) allows study of motor coordination and motor unit activity[5] currently not available. Inclusion of human in the loop feedback of muscle behavior allows study of the hierarchical organization of motor output. Ultrasound provides new possibilities for understanding motor control including behavior emerging at the level of the complete feedback loop.

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3 Cunningham, Harding, Loram & Costen. Automated measurement of human skeletal calf muscle contraction via b-mode ultrasound imaging. in *Medical Image Understanding and Analysis*. 193, 2013).

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5 Harding, Hodson-Tole, Cunningham, Loram & Costen. Automated detection of skeletal muscle twitches from b-mode ultrasound images: An application to motor neuron disease. in *Pattern Recognition (ICPR), 2012 21st International Conference on*. 2630 1051-4651, 2012).

COMPUTER VISION TECHNIQUES FOR THE ANALYSIS ULTRASOUND VIDEO IMAGES OF MUSCLES

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BACKGROUND: Recent advances in computer hardware and software have made the tracking of features in images and the building of 3D models of the environment (referred to as Simultaneous Localization and Mapping) possible. There have also been very significant developments in the segmentation of images into areas reflecting underlying objects and the modelling of changes in their shape. However, it is difficult to apply these techniques directly to videos of muscle ultrasound, due to the lack of distinctive features which can be tracked between frames of the video, the non-standard image-formation process, and also because of the high level of image-noise relative to the differences induced by tissue changes.
AIM: This talk will review the techniques developed in our recent papers to allow measurement of muscle contraction (1), activity (2), fascicle shape (3) and muscle twitches (4). These centre upon the use of parameterized shape models for segmentation and subsequent tracking of transitory features using statistical and information-theory based metrics. It will also suggest methods in which more sophisticated learning-based techniques may be able to allow measurement of muscle parameters in a wider range of experimental circumstances.
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COMPUTATIONAL ANALYSIS OF ULTRASOUND IMAGES TO INVESTIGATE REGIONAL VARIATION IN MUSCLE MOVEMENT

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BACKGROUND: Recently developed methods for computational analysis of muscle ultrasound images have provided new measures of dynamic changes in muscle structure. These include the ability to track fascicle geometries [1] and tissue displacement in different portions of the muscle [2]. Such approaches provide the opportunity to objectively explore the functional significance of different aspects of muscle structure and function in vivo.
Dissections of human cadavers have revealed that some muscles are composed of distinct sub-compartments, identifiable on the basis of muscle fibre geometric properties. Where broad muscle attachments exist it is often easy to identify localized functions which can be attributed to different portions of the muscle. In cases where muscles attach via long tendons, for example human lateral gastrocnemius, the function of such partitioning remains unclear [3]. In addition to intramuscular geometric properties, many muscles span more than one joint and as such movement of different joints may have differing effects on muscle shape, with potential implications for both sensory feedback and optimizing muscle fibre mechanical output during a motor task.
Finally, it has recently been shown that in human medial gastrocnemius the fibres of motor units activated during postural control occupy relatively small spatial territories along the longitudinal length of the muscle, typically spanning approx. 40 mm [4]. It is therefore possible for activity to occur in discrete localised regions of the muscle. Such spatially discrete, localised activity could lead to site-specific, localised changes in muscle shape. Alternatively, mechanical links between fibres and/or geometric muscle properties could lead to the shape changes being more widely distributed. The occurrence of localised or distributed shape changes would have implications for factors such as the potential for sensory feedback from muscle spindles distributed through the tissue and provide insight into the interaction between active and passive material properties within the muscle.
AIM: This talk will therefore provide an overview of the use of B-mode ultrasound image analysis to quantify regional changes in muscle structure resulting from different perturbations and patterns of activation to provide insight into dynamic relationships between muscle structure and function.

REFERENCES: 1) Darby, Li, Costen, Loram & Hodson-Tole (2013) IEEE Trans. Biomed. Eng. 60: 1935-1945; 2) Darby, Hodson-Tole, Costen & Loram (2012) J. Appl. Physiol.112: 313-27; 3) English, Wolf & Segal (1993) Phys Ther 73: 857-867. 4) Vieira, Loram, Muceli, Merletti & Farina (2011) J. Physiol. 589: 431-443

DYNAMIC RECONSTRUCTION OF THREE-DIMENSIONAL MUSCLE ARCHITECTURE USING ULTRASONOGRAPHY

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AIM: We developed an ultrasound-based method for reconstructing the three-dimensional architecture of human muscles in vivo. The method has sufficient time resolution to study dynamic processes such as muscle stretch or the onset of muscle contraction. We illustrate use of the method to examine the contributions of changes in the lengths and three-dimensional orientations of muscle fascicles and aponeuroses to changes in the length of the human gastrocnemius muscle during passive lengthening in vivo.

METHODS: With the knee flexed, the ankle was passively rotated from a plantarflexed to a dorsiflexed position at 5 degrees/second. Ultrasonography was used to acquire longitudinal images of gastrocnemius muscle fascicles (110 mm field of view) at 10 Hz. A semi-automated procedure tracked the location, on the ultrasound image plane, of the points at which individual muscle fascicles inserted on the intramuscular tendinous aponeuroses. The procedure was repeated at 14 sites in the muscle. A 9-camera three-dimensional motion analysis system recorded the location of the ultrasound transducers and the leg in laboratory space, so the location of the ends of the muscle fascicles could be transformed into a leg frame of reference. Information about the location of the ends of the muscle fascicles in the leg frame of reference was used to reconstruct the three-dimensional architecture of the muscle fascicles and aponeuroses at 0.5-degree increments in ankle angle.

RESULTS: The method provided reconstructions of gastrocnemius muscle architecture with acceptable spatial resolution (e.g., RMSE error of fit to aponeuroses of 5 mm) and good temporal resolution (10 Hz). When the gastrocnemius was passively lengthened through 60% of the in vivo range of muscle lengths the proximal and distal aponeuroses experienced longitudinal strains of 6.1% and 4.0%, respectively. Both the proximal and distal aponeuroses translated distally in a leg frame of reference, but the distal aponeurosis translated further than the proximal aponeurosis. The difference in translations provided a measure of the contribution of changes in muscle fascicle length and orientation to changes in muscle length. Muscle fascicles contributed 23% of the total change in muscle length at 60% of the in vivo range of muscle lengths – the remaining 77% is presumably attributable to changes in the length and orientation of tendinous structures. The aponeuroses were initially concave anteriorly and flattened slightly as the muscle was lengthened, and muscle fascicles became more aligned with the long axis of the muscle, but these mechanisms contributed little to the total change in muscle length.

CONCLUSION: The three-dimensional architecture of human muscle fascicles and aponeuroses can be reconstructed by combining conventional two-dimensional ultrasound images of the muscle fascicles with three-dimensional motion analysis. This approach has acceptable spatial and time resolution. It may have application to study of dynamic processes such as muscle stretch or the onset of muscle contraction.

ACKNOWLEDGEMENT: This work was funded by the NHMRC of Australia.

ULTRAFAST ULTRASOUND FOR THE STUDY OF FASCICLES-TENDON INTERACTIONS

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Recent studies measured fascicle length using ultrasound during various tasks such as walking, slow running and jumping (Cronin and Lichtwark, Gait & Posture, 2013). These studies provided a better understanding of fascicle-tendon interactions and demonstrated the fundamental role of tendon for the storage-restitution of elastic energy in order to decrease changes in length of fibers. One of the limitations of conventional ultrasound is the sampling frequency limited to about hundred hertz. While it is sufficient in several research settings, it can not be used to study very fast motions or short events. In that framework, ultrafast ultrasound (up to 10 kHz) can provide very interesting informations.

The key differences between conventional and ultrafast ultrasound will be presented. Then, recent studies using this innovative method will be reviewed. Firstly, it was used in order to separate the contributions of Excitation-Contraction coupling and muscle force transmission processes to the electromechanical delay (Nordez et al., J Appl Physiol 2009). This study provided a better understanding of the electromechanical delay, and several applications were envisaged. Secondly, the technique was used to study concentric isokinetic contractions (Hauraix et al., J Appl Physiol, 2013). Originally, it was shown that fascicles-tendon interactions also play an important role during purely concentric contractions. Thirdly, ultrafast ultrasound measurements were performed during quick release (Farcy et al., J Appl Physiol, 2014) and fast stretching (Hauraix et al. ISEK 2014). It provided the unique opportunity to dissociate muscle and tendon stiffness in vivo.

BIOMECHANICAL FEATURES ARE INVOLVED IN MUSCLE FASCICLE VELOCITY DURING PLANTAR FLEXIONS

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AIM: Muscle typology is considered as the one of the main factors to explain the ability to produce motions with high joint angular velocity. However, it is also suggested that some biomechanical parameters could influence this capacity. The aim of the current study was to better understand the influence of biomechanical parameters on the muscle fascicle behavior during maximal plantar flexions performed at sub-maximal and near maximal joint angular velocities.
METHODS: Thirty-one subjects participated in the current study. First, biomechanical parameters (i.e., muscle fascicle geometry, moment arm, tendinous tissues stiffness) were measured using ultrasound imaging. Second, the participants performed isokinetic plantar flexions at six pre-set angular velocities (i.e., 30 to 330°.s^{-1}). Third, additional maximal plantar flexions were performed on a specific ergometer in order to reach a quasi-maximal joint angular velocity. Ultrafast ultrasound measurements were performed to measure the fascicle shortening velocity of the *gastrocnemius medialis* during contractions.
RESULTS: The relationship between muscle fascicle velocity and joint angular velocity was well fitted by linear regression (Figure 1, R^2 ranged from 0.96 to 0.99) and displayed a high inter-individual variability. Multiple regression model showed that 55% to 81% of variance of muscle fascicle velocity (at a constant pre-set isokinetic angular velocity) can by explained by muscle fascicle geometry ($P < 0.001$). The maximal articular velocity is dependent on the maximal shortening of muscle fascicle (R^2: 0.24; $P < 0.01$).
CONCLUSION: These preliminary results confirm our assumptions according to which biomechanical parameters highly influence the muscle fascicle velocity at pre-set angular velocity. The maximal joint angular velocity seems to depend on the maximal shortening of plantar muscle fascicle. However, further analysis should be conducted to better understand the ability to produce high velocity.

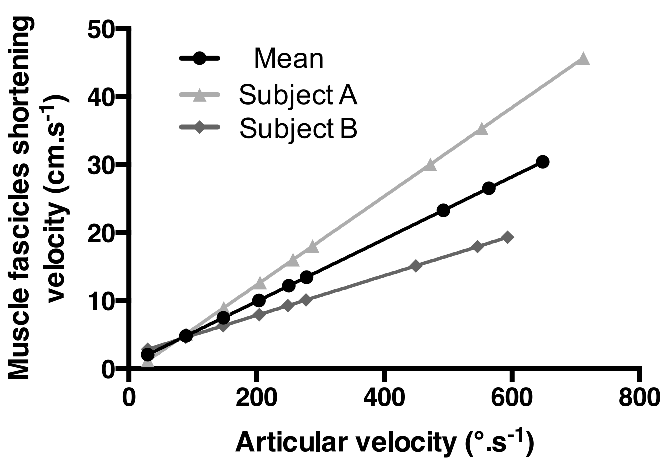

Figure 1: Relationship between muscle fascicle shortening velocity and articular velocity for mean and two typical individual examples.

IS HUMAN MEDIAL GASTROCNEMIUS SHAPE INFLUENCED BY ACTIVATION OF ITS SYNERGISTS?

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BACKGROUND: The human medial gastrocnemius (MG) muscle is linked to both the lateral head of the gastrocnemius (LG) and the soleus muscles, sharing the posterior compartment of the lower leg. Such close proximity and link between these muscles may mean that a muscle changes shape not only due to its activation or to the rotation of associated joints, but also as a result of activation of its synergists.
AIM: To quantify changes in MG shape which occur due to: i) electrical stimulation of MG and ii) electrical stimulation of LG.
METHODS: B-mode ultrasound videos and sEMG were collected from left MG and LG of seven subjects (mean±sd; body mass: 72±11 kg, height: 1.75±0.05 m). Participants laid prone on a surgical couch with the left foot fixed into a custom made shoe between the couch and the wall to minimize movement. A 32 electrode US-EMG matrix[1] was positioned over each muscle belly, with the ultrasound probe secured over the top of the matrix. Branches of the tibial nerve separately supplying the MG and LG were located and independently stimulated (15 times each) during different trials. EMG data were used to assess the level and locations of activation in each muscle during the different stimulation conditions. In ultrasound images collected from MG the edges of the deep and superficial aponeuroses were automatically identified using an active shape model approach[2]. These segmentations have been used initially to provide a measure of MG shape change based on changes in muscle thickness at proximal, middle and distal regions of the imaged area during elicited twitches.
RESULTS: Preliminary assessment of collected EMG signals indicated no significant M-waves occurred in MG when LG was stimulated. Changes in MG shape occurred as a result of activation of MG itself and activation of its synergist LG. Preliminary results show that significant differences in muscle thickness change occurred between the two stimulation conditions in six participants (p<0.001). The direction of change however differed between individuals, with larger changes occurring during direct activation of MG in four participants and during activation of LG in two participants. It is currently unclear why such differences were found between participants. Observations of the direction of displacement of the deep and superficial aponeurosis suggest that different patterns of movement occurred between conditions in each participant, suggesting more detailed analysis of regional patterns of movement of the aponeurosis is warranted.
CONCLUSION: MG shape is influenced by active contraction and activation of its synergists. Differences in the patterns of shape change may have implications for sensory feedback and mechanical co-ordination between muscles.
REFERENCES: 1) Botter, Vieira, Loram, Merletti& Hodson-Tole (2013) J. Appl. Phys. 115: 1203-14; 2) Darby, Hodson-Tole, Costen & Loram (2012) J. Appl. Phys.112:313-27.

Electromyography and kinematics of the neck in a clinical perspective.

Function of the neck, coordination of the neck movements and the motor control of the neck muscles are essential for many daily tasks both in relation to work and private life.
The proprioceptive function of the neck muscles is closely related to neck kinematics that may again be crucial for a tight coordination with eye movements related to high visual demands. Accordingly, from a clinical perspective there has been a large and increasing interest in using biomechanics and electromyography as methods for specification of diagnosis, thereby improving treatment and rehabilitation. This intension works hand in hand with an interest from both ISB and ISEK in a closer integration of the clinical aspects that will add an applied value to these research areas.

This ISB/ISEK session is dedicated to invited presentations that together provide a multidisciplinary approach of state of the art for this type of research in the neck region.

THE INTRINSIC SMOOTHNESS OF MOVEMENT AND NECK MUSCLE ACTIVITY OF UNCONSTRAINED HEAD MOVEMENTS IS NOT DIFFERENT BETWEEN SUBJECTS WITH AND WITHOUT LONG-TERM NECK PAIN

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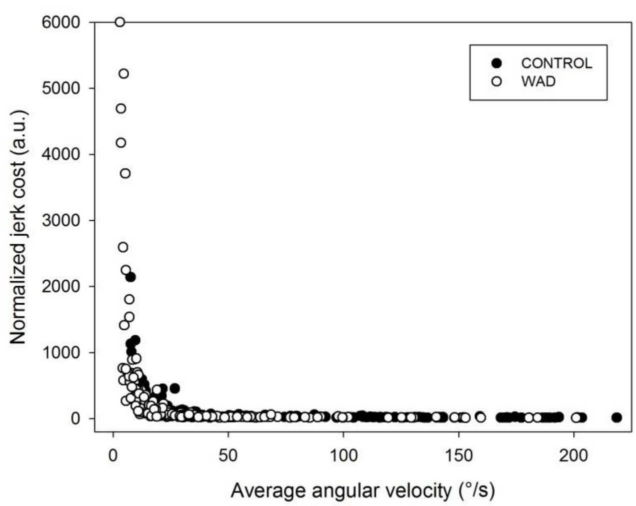
AIM: Long-term neck pain after whiplash associated disorders (WAD) may lead to reduced displacement and peak velocity of neck movements. Dynamic neck movements in people with chronic WAD are also reported to display altered movement patterns such as increased irregularity, which is suggested to signify impaired motor control. As movement irregularity is strongly related to the velocity and displacement of movement, we wanted to examine whether the increased irregularity in long-term WAD patients could be accounted for by these factors.

METHODS: Head movements were completed in four directions in the sagittal plane at three speeds; slow, preferred and maximum in 15 men and women with long-term WAD and 15 healthy, sex and age-matched control participants. Head kinematics and measures of movement smoothness and symmetry were calculated from position data. Surface electromyography (EMG) was recorded bilaterally from the sternocleidomastoid and splenius muscles and the root mean square (rms) EMG amplitude for the accelerative and decelerative phases of movement were analyzed.

RESULTS: The groups differed significantly with regard to movement velocity, acceleration, displacement, smoothness and rmsEMG amplitude in agonist and antagonist muscles for a series of comparisons across the test conditions. Controlling for differences between the groups in displacement and velocity abolished the difference in measures of movement smoothness and rmsEMG amplitude. The figure shows the similar smoothness (given as normalized jerk) for the two groups when plotted against velocity.



CONCLUSIONS: Simple, unconstrained head movements in participants with long-term WAD are accomplished with reduced velocity and displacement, but with normal muscle activation levels and movement patterns when controlled for velocity and displacement. These observations indicate that the reported irregularity often reported for neck pain patients are due to lower movement velocity and smaller displacement.

PAIN EDUCATION AND SPECIFIC NECK AND AEROBIC TRAINING REDUCE PAIN IN PATIENTS WITH CHRONIC NECK PAIN MORE THAN PAIN EDUCATION ALONE - A PRELIMINARY RANDOMISED CONTROLLED TRIAL

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AIM**:** Either specific training of the deep neck muscles or education in pain management (pain education) or aerobic training is known to reduce neck pain in patients with chronic neck pain. Since the combined effect of these interventions is not known, the aim was to study this effect on pain and EMG amplitude of the superficial neck muscle activity.

METHODS**:** Twenty women were randomized to either specific neck and aerobic training and pain education (INV), or pain education alone (CTRL). Inclusion criteria were neck pain for at least six months and a minimum Neck Disability Index (NDI) of 11. CTRL received pain education for 4x1.5 hrs, while INV received the same pain education, in addition to specific neck training and instruction in aerobic training for 8x4 hrs. Surface EMG was recorded from the neck flexors (anterior scalenii (AS), sternocleidomastoid (SCM)) and extensors (NE), normalized to submaximal isometric neck flexion and neck extension, expressed as % submax MVE (Maximum Voluntary EMG). Muscle activity was recorded during the Cranio-Cervical Flexion test (CCFT) and three balance tests (two-legged stance with eyes open and closed, one-legged stance with eyes open). Additional outcomes were postural sway measured on a force platform, maximum neck flexion and extension force, and self-reported outcomes, such as numerical pain rating scale (NRS), SF36, and Global Perceived Effect (GPE).

RESULTS**:** Of the 20 women recruited, eight subjects in the CTRL (age 40.8 yrs) and seven in the INV (age 42.1 yrs) completed the study. Per protocol analyses showed greater pain reduction in INV compared to CTRL (NRS average pain: 2.14 vs -0.13, p = 0.05; present pain: 2.14 vs -1.63, p = 0.03), with a tendency also for a greater GPE in the INV group (1.86 vs -0.38, p=0.06). There was no difference in changed maximum neck flexion and extension force.

Across all CCF-levels INV showed a significantly larger reduction of flexor EMG amplitude (AS: 5.78 vs 4.96%MVE, p=0.003; SCM: 5.48 vs 2.80%MVE, p=0.017; Mean flexors: 5.63 vs 3.89%MVE, p=0.006). The extensor EMG amplitude increased, but significantly less in INV (-4.64 vs -10.31%MVE; p=0.002). During the balance task with eyes closed both groups showed lower neck flexor EMG amplitude (≈8%MVE; $p \leq 0.05$). INV showed trends towards a larger reduction in postural sway in most sway measures. ITT analyses confirmed most of these results.

CONCLUSION**:** Pain education, specific neck muscle and aerobic training reduce neck pain in women with chronic neck pain more than pain education alone. This positive effect seemed also partly to reduce neck flexor muscle activity and improve postural sway. Due to the small sample size, interpretation of these data must be done with caution.

PHYSICAL WORKLOAD ON NECK AND SHOULDER MUSCLES DURING MILITARY HELICOPTER FLIGHT

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AIM: Flight-related neck/shoulder pain is common among military helicopter pilots and crew members. During flight, the flight helmet and additional Night Vision Goggles (NVG) pose a considerable load on the cervical spine. The aim of this study was to quantify the physical workload on the cervical muscles during flight with and without NVG.

METHODS: Nine pilots and nine crew members participated in this study. Before a flight, one pilot and one crew member were equipped with 6 wireless electromyography sensors, positioned bilaterally above trapezius m. (TRA), the upper neck extensors (UNE) and sternocleido-mastoid m. (SCM). Nine repetitive flights were completed, encompassing: Patient-Transport (PT), Patient-Transport with NVG (PT+NVG) and Search And Rescue with NVG (SAR+NVG). A standard helmet (1.85 kg) and NVG (1.1 kg) were used. The EMG signal was normalized using Maximal Voluntary Contractions (MVC) and analyzed for changes in amplitude and distribution of muscle activity by an Amplitude Probability Distribution Function (APDF).

RESULTS: MVC for shoulder elevation (right/left) was: 136.8±41.3 / 120.6±47.0 Nm, and for cervical-flexion and extension: 32.2±14.0 and 42.5±10.2 Nm. EMG sampling time was: 16.9±5.1 min for PT, 22.7±10.8 min for PT+NVG and 21.3±11.1 min for SAR+NVG. Mean muscle activity (%MVE) in UNE was significantly higher than TRA and SCM during all flights, except for crew members during PT. UNE showed significantly higher %MVE during SAR+NVG compared to PT or PT+NVG for pilots. An APDF analysis showed that UNE during SAR+NVG was significantly higher than TRA and SCM, during 10% (APDF 0.1), 50% (APDF 0.5) and 90% (APDF 0.9) of total flight time (Table 1).

		APDF 0.1			APDF 0.5			APDF 0.9		
		PT	PT +NVG	SAR +NVG	PT	PT +NVG	SAR +NVG	PT	PT +NVG	SAR +NVG
Pilots	TRA	0.8±0.8	0.7±0.4	0.7±0.4	1.9±1.9	2.1±1.9	1.9±1.5	5.7±3.8	4.7±2.8	5.4±3.7
	UNE	5.0±1.7	5.3±1.8	5.3±2.2*	8.3±3.4	8.7±3.3	10.4±4.3*	14.0±6.5	14.3±6.3	18.6±8.9*
	SCM	0.8±0.4	0.9±0.4	1.1±0.8	2.1±1.4	2.3±1.8	3.2±2.6	5.1±3.3	5.7±4.3	7.6±4.9
Crew	TRA	0.7±0.8	0.7±0.6	0.6±0.4	3.0±4.6	4.4±3.7	2.8±4.0	13.7±12.2	16.9±13.4	8.3±7.7
	UNE	2.6±1.9	4.0±1.4	3.7±1.1*	7.3±4.1	10.1±3.7	9.0±2.7*	14.2±5.7	18.7±6.0	17.2±5.9*
	SCM	0.6±0.3	0.6±0.4	0.6±0.3	1.6±1.5	1.8±1.6	1.6±1.2	4.2±3.2	5.3±4.0	4.1±3.0

Table 1. Amplitude Probability Distribution Function (APDF) presented in mean and SD.
* Significantly different to trapezius m. (TRA) and sternocleido-mastoid m. (SCM).

CONCLUSION:
Muscle activity in the upper neck muscles was high with an overall level of 10% MVE or above for half of total flight-time. This high level of sustained muscle activity may indicate a risk for developing neck disorders among helicopter crew and pilots.

STABILITY OF SENSOR POSITION ON THE HEAD DURING HEAD AND NECK MOVEMENT

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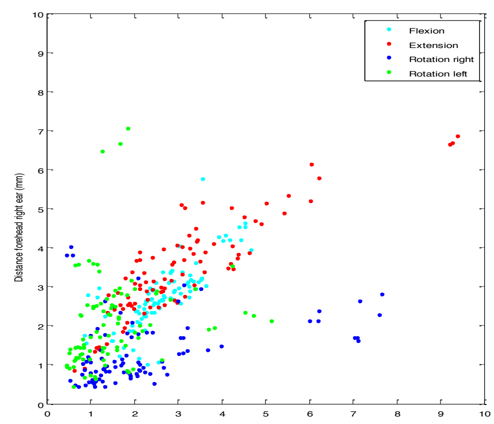
AIM: Rigid plastic sensors are in use in motion tracking of human movement. Positioning and fixation of these sensors are challenging due to possible skin movement both over prominent bone structures and as a result of contraction of underlying muscles. When analysing data from these instruments we assume that the sensors movement represent the movement of the underlying body. This argument is dependent on a rigid sensor positioning through rest and movement. This study will explore how the rigid sensors remain in the same place when fixed to the head. The consequences of any position changes for estimations of movement will be assessed.
METHODS: A 6 DOF electromagnetic motion tracker with rigid plastic sensors was used (Liberty, Polhemus Inc.). 34 persons with and without persistent neck pain have performed 108 head movements with varying speed (self-preferred, slow and fast), direction (flexion, extension and rotation to both sides) and range of movement (maximum, half and approximately 10°). Three sensors were positioned on the head i.e. in the forehead (0.5 cm over arcus superciliaris) and on both sides processus mastoideus. Sensors were fixed with double-sided tape and a headband. The stability of position was tested by assessing the difference between the three sensors. No difference was expected in case of stable position in relation to the skull.
RESULTS: Preliminary analyses showed that during rotation the sensors behind the ears moved differently while they followed the same course during flexion and extension (see figure). This indicates that the sensor may shift as a result of certain movements.
CONCLUSION: The ongoing analysis will provide data on the possible consequences of choosing either position data or Euler angles for motion estimates. Furthermore, we will examine the properties of using one sensor versus a measure based on the three sensors positioned on the skull. Based on the results regarding the sensor stability during movement, the possibility for making a robust head model that can estimate movement originating from either the upper and lower part of the neck can be made.



DIFFERENTIAL KINEMATICS AND MOVEMENT COORDINATION OF THE CERVICAL AND THORACIC SPINES IN PEOPLE WITH CHRONIC NECK PAIN

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AIM: Research on the kinematics and inter-regional coordination of movements between the cervical and thoracic spine in motion adds to our understanding of the performance and interplay of these spinal regions. The purpose of this study was to examine the effects of chronic neck pain on the three-dimensional kinematics and coordination of the cervical and thoracic spine during active movements of the neck.

METHODS: Three-dimensional spinal kinematics and movement coordination between the cervical, upper thoracic, and lower thoracic spine were examined by electromagnetic motion sensors in thirty-four individuals with chronic neck pain and thirty-four age- and gender-matched asymptomatic subjects. All subjects performed a set of free active neck movements in three anatomical planes in sitting position and at their own pace. Spinal kinematic variables (angular displacement, velocity, and acceleration) of the three defined regions, and movement coordination between regions were determined and compared between the two groups.

RESULTS: Subjects with chronic neck pain exhibited significantly decreased cervical angular velocity and acceleration of neck movement (Figure 1). Cross-correlation analysis revealed consistently lower degrees of coordination between the cervical and upper thoracic spines in the neck pain group (Figure 2). The loss of coordination was most apparent in angular velocity and acceleration of the spine.

CONCLUSION: Assessment of the range of motion of the neck is not sufficient to reveal movement dysfunctions in chronic neck pain subjects. Evaluation of angular velocity and acceleration and movement coordination should be included to help develop clinical intervention strategies to promote restoration of differential kinematics and movement coordination.

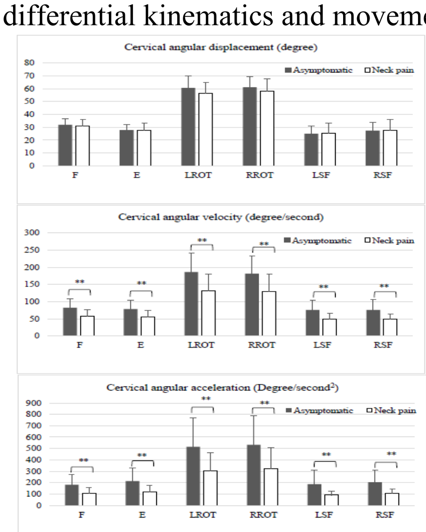

Figure 1. Cervical spine kinematics during neck movements.

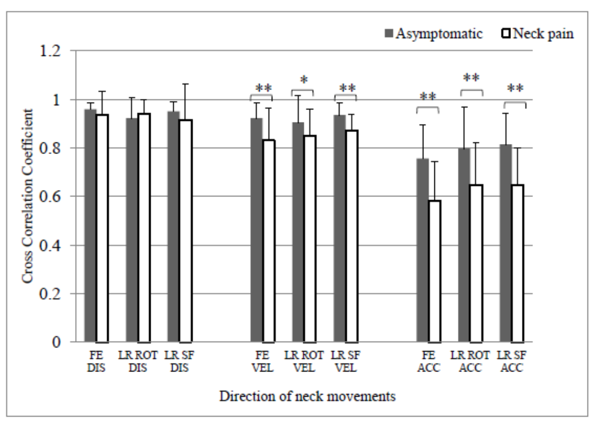

Figure 2. Cross Correlation analysis between cervical and upper thoracic spine kinematics.

INVESTIGATION OF CERVICAL MOVEMENTS IN NECK PAIN PATIENTS WITH THE FINITE HELICAL AXIS APPROACH

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AIM: The aim of the present study was the analysis of cervical kinematics of neck pain patients using finite helical axis.

METHODS: 47 female subjects were enrolled in the study, 17 with neck pain and 30 healthy controls. The subjects were asked to perform voluntary cervical movements in all three cardinal planes at a natural speed. Position and orientation of the head was registered with the VRRS Cervix, a non-invasive 3D-electromagnetic device. The Minimum Convex Hull method and the angle between IHA (Instantaneous Helical Axis) and FHA were calculated as a measure of dispersion (see figure). The FHA dispersion can be represented by the minimum convex hull and the distribution of angles of the IHA relative to the FHA.

RESULTS: Healthy subjects had significantly larger range of movement (RoM) compared to the neck pain patients (152±16.5° and 137±18.8° respectively). The CH area was also significantly larger in healthy subjects (9.11±2.86cm2 and 7.35±4.72cm2 respectively). The mean angle was slightly higher in healthy subjects (4.52±1.12° and 3.95±1.0° respectively) but not significantly different.

CONCLUSION: Neck pain patients exhibited a reduced RoM and CH compare to healthy subjects while no difference has been detected in the distribution of angles of the IHA.

ACKNOWLEDGEMENT: The study was supported by Thim van der Laan Foundation

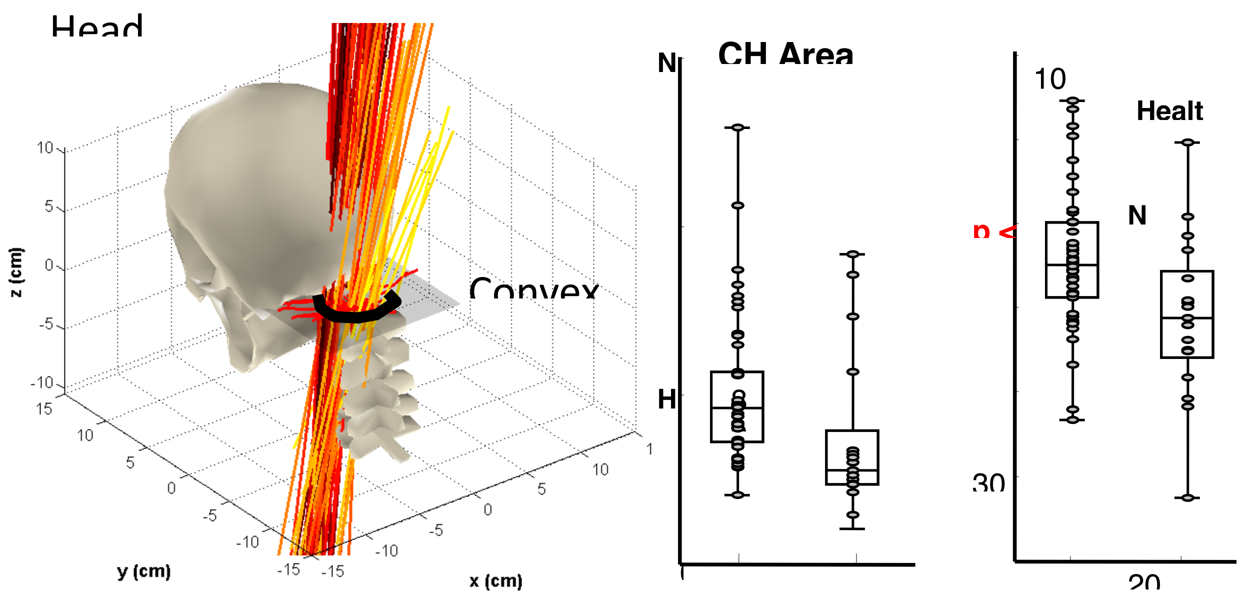

Figure 1: Representation of the finite helical axis during head rotation and differences in convex hull area and range of movements in healthy subjects and patients with neck pain.

Biomechanics 4 (Sala 2LM 9.30-11.00)

THE EFFECTS OF MILITARY BODY ARMOUR ON POSTURE AND MUSCLE ACTIVATION DURING MANUAL HANDLING TASKS

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AIM: Low back pain is the most common musculoskeletal injury in military populations. This injury has been linked to the manual handling tasks soldiers perform as well as the added mass of military body armour. Modern military personnel have a selection of different configurations of military body armour, each with varying weight and movement restriction. These personnel have little scientific evidence to guide their choice. Thus this study investigated the effects of wearing different configurations of body armour on posture and muscle activation during military-specific manual handling tasks.
METHODS: Sixteen males (age: 21 ± 1 years, height: 181 ± 8.3 cm, weight: 74.9 ± 7.5 kg) attended a single testing session. Each participant was randomly assigned to five conditions (four armour and a control i.e. no armour) whilst completing three military-specific tasks. These comprised an ammunition box lift and place, ammunition box lower and place and a sandbag lift and place. Institutional ethical approval along with participant informed consent was obtained prior to data collection. Each task was split into finite execution phases for processing. Three-dimensional motion analysis captured and quantified all kinematic data while synchronised wireless surface electromyography (EMG) was used to assess the muscle activation levels of lumbar erector spinae and trapezius.
RESULTS: All tasks necessitated participants adopt severe trunk postures. The average trunk flexion value during the ammunition box lift and sandbag lift tasks was 59° (95% CI 53.9°-63.3°) and 60° (95% CI 54.8°-65.4°), respectively. When comparing differences between conditions, average trunk flexion during the ammunition box carry and sandbag carry was 4° ± 2.4° ($p<0.001$), and 4° ± 0.5° ($p<0.001$), higher for the heaviest armour type compared to the control condition, respectively. Conversely, trunk rotation range of motion during the ammunition box place was 12° ± 7.7° lower for the heaviest armour type against control ($p<0.001$). Synchronised EMG revealed moderate levels of activation (20-30% MVIC) during each task. However, there were no significant differences in muscle activation level between the different armour configurations tested and the different tasks tested.
CONCLUSION: This study's findings support the notion that body armour increases exposure to forward trunk flexion and restricts multi-planar movement. Such postures have been associated with low back pain development. Further, these postures coupled with the moderate levels of muscle activation recorded can place military personnel at greater risk of injury. Considering prolonged armour wear is mandatory for specific armed forces, incorporating rest periods and/or managing task demands could minimise injury risk in these personnel. This strategy does warrant further investigation. Also, designing body armour specific to task demands could facilitate reducing postural strain.
ACKNOWLEDGEMENT: The authors would like to acknowledge the contribution of Australian Defence Apparel to this project.

MUSCLE ACTIVITY RESPONCE TO ANKLE PLANTAR FLEXION CHANGES DURING KNEELING

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AIM: To investigate the effects of ankle plantar flexion on muscle response during kneeling.
METHODS: Five healthy subjects (3 males and 2 females, mean age of 24) with no previous history of knee or low back injury agreed to participate in this study by signing a consent form approved by the Institutional Review Board. All subjects were instructed to kneel on a kneeling mat placed over a force plates for 15 min while maintaining full knee flexion. Two trials per subject were collected in random order: one with the ankle plantar flexed and the second with the ankle in a neutral position (0 degree flexion), with a 15-20 minute break between trials. The sEMG signal of Vastus Lateralis (VL), Vastus Medialis (VM), Rectus Femoris (RF), Rectus Abdominis (RRA & LRA), and Erector Spinae (RES & LES) was recorded using wireless surface electrodes at 2000Hz with corner frequencies 10-500Hz. The root mean square (RMS) amplitudes for the entire trial were normalized (nRMS) to the average RMS value of the first minute of kneeling. The percent changes in nRMS between ankle plantar flexion conditions were calculated by dividing the difference between flexed and neutral position mean nRMS values by the neutral position values. A paired t-test (□=0.05) was conducted for comparisons between the two ankle postures.
RESULTS: Significant decreases in muscle response between the flexed and neutral ankle positions of 66% (p=0.037) and 23% (p=0.009) were observed for the TA and RRA respectively. The decrease in TA activity is likely due to its role in ankle flexion. While decreases in all other muscle nRMS values were observed, except the RES, the differences were not statistically significant (Figure 1). Differences in muscle response between trials, in particular the decrease in RRA and increase in RES activity, were mainly due to lateral and sagittal shifting of the body mass in an attempt to adjust to the changes in ankle posture. Force plate results confirmed that during neutral ankle plantar flexion kneeling some subjects leaned forward and placed additional load on the dominant (right) side.
CONCLUSION: Differences in muscle response during full knee flexion kneeling were observed between flexed and neutral ankle plantar position trials. This finding underscores the importance of body position adjustments as a result of the ankle joint position adopted during kneeling.

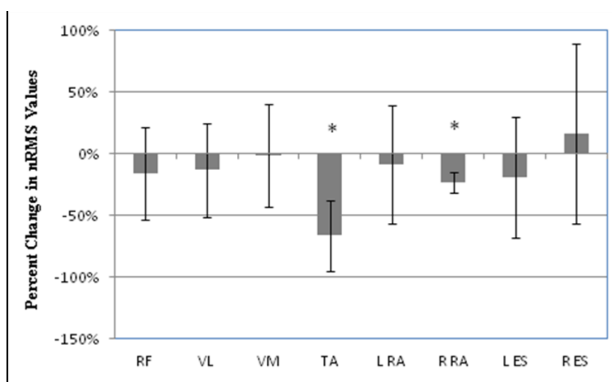

Figure 1: Percent change in nRMS values between flexed and neutral ankle plantar position.

INFLUENCE OF KNEELING DURATION ON MUSCLE CO-ACTIVATION CHANGES

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AIM: To investigate the influence of kneeling duration on leg and torso muscle co-activation pattern changes.
METHODS: Eight healthy subjects (7 males and 1 female, age range 20 – 50 years) with no previous history of knee or low back injury agreed to participate in this study and signed consent form approved by the University of Wisconsin-Milwaukee Institutional Review Board. Subjects were instructed to kneel on a kneeling mat placed over a force plates for 30 minutes while maintaining 90º of knee flexion. sEMG signals of Biceps Femoris (BF), Medial Gastrocnemius (MG), Rectus Abdominis (RA), Erector Spinae (ES), Rectus Femoris (RF), and Tibialis Anterior (TA) was recorded using wireless surface electrodes at 2000Hz with corner frequencies 20-500Hz. Root mean square (RMS) amplitudes for the trial were normalized to the RMS value of the first minute of kneeling. Co-activation coefficients: RF relative to BF, RA relative to ES and TA relative to MG were calculated by dividing the normalized agonist RMS by the antagonist normalized RMS. Significant co-activation between kneeling duration and muscle co-activation was determined as $p < 0.05$.
RESULTS: The result shows different co-activation patterns of the leg and torso muscles during kneeling. The changes in muscle co-activation were found to vary significantly for the pairs RF:BF (range 31-37%, $p = 0.000$), RA:ES (range 52-178%, $p = 0.000$) and TA:MG (range 35-63%, $p = 0.000$) as the duration of kneeling progressed (Figure 1). The changes in muscle co-activation supported previous evidence that during kneeling subjects leaned forward and backward as a strategy to redistribute knee joint loading – an attempt to minimize pain in the knee and low-back.
CONCLUSION: Kneeling duration has a strong influence on muscle co-activation changes and is an important parameter for assessing kneeling effects on muscle response. Understanding how duration impacts the leg and torso muscles is an important step in determining kneeling limits and potential interventions.

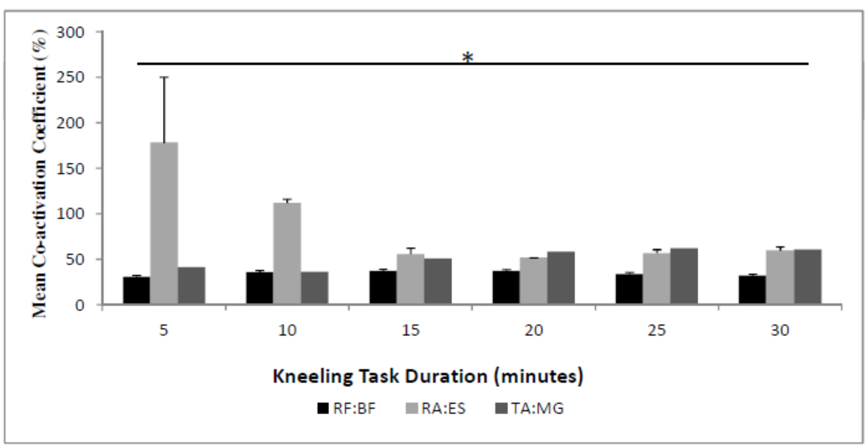

Figure 1: Muscle co-activation coefficient variation with kneeling duration.

AGE RELATED CHANGES IN TRUNK FLEXION EXTENSION TESTING

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AIM: The flexion relaxation phenomenon (FRP) of lumbar extensor muscles expressed by surface electromyographic (SEMG) amplitude and the flexion relaxation ratios derived from dynamic trunk flexion and extension phase of testing were recommended to objectively differentiate normal from abnormal findings in young and middle age persons. Normal aging is associated with changes of neuromuscular activation but literature on individuals older than 55 years is sparce. This study was conducted to examine for age related differences in neuromuscular activation of back extensor muscles performing trunk flexion extension testing.

METHODS: 38 healthy volunteers older than 50 years (20 females) and another 43 volunteers younger than 50 years (19 females) performed standardized dynamic trunk flexion extension testing with an additional isometric testpoint half way between upstance and maximum trunk flexion (half trunk flexion) position in both trunk flexion and extension phases. Lumbar extensor muscle SEMG activity was recorded continuously from multifidi muscles at L5 level and rout mean square (RMS) SEMG amplitudes were normalized to 80% of individual maximum voluntary contraction (MVC). Data from flexion and extension phase isometric testpositions were averaged.

RESULTS: Older volunteers identified significantly higher lumbar extensor muscle SEMG amplitude in upstance and maximum trunk flexion position and hence incomplete flexion relaxation phenomenon compared with youngers. SEMG amplitude in isometric half trunk flexion position was similar in both age groups. All flexion relaxation ratios derived from peak SEMG amplitudes during dynamic flexion and dynamic extension phase and ratios derived from isometric half trunk flexion testpoint were significantly lower in older individuals compared with youngers.

CONCLUSION: Trunk flexion extension testing of healthy individuals revealed age related differences in flexion relaxation phenomenon and flexion relaxation ratios. Thus data derived from young and middle age persons should not be used for differentiation between normal and abnormal in individuals older than 50 years of age.

VALIDITY OF FORCE MEASUREMENT BY INSOLES IN SIMULATED WORK TASKS

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AIM**:** Forceful exertions e.g. when performing heavy lifting, may contribute to musculoskeletal disorders. There is a paucity of methods to measure forces during lifting in field studies of mechanical exposures at the workplace. The present study sought to measure external forces during physical activity by pressure measurement insoles. The aim of the present investigation was to validate a pressure-measurement insole system (medilogic®insoles, T&T Medizintechnik GmbH, Schönefeld, Germany) against a force platform.
METHODS**:** Static tests: medilogic®insoles were gradually loaded with flat metal weights from 0 to 95 kg every 30 seconds to investigate linearity and reliability. Dynamic tests of assessment force during work taks: 15 participants performed five different protocols of working tasks: standing, walking, lifting an object, kneeling, and catching an object. Measured and calculated force data of the insoles were compared with recorded data from 3 force platforms(AMTI LG6-4-1, Watertown, MA, USA) during the tasks.
RESULTS**:** Linearity under static load varied between individual soles. The test-retest reliability was adequate (Inter Class Correlation (2, 3): > 0.999 for all soles). By calibration to bodyweight, root mean square errors (RMSE) and maximum error (MaxE) differed with type of task: standing (RMSE: 11.0 $\pm$ 1.9 %, MaxE: 15.6 $\pm$ 2.5 %), walking (13.4 $\pm$ 0.8, 17.5 $\pm$ 0.6), lifting (10.2 $\pm$ 1.3, 14.0 $\pm$ 1.0), catching an object (6.7 $\pm$ 4.1, 8.5 $\pm$ 4.5), and kneeling (140.1 $\pm$ 126.7, 158.4 $\pm$ 146.3). In repeated walking trials with weights carried ranging from 0 to 30kg a significant increase in measured load was found ($p < 0.001$, Friedman test) was found. The measured mean values were similar to carried weights ($p>0.05$, Wilcoxon Test).
CONCLUSION**:** Medilogic®insoles can be used to measure external loads in simulated work tasks. RMSE and MaxE were acceptable, except for situations with strong bended soles and high point loads, e.g. during kneeling. A deviation in accuracy of about 10 to 15 percent depending on the situation has to be taken into account. A calibration to bodyweight before the measurements is necessary. Concomitant observation of task type performed is recommended in field studies.

UPPER LIMB STRATEGIES DURING MANUAL BOX HANDLING PERFORMED BY EXPERIENCED AND INEXPERIENCED SUBJECTS

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AIM: The aim of this study was to compare posture and muscle activation between experienced and inexperienced subjects during box handlings. METHODS: Fifty-eight right-handed men participated – 37 inexperienced (23.85±3.97yr; 73.95±10.35Kg, 1.71±0.03m); 21 experienced (29.39±6.45yr; 81.36±13.36Kg, 1.70±0.06m, 8.8±4.7yr of experience). A regular cardboard box (44x31x31.5 cm, 15Kg) was randomly moved from a fixed surface (WL: waist level) to two delivering heights (GL: ground level; SL: shoulder level). Bilateral wrist and elbow postures were recorded at 20Hz using electrogoniometers (Biometrics Ltd.). Upper arms elevation was measured using inclinometers (Logger Teknologi) at 20Hz. Surface electromyography (sEMG) was recorded bilaterally at 1000Hz from upper trapezius, biceps brachii and wrist extensor muscles (Myomonitor IV, DelSys). Active single differential electrodes were use (#DE-2.3, DelSys). Methodological procedures for both data collection and processing were performed according to a previous study (Silva et al, 2013 - Int J Ind Ergon 43:154-160). Once normality and homoscedasticity assumptions were attended, groups were compared through t-test for independent samples. RESULTS: All data are presented in Table 1. In general, expert subjects had larger postures in wrists and elbows, and lower humeral elevation and sEMG during box handlings. The most expressive differences between experienced and inexperienced subjects occurred at GL. On the other hand, handlings performed at SL have shown similar postures for both groups. Experts had significantly lower sEMG even when handling at SL. These results agree with several studies focusing on differences in spinal biomechanics between experts and novice workers. CONCLUSION: Experienced subjects have shown beneficial upper limb strategies during box handling. Guidelines for MMH training of novice workers should consider these strategies in order to provide safer biomechanical demands during such tasks.

Table 1. Mean and standard deviation values for right and left upper arm: 90th percentile of wrist extension; 90th percentile of elbow flexion and upper arm elevation, and sEMG of wrist extensors, biceps, and upper trapezius muscles during handlings performed at ground and shoulder level.

	Postures	Ground Level			Shoulder Level		
		Inexperienced	Experienced	p-value	Inexperienced	Experienced	p-value
RIGHT	Wrist	32.05±10.73	-22.86±11.65	0.014*	-21.88±11.10	-23.18±7.57	0.340
	Elbow	31.99±11.97	44.84±23.08	0.001*	22.58±9.93	46.88±20.52	0.000*
	Upper arm	83.61±11.79	38.07±48.25	0.000*	38.67±16.12	40.47±28.29	0.280
	Wrist extensors	0.62±0.27	0.40±0.25	0.000*	0.55±0.24	0.33±0.18	0.000*
	Biceps	0.82±0.72	0.49±0.34	0.017*	0.97±0.78	0.84±0.91	0.110
	Upper trapezius	2.66±3.28	0.27±0.14	0.000*	7.63±4.50	0.50±0.27	0.013*
LEFT	Wrist	20.75±11.66	-31.01±10.77	0.003*	-19.31±11.70	-25.38±8.99	0.060
	Elbow	35.55±14.44	53.70±15.55	0.000*	15.80±8.44	45.27±22.38	0.000*
	Upper arm	79.77±14.49	28.75±38.51	0.000*	37.27±19.93	39.03±33.08	0.000*
	Wrist extensors	1.33±4.26	0.33±0.22	0.000*	0.89±1.22	0.34±0.20	0.000*
	Biceps	0.71±0.34	0.49±0.34	0.080	0.93±0.49	0.57±0.35	0.011*
	Upper trapezius	0.48±0.19	0.24±0.18	0.000*	0.317±0.26	0.47±0.36	0.180

* statistically significant values in between groups comparison; alfa at 0.05.

KINEMATIC AND KINETIC CHARACTERISTICS OF HUMAN LOWER EXTREMITIES DURING WALKING ON CROSS-SLOPE

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AIM: Human gait activity such as walking on inclined road surfaces is common because humans exhibit bipedal locomotion. Although accessibility concept is universal, inclined walkways (usually 2°–3°) are still prevalent in modern cities for facilitating drainage flow. The purpose of this study was to investigate the kinematics and kinetics of lower extremities of humans during walking on a laterally and medially inclined surface.

METHODS: Twelve healthy, male volunteers aged 20 to 22 years participated in this study. They were asked to walk thrice at a preferred speed on a flat surface, laterally and medially inclined at 6°. Three-dimensional angular displacements and moments of the hip, knee and ankle were measured using the VICON Nexus system. The EMG activities of the gluteus medius, tensor fasciae latae, rectus femoris, semitendinosus, semimembranosus, tibialis anterior, gastrocnemius and fibularis longus were recorded using surface electrodes at a sampling rate of 1000 Hz. These EMG results were synchronized with the VICON data and were processed as integrated electromyograms (iEMGs). Kinematics, moments, and iEMGs of joints were analyzed using repeated measures ANOVA.

RESULTS: Compared with the other angle of the joints in the frontal plane during the stance phase under the three walking conditions, the maximum abduction angle of the hip during walking on the laterally inclined surface was significantly smaller (table.1), The eversion moments of the ankles during the initial and mid-stance phases on the laterally inclined surface was significantly larger than those during the other conditions (table.2) ($p<.05$). No significant difference was found in the iEMG results for those muscles.

CONCLUSION: Compared with the other walking conditions, a stress was apparently induced on the ankle and hip joints producing a change in the angle and moment along with a compensatory body mechanism with muscular activities during the initial and mid-stance phase while walking on the laterally inclined surface.

Motor Control 2 (Sala 4LM 9.30-11.00)

CHARACTERIZATION OF UPPER TRAPEZIUS MOTOR PATTERNS FROM WORKSITE ELECTROMYOGRAPHY IN HEALTHY OFFICE WORKERS

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AIM: The aim of the study was to characterize and compare dominant and non-dominant motor patterns of the upper trapezius muscle from worksite electromyography (EMG) recordings in a large sample of healthy office workers, and to examine the day-to-day reliability of these characteristics.
METHODS: Surface EMG was used to record bilateral upper trapezius muscle activity during whole-day work shifts (6.85 ± 0.53 hours) in 77 participants using a data logger. Two work shifts were recorded in 65 participants. Reference voluntary effort (RVE) was recorded prior to and immediately after each work shift by having participants hold a 1 kg weight in each hand with 45 degrees of shoulder abduction in the scapular plane. ECG artifacts were removed from EMG data prior to RMS processing and normalization to RVE. Mean amplitude, gap frequency, percent muscular rest, amplitude probability distribution function (APDF), and a clustered exposure variation analysis (CEVA) were calculated for each hour recorded and averaged within shifts. The APDF was used to determine static, median, and peak levels of muscle activity (90, 50, and 10% of recording time, respectively), whereas CEVA was used to quantify periods of low, moderate, and high muscle activity performed for short or prolonged durations. Measures were compared between dominant and non-dominant muscles. Intraclass correlation coefficients (ICC) were calculated for each measure to assess the reliability of motor patterns between workdays.
RESULTS: All values are reported as mean (SD) of dominant vs. non-dominant upper trapezius. The dominant upper trapezius demonstrated significantly higher levels of muscle activity (mean amplitude 25.9 (10.1) vs. 22.0 (10.0)%RVE; static level 1.42 (2.0) vs. 0.94 (1.4)%RVE; and median level 16.9 (10.6) vs. 13.3 (9.8)%RVE) and significantly lower muscular rest (31.7 (13.7) vs. 39.0 (15.8)% recording time). There were no significant differences between sides for peak amplitude (67.5 (24.5) vs. 61.4 (26.4)%RVE) or gap frequency (13.9 (4.6) vs. 15.9 (9.3) gaps/min). CEVA measures revealed significantly greater short duration, moderate amplitude (34.0 (9.8) vs. 30.3 (10.3)% recording time) and short duration, high amplitude (15.4 (9.1) vs. 12.8 (8.3)% recording time) activities for the dominant trapezius, whereas the non-dominant trapezius showed greater low amplitude, short duration (34.2 (11.9) vs. 38.5 (13.4)% recording time) and low amplitude, long duration (11.9 (8.3) vs. 14.2 (10.6)% recording time) activity. All measures demonstrated good day-to-day reliability, with ICC values ranging between 0.65 and 0.89 on the dominant side, and 0.45 and 0.86 on the non-dominant side.
CONCLUSION: Significant differences between time and amplitude domain measures of motor activity in the dominant and non-dominant upper trapezius muscles reflect asymmetrical workloads placed on the trapezius during office work. These differences in workload may contribute to the development of chronic musculoskeletal pain conditions, common among office workers. The high reliability and sensitivity of occupational exposure measures to detect within-subject differences in workload indicate their potential use in assessing modifications to muscle activity and workload for preventative interventions.
ACKNOWLEDGEMENTS: Funded by NIH R01 AR056704 to KSM

CONSISTENCY OF INDIVIDUAL MOTOR VARIABILITY TRAITS WHEN PERFORMING REPETITIVE PRECISION WORK

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INTRODUCTION & AIM**:** Motor variability (MV) refers to the intrinsic variability naturally present in the motor control system. Occurring even in the simplest movements, it is usually manifested as a difference in kinematics and/or muscle activities between successive repeats of a task that are identical in performance. An interest in MV has recently emerged in several fields of application such as occupational research, clinical research and sports biomechanics, suggesting that MV may have an important functional role in skill acquisition, and that MV's associations with pain and fatigue may play a decisive role in rehabilitation (Srinivasan & Mathiassen 2012). Also, individuals with a larger MV would hypothetically be better protected against overuse injuries, and recover faster after disorders affecting motor performance. However, whether the extent of MV is, indeed, a consistent individual trait across different tasks and several days is not known. This study investigated whether individuals form clusters systematically differing in the size of MV when performing repetitive upper-extremity precision work.

METHODS**:** A laboratory-based simulation of precision work was developed using a 'pipetting' task paradigm, in which liquid was repeatedly transferred from one tube to another, with a cycle time of 2.8s. This task was performed by 14 healthy female subjects, aged 20-45 years, right-handed and experienced in pipetting, on 3 different days under identical experimental conditions. Kinematic data were obtained using an electromagnetic motion capture system (FASTRAK). MV in shoulder elevation, elbow flexion and shoulder-elbow coordination were operationalized using cycle-to-cycle standard deviations across 20 pipetting cycles of kinematics parameters including joint range of motion, average and peak velocities, time to peak velocities, average angle and phase. Multivariate analysis was conducted on this data using Principal component analysis (PCA), Hierarchical cluster analysis and Partial least squares discrimination analysis (PLS-DA) in SIMCA+P 12.0, (Umetrics, Sweden) in order to analyze underlying relationships among variables and individual patterns in the data matrix.

RESULTS**:** Four PCA components (Kaiser Criterion, Eigenvalues>1) accounted for 80.2 percent of the total variance and subsequent cluster analysis identified two distinct sub-groups in movement behavior. Eleven variables were influential in discriminating between the two clusters according to the PLS-DA standard criteria. Among those, the four most important were the standard deviations of: Average and peak velocities and range of motion of shoulder elevation and average elbow flexion angle. Sub-group 1, consisting of 4 (of total 14) individuals represented those with a larger MV compared to sub-group 2.

DISCUSSION**:** The finding that individuals clustered into 2 groups showing systematic differences in variability, even in this small and homogenous sample of 14 healthy young women, indicates that there may indeed be consistent individual traits in motor variability. As a next step, we will answer whether these traits remain consistent across days and when work factors such as work pace or precision are slightly changed; and whether individual traits of motor variability are associated with differences in physiological responses indicating fatigue and risk of contracting musculoskeletal disorders.

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STATIC MUSCLE ACTIVITY AND MUSCULAR REST THROUGHOUT THE WORKDAY PREDICT DEVELOPMENT OF CHRONIC NECK PAIN IN OFFICE WORKERS

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AIMS: The development of neck pain in high risk occupations has often been attributed to overuse of cervical musculature caused by excessive physical and/or psychological stress in the workplace. However, evidence from prospective studies to verify the contribution of excessive muscle activity to future development of neck pain is lacking. The purpose of this prospective investigation was to determine whether electromyographic (EMG) measurements of cervical muscle activity in the workplace predict the development of chronic neck pain in office workers.
METHODS: Seventy-seven healthy office workers (mean (SD) age 31.0(6.9), 78% female) within 3 months of initial hire at their current job and working at least 30 hours per week at a computer participated in worksite EMG monitoring of the bilateral upper trapezius (UT) muscles on two separate workdays. Participants were then monitored with monthly surveys over the course of one year for the development of chronic neck pain, defined as ≥10% neck pain related disability for 3 or more months. Occupational exposure measures were calculated from the amplitude probability distribution function of worksite EMG recordings. Outcomes included static EMG, median EMG, peak EMG, muscular rest, and EMG gaps per minute. Occupational exposure outcomes were entered into a logistic regression model to assess odds ratios (OR) for predicting the development of chronic neck pain.
RESULTS: Fourteen individuals (18.2%) developed chronic neck pain during the 12 month follow up. The group who developed neck pain demonstrated lower static EMG (OR 0.12 (95% CI, 0.03-0.56), $p<0.01$) and decreased muscular rest (OR 0.78(95% CI, 0.63-0.97), $p=0.03$) in the dominant UT over the course of the workday.
CONCLUSIONS: Decreased muscular rest and lower static muscle activity of the dominant UT in the workplace predict the future development of chronic neck pain in office workers. Reduced muscular rest is consistent with the development of overuse injuries caused by insufficient time to recover from physical and metabolic demands placed on the muscle throughout the workday. Low levels of static muscle activity in those who developed neck pain are contrary to expectation, and may suggest that the amplitude of muscle contraction is less relevant to the development of overuse injuries than the opportunity to rest and recover between contractions. Low levels of static activation of postural muscles throughout the workday may reflect reduced postural support of the cervical spine which might also increase the risk of injury.

CHANGED KNEE MUSCLE ACTIVATION STRATEGY AND FASTER RATE OF FORCE DEVELOPMENT IN CHILDREN WITH GENERALIZED JOINT HYPERMOBILITY

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AIM: Generalized Joint Hypermobility (GJH) is associated with increased risk of musculoskeletal pain and injuries. Our knowledge on muscle activation and motor function is insufficient. The aim was to study knee muscle activation strategy and performance in girls with GJH.

METHODS: Girls with GJH (n=16, age 14 yrs, Beighton score 6.8, no or minimum knee pain) and healthy controls (CTRL) (n=11, age 14 yrs, Beighton score 1.8) performed isometric knee flexion (knee angle: 90°, 110°, 130°) and extension (knee angle 90°) at 20%Maximum Voluntary Contraction (MVC), as well as explosive isometric knee flexions at 90° (> 50%MVC) while sitting. EMG was recorded from knee extensor and flexor muscles, and expressed in %EMG_{max}. Extensor and flexor muscle activation, co-activation ratio ((antagonist/agonist) x 100) and knee flexion rate of force development (RFD) (15%-35%MVC) were calculated.

RESULTS: During knee flexions, a difference in flexor muscle activation between GJH and CTRL developed gradually with increasing knee angle. Thus, average flexor muscle activation (m. biceps femoris and m. semitendinosus) was 17.4%EMG_{max} vs. 20.2%EMG_{max} at 130° flexion (p=0.11) while it was 25.8%EMG_{max} vs. 33.6%EMG_{max} at 90° flexion (p=0.03), for GJH and CTRL, respectively. For the gastrocnemius muscle and the knee extensor muscles (m. vastus medialis and m. vastus lateralis) no between group differences were found at any knee flexion angles. During knee extensions a tendency to lower average flexor muscle activation (2.6%EMG_{max} vs. 3.3%EMG_{max}, p=0.10) was found for GJH. No between group differences were found for the knee extensor muscles and for gastrocnemius. Co-activation ratio during flexion at 90° knee angle was higher for GJH than for CTRL (15.8% vs. 12.0%) (p=0.04) but tended to be lower during 90° extension (14.2% vs. 19.9%) (p=0.07). Maximum RFD measured during the explosive isometric knee flexion was 53% faster for GJH than for CTRL (273Nm/s vs. 178Nm/s) (p=0.04) with no between group difference in muscle strength. Faster isometric knee extension RFD has been reported in young women with GJH and may explain why 10-yrs. old children with GJH perform better in vertical counter movement jump than controls (1,2).

CONCLUSION: Knee muscle activation strategy during knee flexions in GJH is changed relative to CTRL towards less activation of the hamstring muscles in flexed knee positions. Thus, the increased co-activation ratio in GJH could be explained by decreased agonist drive to the hamstrings. The difference in muscle activation strategy disappeared in more extended knee positions. Motor performance in terms of isomeric knee flexion RFD was higher in GJH than in CTRL.

ACKNOWLEDGEMENT: The study is supported by The Arthritis Research Association,

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ANALYSIS OF THE MUSCUALR COORDINATION OF BICEPS BRACHII AND BRACHIORADILAIS DURING ELBOW FLEXION AND EXTENSION IN DIFFERENT AGULAR VELOCITIES

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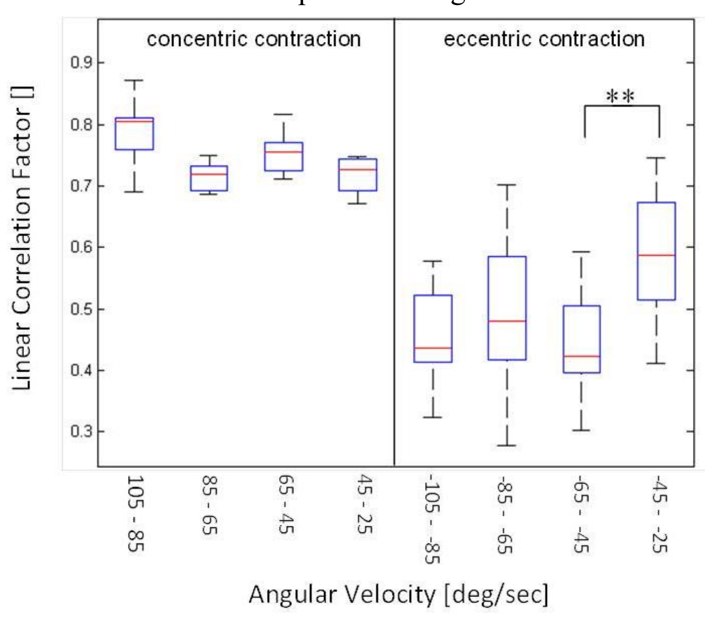
INTRODUCTION: Does it matter how fast we move? The question plays an important role if biomechanical considerations of muscular coordination are considered. Neuromuscular modelling strategies as well as the knowledge of the mechanism behind pathologies with a velocity-dependent character, like spasticity, can benefit from such detailed angular velocity dependent descriptions. Therefore, the interplay of the synergistic muscles, biceps and brachioradialis during elbow flexion and extension in different angular velocities is analyzed.

METHODS: Elbow flexion and extension was assessed in 14 healthy subjects, 7 men (27.2 $\pm$ 7.6) and 7 women, (24.6 $\pm$ 2.2). Synchronously to surface Electromyography (sEMG) of biceps and brachioradialis, elbow flexion and extension angles, as well as the corresponding angular velocities, were recorded. During the measuring procedure the angular velocity was varied in the range of 20-120deg/sec with the help of a real-time visual feedback.

In order to compare the interplay of the two muscles, an individual three dimensional function of each muscle and subject is introduced, which describes the amplitude of the enveloped sEMG signal of each muscle as a function of angle and angular velocity. These functions of all subjects were further analyzed to extract combinations of angles and angular velocities, where a change in the muscular coordination can be observed.

RESULTS: The three dimensional functions of all subjects showed a deviation between muscular activation patterns of biceps and brachioradialis regarding the eccentric contraction phase for angles between 50-100 degrees, whereas during concentric contractions the activation profile of both muscles resemble themselves. Therefore, individual linear correlation factors were regarded showing a significant change between muscular activation of biceps and brachioradialis for angles ranging from 50-100 degree and angular velocities between -45 to -65 deg/sec ($p = 0.002$), Figure 1. During concentric contractions no changes in different angular velocities were observed.

CONCLUSION: There is a significant impact of the angular velocity on the muscular coordination between biceps and brachioradialis during eccentric contractions, but not during concentric contractions.



THE EFFECTS OF UPPER LIMB ELEVATION ANGLE AND PLANE ON MOTOR CORTEX ACTIVATION OF THE FOREARM MUSCLES

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AIM: To facilitate reaching movements, the motor cortex must activate muscles of the upper limb. However, it is not clear how shoulder position affects cortical output to hand and forearm muscles. Two factors that may impact cortical activation of hand and forearm muscles include shoulder elevation angle and plane. The aim of this study was to determine changes to cortical activation of the forearm muscles that occur with changes in angle and plane during static shoulder positions.

METHODS: Ten participants (8 male, 2 female, mean age: 22.4 ± 2.5 years) positioned their arm at three elevation angles (45º, 90º and 120º) in two planes (flexion and abduction) for a total of six postures per participant. Four muscles on the right forearm were monitored with surface electromyography (Cambridge Electronic Design, Cambridge, UK). Muscles included extensor carpi ulnaris (ECU), extensor carpi radialis (ECR), flexor carpi ulnaris (FCU), and flexor carpi radialis (FCR). Transcranial magnetic stimulation (TMS) was delivered sequentially between 85 and 205% of participants' resting threshold. Peak-to-peak amplitudes of motor evoked potentials recorded during rest were used as measures of corticospinal activity. In a separate component, cortical silent period was measured during a background contraction (5% maximal voluntary contraction) of the ECR.

RESULTS: Peak-to-peak amplitude at each stimulation intensity was modeled using a Boltzmann sigmoidal function and comparisons were made at the level where the data plateaued. Repeated measures ANOVA showed a significantly higher plateau for ECU at increased angles ($F_{1.42, 25.49} = 4.834$; $p = 0.026$). Plateau of ECU varied with an activation of 0.98 ± 0.14 mV (mean ± SE) with the arm at 45° flexion, to 0.94 ± 0.14 mV and 1.18 ± 0.18 mV at 90° and 120° flexion, respectively. For abduction, ECU varied from 0.94 ± 0.12 mV to 1.15 ± 0.16 mV and to 1.27 ± 0.23 mV at 45°, 90° and 120° abduction, respectively (Figure 1A). Cortical silent period was measured as the time from the TMS stimulus to re-onset of muscle activity. Repeated measures ANOVA showed a significant difference for FCR between planes ($F_{1, 24} = 4.770$, $p = 0.039$) with greatest differences seen between flexion and abduction at 90° (163 ± 17 ms to 180 ± 12 ms) and 120° (156 ± 12 ms to 173 ± 17 ms) (Figure 1B).

CONCLUSION: These results suggest that there is increased cortical output to ECU in response to increased arm elevation angles, with flexion having shorter silent periods than abduction. Future work could include differentiating supraspinal changes from spinal.

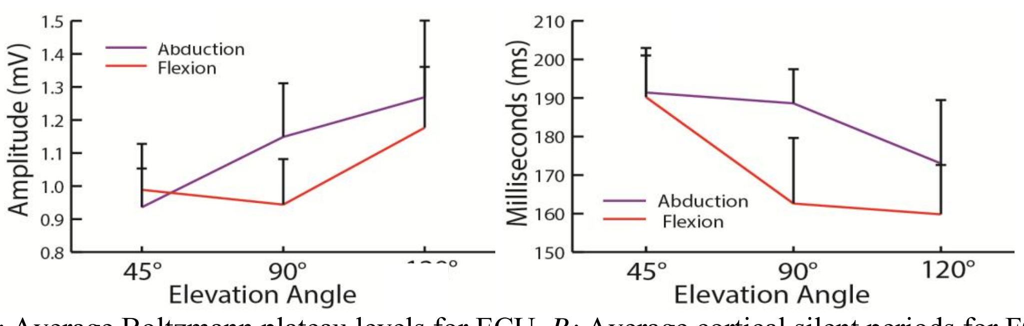

Figure 1. *A:* Average Boltzmann plateau levels for ECU. *B:* Average cortical silent periods for FCU. Elevation angles and both planes are shown in each figure. * represents $p < 0.05$

NONIVASIVE REAL-TIME TRACKING OF MOTOR UNIT DISCHARGE PATERNS

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AIM: A method for real-time tracking of motor unit (MU) discharge patterns out of high-density surface EMG is presented. It provides highly accurate and immediate feedback on the identifiable MUs and their discharge properties, and, thus supports online tailoring of the experimental protocol and/or clinical investigation during the very measuring session.
METHODS: In calibration phase, Convolution Kernel Compensation (CKC) technique [1] was used for offline identification of Bayesian optimal filters of MU discharge patterns out of 10 s long surface EMG signals recorded by 5×12 electrodes with interelectrode distance of 5 mm and sampled by EMG-USB2 amplifier (OT Bioelettronica) during isometric 20%, 40% and 60% maximum voluntary contraction (MVC) of tibialis anterior (TA) muscle in four healthy male subjects. For each subject, the filters from different contraction levels have been collected into a MU filter bank and used for online MU tracking during the 20 s long isometric TA contractions at 20%, 40% and 60% MVC in the same subject. A Pulse-to-Noise Ratio (PNR) metric [2] was used to assess the accuracy of every identified MU discharge pattern during the online MU tracking phase.
RESULTS: Filters of 13±3 MUs, 15±2 MUs and 14±1 MUs per subject were identified in offline calibration phase from 20%, 40% and 60% MVC contractions, respectively. 87%±13%, 79%±17% and 77%±4% of these MUs were active also during the online motor unit tracking at 20 %, 40% and 60% MVC contractions, respectively. As assessed by the PNR metric [2], all these MUs have been tracked with sensitivity in identification of their discharge patterns between 95 % and 100 %, regardless the contraction level. Computational complexity of online MU tracking was relatively low, occupying ~20 % of CPU time on a standard personal computer.
CONCLUSION: Although limited to isometric contractions, the presented method supports online studies of motor plasticity, implementation of advanced feedback modalities during neurorehabilitation, therapies and training of athletes, and advanced studies of myoelectric control of neuroprosthesis. By providing the immediate feedback on muscle control strategies, it has the potential to significantly boost both the quality of surface EMG recordings in clinical and experimental setups and the basic research in neurophysiology, neurorehabilitation, neuroprosthetics, ergonomics and sport sciences.
ACKNOWLEDGEMENT: This study was supported by the Commission of the European Union, within 7th Framework Programme, under Grant Agreement number ICT-2011.5.1-287739 "NeuroTREMOR: A novel concept for support to diagnosis and remote management of tremor."
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Movement Disorders 2(Sala Cesarea 12.00-13.00)

ADULTS WITH GENERALISED JOINT HYPERMOBILITY DISPLAY CHANGED MOVEMENT PATTERN DURING COUNTER MOVEMENT JUMP

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AIM: Adults with Generalised Joint Hypermobility (GJH) are diagnosed clinically by passive joint movement tests (Beighton score of ≥4 positive joints of 9). Whether an increased ROM is present in adults with GJH compared with non-GJH (NGJH), also during a functional task, such as counter movement jump (CMJ), is not known. Further, adults with GJH have increased risk of joint injuries, especially in the knees [1]. Changed movement pattern during CMJ is a risk factor for knee injuries. This has not been studied in adults with GJH. The aim was to investigate differences in lower extremity kinematics during CMJ between adults with and without GJH.
METHODS: A total of 30 parents to the children of a cohort of schoolchildren in two medium sized Danish municipalities were recruited randomly and consecutively, including 14 adults with GJH (Beighton score ≥4/9 and at least one hypermobile knee), and 16 adults with NGJH (Beighton score <4/9 and no hypermobile knee). Exclusion criteria were previous serious trauma to the lower extremities and lumbar spine, and serious hereditary diseases. All subjects performed three maximum CMJ's akimbo on a force plate. CMJ was recorded (50 Hz) in 3-D by five cameras. Outcome measures for each subject comprised six kinematic parameters in the sagittal plane during the whole CMJ sequence, besides the specific joint angles at take-off and landing, for right and left ankles, knees and hips.
RESULTS: Mean Beighton score was 7.2 and 0.8 in adults with GJH and NGJH, respectively (p=0.028), and mean age was 40.3 yrs, with no between group difference in age and BMI. Increased ROM during the whole CMJ sequence was found in both hips (p=0.023; p=0.034) and knees (p=0.025; p=0.021) in GJH, corresponding to a mean group difference of 8-12°. During take-off adults with GJH had significantly smaller mean flexion in the left hip (14.03° vs 19.39°; p=0.027) and left knee (5.09° vs 10.66°; p=0.020), and during landing a larger mean flexion in the right knee (40.86° vs 33.90°; p=0.030). There was no difference in vertical jump height, but self-reported knee function and general health was significantly reduced in GJH.
CONCLUSIONS: Increased ROM in the hips and knees during a functional task corresponds with increased ROM, measured passively by clinical examination. Changed movement pattern during take-off and landing may contribute to the increased risk of injuries in GJH. Further studies should verify and eventually implement this information in prevention strategies of injuries and development of osteo-arthritis for this group

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ANALYSIS OF POSTURAL CONDITIONS OF THE JAW IN PATIENTS WITH ACQUIRED IMMUNODEFICIENCY VIRUS

Silva GP[1,2], Ferreira B[1,2], Arnoni VW[2], Gonçalves CR[2], Machado AA[1], Siéssere S[2], Semprini M[2], Regalo SCH[1,2].

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AIM : AIDS is a complex chronic viral disease and incurable until the moment transmitted by blood , semen , vaginal fluids and breast milk . Is currently considered a public health challenge in terms of its prescriptive nature of diagnosis and treatment , when compared to other diseases that humanity is subjected . Thus , we can highlight the importance of proposing differential diagnoses in order to enhance the rehabilitation plans that enhance the quality of life of these individuals . Thus , the aim of this study was to analyze the effects of HIV type 1 during activities related postural conditions of the mandibular in patients with this syndrome.
METHODS: In this study 60 subjects were selected of both genders, with a mean age of 36.77 ± 9.33 years, were divided into two groups: Group 1 (G1), 30 individuals with HIV subtype 1 (HIV-1 group) and Group 2 (G2), 30 individuals with no medical diagnosis of infectious diseases, Ribeirao Preto of the community and region. These were assessed for muscle activity by surface electromyography, clinical conditions related to posture the mandible: rest, protrusion, right and left laterality of right and left temporal muscles (TD and TE), right and left masseter (MD and ME) and right and left sternocleidomastoid (ECOMD and ecome) for 4 seconds each clinical condition. The EMG values were normalized by maximum voluntary contraction for 4 seconds and statistically analyzed (test tp <0.05).
RESULTS: The results demonstrated significant statistical values (test tp <0.05) in the clinical condition of rest for the TD, TE and ecome muscles, provided that protrude TD, TE, and ECOMD ECOME, provided laterality right values were significant for the TD, TE and ECOMD muscles and the condition of left handedness for TD, MD, and ECOMD ECOME muscles.
CONCLUSION: Individuals infected with the human immunodeficiency virus showed higher average EMG for all muscles tested, which demonstrates a higher requirement of the musculature of the stomatognathic system to perform maintenance of mandibular posture.
ACKNOWLEDGEMENT: FAPESP (n° 2012/04630-6).

EVALUATION MASTIGATORY EFICIENCY OF PATIENTS WITH DUCHENNE MUSCULAR DYSTROPHY

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AIM: The Duchenne muscular dystrophy is caused by changes in the locus of the X chromosome Xp21, essentially in the gene (dys) that encodes a protein called dystrophin. Carriers of Duchenne disease have clinical loss of muscle strength gradually, starting in the lower limbs that stretches all the muscles of the human body. Thus, this study aims to analyze the masticatory efficiency in individuals with Duchenne muscular dystrophy.
METHODS: Were selected 40 male subjects aged between 04-15 years, mean age 10 ± 4 years, divided into two groups matched for age, weight and height: GI - Carriers of Duchenne muscular dystrophy (n = 20). G2 - Control: individuals without a diagnosis of Duchenne muscular dystrophy (n = 20). The participants in this study subjects underwent rating of the stomatognathic system by surface electromyography during clinical conditions Chewing parafilm M ®, raisins, and Chew chewing peanuts, temporal, masseter and sternocleidomastoid muscles bilaterally for 10 seconds each condition clinic. The EMG values were normalized by the clinical condition of maximum voluntary contraction for 10 seconds. The normalized EMG data were subjected to statistical analysis (test tp <0.05).
RESULTS: The statistical results showed significant differences in all clinical conditions for the temporal muscle, masseter and sternocleidomastoid both sides.
CONCLUSION: Subjects with Duchenne muscular dystrophy present reduction of masticatory efficiency in clinical conditions used in this study.
ACKNOWLEDGEMENT: FAPESP (n° 2012/12673-7).

AN ELECTROMYOGRAPHY STUDY OF MUSCLE PATTERNING IN PATIENTS WITH COMPLEX SHOULDER INSTABILITY

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INTRODUCTION: Those with atraumatic shoulder instability or "Polar Type III" under the Stanmore Classification[1], are a poorly understood patient group. The aim of the study was to use Electromyography (EMG) to investigate shoulder muscle activation during an arm elevation task based on activities of daily living.

METHOD :32 patients and controls with atraumatic shoulder instability were included. Surface electrodes were utilized to record the activity of 10 muscles: upper trapezius, serratus anterior; pectoralis major; biceps brachii; lattissimus dorsi, teres major, infraspinatus, anterior, middle, and posterior deltoid. Signals were recorded using a telemetry based EMG system during a reliable and accepted EMG testing protocol (based on the FIT-HaNSA functional assessment) which involved consecutive lifting of a weight from a low shelf to a high shelf (phase 1) and back (phase 2) [2] [3] .

RESULTS: Significantly greater activity (mean ± SEM) was seen in the latissimus dorsi during both phases of the movement protocol in the patient group: Phase 1 - 52.8% ± 9.1 vs 21.3% ± 6.7 (p-value 0.017); phase 2 - 52.8% ± 11.9 vs 18.9% ± 5.6 (p-value 0.044). No significant differences were identified in the other muscles of study, Figure 1.

CONCLUSION: Our study is the first EMG prospective study studying this patient group[4]. The study demonstrates that in those with atraumatic shoulder instability there is an over activation of Latissimus dorsi in both phases of a functional lifting activity.

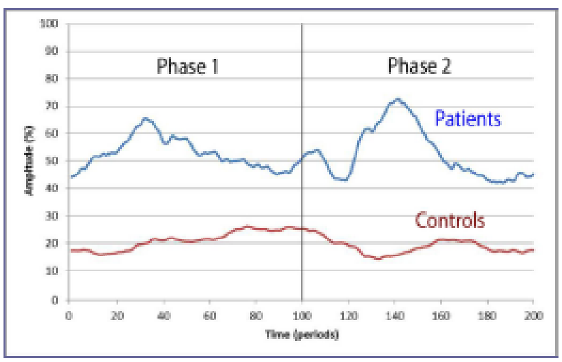

Figure 1 – EMG activity of Latissimus Dorsi

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3-DIMENSIONAL CERVICAL KINEMATICS IN CHRONIC NECK PAIN PATIENTS AND IT RELATIONSHIP WITH PAIN LOCATION

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AIM: The aim of this study is to analyze quantitative and qualitative aspects of active cervical kinematics in chronic a-specific neck pain patients (CNP's). Kinematics were related to pain-location and self-reported signs of motor control impairment and functional disability.
METHODS: 41 CNP's and 156 asymptomatic controls were recruited. Active cervical spine movements were registered using an electromagnetic tracking system (Flock of Birds®-Ascension Tech©). Three-dimensional kinematic parameters were calculated for active axial rotation, lateral bending and flexion-extension. As quantitative parameters ROM, Euclidean norm, Cross-Correlation and Ratio of the main and coupled motion were used. Jerk index and the difference between the original data and the sixth-polynomial fit were used to describe qualitative aspects of the motion. Patient subgroups were defined based on uni- versus bilateral pain location (asymmetrical and symmetrical). Additionally patients reported subjective experiences of impaired motor control and functional disability by means of the Neck Disability Index (NDI, Vernon and Mior 1991) and 7 items of the Clinical Cervical Spine Instability questionnaire (CCSI, Cook et al 2005).
RESULTS: During lateral bending the ROM of the main motion demonstrated significant higher values ($p=0.001$) in the controls (mean: 68.67°±15.17°) compared to CNP's (mean: 59.28°±15.41°). Significant differences were demonstrated between subgroups for several kinematic parameters ($p<0.05$). Although differences were predominantly recorded between the "symmetrical" and "asymmetrical" pain group, a few parameters also distinguished subgroups from controls. On average the symmetrical group showed significant less harmonic movement patterns, expressed by qualitative parameters, in comparison with the "asymmetrical" group and controls (figure 1). Furthermore, the "asymmetrical" group showed significant lower scores on quantitative parameters compared to the "symmetrical" group and controls. Self-reported feelings of motor control impairment and functional disability correlated moderately with changes in qualitative parameters.
CONCLUSION: In this study CNP's and controls only differed significantly in one quantitative parameter, the ROM during lateral flexion. The subgroup of CNP's with a symmetrical pain pattern showed significant poorer quality of movement while those with asymmetrical pain showed a significantly reduction in quantitative measures. Subgrouping of CNP's based on pain location may be of help for further research on therapeutic strategies.

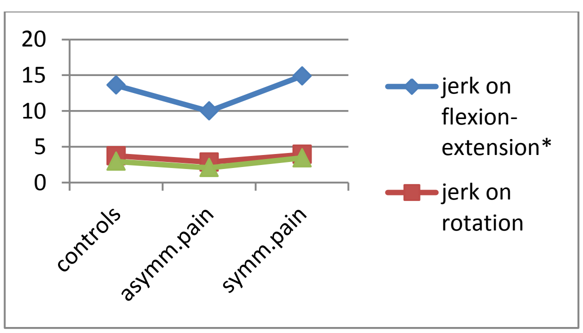

Figure 1. Jerkiness of the main and conjunct movements during flexion-extension. (smaller values indicate a more smooth movement) *=$p<0.05$

Muscle Pain (Sala 1LM 12.00-13.00)

MORE PAIN, LESS GAIN: FATIGUE-RELATED FIRING OF MUSCLE NOCICEPTORS REDUCES VOLUNTARY ACTIVATION OF IPSILATERAL BUT NOT CONTRALATERAL LOWER LIMB MUSCLES

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AIM: During fatiguing exercise of the upper limb, firing of group III/IV muscle afferents can act to limit voluntary drive not only to fatigued muscles, but also to unfatigued muscles within the same limb (1). For the lower limbs, blockade of group III/IV afferents can allow increases in voluntary drive (2) but the inverse, that increased firing of these afferents contributes to decreases in voluntary drive, has not been demonstrated. Moreover, the distribution of any such effects is unknown. The aim of this study was to determine the effects of group III and IV muscle afferents from fatigued ipsilateral and contralateral extensor muscles and ipsilateral flexor muscles of the knee on voluntary activation of the knee extensor muscles.

METHODS: In three experiments subjects sat with the right leg strapped to a transducer to measure knee extensor force. For Experiment 2 we also measured force from the right knee flexors. For Experiment 3 we also measured force from the contralateral (left) knee extensors. Paired electrical stimuli (doublet) were delivered to the femoral nerve to evoke increments in force from the knee extensors during (superimposed twitch) and after maximal efforts to provide a measure of voluntary activation. In Experiment 1, on two days, subjects (n = 9) performed brief maximal voluntary contractions (MVCs) of knee extensors before and after a 2-min MVC of the extensors. Experiments 2 and 3 were similar to Experiment 1 except subjects performed 2-min MVCs of the right knee flexors (Experiment 2; n = 8) or of the contralateral (left) knee extensors (Experiment 3; n = 8) prior to brief right extensor MVCs. For each experiment, on one day a blood pressure cuff occluded blood flow of the fatigued muscles, and so maintained firing of group III/IV muscle afferents.

RESULTS: *Experiment 1*. After the 2-min *extensor* contraction, both mean knee *extensor* force (14.3 ± 11.9% v. 66.9 ± 11.1% peak MVC respectively; $P < 0.001$) and voluntary activation (47.1 ± 18.8% v. 86.8 ± 7.7%, respectively; $P < 0.001$) were lower with than without occlusion of blood flow. *Experiment 2*. After the 2-min knee *flexor* MVC, both mean knee *extensor* force (67.6 ± 22.8% v. 95.7 ± 9.8% peak MVC; $P < 0.05$) and voluntary activation (59.0 ± 20.6% v. 79.1 ± 8.9%; $P < 0.01$) were lower with than without occlusion of blood flow. *Experiment 3*. After the *contralateral* (left) MVC, both mean knee *extensor* force (102.4 ± 9.6% peak MVC v. 99.0 ± 7.5% peak MVC; $P = 0.48$) and voluntary activation (92.1 ± 5.6% v. 92.9 ± 4.1%; $P = 0.65$) of the right leg were no different with or without occlusion of blood flow.

CONCLUSION: Following a fatiguing lower limb contraction, activity in group II/ IV muscle afferents can act to reduce voluntary activation and hence, force production of the fatigued muscle and of a non-fatigued antagonist muscle in the same limb. However, continued firing of group III/IV muscle afferents from the contralateral (left) limb had no effect on the unfatigued right leg. This suggests there is no 'cross-over' effect mediated by group III/IV muscle afferents on central fatigue in the lower limbs.

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TOPOGRAPHICAL MAPPING OF SURFACE EMG AMPLITUDE IN SUBJECTS WITH MYOFASCIAL TRIGGER POINTS IN THE UPPER TRAPEZIUS MUSCLE

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AIM: This study applied topographical mapping of upper trapezius (UT) surface EMG amplitude to evaluate the location of the peak EMG amplitude in subjects with myofascial trigger points (MTrPs) within the UT muscle and healthy subjects.

METHODS: Thirteen subjects with MTrP in the UT muscle and 12 healthy subjects participated. Surface EMG was recorded from the UT using a matrix of 64 electrodes aligned with an anatomical landmark system (ALS). Each subject completed a shoulder elevation task consisting of a series of six ramp contractions at 15% or 60% MVC each lasting 30s. Surface EMG signals were divided in epochs of 1s and topographical maps of the EMG average rectified value (ARV) were computed for each epoch. The EMG peak amplitude was identified for each epoch and its location with respect to the ALS was assessed during the ramped contractions.

RESULTS: The location of the peak EMG amplitude in subjects with MTrP was -0.32 ± 1.2 mm at 15% MVC and -0.35± 0.9 mm at 60% MVC relative to the ALS whereas in healthy subjects, the peak EMG amplitude was 1.0 ± 1.3 mm at 15% MVC and 1.3 ± 1.1 mm relative to the ALS (difference between groups: $P<0.05$). The difference between the exerted force and the target force was higher in subjects with MTrP during the 60% MVC ramped contraction.

CONCLUSION: Subjects with MTrPs displayed a different spatial distribution of the EMG amplitude over the UT muscle during a task of shoulder elevation. The peak amplitude of the surface EMG was located more caudally in subjects with MTrP compared to healthy subjects. Furthermore, subjects with MTrP showed reduced force accuracy during the 60% MVC ramped contractions.

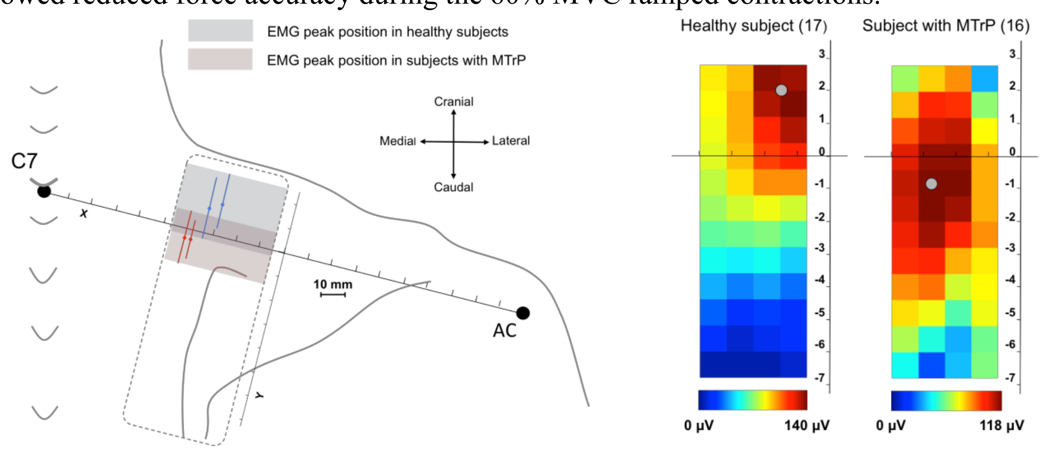

Figure 1: A) Location of the peak EMG amplitude relative to the ALS B) Topographical maps of EMG amplitude during ramps at 60% MVC in two representative subjects. The grey circles indicate the EMG peak locations.

MOTOR RESPONSES TO SIMULATED WORKPLACE STRESSORS DO NOT PREDICT DEVELOPMENT OF CHRONIC NECK PAIN IN OFFICE WORKERS

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AIM: Static muscle activity and periods of muscle rest in the workplace have recently been shown to predict development of neck pain in office workers. Electromyographic (EMG) assessments during experimental simulations of stressful workplace tasks have commonly been used as a surrogate for motor responses assumed to occur during actual workplace activities in this population. Although previous studies have shown that individuals with neck pain demonstrate an impaired ability to relax their muscles compared to healthy individuals when exposed to simulated workplace stressors, it is unclear whether these abnormal motor responses are a cause or consequence of neck pain. The purpose of this prospective investigation was to determine whether motor responses of cervical muscles to simulated workplace stressors predict the future development of chronic neck pain in office workers. A second purpose was to determine the association between muscle activity recorded during simulated and actual workplace activities.
METHODS: One hundred and fifty six healthy office workers (mean (SD) age of 30(8) years, 79% female) completed simulated office tasks at a computer workstation under low stress and high stress conditions. The acute psychosocial stressor combined time and accuracy demands with low social support. Bilateral upper trapezius (UT), sternocleidomastoid (SCM), and cervical extensor (CE) muscle activity was measured using surface EMG. Static EMG and muscular rest were also quantified from EMG recordings collected during two 7-hour workdays for a subgroup of 77 participants. All participants were monitored for one year for development of chronic neck pain, defined as ≥10% neck related disability for 3 or more months. Motor responses to the simulated workplace stressor were entered into a logistic regression model to determine odds ratios for the development of neck pain.
RESULTS: Thirty-two individuals (21%) developed chronic neck pain over the course of the year. Exposure to the psychosocial stressor significantly increased EMG activity in the UT (1.66 (8.2)%, $p=0.03$), but not the SCM or CE muscles ($p\geq0.16$). However, these increases in UT muscle activity did not predict the development of chronic neck pain ($p\geq0.49$). Additionally, there were no significant associations between motor responses to the simulated workplace stressor and either static muscle activity or muscular rest throughout the workday.
CONCLUSIONS: Although many studies have examined simulated workplace stressors as a surrogate for motor behaviors that may increase the risk of overuse injuries in the workplace, our results do not support this methodological approach for investigating the future risk of neck pain in office workers. Habitual patterns of muscle activity, which likely reflect a combination of both physical and psychological stressors in the workplace, are more relevant to injury risk than motor responses to an acute psychosocial stressor.
ACKNOWLEDGEMENTS: Funding sources: NIH R01 AR056704 awarded to KSM, Foundation for Physical Therapy PODS II awarded to BS

EFFECTS OF FATIGUE ON MOTOR UNIT ACTION POTENTIAL PROPERTIES IN THE FDI MUSCLE

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AIM: The neural adaptations that occur in the recruitment and regulation of motor unit (MU) activity during muscle fatigue in healthy subjects are still unclear. The absence of consistent observations in the literature on motor unit activity during fatiguing contractions has been previously attributed to inadequate sample size [1], a limitation associated with intramuscular electromyography (EMG). However, the interpretation of neural strategies using surface EMG is also prone to erroneous conclusions in the absence of information about the underlying MU action potentials (MUAPs). The aim of this study was to investigate the changes in the recruitment of MUs as a result of fatigue in the First Dorsal Interosseous (FDI) muscle by simultaneously examining the global interference EMG signal and individual surface decomposed MUAPs. Surface EMG incorporates the net effect of central and peripheral properties of the neuromuscular system and single MUAPs convey information on membrane fiber properties, providing a dual perspective on the adaptations observed.

METHODS: Surface EMG was recorded from the FDI muscle using the novel Delsys Precision Decomposition System [2]. EMG activity was recorded during isometric abduction of the FDI at 20 % MVC (maximum voluntary contraction), before and directly after a fatiguing isometric contraction at 30 % MVC held until task failure. Additional 20% MVC contractions were recorded following a 10 min recovery period of. An analytical method, utilizing the spike triggered average of the derived MU spike times [3], was applied to assess the reliability of decomposed MUs from the output of the surface EMG algorithm.

RESULTS: An increase in the duration and amplitude of the decomposed MUAPs directly following the fatiguing contraction was observed. After the recovery period, MUAP duration recovered to the values obtained pre-fatigue, however, the median amplitude of the population of the decomposed MUAPs remaining high.

CONCLUSION: The increase and recovery of MUAP duration reflects the well-established reduction of muscle fiber conduction velocity during fatigue. The increase in MUAP amplitude may also correspond to changes in the intracellular action potential or, alternatively, suggest the recruitment of larger amplitude, higher threshold motor units to compensate for fatigue and maintain the target force. The dissociation between changes in amplitude and duration after the recovery period, however, favours the latter hypothesis that these variations may are not caused solely by fatigue-altered metabolic and ionic properties of the muscle. Changes in the amplitude and median frequency of the global EMG signal support the alterations observed at the MU level.

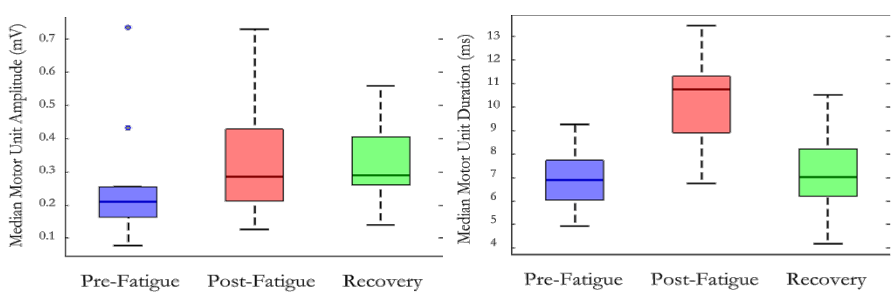

Figure 1: Median MUAP (a) amplitude (b) duration pre-fatigue, post-fatigue and after 10 mins recovery.

[1] Enoka, R. M., & Fuglevand, A. J. (2001), Muscle & nerve, 24(1), 4-17. [2] De Luca, *et al*. (2006), J Neurophysiol, 96(3), 1646-1657. [3] Hu, X., *et al*. (2013), J Neurophysiol, 110(5), 1205-1220.

SURFACE ELECTROMYOGRAPHIC BACK EXTENSOR MUSCLE FATIGUE IN PERSONS OLDER THAN 50 YEARS

Ebenbichler G[1,2], Habenicht R[1], Mair P[1,5], Kienbacher T[1], Starek C[1,4], Kollmitzer J[1,3,4]

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BACKGROUND: Median frequency surface electromyographic (MF-SEMG) fatigue testing may provide a functional diagnostic measure to objectively assess age related alterations of both back muscle structure and function in elderly persons. However, research so far has failed to demonstrate relevant age specific differences in these muscles if using this methodology. Such lack of finding might be due to administration of inappropriate back muscle fatigue protocols that neither allowed entire recruitment of all motor units available within the back extensors nor a wide sense occlusion of back muscle blood perfusion.

AIMS: To examine whether or not MF-SEMG back extensor fatigue will differ between healthy volunteers older than 50 years when compared to younger than 50 years old ones, if a protocol is used that allows for an optimum standardization of the muscle fatigue process.

METHODS: A total of 42 older (21 females; mean age 67 (±10.5) years old) and 44 younger persons (19 females; 33 (± 10) years old) performed submaximum, isometric trunk extensions at 80% MVC in a seated position and with their trunks 30° anteflexed using a back extension dynamometer (Technogym®, Italy). Surface electromyograms were recorded bilaterally from the L1 (iliocostalis lumborum), L2 (longissimus), and L5 – (multifidus) recording sites. Main outcome variables were: 1) peak back extension moment 2) initial median frequency, 3) frequency slope normalized to the initial median frequency, and 4) uncompensated and compensated values of individual MF-EMG muscular imbalances. 2-factorial ANOVAs served to examine for age and gender specific effects. Post hoc analyses were performed, using unpaired t-test with boot straps.

RESULTS: Maximum back extension moment was non-significantly smaller in older than younger participants but highly significantly different between males and females. Initial median frequency values were overall higher in older testees with significant differences at the L5 recordings sites. The MF-SEMG fatigue slopes were significantly less steep in older volunteers if recorded from the L5 recording sites or if the most negative slopes or the slope of all electrodes was considered. The L2 recording site demonstrated a tendency toward significantly less steep slopes in the elderly. There were no significant gender specific differences observed for the aforementioned variables nor were there any age or gender specific differences identified for the compensated or uncompensated MF-EMG imbalances.

CONCLUSION: Using appropriate test protocols that allow optimum standardization of the muscle fatigue process, the MF-SEMG fatigue method is able to demonstrate both functional and structural alterations of aging back muscles. Thus, this method may be recommended as a future screening tool to objectively identify elderly persons who are at risk for "sarcopenia" and/ or to plan early preventive or rehabilitative interventions intended to postpone this process.

Modelling & Signal Processing 3 (Sala 2LM 12.00-13.00)

AN EMG-DRIVEN MUSCULOSKELETAL MODEL TO ESTIMATE MUSCLE FORCES USING NEURO-FUZZY SYSTEM IDENTIFICATION

Jafari Z[1], Marateb HR [1], Rojas M[2], Muceli S[3], Mañanas MA[2], Farina D[3]

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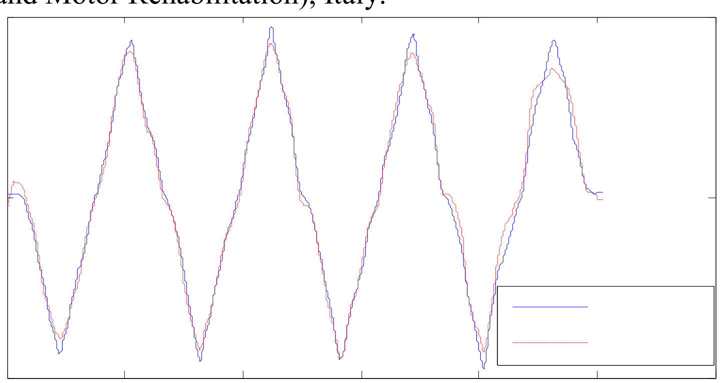
AIM: The aim of this project is to design an *interpretable* expert-based system for muscle force prediction from surface EMG (sEMG) signals. Almost all of the methods proposed in this domain are based on the black-box linear/nonlinear mathematical models, whose clinical interpretation is not straightforward. In this project, fuzzy systems were used for EMG-Force modeling since they are generic approximations of nonlinear systems. Also, uncertainties, unpredictable dynamics and other unknown phenomena that cannot be mathematically modeled at all, are demonstrated by a set of fuzzy rules.
METHODS: Surface EMG signals from Biceps Brachii (BB), Brachioradialis (BR), lateral and medial head of Triceps Brachii (TBL and TBM) of five healthy subjects were recorded with 8-channel linear electrodes (IED of 5 mm) during voluntary flexion-extension isometric contractions. Simultaneously, the torque signal was also sampled and displayed for the force feedback. A set of ramp signals at 30, 50 and 70% MVC were recorded. Single differential (SD) signals were computed along the fiber direction and used for further processing. sEMG and torque signals were appropriately filtered and low-quality signals were excluded from the analysis. The envelope of sEMG signals was extracted by a non-causal digital low-pass filter on the rectified signals (EMG amplitude). For each muscle, Robust Principal Component Analysis (RPCA) was used to extract the main channel whose CPV was less than 99%. A Sugeno (TSK) type-1 Fuzzy system was designed based on the input (EMG amplitude), and output (recorded force). For each recording, Neuro-fuzzy identification (Bontempi and Birattari, 1999) was performed on a training set in a 10-fold cross-validation framework and a fuzzy structure with the lowest complexity (#rules), and highest fitness value (%VAF) was selected. The parameters #rules (training set) and the %VAF (validation set) were reported.
RESULTS: The output parameters of the fuzzy system tuned on the first subject is shown in Table 1. The proposed model was fitted on not only this subject (mean %VAF>94%), but also for all the subjects at different contraction levels (mean % VAF=91.5±5.9). It also showed that the lower number of rules, results in less over-tuning and more generalization capability. Comparing the fuzzy rules, different control mechanisms were activated at higher MVC. The torque estimation for the 2nd subject at 50% MVC on the test set was shown in Figure 1. It shows that the predicted torque nicely follows the recorded torque.
ACKNOWLEDGEMENT: The HD-sEMG data set used in this study was recorded at LISiN (Laboratory of Engineering of Neuromuscular System and Motor Rehabilitation), Italy.

Table 1: Performance indices of the first subject's model

Indices / % MVC	**% VAF**	**# rules**
30	95.6±2.9	3
50	98.5±0.8	4
70	94.6±5.4	5



OVER WHAT BANDWIDTH SHOULD AN EMG SIGNAL BE WHITENED?

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AIM**:** Most surface EMG electrode systems have a passband out to 400–600 Hz. In contrast, many studies of EMG signal whitening have used custom wideband electrode systems, and have whitened the EMG signal out to 1000–2000 Hz. We systematically investigated the performance of EMG whitening as a function of maximum available signal frequency. Whitening decorrelates the EMG signal and has been shown to be advantageous in EMG-force processing and EMG amplitude estimation.

METHODS**:** Previously collected EMG data from 54 healthy subjects were reanalyzed. Two constant-posture contraction types were studied. First, EMG-force processing was studied utilizing low-level, torque-varying contractions which averaged 18.5 $\%MVC_F$ (percent flexion MVC). Second, EMG amplitude estimation was studied utilizing medium-level, constant-torque contractions (50% MVC). Both analyses assessed performance vs. the frequency band over which whitening was performed.

RESULTS**:** For the low-level, torque-varying contractions (effort levels consistent with most daily tasks), EMG-force performance utilizing frequencies out to 400–500 Hz did not differ significantly ($p<0.01$) from utilization of the full 2000 Hz bandwidth. For the medium-level 50% MVC contractions, performance utilizing frequencies out to 800–900 Hz did not differ significantly from utilization of the full bandwidth.

CONCLUSION**:** Conventional electrode systems with bandwidths out to ~500 Hz provide all of the whitening benefits of wider band systems for the lower-level contractions of typical daily effort. Wider band systems are advantageous for more strenuous activities. Lower noise EMG acquisition systems may also take advantage of higher signal frequencies.

REFERENCE: Dasog et al., Electromyogram Bandwidth Requirements When the Signal is Whitened. IEEE Trans Neural Sys Rehab Eng, in press.

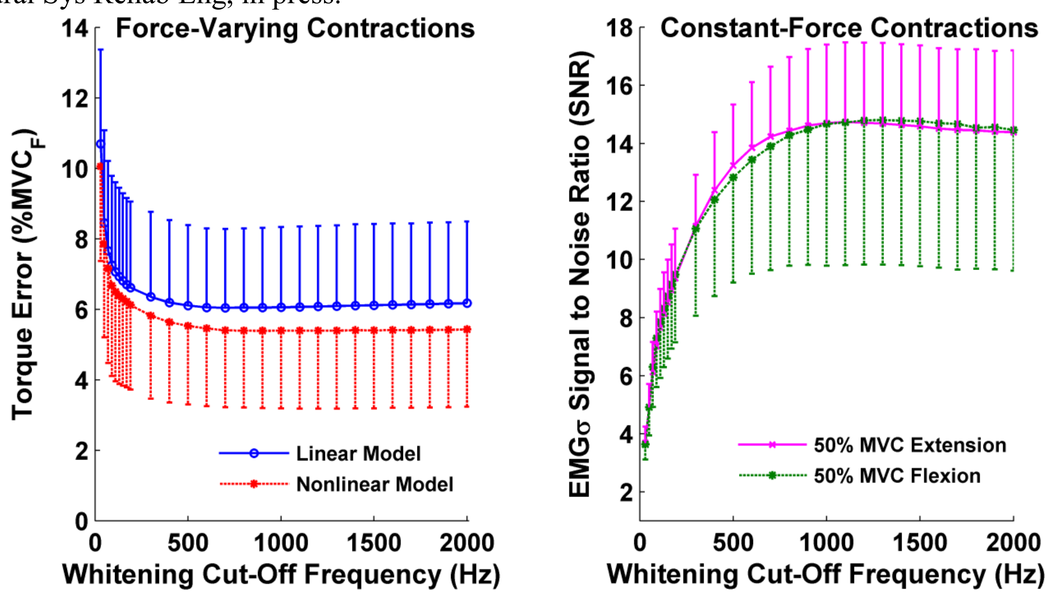

Figure 1: Left: EMG-torque error vs. whitening bandwidth for linear and nonlinear dynamic models. Right: EMG amplitude estimation SNR from 50% MVC trials vs. whitening bandwidth.

COMPARISON OF DIFFERENT DIGITAL FILTERING TECHNIQUES FOR SURFACE EMG ENVELOPE RECORDED FROM SKELETAL MUSCLE

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AIM: The choice of filter parameters that would provide the "best" estimate of EMG envelopes is an open issue. This study investigates the most appropriate mono- or bi-directional low pass filters (LPF) for extracting the EMG envelope.
METHODS: Four different filter types (Butterworth/B, Chebyshev/1C, Inverse Chebyshev/2C, and Elliptic/E) were considered. Four cut off frequencies (1Hz, 3Hz, 5Hz, and 10Hz), five filter orders (1st to 5th for each direction), and two configurations (mono- /MD filtering or bi-directional/BD filtering) were tested with 100 simulated interference EMG signals, each 9s long, obtained by applying Shwedyk filter to white noise and modulated by a rectangular gate function resulting into 3s burst signals. The performance of the 160 filters was evaluated through: rise time, time delay, computation time and average of root mean square error (RMSE) over 100 signals between the true calculated average rectified value (ARV) of the input and the ARV of each output signal in percentage to the ARV of the input. Selected filters were applied to sEMG signal recorded from *biceps brachii* during maximum voluntary contraction.
RESULTS: A boundary performance was found for MD and BD filters in the RMSE and rise-time space (Figure 1A, 1B). Filters near the boundary line can be classified into filters that yield low RMSE but long rise-time, short rise-time but high RMSE, and filters with performance in between. Application of these filters to the same rectified monopolar sEMG signals from *biceps brachii* yields different envelopes as shown in Figure 1C.
CONCLUSION: Selection of the filter has a distinctive trade-off for specific application. The globally best filters are those with zero delay and closest to the ideal filter, i.e. zero RMSE and zero rise time. Based on the results, the globally best MD filter is 1st order Inverse Chebyshev LPF with 3 Hz cut off frequency while the best BD filter is 1st order Elliptic LPF with 1 Hz cut off frequency.

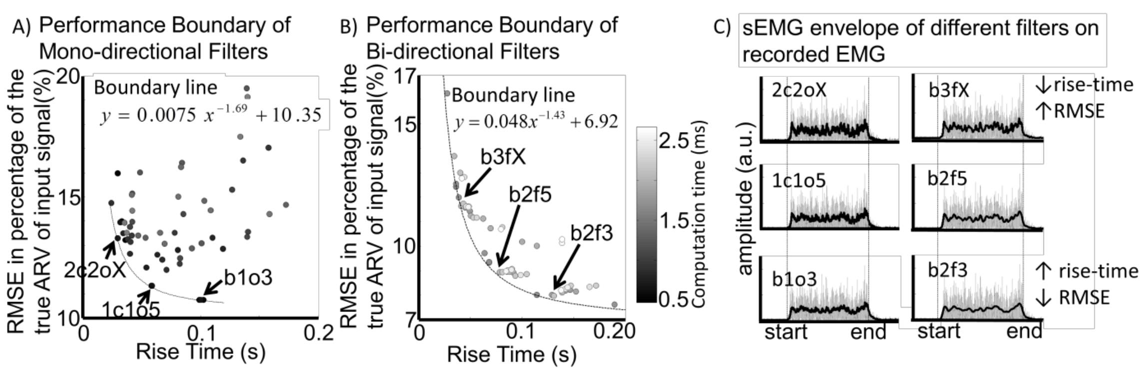

Figure 1: A) and B) Performance boundaries limiting the shortest rise time and lowest RMSE that can be achieved by MD and BD low pass filters. C) performance of filters applied to sEMG of biceps brachii. MD and BD filter indicated by letter 'o' and 'f' respectively. The last letter indicates the cut off frequency ('X'=10). Third letter from the end indicates the order of the filter in one direction. The fourth and fifth letter from the end indicate the type of filter.

SUPPRESSION OF PATHOLOGICAL OSCILLATORY NEURAL ACTIVITY IN A MODEL OF DEEP BRAIN STIMULATION IN PARKINSON'S DISEASE: COMPARISON OF THEORETICAL AND EXPERIMENTAL DATA

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AIM: This study explores the generation, and suppression through high frequency stimulation, of pathological neural oscillatory activity associated with Parkinson's disease in a theoretical model. The relationship between oscillation amplitude and the amplitude of the applied stimulation is examined theoretically and then compared with experimental data recorded in patients. The suppression of beta frequency (13-30Hz) local field potential oscillations with the application of DBS has been shown to occur in parallel with an improvement in motor symptoms of the disease, particularly bradykinesia and rigidity, although the exact mode of action through which this occurs is not clearly understood.
METHODS: A model comprised of two interconnected nuclei was used to represent pathological synchronous oscillatory activity within the cortico-basal ganglia network in Parkinson's disease. Each nucleus is comprised of a nonlinear sigmoidal element in series with a second order transfer function. High frequency stimulation was applied additively at the input to one nucleus. The relationship between stimulation amplitude and the amplitude of oscillatory activity in the model was established using methods from nonlinear control theory. The model was tuned and the theoretical results compared to data recorded via implanted stimulation electrodes from the STN of three Parkinsonian patients at the University of Oxford. The local field potential was recorded as the amplitude of applied stimulation was increased.
RESULTS: The theoretical model of pathological beta band neural activity predicts a reduction in oscillation amplitude as the amplitude of the applied stimulation is increased. This result is in agreement with that observed in the recorded patient data. The fit of the theoretical curve for each individual patient data set is illustrated in Fig. 1.
CONCLUSION: The simplified model used in this study to examine the relationship between oscillatory neural activity associated with Parkinson's disease and its suppression by DBS can be optimized to fit clinically recorded data on a patient by patient basis. This offers the future possibility to use the model as a clinical tool to identify optimal stimulation settings to achieve suppression of pathological oscillations whilst satisfying criteria such as minimization of energy or suppression of side effects.

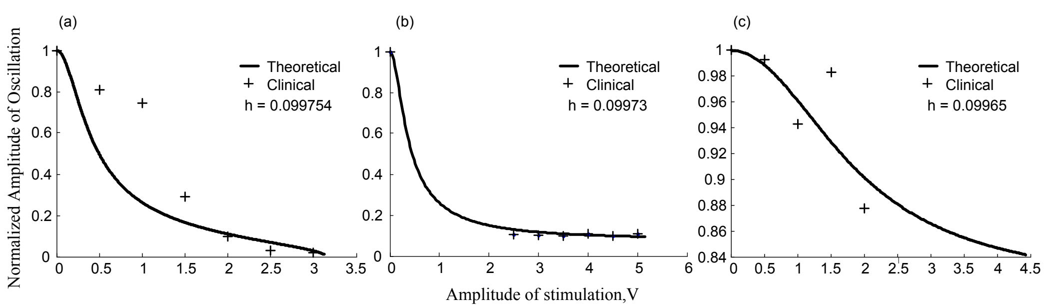

Figure 1: Amplitude of oscillations (normalized) as a function of the amplitude of applied stimulation for theoretical fourth order model of synchronous neural activity. The model has been fitted to STN local field potential data recorded in three individual patients, (a)-(c).

INTER-ELECTRODE DISTANCE AND THE REPRESENTATION OF SOLEUS AND GASTROCNEMIUS MOTOR UNITS IN THE SURFACE EMG

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AIM: To evaluate whether greater inter-electrode distances may lead to more representative action potentials from gastrocnemius motor units with negligible cross-talk from soleus.

METHODS: Monopolar surface EMGs were detected with an array of 32 electrodes (5 mm inter-electrode distance) positioned along the longitudinal axis of the medial gastrocnemius. Signals were collected while 10 healthy subjects stood at ease. EMGs were triggered (20 ms epochs) with the firing instants of motor units decomposed from intramuscular EMGs recorded with two pairs of wire electrodes, inserted one into the medial gastrocnemius and one into the soleus muscle. The triggered EMGs were then averaged. Differential EMGs were computed from the averaged signals for different inter-electrode distances, from the smallest distance (i.e., 5 mm) to the distance defined between the most proximal electrode and the electrode located just proximal to the distal extremity of the superficial aponeurosis.

RESULTS: Although we collected data from 10 subjects, results are shown for a single, representative participant (Figure). Action potentials were clearly represented in surface EMGs triggered with the firing pattern of gastrocnemius motor units, regardless of the inter-electrode distance tested. Larger gastrocnemius potentials were however obtained for greater inter-electrode distances. For the soleus motor units, action potentials in the surface EMGs appeared clearly only for inter-electrode distances greater than 7 cm. For smaller inter-electrode distances, the RMS amplitude of surface EMGs triggered for soleus motor units was less than 10% of that of surface EMGs triggered for gastrocnemius motor units.

CONCLUSION: Increasing the inter-electrode distance by certain amounts seems to provide representative EMGs from the gastrocnemius muscle with negligible, soleus cross-talk.

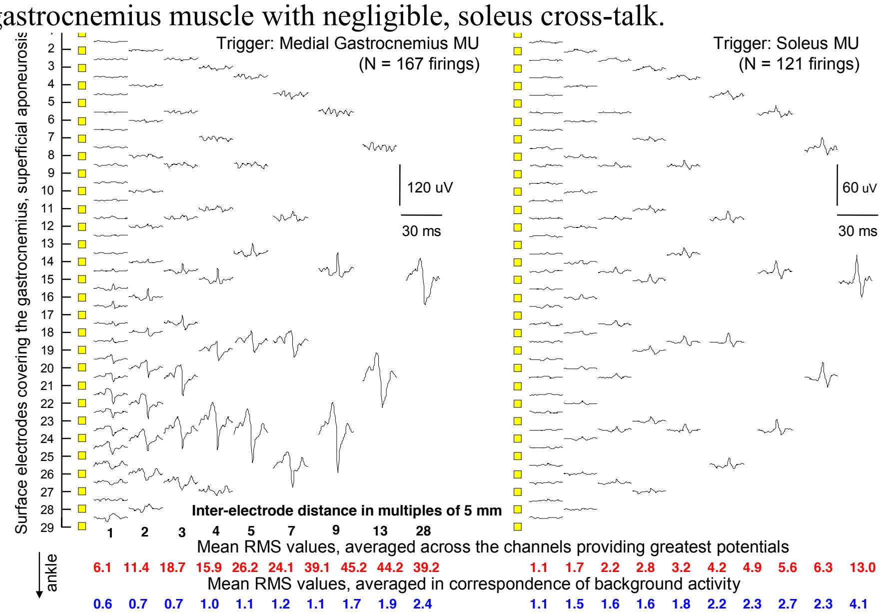

Figure 1: Surface EMGs recorded from gastrocnemius muscle and triggered and averaged with the firing instants of two motor units, one from gastrocnemius and one from soleus muscle.

Multichannel EMG 2 (Sala 4LM 12.00-13.00)

TASK VARIATION CANNOT PREVENT SIGNS OF MUSCLE FATIGUE BASED ON MULTICHANNEL EMG

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AIM: Previous research has studied task variation in very short duration tasks not as such comparable with practice. The purpose of this study was to establish the effect of task variation on both objective and subjective recordings of shoulder fatigue during repetitive assembly work.
METHODS: 14 healthy right-handed subjects (7F & 7M) performed a one-hour assembly task during three conditions: a continuous condition (BC) and two conditions with a one-minute rest break (IC) or a dynamic task (DC) every 12th minute. We measured muscle activation in the M. Trapezius and M. Deltoid with multichannel surface electromyography (EMG), 3D posture and movement of the right upper extremity, local subjective shoulder exertion with the CR-10 Borg scale and absolute force (right shoulder in 90° ante flexion) with a 6-DOF force transducer.
RESULTS: In all three conditions, fatigue occurred based on subjective rating and on the EMG amplitude (ARV) and median frequency (MdPF) of the M. Trapezius Transversus. Distance travelled by the acromion and elbow increased within each condition. We observed no fatigue in postural parameters and absolute force. The one-minute task variation only significantly affected the ARV of the M. Trapezius Transversus: the ARV increased less in the IC than in the BC. We also looked at the variability of the EMG and posture parameters: ARV increased, but MdPF and posture parameters did not change systematically. Task variation had no effect on variability.
CONCLUSION: Muscle fatigue was not directly affected by task variation, which might be partly due to the increased ARV variability and the increased distance travelled by the acromion and elbow during each condition. However, it could also be that the introduced task variation, although likely to be translated into practice, was too short to find effects on the outcome parameters. In the current set-up, especially EMG might not have been sensitive enough to indicate the apparently small changes in fatigue between conditions at this low-intensity level.

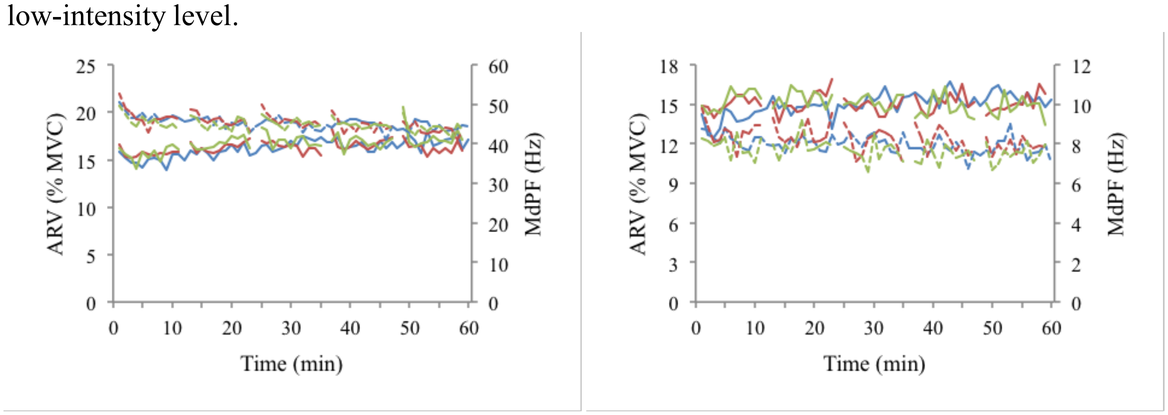

Figure 6: The left figure shows the ARV (solid lines) and MdPF (dotted lines) for each condition (blue is BC, red is IC, green is DC) of the Transversus. The ARV increases and the MdPF decreases within each condition, IC increases less than BC. The right figure shows the variability of ARV and MdPF, only the ARV significantly increases within BC and IC and task variation shows BC to increase more than IC.

ELECTROMYOGRAPHIC ANALYSIS OF HUMAN BACKWARD LOCOMOTION AT DIFFERENT SPEEDS

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AIM: Backward walking is a common tool for lower extremity rehabilitation in clinical settings or recreational sports and is increasingly being used as a rehabilitation technique for individuals with neurological and orthopedic impairments (Ortega & Farley, 2007). However, the speed that should be used during backward locomotion is not known. The purpose of this study was to investigate muscle activity during different speeds of backward locomotion using EMG.
METHODS: Ten people (age 21.5±0.52 years, BMI 24.62±2.53 kg/m^2) volunteered to participate in the study. We recorded their movement using the Vicon analysis system consisting of 9 digital cameras (Vicon 612, Oxford Metrics) to define the stance phase and swing phase. The Biopac mp150 device was used to record the surface EMG. All of the data were synchronized with the Vicon analysis system. All subjects walked backward for three minutes. We recorded the backward walking at different speeds (0.6, 0.8, 1.0, 1.2 and 1.4 m/s). The EMG activities were recorded from the following muscles: rectus femoris, vastus lateralis, vastus medialis, biceps femoris, semitendinosus, gastrocnemius and tibialis anterior. We analyzed the complete gait cycle (100%) for all trials.
RESULTS:
The EMG signals were ensemble averaged from ten people (Figure 7). We found on EMG that the VL and VM were activated more than other muscles were at speeds of 0.6 and 0.8 m/s. The ST and GT muscles were activated at higher speeds.

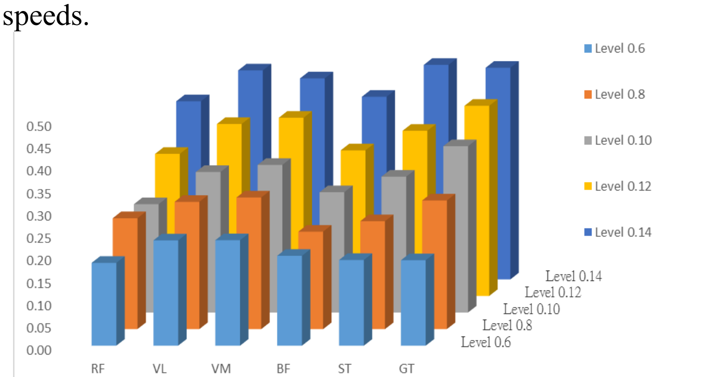

Figure 1: Average EMGs of the 10 subjects at different speeds

CONCLUSION: During the stance phase, the muscle activity sequence was RF, VL, ST, GT, VM and TA. There was muscle co-contraction in the VM, VT and VT. During the swing phase, the muscle activity sequence was VL, GT, TA and ST. We found that all muscle activity was higher at increased treadmill speeds. We conclude that as the treadmill speed increases, lower limb muscles may lose their coordination.

MUSCLE FIBER CONDUCTION VELOCITY IN DIFFERENT GAIT PHASES OF EARLY, INTERMEDIATE AND LATE STAGES OF DIABETIC NEUROPATHY

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E-mail: icnsacco@usp.br

AIM: We aimed at investigate if different diabetic neuropathy degrees have distinct muscle fiber conduction velocity (MFCV) during gait phases for lower limb muscles.

METHODS: Forty-five patients (58.8±5.3 yrs) with diabetes were classified in progressive degrees of diabetic neuropath: absent (n=11), mild (n=14), moderate (n=11), severe (n=9), according to a fuzzy model, and matched with ten healthy controls. These subjects walked at a self-selected pace while GRF, lower limb kinematics and sEMG (4 electrode linear arrays) were recorded. Ankle power was used to divide stance into early (eccentric lowering of the foot) mid (eccentric after foot flattening) and propulsion (concentric) phases; swing phase was determined by means of GRF. MFCV was calculated from EMG signals from tibialis anterior (TA), gastrocnemius medialis (GM), vastus lateralis (VL) and biceps femoris (BF), using a maximum likelihood algorithm with 30ms standard deviation gaussian windows. Groups were compared using ANOVAs followed by Newman-keuls post-hoc test ($p<0.05$).

RESULTS: For all variables observed, there was a trend for decrease in MFCV values as neuropathy progresses (table 1), which is expected since the disease leads to a loss of muscle fiber diameter due to atrophy after deinnervation and reinnervation and muscle quality loss. Unexpectedly, for TA, GM and BF the severe group has higher MFCV than other diabetic groups. The reason because only the most compromised individuals show an increase in MFCV when compared to earlier stages of neuropathy is that two events might be occurring concomitantly: (i) since type I muscle fibers are lost in the course of the disease, type II fibers would remain functional leading to an increase in MFCV independently of the central nervous system´s selective bias; (ii) the progressive shift of preferential recruitment from type I to type II fibers, enabling the generation of faster changes in muscle tension, needed if sensory input is severely impaired. These observations are corroborated by the fact that VL has less type I fibers and did not present the same recovery in MFCV.

CONCLUSION: A general decrease in MFCV with neuropathy progression was observed in all diabetic patients, except for those in the severe group, which means that the recruitment pattern in this particular group shifts to primarily activating phasic muscle fibers.

ACKNOWLEDGEMENT: FAPESP (processes 2011/15770-0 & 2013/06123-7)

Table 1: MFCV values (mean ± standard error)

Variable	Condition	Control (n=10)	Absent (n=11)	Mild (n=14)	Moderate (n=11)	Severe (n=9)	p
MFVC (m/s) **TA**	Early stance	4.71±0.22^{a}	4.95±0.21	4.19±0.19	4.63±0.22	5.03±0.24^{a}	0.035
	Midstance	5.01±0.14	4.96±0.14	4.90±0.12	4.76±0.14	5.29±0.15	0.144
	Propulsion	5.25±0.20^{a}	5.73±0.20^{b}	4.79±0.17^{b,c}	5.18±0.19^{d}	6.02±0.22^{a,c,d}	0.000
	Swing	4.62±0.17	4.54±0.18	4.36±0.15	5.20±0.17*	5.94±0.18*	0.000
MFVC (m/s) **GM**	Early stance	5.46±0.23^{a,b}	4.77±0.23^{c}	3.74±0.20^{a,c,d}	4.13±0.22^{b,e}	5.32±0.26^{d,e}	0.000
	Midstance	8.46±0.31^{a}	7.51±0.31	6.77±0.29^{a}	5.70±0.29*	7.66±0.34	0.000
	Propulsion	6.33±0.19	4.94±0.19	4.90±0.16	4.69±0.18	5.57±0.20	0.000
	Swing	6.04±0.19*	4.46±0.20	4.87±0.17	4.47±0.19	5.16±0.20*	0.000
MFVC (m/s) **VL**	Early stance	6.58±0.29*	4.64±0.27	4.83±0.27	5.13±0.28	4.32±0.30	0.000
	Midstance	5.15±0.19	4.45±0.19	5.02±0.17	4.78±0.19	475±0.19	0.080
	Propulsion	5.91±0.21*	4.92±0.21	5.04±0.19	4.99±0.21	5.21±0.23	0.005
	Swing	5.06±0.16^{a,b}	4.59±0.17^{a,c}	5.33±0.15^{c,d}	5.12±0.16^{e}	4.41±0.17^{b,d,e}	0.000
MFVC (m/s) **BF**	Early stance	6.60±0.32^{a,b}	4.34±0.33^{a,c,d}	4.67±0.31^{b,e}	5.79±0.33^{c}	6.12±0.37^{d,e}	0.000
	Midstance	5.38±0.20*	3.59±0.20*	4.50±0.17	4.82±0.20	4.27±0.22	0.000
	Propulsion	5.65±0.21*	4.42±0.20	4.26±0.18	4.46±0.20	4.72±0.23	0.000
	Swing	6.32±0.24	3.76±0.26	569±0.22^{a}	4.94±0.24	5.12±0.26^{a}	0.000

**represents the significantly different; $^{a, b, c, d, e}$ represent the difference between the groups.*

STRATIFYING SHOULDER PATHOLOGY: A NOVEL APPLICATION OF THE MOVEMENT DEVIATION PROFILE

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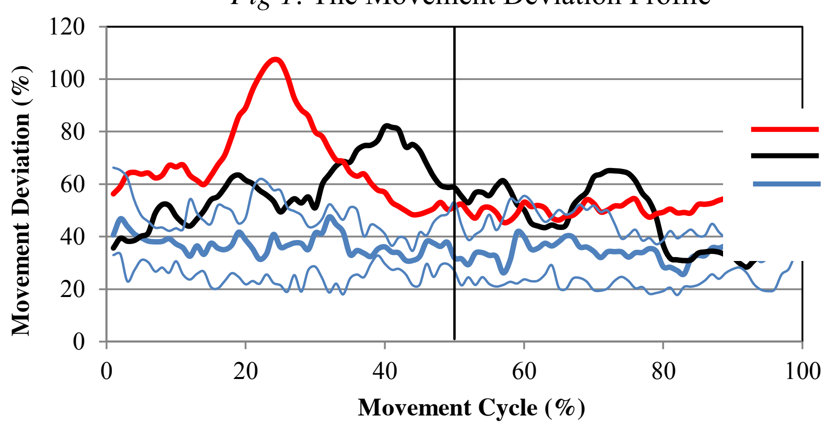
AIM**:** Electromyography (EMG) is a powerful research tool. However, simultaneously conceptualising the multiple time-varying signals generated is a challenge. The Movement Deviation Profile (MDP) uses a self-organising map (a type of neural network) to integrate these signals and describe, in a single curve, the points at which during a movement patients deviate from normality[1]. The study aims to examine the use of the MDP in stratifying shoulder pathology by assessing muscle activation patterns in two distinct patient groups with reference to healthy controls.

METHOD**S:** 13 healthy controls, 5 patients with complex shoulder instability (CSI) and 11 patients with a massive rotator cuff tear (MRCT) were included. EMG was recorded from 8 shoulder girdle muscles as a 1kg mass was lifted repeatedly from a shelf positioned at the participants waist to a second 25 cm above (phase 1) and back (phase 2). The MDP was calculated using a computer program written and published by one of the authors (GB)[1].

RESULTS**:** There was no significant difference in mean MDP between study groups: 52.2% ± 9.5% in the CSI group and 59.8% ± 24.3% in the MRCT group (p=0.387). However, temporal differences in the MDP profiles are seen in *Fig 1*: in the CSI group time at peak MDP was 45.2% movement cycle completion and 26.0% in the MRCT group.

CONCLUSION**:** Clear differences are illustrated with respect to the MDP profiles between the two pathological groups, despite the mean MDP values being similar. The MDP is time sensitive and describes the deviation from normality at all points in a movement cycle and can therefore be used to differentiate between pathological groups. This has clinical implications as patients can be categorised along a disease spectrum which can form the basis for offering targeted treatment.

Fig 1: The Movement Deviation Profile



[1] Barton et al. Movement deviation profile: a measure of distance from normality using a self-organising neural network. Hum Mov Sci 2012; 31(2):284-94.

BIOMECHANICAL CORRELATES OF LONG-STANDING ADDUCTION RELATED GROIN PAIN IN PROFESSIONAL AND AMATEUR FOOTBALLERS: A CASE-CONTROL STUDY.

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AIM: Long standing adductor related groin pain (LSARGP) is common, troublesome and recurrent. We aimed to better understand associated biomechanical factors by measuring lumbo-pelvic kinematics and muscle activation patterns in professional athletes compared with controls in order to guide prevention and rehabilitation.
METHODS: 20 professional (10 unilateral pain) and 19 male amateur (9 unilateral pain) footballers were recruited. Surface electromyography (sEMG) and 3D motion capture (CodaMotion) were applied during standing hip flexion (SHF). Analysis focused on gluteus medius (GM) versus adductor longus (AL) muscle activation ratio and kinematics of the hip joint in early, middle and end phase of SHF while standing on a symptomatic leg.
RESULTS: GM vs AL ratio was significantly ($p<0.01$) decreased in amateur but increased ($p=0.02$) in professional symptomatic athletes compared to matched control groups. Kinematic analysis of professionals with LSARGP showed increased abduction compared to control group, while symptomatic amateurs were more internally rotated and flexed compared to control group.
CONCLUSION: Our data suggest that rehabilitation of LSARGP needs to be sport and activity level specific as marked biomechanical differences manifest in both amateur and professional footballers with LSARGP compared to controls and also between injured groups. A secondary finding worthy of note is a tendency to injure different sides, suggesting different injury mechanisms.

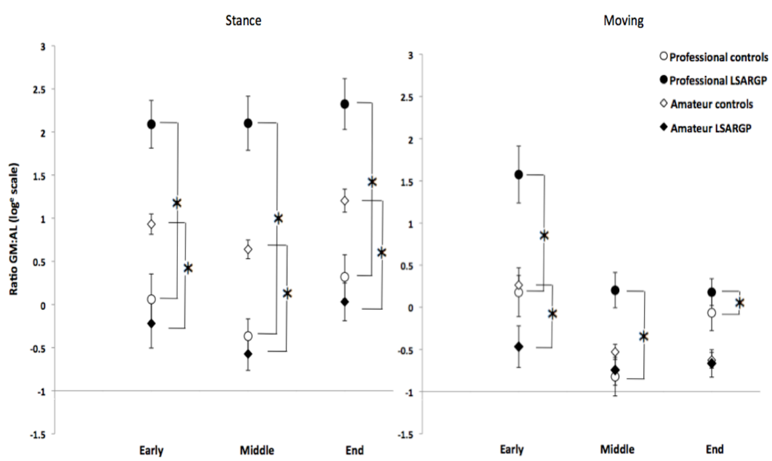

Figure 1: Mean (bars indicate standard deviation) of log GM:AL muscle activation ratio in rugby players with LSARGP and well-matched controls in three phases of the injured leg while moving during standing hip flexion (* indicates $p < 0.05$).

Physiscal rehabilitation & Medicine 2 (Sala Cesarea 15.30-16.30)

EFFECT OF PROPORTIONAL CONTROL ON THE VOLUNTARY USE OF SIMULTANEOUS MYOELECTRIC CONTROL

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AIM: The objective of this study was to compare the simultaneous control of prosthesis degrees of freedom (DOF) when using two myoelectric control systems, differing only in their ability to provide proportional velocity control.
METHODS: Five able-bodied subjects used fine wire EMG to control a cursor in a virtual Fitts Law task. Subjects controlled movement in three DOFs using a “parallel dual-site” myoelectric control system (“direct control”), where subjects could control DOFs simultaneously. Subjects were provided targets that required use of 1-, 2-, or 3-DOFs to complete the task. Fitts Law performance metrics and the use of simultaneous control were evaluated when subjects did and did not have proportional control of the cursor velocity.
RESULTS: For all target complexities, proportional velocity control of the cursor allowed subjects to complete the Fitts Law test with higher throughput and greater path efficiency than when subjects did not have proportional velocity control. With proportional velocity control, subjects chose to simultaneously control the DOFs (Figure 1). Subjects used simultaneous control during 44.5% ± 4.0% of the 2-DOF trial durations and 41.1% ± 5.6% of the 3-DOF trial durations. However, without proportional velocity control, subjects primarily activated DOFs sequentially (Figure 2). Subjects simultaneously activated DOFs during only 10.9% ± 3.8% of 2-DOF trial durations and 8.3% ± 3.5% of 3-DOF trial durations.
CONCLUSION: Though simultaneous control was available to subjects during both experimental conditions, subjects primarily chose to use simultaneous control when they could proportionally control the velocity of the cursor. These results highlight an important consideration for simultaneous control of myoelectric prostheses -- that the potential benefit of simultaneous control on real-time controllability may be affected by other characteristics of the myoelectric control system.

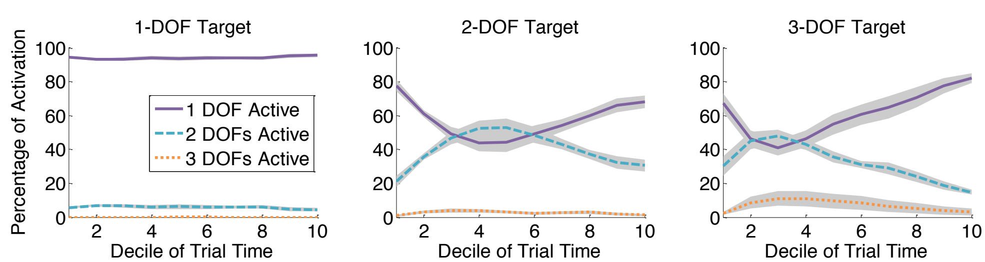

Fig. 1: Use of simultaneous control when proportional control was available. Standard error is shaded.

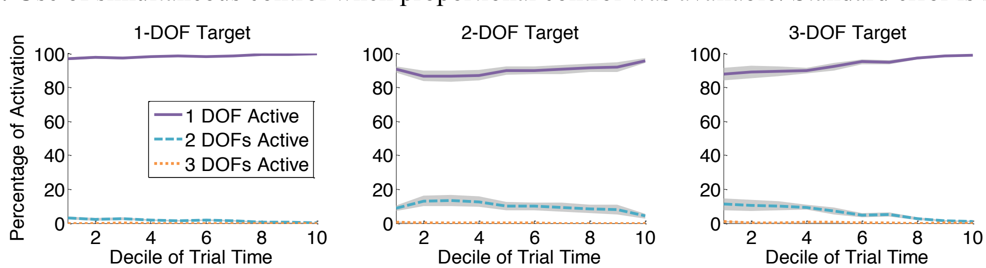

Fig. 2: Use of simultaneous control when proportional control was not available. Standard error is shaded.

AN EFFECTIVENESS OF M-WAVES ELICITED BY ADDITIONAL PULSES IN MUSCLE FATIGUE EVALUATION FOR REPETITIVE TRAINING WITH FES IN MOTOR REHABILITATION

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AIM: Although functional electrical stimulation (FES) can be effective for rehabilitation training, muscle fatigue occurs in early stages during FES control. Muscle fatigue evaluation using M-waves elicited by additional pulses was tested in comparing to the traditional fatigue index in repetitive force and movement productions with surface electrical stimulation.
METHODS: M-waves were measured under the two conditions of repetitive knee extension force production and repetitive knee extension movement with 4 neurologically intact subjects. Electrical stimulation was applied to the vastus lateralis through surface electrodes, and the EMG signals from the muscle were measured. Two types of burst stimulation (15 single-pulse stimulation in a burst and 15 single-pulse stimulation with 1 additional pulse to make a double-pulse stimulation in a burst) were applied alternately in one experimental session. The pulse interval of the double-pulse was varied between 2ms, 3ms and 5ms.
RESULTS: The change in M-wave amplitude elicited by the single pulse in a burst stimulation showed less relevant results against decrease of force production under the isometric condition and increase of burst duration under the knee extension angle control during muscle fatiguing. On the other hand, M-wave amplitudes elicited by the 2nd pulse of a double-pulse decreased with both measurement conditions. Traditional fatigue indexes were calculated from muscle force ($FI_f(n)$) or burst duration ($FI_s(n)$) as the reference of muscle fatigue, where n is the cycle number of the repetitive force or movement productions. Fatigue index calculated from M-wave amplitudes elicited by the 2nd pulses ($FI_{ad}(n)$) showed good estimates of muscle fatigue ($FI_f(n)$ and $FI_s(n)$) during repetitive training (Fig.1), while the M-waves by the single pulse did not it. M-waves elicited by the additional pulses would provide useful information for muscle fatigue evaluation.

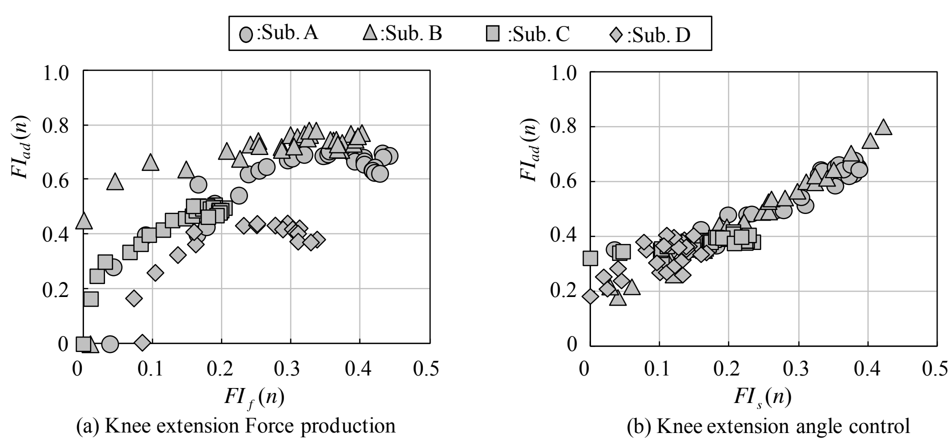

Figure 1: Relationships between the previous types of fatigue index ($FI_f(n)$ and $FI_s(n)$) and fatigue index calculated from M-wave amplitudes of the 2nd pulses of double pulses ($FI_{ad}(n)$).

PATIENT-TAILORED SUPERVISION OF MOVEMENT PERFORMANCE DURING ENDEFFECTOR-BASED, ROBOT-ASSISTED REHABILITATION OF UPPER EXTREMITIES

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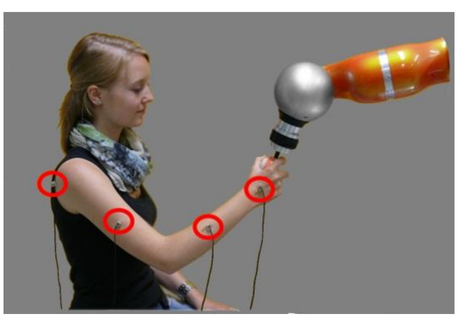
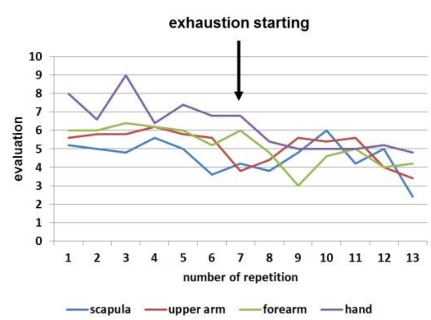
AIM: Millions of people worldwide suffer from stroke each year. One way to assist patients cost-effectively during their rehabilitation process are endeffector-based robot-assisted rehabilitation systems. Such systems allow the patients to use their own movement stragies to perform a movement task which encourages them to do self-motivated training but also allow compensation movements if they have problems executing the movement tasks. Consequently, the movement of the patient has to be supervised during the rehabilitation process to detect potential harmful compensation movements. The aim of this paper is to introduce a device which allows the detection as well as a patient-tailored evaluation of the executed movements.
METHODS: Inertial measurement units (IMU) have been used to detect the performed movements. One IMU is mounted on each segment of upper extremity. By using an unscented Kalman filter the orientation of each arm segment has been estimated out of the recorded data of the IMUs. This allows detection of the patient's arm movements while training with the training robot. The training is divided into two phases: the teaching and the exercise phase. During the teaching phase the physiotherapist guides the patient's arm to perform the desired movement. The robot passively follows the patient's hand recording its endeffector position meanwhile. Simultaneously the IMUs record the movement of the patient's arm segments providing reference data about the movement which shall be trained. During the exercise phase the robot continuously replays the recorded trajectory and thus guides the patient's hand with the same trajectory and velocity profile the physiotherapist did. Additionally, during each exercise the movements of the patient's arm segments are recorded by the IMUs. The IMU data of the teaching and the exercise phase are compared to each other and evaluated by using fuzzy logic which represents the individual movement performance by a number between 0 (bad movement performance) and 10 (perfect movement performance).RESULTS: To demonstrate the feasibility of the approach, five healthy subjects and one subject suffering from a hemiparesis after stroke were asked to repetitively perform a "hand from knee to mouth" movement. Movement performance during each repetition has been evaluated by the introduced device. Figure 1B exemplarily the movement behavior of the patient. Decreasing movement performance can be found after 7 repetition associated with compensation movements





DYNAMICS OF MALE PELVIC FLOOR MUSCLE CONTRACTION OBSERVED WITH TRANSPERINEAL ULTRASOUND IMAGING DIFFER BETWEEN VOLUNTARY AND EVOKED COUGHS

Hodges PW[1]; Stafford RE[1]; Mazzone S[1]; Ashton-Miller JA[2]; Constantinou C[3]

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AIM: Coughing provokes stress urinary incontinence and voluntary coughs are employed clinically to assess pelvic floor dysfunction. Understanding of urethral dynamics during coughing in men is limited and it is unclear if voluntary coughs are an appropriate surrogate for spontaneous coughs. We aimed to investigate the dynamics of urethral motion in continent men during voluntary and evoked coughs.
METHODS: Thirteen men (28-42 years) with no history of urological disorders volunteered to participate. Transperineal ultrasound (US) images were recorded and synchronised with measures of intra-abdominal pressure (IAP), airflow and abdominal/chest wall electromyography during voluntary coughs and coughs evoked by inhalation of nebulised capsaicin. Temporal and spatial aspects of urethral movement induced by contraction of the striated urethral sphincter (SUS), levator ani (LA) and bulbocavernosus (BC) muscles and mechanical aspects of cough generation were investigated.
RESULTS: Results showed coughing involved complex urethral dynamics. Urethral motion implied SUS and BC shortening and LA lengthening during preparatory and expulsion phases. Evoked coughs resulted in greater IAP, greater bladder base descent (LA lengthening), and greater mid-urethral displacement (SUS shortening). The preparatory inspiration cough phase was shorter during evoked coughs as was the latency between onset of mid-urethral displacement and expulsion. Maximum mid-urethral displacement coincided with maximal bladder base descent during voluntary cough, but followed it during evoked cough.
CONCLUSION: The data revealed complex interaction between muscles involved in continence in men. Spatial and temporal differences in urethral dynamics and cough mechanics between cough types suggest voluntary coughing may not adequately assess capacity of the continence mechanism.

ACKNOWLEDGEMENT: Funding was provided by the Australian Research Council.

EXAMINATION OF MOTOR UNIT AND MUSCLE ACTIVATION INDEXES IN STROKE

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AIM: The objective of this study was to assess complex neural and muscular changes in hemiparetic hand muscles post stroke by applying noninvasive and convenient surface electromyography (EMG) measurements.
METHODS: Compound muscle action potential (CMAP) and voluntary surface EMG signals at different contraction levels were measured for paretic and contralateral first dorsal interosseous (FDI), thenar and hypothenar muscles in 12 stroke subjects. A motor unit index technique was then applied to assess motor unit number and size changes, and a muscle activation index (AI) was also calculated.
RESULTS: Analysis of the three hand muscles indicated diverse changes in CMAP, motor unit number index (MUNIX) and motor unit size index (MUSIX) measurements. Overall, the hand CMAP and MUNIX (by combining the three muscles) were significantly reduced in paretic side compared with contralateral side, whereas the hand MUSIX was not significantly different. Consistent findings were observed for the three hand muscles that there was a significant reduction of the muscle AI in the paretic side. Regression analysis did not reveal a correlation between the relative reduction of grip strength and the relative alterations in hand CMAP, MUNIX, MUSIX, and AI measurements.
CONCLUSION: Results supported that examination of motor unit and muscle activation indexes can provide important information that helps reveal the underlying neuromuscular mechanisms of motor impairment in patients with stroke. A major feature of such examination is the primary reliance on surface EMG, which offers practical benefits because it is noninvasive, induces minimal discomfort and can be performed quickly.

Motor Performance & Sport Science 2 (Sala 1LM 15.30-16.30)

ELECTRIC ACTIVITY PROFILE OF QUADRICEPS MUSCLE PORTIONS DURING SQUAT WITH ABDUCTION AND HIP ROTATION

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AIM: The purpose of this study was to determine the profile of the electrical activity of the quadriceps muscle portions during free squats as a function of lateral rotation and hip abduction separately and concurrently.
METHODS: Twenty healthy subjects (10 males and 10 females, 21.7±3.8 yrs) with previous experience in squat and no history of hip or knee surgery participated in this study. Myoelectric signal from rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL) and vastus medialis oblique (VMO) were acquired by means of circular bipolar adhesive electrodes of Ag/AgCl (ϕ=10mm, inter-electrode distance=20mm). EMG signals were passed through a 10-500Hz bandwidth filter, amplified (gain=1000), sampled at 2kHz. Hip and knee range of motions were assessed using two electrogoniometers synchronized with the raw EMG in order to limit hip flexion in 90º and knee flexion in 60º, and to recognize ascending and descending phases of squatting. Three variations of free squatting exercises were performed: (1) feet parallel and neutral hips, (2) feet parallel and hips in 45º abduction, (3) hips in 45º abduction and 45º external rotation, with four repetitions each. The Root Mean Square (RMS) values were calculated for squatting eccentric and concentric phase. Linear envelopes were calculated using a RMS moving average (0.1s, 2% Gaussian window) and peak activation values (mean normalized) were determined for the entire movement cycle. ANOVA for repeated measures was used to compare between exercises for each muscle and between muscles for the same exercise, followed by Tukey HSD post hoc test (α<0.05).
RESULTS: RMS values showed a higher activation for VL muscle for concentric phase during the abduction squatting when compared to the other ones. Table 1 presents peak activations data. For the exercise with the neutral position the RF muscle activated less than the other muscles. During squatting with hips abduction and external rotation the VL muscle showed a higher peak activity, VM muscle activation was greater than RF and VL, and VMO activation was greater than RF.
CONCLUSION: The RF muscle activates more with 90 ° of knee flexion and the fact that our study has played only up to 60 ° of knee flexion could justify the lower activation of RF when compared to the other muscles during the squatting in neutral position. Squat with hips abduction and external rotation puts a greater tension on the adductor muscles by deviation of the points of origin and insertion. VMO fibers are attached to the fibers of the adductor magnus, forming a loop extension of the knee, which would explain the increased activation of the VMO during the squat in abduction and external rotation in a closed kinetic chain.

Table 1: Peak activation (%) for the variations of squat exercise.

Muscle	Exercise 1	Exercise 2	Exercise 3	p (between exercises)
VMO	2.8 ± 0.5	2.7 ± 0.6	2.7 ± 0.6 ^{b}	0.2502
VM	3.0 ± 0.8*	2.6 ± 0.6*	2.9 ± 0.7 $^{c\,d}$	**0.0097**
VL	3.1 ± 1.0	3.2 ± 1.5 ^{c}	2.6 ± 0.9$^{\&\,c}$	**0.0019**
RF	2.4 ± 0.4 ^{a}	2.4 ± 0.4	2.4 ± 0.5 $^{b\,d}$	0.6138
p (between muscles)	**<0.0001**	**<0.0001**	**0.0002**	

** represents difference between exercises; $^{\&}$represents significantly different exercise, ^{a} represents the significantly different; $^{b,\,c,\,d}$ represent the difference between the muscles.*

SURFACE EMG AMPLITUDE IS NOT A RELIABLE MEASURE OF NEURAL ADAPTATION DURING STRENGTH TRAINING. A SIMULATION STUDY

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AIM: The relative contribution of neural factors to strength gain before muscle hypertrophy is often assessed through changes in the relationship between force and surface EMG amplitude (measured by EMG integral or root mean square amplitude, RMS). It has been hypothesised that prior to training, central nervous system is not capable of activating all motor units (MUs) even at maximal voluntary contractions. This opinion is widely accepted in sports physiology, although it contradicts numerous experimental results. Thus, the increased central drive to the muscle is perceived as main contributor to the induced strength gain in the early stages of training regimens. High loads are usually recommended for strength gain (American College of Sports Medicine, 2009) since it is believed that large, fast MUs are recruited only at high forces. The neural adaptation is seen also as increasing MU firing rates, and MU synchronisation. It was suggested that EMG provides the most direct assessment of neural adaptation to training. Thus, the increase in EMG amplitude found after strength training of different regimens is often related to neural adaptations. However, there is also evidence of no change or even decrease in EMG amplitude characteristics following training. Our aim was to test the validity of using the increase in surface EMG amplitude as a measure of neural adaptation during the early gains in strength.

METHODS: EMG signals detected by a surface bipolar electrode with inter-pole distance of 20 mm at different radial distances from the muscle fibres and longitudinal distances from the end-plate area were simulated. The model considered the activation of a muscle with circular area (20 mm diameter) that comprised 125 MUs, grouped in 4 MU types, and muscle fibres with a mean length of 123 mm and an asymmetrical end-plate position. The MU potentials were simulated as a convolution between the sum of the input responses of all the fibres in the MU, and the intracellular action potential (IAP). IAP could change due to altered intracellular Ca^{2+} homeostasis that starts in, and occurs predominantly in fast fatigable (FF) muscle fibres at activation preceding muscle fatigue. Therefore, we evaluated the increases in the RMS of the EMG signal due to this possible IAP change (elevation of the intracellular negative after-potential) in FF muscle fibres, or due to the possible alteration in the neural drive (simulated as a 25%-increase of all MU firing rates).

RESULTS: Lengthening of the IAP profile due to elevation of the negative after-potentials affected the amplitude characteristics of surface EMG detected at any axial distance stronger than alteration in the neural drive. This is irrespective of the fact that the elevation of the IAP negative after-potential was applied to FF MUs only, while changes in frequency of activation (simulating neural drive changes) were applied to all MUs. In the deeper muscles, where the fibre-electrode distance was larger, the peripheral effect was more pronounced. The normalization of EMG amplitude characteristics to an M-wave one resulted only in partial elimination (better for shorter distances) of the influence of the peripheral factor.

CONCLUSION: The increase in the amplitude of surface EMG during the early gains in strength should not be directly related to the changes in the neural drive.

ACKNOWLEDGEMENT: This work was supported by the Bulgarian National Science Fund, grant DMU03/75.

QUADRATUS FEMORIS: AN EMG PROFILE OF WALKING AND RUNNING IN HEALTHY YOUNG ADULTS

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AIM: Quadratus femoris (QF) is considered one of the most important muscles for hip joint stability. Despite the theoretical importance of this muscle, there is currently no electromyography (EMG) research that illustrates the activity of QF during any task, on any population. Examining the activity of QF in walking and running may inform the proposed role of the QF in hip motion and stability. Walking is an important functional task and fundamental part of daily lives for many. Running is an increasingly popular recreational and sporting activity. Both tasks are commonly assessed clinically and for research purposes since variations in gait can indicate the presence of injury or disease. The aim of this research was therefore to illustrate the EMG profile of QF in both of these functional tasks, in healthy young adults.

METHODS: A bi-polar, Teflon coated stainless steel fine-wire electrode was inserted with the aid of a 9cm spinal needle under real-time ultrasound imaging into the belly of QF (stance leg), in ten healthy young adults free of hip and lower limb pathology. The activity of QF was collected while participants walked (comfortable self-selected walking speed) and ran (a comfortable jog that would be paced for a 5km run) along a ten metre pathway. Data were collected from the middle two strides of four walking and four running trials. The EMG signals were filtered and processed to remove artefact and generate a linear envelope. Grand ensemble curves were developed to illustrate the mean (± 95% confidence interval) EMG profile of walking and running across all participants. The EMG profile was amplitude normalized to per cent of maximum isometric voluntary contraction (measured across five actions), and time normalized to per cent of the gait cycle.

RESULTS: One participants' data were affected by artefact; therefore the results of nine participants are presented. There were two to three EMG bursts of QF within the stance phase of walking, with the majority of activity occurring in early stance. There was minimal activity in swing. On the other hand, while running, QF displayed one large burst of activity in stance, and a further burst in swing.

CONCLUSION: This is the first study to present EMG data on QF within any population, during any task. It provides normative data during walking and running, and contributes to the understanding of the role of QF at the hip. These results may be used for future comparisons with pathological or sporting populations.

THE EFFECT OF MOVEMENT VELOCITY ON MUSCULE SYNERGY DURING BENCH PRESS

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AIM: The weight training recommendations about movement velocity may be different depending on the target parameter. Experts advise for slow or high velocity to improve the strength or power output, respectively. Thus, we have investigated the effect of movement velocity on the alteration of muscle synergies between and within individuals during bench press.
METHODS: Thirteen trained male individuals participated in the study. We first set up surface electromyography (EMG) on thirteen muscles which are expected to be involved in the task. After warming up, we identified the 3 repetition maximum (3RM) for each individual. The individuals underwent two randomly ordered exercise protocols, i.e., a low and a high velocity bench press. The low and high protocols consisted of three and two sets performed at 45% 3RM load, respectively. Each set included eight and twelve repetitions of bench press, with each repetition performed over 6 and 1.6 seconds, respectively. The individuals followed the pace of a metronome so that the duration of eccentric and concentric phases of the exercise were kept approximately equal. Integrated EMG over each repetition was obtained and normalized to the corresponding maximum EMG obtained during 3RM procedure. Muscle synergies were extracted from the bench press repetitions using the non-negative matrix factorization algorithm for low and high protocols separately. The similarity and synchrony of extracted synergy vectors and activation coefficients were compared within subject-across protocols and between subjects-within protocol by estimating the cross-correlation function and finding its maximum and the corresponding time lag.
RESULTS: Two synergy vectors and activation coefficients described more than 90% of the dataset variability and represented the eccentric and concentric phases of the movement. The similarity of the activation coefficient representing the concentric phase was higher between subjects-within protocol compared with its similarity within-subject-across protocols. Concomitantly, both activation coefficients displayed higher synchrony between subjects-within protocol compared to their synchrony within subject-across protocols.
CONCLUSION: We concluded that the activation coefficient, especially during the concentric phase, is robust across individuals indicating a robust temporal pattern of muscular activity across individuals at both protocols but the muscle synergy vector seemed to be individually assigned delineating an individual motor strategy performing the task.
ACKNOWLEGMENTS: The authors would like to thank Marianne Gilbak Jensen and Mathias Mark Christensen for their help during data collection.

CORE MUSCLE ACTIVATION AND TRAINING IN SUSPENSION EXERCISES

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AIM: The assessment of abdominal muscles has become popular in recent years because the *core training* is now considered a pivotal approach for a number of fields. Exercises carried out in suspension and unstable condition, with lower or upper limbs hanged with ropes free to oscillate, are now widely used in sport training. Since it is difficult to quantify the training load of such exercises, the aim of this study was to characterize and classify core training exercises executed in suspension modality on the base of muscle activation and perceived exertion.

METHODS: Seventeen active male subjects performed 16 suspension exercises typically associated with core training and three traditional exercises performed in stable condition (crunch, sit-up, back extension). Surface electromyographic signals were recorded from lower (LRA) and upper portion (URA) of rectus abdominis, external oblique (EO), internal oblique (IO), lower (LES) and upper portion (UES) of erector spinae muscles using concentric bipolar electrodes. The average rectified value (ARV) was estimated over a repetition for each muscle and then was normalized with respect to individual maximum voluntary isometric contractions. Normalized ARV of each muscle was classified as: very high (>80%); high (61-80%); moderate (41-60%); low (21-40%); very low (<20%). At the end of each execution subjects were requested to assess the intensity of perceived exertion (OMNI perceived exertion scale).

RESULTS: Each exercise was characterized on the base of both normalized activation of muscles involved and the perceived exertion, as depicted in the representative example reported in figure 1. The normalized values of URA, LRA, IO and EO were overall greater in suspension than in traditional exercises ($p<0.01$). URA showed high normalized ARV in seven exercises while OE in five exercises out of 16. All other muscles and exercises showed moderate or low normalized ARV. Exercises with high muscle activation associated with perceived exertion reported by subjects higher than 7.0 of OMNI scale.

CONCLUSION: This study provides a database allowing to select core training exercises on the base of quantitative data about activation of involved muscles and estimation of perceived exertion. In general rectus abdominis and obliquii muscles were higher activated in suspension exercises than in traditional exercises. Moreover various exercises of suspension training modality allowed activating such muscles at high intensity.

Figure 1: Representative example of one of the 16 studied exercises. The initial (left panel) and final (central panel) positions of an exercise repetition are depicted. On the right panel are reported: the name of the exercise; the perceived exertion intensity (mean±SD, OMNI scale); the normalized ARV (mean±SD) for each muscle.

Movement Disorders 3 (Sala 2LM 15.30-16.30)

ACTIVATION OF SINGLE MOTOR UNITS IN SPASTIC MUSCLES

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AIM: About 15 million people suffer from stroke each year worldwide and approximately 10% subsequently remain with spastic impairments which result from the lesion in the neuronal tissue of the brain. Spastic impaired muscles show an increase in muscle tone. Detailed information about these changes in the activation pattern of spastic muscles can be gained from single motor unit action potentials. The aim of the study is the noninvasive detection of the influence of spasticity on the activation of single motor units.

METHODS: The activation of motor units is measured noninvasively with high-spatial-resolution-electromyography (HSR-EMG). The HSR-EMG is the combination of a multi-electrode array and a two-dimensional spatial filter and enables a noninvasive recording of the activity of single motor units. For the study the activation of single motor units of the abductor pollicis brevis muscle of 5 stroke patients was measured during maximum voluntary contraction. The measured data of stroke patients were compared to the activity of single motor units of patients with a peripheral neuronal disorder in order to get specific characteristics of the activation of single motor units in spastic muscles.

RESULTS: The measured data of the activation of motor units in spastic muscles show significant differences compared to the signals of patients with spinal muscle atrophy. The characteristics of the signals of spastic muscles are isolated action potentials with a high amplitude and rarely background activity. The firing rate of single motor units is extraordinarily constant at a frequency of 8-12Hz. In contrast the signals of muscles with the peripheral neuronal degeneration show a more random distribution of action potentials and maximum amplitude values.

CONCLUSION: Due to the loss of functional motor units the signal of a peripheral neuronal degeneration results in less overall activity of motor units. In a spastic muscle the isolated action potentials and the lack of background activity also lead to the assumption that only a small number of motor units can be activated. The specific characteristic of the activity in spastic muscles is the constant firing rate which cannot be found in the signals of peripheral neuronal disorders.

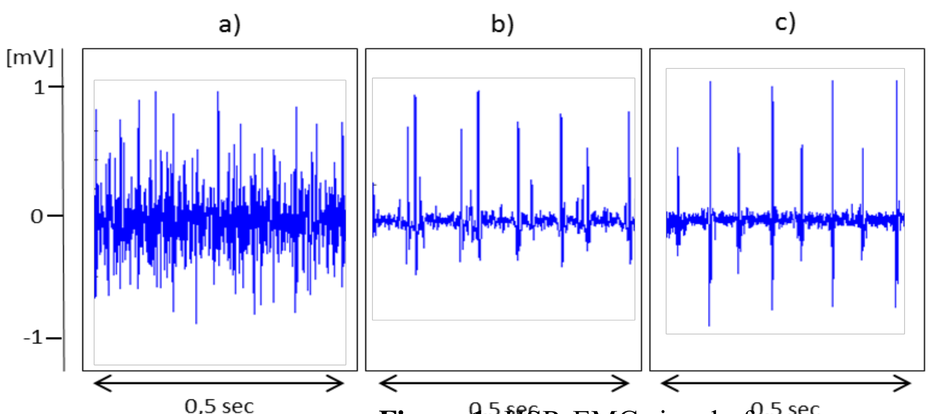

Figure 1: HSR-EMG signal of
a) healthy muscle, b) spinal muscle atrophy, c) spastic muscle

IS IMPROPER INTER-MUSCULAR MECHANICAL COUPLING A KEY DETERMINANT FOR SPASTIC MUSCLE'S ABNORMAL MECHANICS?

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AIM: Recent intra-operative spastic gracilis (GRA) muscle active force (F_{GRA}) vs. knee joint angle (KA) data showed no abnormal muscular mechanics (i.e, no narrow operational joint range of force exertion and no supreme active resistance capacity to stretch at low length), if the muscle was stimulated alone [1]. This, unlike in typical daily activities can limit inter-muscular mechanical interactions, which have been shown in earlier work to affect muscular mechanics substantially [2-3]. We aimed at testing the hypothesis that KA-F_{GRA} curves of spastic GRA muscle activated simultaneously with a knee extensor are representative of joint movement disorder.

METHODS: Experiments were performed during remedial surgery of spastic cerebral palsy (CP) patients (n=6, 10 limbs tested). Condition-I: F_{GRA} were measured in flexed knee positions (KA=120°, and 90°) after activating the GRA, exclusively. Condition-II: KA-F_{GRA} data were measured from KA=120° to full extension (0°) after activating the vastus medialis (VM), simultaneously.

RESULTS: Condition-II vs. I: F_{GRA} changed in all comparisons. Therefore, inter-antagonistic interaction was evident, however added VM activation did not consistently cause a F_{GRA} increase. Condition-II: F_{GRA_peak} equalled mean 47.92N (SD 22.08N). Seven limbs showed availability of high muscle force in flexed knee positions (%$F_{GRA\_peak\ at\ KA=120°}$ equals minimally 84.8). KA-F_{GRA} curves of four of them showed a local minimum followed by increasing F_{GRA} (explained by increasing passive force, indicating that GRA muscle attains lengths unfavourable for active force exertion). For these limbs, substantial active resistance capacity of short GRA muscle and narrow operational joint range of force exertion do indicate abnormality. However, remainder of the limbs showed no such abnormality.

CONCLUSION AND IMPLICATIONS: Our hypothesis is confirmed for most, but not all limbs studied. Therefore, inter-antagonistic mechanical interaction can indeed be a factor for abnormal mechanics of spastic muscle. As such interaction occurs also in healthy people with no joint movement disorder, our findings indicate that an "improper inter-muscular coupling" may be one important aspect of the pathology in spastic paresis. Surgery for restoration of function involves dissections of target muscle's belly prior to the main intervention e.g., a tendon transfer. We have discussed the potential role of the dependency of mechanics of spastic muscle, as well as such surgery on inter-muscular interactions [3]. Our findings support those earlier opinions and suggest that dissections removing or limiting inter-muscular coupling alone may be relevant for the surgical outcome. However, the particular condition tested appears not to be the exclusive source of the effect probed, which indicates the need for further exploration of other inter-muscular mechanical interaction possibilities.

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LOWER LIMB ANTAGONIST MUSCLE CO-ACTIVATION IN ATAXIC GAIT

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INTRODUCTION: An increase in antagonist muscle co-activation, observed in motor impaired individuals, is an attempt of the neuromuscular system to provide mechanical stability by stiffening joints. One of the neurological diseases that impact most on stability is cerebellar ataxia, which is typically characterized by irregular and unstable gait and a high variability of all time-distance parameters. The aim of this study was to investigate the co-activation pattern of the antagonist muscles of the ankle and knee joints during walking in patients with cerebellar ataxia.
METHODS: The gait of a sample of 17 ataxic patients (5 SCA1, 4 SCA2, 8 SAOA) and 17 age-matched healthy adults was analyzed by means of an optoelectronic motion analysis system integrated with a surface electromyograph. The disease severity of ataxic patients was rated with ICARS scale. The gait speed was matched between groups. The following parameters were investigated: variability of time-distance parameters, joint ranges of motions, level of antagonist co-activation of vastus lateralis- biceps femoris (VL-BF) and tibialis anterior/gastrocnemius medialis (TA-GM) muscles. The co-activation indexes of ataxic patients were compared with those of controls and correlated with clinical and gait variables.
RESULTS: In ataxic patients, we found a significant increase in knee and ankle joint muscle co-activation, which was correlated with ICARS scores and due to wider and higher EMG peaks for all the muscles. The increased co-activation index of the knee joint muscles was significantly correlated to the number of falls per year reported by patients.
CONCLUSION: The increased co-activation observed in these cerebellar ataxia patients may be a compensatory strategy serving to reduce gait instability. Indeed, this mechanism allows patients to reduce the occurrence of falls. The need for this strategy, which results in excessive muscle co-contraction, increased metabolic costs and cartilage degeneration processes, could conceivably be overcome through the use of supportive braces specially designed to provide greater joint stability.

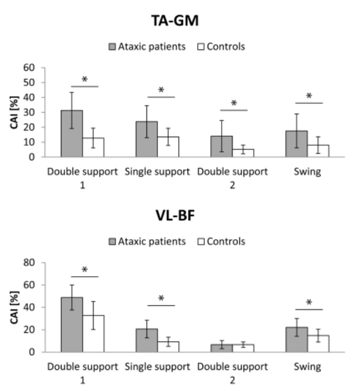

Figure 1: Co-activity index of the ankle and knee antagonist muscles calculated in the four sub-phases of the gait cycle in patients and controls.
* = significant differences.

COORDINATION OF MUSCLE ACTIVITY DURING OVERGROUND WALKING IN CEREBELLAR ATAXIA

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AIM: Several studies support the idea that the central nervous system relies on a modular architecture to control and coordinate muscle activity during human locomotion. Cerebellar ataxia (CA) is known to affect gait resulting in deficits in multi-joint coordination and stability. To better understand the effects of CA on multi-muscle coordination pattern, here we studied idiosyncratic features and impairments in the spatiotemporal structure of leg muscle activity and their relationship to the biomechanics of CA gait.
METHODS: To this end, we acquired the electromyographic (EMG) activity of 12 lower limb muscles and analyzed kinematic and kinetic parameters of 19 ataxic patients during overground walking and compared them with those of healthy controls. Motor modules composed by basic muscle activation patterns and their respective weightings were extracted from the EMG signals by non-negative matrix factorization.
RESULTS: The results showed that the most marked feature of neuromuscular control of gait in CA was widening of EMG bursts and basic activation patterns, leading also to an increased co-contraction of muscles. At matched speeds, patients demonstrated higher inter-stride variability in kinematic curves and significant changes in the stride length, stride width and angular range of motion compared with controls. Gait kinetics revealed also an abnormal transient in the vertical ground reaction force and instability of limb loading at heel strike in CA. The observed widening of basic activation patterns correlated with the severity of pathology (clinical ataxia scale ICARS) and impairments in the biomechanical output.
CONCLUSIONS: The findings highlight the contribution of the cerebellum to shaping/optimizing basic muscle activity patterns in locomotion.

Table 1: Patients' characteristics. Cerebellar patients were rated using the International Cooperative Ataxia Rating Scale (ICARS) (Trouillas et al., 1997).

Group	**Ataxic group (n=19)**	**Healthy group (n=20)**
Sex (male/female)	14/5	13/7
Age (yr. ±SD)	50.4 ±10.7	52.2 ±13.3
ICARS-global ±SD	11.2 ±6.5	

UPPER BODY KINEMATICS IN PATIENTS WITH CEREBELLAR ATAXIA

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AIM: The role of the upper body movement on the ataxic gait is still unknown. Although abnormal oscillations of the trunk has been reported in literature, no quantitative studies have detailed the upper body kinematic behavior in the ataxic patients so far. Studying the upper body movements in ataxic patients could be helpful in planning a specific rehabilitation treatments or in designing new orthotic devices. METHODS: In order to asses the upper body motion, we measured the range of motions (ROMs) of the head and trunk segments on sagittal, frontal and yaw planes in 16 patients with degenerative cerebellar ataxia during gait, at their self selected speed, through an optoelectronic motion analysis system. The data obtained were compared with the those from a gender-, age- and gait speed-matched sample of healthy subjects and correlated with the gait (time-distance means and CVs) and clinical (disease onset, duration and severity) variables. RESULTS: The results showed a significant larger head and/or trunk ROMs in ataxic patients than controls in all three spatial planes, a significant correlation between the trunk ROMs and disease's duration and severity (in sagittal and frontal planes) and time distance parameters (in yaw plane) and between both the head and trunk ROMs and swing phase duration's variability (in sagittal plane). Furthermore, ataxic patients showed a "flexed posture" of both the head and the trunk during walking. CONCLUSION: our study revealed an abnormal behavior of the upper body in ataxic patients manly resulting in a flexed posture and larger oscillations of the head and trunk. The correlation analyses suggest that the longer and more severe the disease the wider the upper body oscillations and that the wide trunk oscillations may explain some aspect of gait variability. Specific rehabilitation treatments or the use of elastic orthoses may be particularly useful in ataxic patients in order to reduce trunk oscillations and improve dynamic stability.

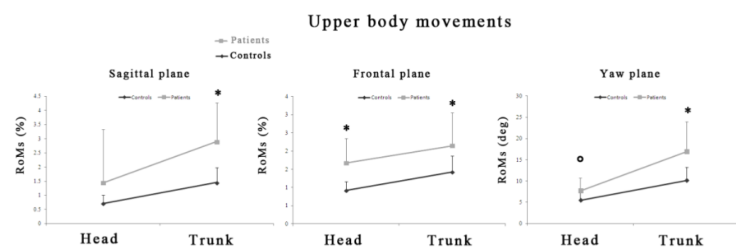

Figure 1: Mean values and standard deviation of the head and trunk ROM values in the sagittal, frontal and yaw planes in both patients (gray squares) and controls (black circles). *Significant difference between groups with p<0.01 and °Significant difference between groups with p<0.05.

Biomechanics 5 (Sala 4LM 15.30-16.30)

BIOMECHANICAL DIFFERENCE BETWEEN OVERGROUND AND TREADMILL WALKING AND RUNNING

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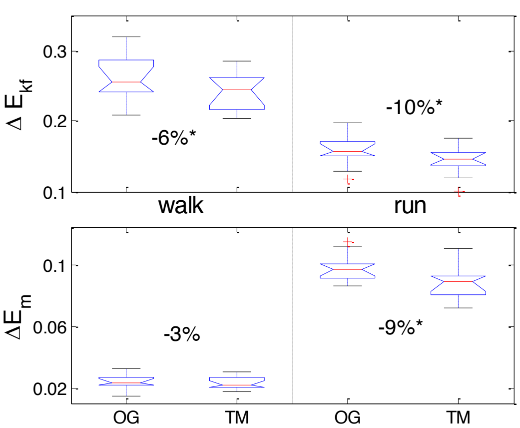
AIM: When walking or running, a decrease followed by an increase of the center of mass (COM) forward velocity can be observed. The aim of this study was to compare the COM energy variation and the muscle activity between OG and TM locomotion.
METHODS: Ten experienced healthy male runners participated in the experiment. They had to walk and run OG at self-selected velocity before walking/running at the same velocity on the TM. We measured full-body kinematics and surface EMG of lower limb muscles. Based on segment kinematics we determined contact time, landing angle and the COM trajectory in sagittal plane, which was used to determine different energy components: potential energy (E_p) kinetic vertical/forward (E_{kv}/E_{kf}) and the sum of these energies (E_m). For each step and energy component we determined the relative energy fluctuation (ΔE) and the mean/max EMG amplitude during each contact/flight phase.
RESULTS: Subjects walked at 1.5±0.1m/s and ran at 3.0±0.3m/s in both conditions. Contact time showed a slight (2.8%) significant reduction for TM walking (p=0.014), but no difference between OG and TM running (p=0.091). The landing angle was significantly more vertical for TM walking (9%) and running (20%, p<0.001). ΔE_p and ΔE_{kv} showed no significant difference between OG and TM (p>0.052), whereas ΔE_{kf} showed a significant reduction for TM walking (6%) and running (10%, p<0.006). ΔE_m and the EMG amplitude showed only a significant reduction for TM running (9%, p<0.001) compared to OG, but not for waling in both conditions (p=0.644).
CONCLUSION: For both, walking and running, a reduction in ΔE_{kf} was observed on the TM compared to OG, which could be related to a more vertical landing angle on the TM. The total mechanical energy variation ΔE_m and the muscle activity were only reduced for TM running, but not for walking. Most reductions where found for muscles responsible for forward braking propulsion. These results imply that TM walking is energetically comparable to OG, whereas the work expenditure was lower for TM running compared to OG running.



ACKNOWLEDGEMENT: Swiss Federal Office of Sport for supporting this project.

Figure 1: Overall differences of ΔEkf and ΔEm between OG and TM locomotion. The middle line of the boxplot represents the median value, error bars the range, lower/higher boxes with notches represent the interquartile range. ΔEkf showed a significant (*) reduction for walking and running, whereas ΔEm showed only a significant reduction for running but not for walking on the TM

EFFECT OF GENDER AND WALKING SPEED ON GAIT VARIABILITY IN HEALTHY YOUNG SUBJECT

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AIM: Repetition in walking may vary from trial to trial: gait parameters are not constant but they rather fluctuate in the course of time and change from one stride to the next, even if environmental and external conditions are fixed. The variability of spatial-temporal parameters represents the consistency of the motion of the lower limbs from stride to stride, while the variability of joint motions may reflect the flexibility of movement patterns and joints. The variability of spatial-temporal parameters and the variability of angular parameters together represent the complexity of gait, which is an index of the stability of gait. The aim of this study was to specify the effect of gait speed and gender on the variability of gait.
METHODS: The investigated group consisted of 20 women (age 21.6 ± 8.7, body mass 66.3 ± 9.7, body height 161.2 ± 13.5) and 13 men (age 23.2 ± 1.6, body mass 79.9 ± 11.3, body height 177.4 ± 9.8). Gait analysis was performed using a zebris CMS-HS (zebris, Medizintechnik GmbH, Germany) ultrasound-based motion analysis system on 1.0 m/s, and 1.2 m/s controlled gait speed. The spatial coordinates of the designated anatomical points were used to calculate spatial-temporal and angular parameters such as step length, walking base, duration of double support phase, duration of support phase, cadence, knee and hip angles, pelvic flexion-extension, obliquity, and rotation. The variability of spatial-temporal parameters was characterized by a coefficient of variance (CV), which is a percentage ratio of standard deviation and mean. The variability of angular parameters was represented by the mean coefficient of variance (MeanCV), which is the average CV over all integer percents.
RESULTS: The CV values of spatial-temporal parameters were the lowest, the Mean CV of angular parameters was the highest at 1.2 m/s in the healthy group, which is the self-selected walking speed of the group. The CV values increased and the Mean CV values decreased (though not significantly) if the walking speed differed from the self-selected walking speed. At female subjects the CV values of spatial parameters were significantly lower, and the Mean CV values of angular parameters were significantly higher than the values of male subjects. The tendency for changes in the variability of spatial-temporal parameters and the variability of angular parameters appear controversial, similarly to the tendency at the change of walking speeds.
CONCLUSION: On the basis of our results it can be established that walking speed the variability of gait parameters and the most comparable limb movement was found when the analysis was done at speeds near the self-selected walking speeds. On the basis of the results it can be established that the capability of responding to different perturbations and adapting to changes in the environment is better at females than at males. This can be caused by the better flexibility of female joints. This means that the values of gait variability should be compared by taking gender into account.
ACKNOWLEDGEMENT: This project is supported by the Hungarian Scientific Fund (K083650).

A METHODOLOGICAL SET-UP TO MEASURE MECHANICAL EXPOSURES IN THE FIELD: POSTURE, MUSCLE ACTIVITY AND FORCE USE

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AIM: Several mechanical exposures at the workplace are known as risk factors for musculoskeletal disorders. Direct measurements in the field are often preferred to quantify these exposures. Postures (e.g. inclinometry) and muscle activity (e.g. electromyography) may be measured by discreet instruments that have been used for decades. The use of force in occupational tasks is more difficult to quantify. Previously it has either been assessed by biomechanical modeling or measured by comprehensive use of equipment. The aim is here to describe the choice of a methodological set-up to quantify posture, muscle activity and force to be used in an ongoing field study of physical demands at work.
METHODS: Duration and frequency of selected activities and postures will be analyzed by triaxial accelerometers (Actigraph GT3X+, Florida, U.S.A.). Heart rate monitoring will be used as proxy for energy expenditure (Actiheart, Camntech, Cambridge, U.K.). Bilateral activity of the upper trapezius' and erector spinae muscles will be assessed to quantify muscle activity patterns and percent of maximal voluntary contraction used during work (Mobi-8, TSMi, The Netherlands). Medilogic®insoles sport (T&T Medilogic Medizintechnik GmbH, Germany) will measure pressure load under the feet. Each sole contains in between 125-255 sensors depending on size, each sensor sampling with 40Hz.
RESULTS: The validity of actigraph, actiheart and electromyographic methods are well described in previous studies. The figure below shows an example of the use of different size insoles as a mean during 20 seconds walking on uneven floor while carrying different weights equally distributed in both hands.
CONCLUSION: This abstract describes the methodological set-up of a study in progress that among other aspects will quantify force exertion by using insole pressure load.

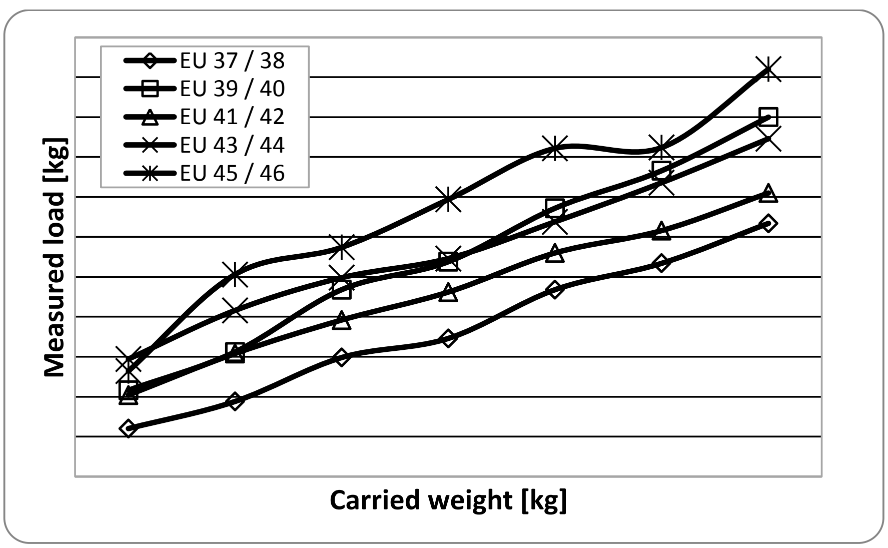

Figure: Insole force measurement related to walking with weights for different insole sizes (N=5). Body weight is subtracted from the measures.

DIFFERENCES BETWEEN BAREFOOT AND SHOD ELECTROMYOGRAPHY (RMS AND MEDIAN FREQUENCY) AFTER RUNNING 10KM

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AIM: Barefoot running has been proposed as the most natural, efficient and safest way to run. Biomechanical differences have been explored between barefoot and shod running. The neuromuscular responses of the lower limb musculature during running in the barefoot and shod conditions have not been fully explored and may reveal certain subtleties in control and adaptation. A further aim was to describe the response between conditions as a result of fatigue.

METHODS: Twenty-eight recreational runners with a 10km race time <50 minutes, first performed a 10km familiarization time trial on a treadmill. During the second visit participants ran down a 40m runway and over a floor embedded force plate at 4.3min/km. This was performed seven times in both the shod and barefoot condition. These were conducted prior to and post a run at the10km pace achieved from the familiarization for 10km. EMG activity was recorded using a telemetric EMG system. The following lower limb muscles were recorded: Vastus lateralis (VL), Rectuc Femoris (RF), Biceps femoris (BF), Tibialis anterior (TB) and lateral gastrocnemius (LG). The raw EMG signal was filtered using a 50Hz notch filter. The signal was then filtered a second time using a 15-500 Hz band pass filter. The data were smoothed using route mean squared analysis (RMS), calculated as a 50ms-moving window. Thereafter, data were segmented into pre-activation, defined as 100ms prior to initial ground contact, and ground contact, defined between initial ground contact and toe off as determined by a force plate. Fast Fourier Transform was applied to obtain median frequency for analysis of fatigue.
RESULTS: Fatigue related frequency changes were found in an increase in median frequency in the LG and a decrease in RF. Condition differences related to RMS were found with higher activity in VLO and lower LG activity when shod during stance. During pre-activation TA was higher and in LG and PL activity was lower when shod.
CONCLUSION: It appears that that condition differences were mostly found in the shank musculature during pre-activation with the anterior muscle (TA) exhibiting greater activity in the shod than barefoot condition, indicating the increased dorsiflexion prior to ground contact when wearing shoes. The effect of shoes also was illustrated in the decreased muscle activity in the posterior and lateral stabilizers. During stance LG was found to be less active and VLO was found to be more active in the shod when compared to the barefoot condition. This may be indicative of the muscular work differences with the interaction of shoe cushioning and the change in joint biomechanics. With regards to fatigue, a decrease median frequency was found in RF illustrating the fatigability of the bi-articulate work performed by RF. Interestingly, an increase median frequency was found in LG, this might be a result of a change in running biomechanics and subsequent change in muscle fibre type.

Poster Sessions

Poster Session 4 (Poster Area 11.00)

Poster Session 4 (Poster Area 11.00)

MEASUREMENT OF 5×5 MECHANOMYOGRAPHIC SIGNALS AND 64-CHANNEL ELECTROMYOGRAPHIC SIGNALS

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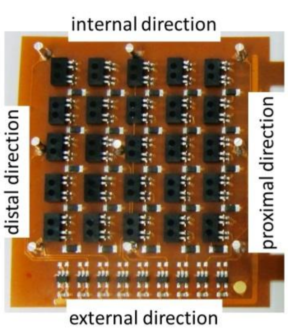
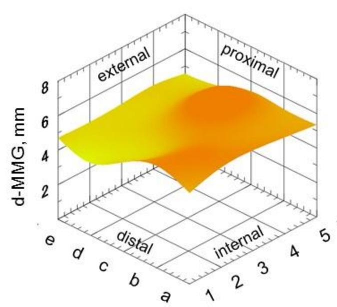
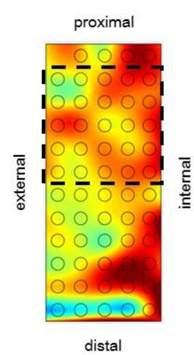
AIM: We previously proposed a 5×5 multichannel displacement-mechanomyogram (d-MMG) array transducer (Figure a). It is possible to measure d-MMG signals at 25 measuring points on the skin surface and to draw d-MMG map in the range of 40 mm × 40 mm. In this study, we drew a d-MMG map and a 64-channel EMG map of the rectus femoris (RF) muscle during voluntary isometric contraction.
METHODS: The RF muscle of subject's right (dominant) leg during isometric contraction was examined and his knee joint was fixed at 65° of flexion angle. The muscle contraction force was slightly strong. First the d-MMG was measured on the surface of RF using the 5×5 d-MMG transducer whose measuring points were located every 10 mm two-dimensionally. Subsequently the 64-channel EMG was measured on the same surface of RF. The EMG electrodes were located every 8 mm two-dimensionally (EMG-USB1 64, OT Bioelettronica, Italy). The experiment was performed with approval of the ethic committee of Okayama University.
RESULTS: Figure b shows the 5×5 d-MMG mapping on the subject's RF muscle at the slightly strong contraction. The vertical axis indicates the displacement [mm] from the skin surface. The bigger deformation points (brown) were close to the internal and proximal side. Figure c shows the two-dimensional color map of 64-channel EMG and the blue points were identified with an innervation zone. The square domain surrounded in a dashed line on the color map shows a measurement domain of d-MMG. The points of bigger EMG (red) were found in the internal and proximal side and were similar to those of d-MMG.
CONCLUSION: The 5×5 multichannel d-MMG array transducer was applied to the measurement of d-MMG during isometric contraction, and it succeeded in drawing the d-MMG map in the range of 40 mm × 40 mm. The multichannel EMG map was also drawn in the same domain. A future investigation is being considered for the two-dimensional propagation of d-MMG signal with surface EMG signals and ultrasonic echo imaging.







ACKNOWLEDGEMENT: This research was partially supported by a Gant-in-aids for Scientific Research (22300157, 25350529) from Japan Society for the Promotion of Science (JSPS).

FORCE DEPRESSION, EMG AND PENNATION ANGLE OF KNEE EXTENSORS

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AIM: This study investigated force depression (FD) after isokinetic (ISK) and isotonic (IST) exertion by means of measuring the maximal torque and EMG signal of knee extensors.
METHODS: 23 subjects (24±2.4) and 22 (22±2.3) years old participated on protocol #1 (P1) and #2 (P2), respectively. In both protocols subjects performed reference isometric (REF) and isometric tests preceded by one concentric exercise. Isometric test of P1 was maximal and the concentric ones were maximal and submaximal, performed in a BIODEX machine. P2 comprised 100% and a 60% of the 1RM, and same testes were preceded by isotonic exertions at the same respective levels, performed in an extensor chair. During P1, the EMGs of vastus lateralis (VL), rectus femoris (RF) and vastus medialis (VM) were registered. During P2, the EMG of VL was registered and the pennation angle (PA) of isometric tests measured. REF tests were performed with the knee at 120^o and the concentric tests started at 80^o ant ended at 120^o, being all testes monitored by an eletrogoniometer. The order of all tests was counterbalanced. The RMS-EMG and the MF of the isometric tests were compared within P1, and within P2 protocols. The PA of REF tests were compared to isometric tests after concentric exertion.
RESULTS: Significantly lower (p=0.007) torque was found after ISK exertion, but no difference was found after submaximal on P1. The RMS-EMG after submaximal exertion was higher and FM lower after ISK (figure 1). For P2, The RMS-EMG of VL was higher after maximal concentric (p=0.008) action, which also showed increasing in PA (p=0.013), and submaximal (p=0.008). The MF was lower only after maximal exertion (p=0.012).

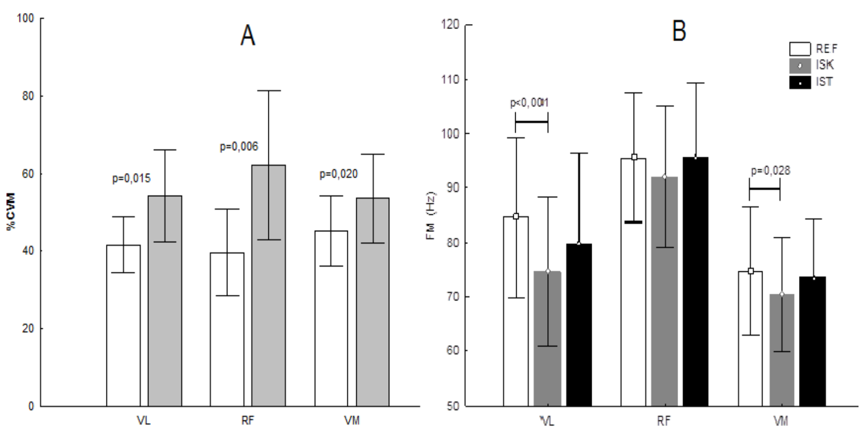

Figure 1 – RMS-EMG expressed as percentage of maximal (A) during REF and ISK, and MF (B) of the isometric tests performed after isokinetic (ISK) and isotonic (IST). All results are related to P1.

CONCLUSION: FD after maximal concentric exertion was observed in the knee extensors due to the torque decrease. The increase in EMG activity may be accounted to the FD. The increase in PA after a very short concentric contraction (less the 5s) is surprising, and might be due to FD. AS FD is not a fatigue related phenomenon the decreased in MF is not well explainable, but the increase in PA may in part explain the change of such a variable, since it changes the orientation of the electrodes in relation to the fibers. As already shown for small muscles, EMG appears to be promisor to evaluating FD in higher volume muscles.

CHANGES IN EMG AND PENNATION ANGLE OF VASTUS LATERALLIS AS A RESULT OF FORCE ENHANCEMENT

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AIM: The present study investigated the EMG signal of the vastus lateralis (VL) pennation angle (PA) during isometric contractions after isotonic eccentric exertions, and compared the results to reference (REF) isometric contractions, trying to establish a relationship between the results and the presence of force enhancement (FE).
METHODS: 10 males (26±3.5) and 9 females (24±2.8) years old participated as voluntary in this study. The protocol of test consisted by first obtaining the 1RM load. Further, 5s of isometric reference tests at 1RM and 60% of 1RM, as well as 5s of isometric tests at these same loads, exerted just after eccentric movements at the respective loads were performed. All tests were accomplished in an extensor chair, and the isometric tests were achieved with the knee at 90^{o}, whereas the eccentric ones started with the knee at 130^{o}. All testes were monitored by an electrogoniometer and the order of tests was counterbalanced. The PA and the EMG of VL were registered, and only the 5s of the isometric tests were processed for further analysis. The statistical test was applied to the RMS-EMG (t test), and to the median frequency (MF) and PA (repeated measures ANOVA).
RESULTS: Significantly lower RMS-EMG value was found after maximal and submaximal exertion than during the REF (figure 1). No significance difference was found on MF ($p=0.73$) and PA ($p=0.82$) when comparing REF tests maximal or submaximal to the post eccentric maximal or submaximal.

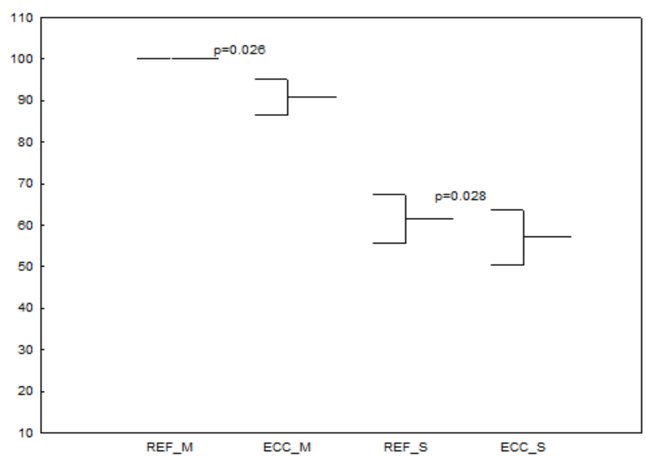

Figure 1 – RMS-EMG expressed as percentage of the value obtained during maximal reference test (REF_M). ECC_M) Post eccentric maximal; REF_S) Reference submaximal; ECC_S) Post eccentric submaximal. The p values were obtained by t tests.

CONCLUSION: The lower EMG activity during the isometric test, performed after eccentric contraction than during a pure isometric action at the same knee angle, suggests the presence of FE, similarly to previous report for small muscle. The lack of difference in PA is an important finding since PA has been shown to increase as a result of force depression, an antagonist phenomenon of FE. Further, the maintenance of MF values after eccentric exertion is expected because FE increases the muscle force capacity.

ANKLE-FOOT MECHANICS ON EN POINTE IN BALLET DANCERS WITH POINTE SHOES AND SOFT SHOES

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AIM: Ballet dancers injuries are usually seen recurrently jump landings and extremely plantar flexion on tiptoe. The purpose of this study is to investigate the ankle-foot mechanics during performing enchappé, jumping on maximum dorsi- and plantar- flexion, in ballet dancers wearing different kinds of shoes; ballet soft shoes and pointe shoes.
METHODS: This study enrolled 18 collegiate female ballet dancers, who have been trained in pointe shoes over five years. Their dancing experiences and healthy situation were recorded first. Then, every subject was asked to perform ”echappé” for twelve times; six times with soft shoes and six times with pointe shoes. A six-camera VICON motion analysis system combined with two AMTI force plates were used to collect the 3-dimensional kinematic and kinetic data. We divided the ”echappé” movement into two phases. The first phase is the front 50% of the movement cycle that starts from the 5th position, standing on maximum dorsiflexion, jumping and then landing on the pointe. The second phase is from the pointe position, standing on maximum plantarflexion, transitioning and landing to 5th position, then the next enchappe can be followed. The various kinetic and kinematic variables were compared between two types of shoes using paired t-test in SPSS software with significant level set at 0.05.
RESULTS: The results of this study showed that no matter what kind of shoes, the ground reaction force (GRF) in phase two, transition to 5th position, were significant greater than phase one: landing on pointe. Further comparison between the GRFs in different shoes types, the pointe shoes was significant greater than ballet soft shoes while landing transition to 5th position. For the kinematic results, we calculated the angles of three joints in foot and ankle area: hindfoot-to-lower leg, forefoot-to-hindfoot, and 1st metatarsal-to-forefoot, in three orthogonal planes in space. In the sagittal plane, the largest contribution to the plantar flexion angle was at the hindfoot-lower leg joint. Wearing pointe shoes needed significant more plantar flexion angle than in the soft shoes, especially in the hindfoot-leg joint. In the frontal plane, the angles between two types of shoes has significant different angles on the forefoot-hindfoot segment. Dancing on pointe shoes has much more eversion angles than dancing on soft shoes. Also, in the horizontal plane, the pointe shoes would have more internal rotation angles in hindfoot than the soft shoes, while more external rotation angles in the soft shoes. Furthermore, the 1st metatarsal has a significant abduction angle in soft shoes than in pointe shoes.
CONCLUSION: In this study, the ankle-foot mechanics was revealed in different footwear in ballet dancers, and the information could be a reference in understanding the joint that helps in reducing the risk of ankle and foot injuries in ballet dancers.
ACKNOWLEDGEMENT: This study is supported by the National Science Council of Taiwan (NSC-101-2815-C-039-007-H).

LOWER EXTREMITY COORDINATION AND INJURIES DURING RUNNING

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AIM: The purposes of this study were to determine the pattern and variability of the inter-joint coordination effects on the landing loads of lower extremity during running for providing information about the risk of injury.
METHODS: Kinematic data were collected by an eight-camera motion analysis system (Qualisys motion system) sampling at 200 Hz. Ground reaction forces were collected by two AMTI force plates (1000 Hz). Kinematic and force data were analyzed by using The MotionMonitor analysis software. The subjects of heel-toe running test were forty university students of physical education department. According to the impact force during landing phase, the subjects were selected into two groups: high injury risk group (N=10) and low injury risk group (N=10). The dynamical system approach was used to analyze the pattern and variability of the inter-joint coordination with the mean absolute value of the ensemble relative phase angle curve value (MARP) and the deviation phase (DP). Statistical analysis was performed with SPSS 14.0 for Windows. The significance level was set at α=0.05.
RESULTS: The results were show in Table 1. The high injury risk group produced a significantly smaller MARP of knee flexion/extension - ankle inversion/eversion and DP of hip flexion/extension - knee flexion/extension during breaking phase in comparison to the low injury risk group ($p < 0.05$).
CONCLUSION: We infer that less independence of knee-ankle and lack of flexibility and adaptation of hip-knee during breaking phase of running may increase the lower extremity injury risk.
ACKNOWLEDGEMENT: This research was supported by National Science Committee grants (NSC 101－2410－H－259－080－).

Table 1: The peak ground reaction force and inter-joint coordination parameters.

Group	**High injury risk group**	**Low injury risk group**
Peak vertical ground reaction force (BW) *	2.00 ± 0.33	1.43 ± 0.07
MARP of knee flexion/extension – ankle inversion/eversion *	0.56 ± 0.14	0.75 ± 0.18
MARP of knee flexion/extension – ankle plantarflexion /dorsiflexion	1.10 ± 0.26	1.11 ± 0.18
MARP of hip flexion/extension –knee flexion/extension	0.88 ± 0.06	0.85 ± 0.10
DP of knee flexion/extension – ankle inversion/eversion	0.05 ± 0.02	0.05 ± 0.01
DP of knee flexion/extension – ankle plantarflexion /dorsiflexion	0.06 ± 0.02	0.05 ± 0.01
DP of hip flexion/extension –knee flexion/extension *	0.03 ± 0.00	0.04 ± 0.00

* indicates a significant difference ($p < 0.05$) between high injury risk group and low injury risk group.

EVALUATION OF DIFFERENT TIME PERIODS OF SUBMAXIMAL ISOMETRIC REFERENCE CONTRACTION TO NORMALIZE ELECTROMYOGRAPHY DATA ON MANUAL HANDLING TASKS

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AIM: To compare the fatigue development during submaximal isometric reference contraction time periods, in order to indicate the more adequate test duration to normalize electromyography data of lumbar muscles on manual material handling tasks. METHODS: Thirteen male healthy subjects (age 24.1±3.8 years, weight 78.2±14.7 kg and height 1.8±0.1) were selected from a university student's population. The electrical muscle activity was recorded for the iliocostalis portion of erector spine (IL), rectus abdominis (RA) and lumbar multifidus (MU) muscles bilaterally (Wireless Trigno®, DelSYS®, Boston, USA), with an acquisition frequency of 4000 Hz. Submaximal isometric reference contraction was performed three times with the subject in the standing position, knees slightly flexed, trunk at 45° of flexion, holding a box of 16 kg. The reproducibility of the subject's position was guaranteed by the use of a goniometer. Data were processed in time and frequency domains. In the time domain, the root mean square (RMS) of the EMG signal amplitude was calculated for the total signal and for periods of 5 seconds. Data were analyzed using repeated measures ANOVA, comparing the RMS at 5, 10 and 15 seconds. In the frequency domain, the median frequency was obtained every 10% of the contraction time. A linear regression was performed and slope was used for the identification and quantification of muscle fatigue. Negative values of the slope were considered muscle fatigue index. RESULTS: The amplitude of the EMG signal statistically differs between the different time periods for all muscles ($p<0.01$). The post-hoc analysis showed that 5 seconds RMS was smaller than 10s ($p<0.01$) and 15s ($p<0.01$) for all muscles. For left MU there are also differences between 10 and 15 seconds, being the 10 seconds RMS larger than the 15 seconds RMS. For the right RA the 15 seconds RMS was larger than 10s ($p<0.01$). The regression analysis showed that fatigue occurred for all muscles in the 15 seconds period. The fatigue index values were -0.12 for left IL, -0.13 for right IL, -0.22 for left MU, -0.19 for right MU, -0.11 for left RA, -0.13 for right RA. The fatigue analysis of 5 seconds of duration showed that the index occurred for right IL (slope=-0.001), left MU (slope=-0.08), right MU (slope=-0.04), right RA (slope=-0.03). CONCLUSION: EMG amplitude values differ between the different durations of the submaximal reference contraction and fatigue occurred in all tested muscles in the 15 seconds period. Even in the shorter duration of contraction (5 seconds), the fatigue still developed. The present results may indicate that reference contraction with 15 seconds are not recommended for manual material handling tasks due to fatigue. Also, lighter loads must be tested in order to achieve a submaximal reference contraction that is fatigue free.

COMPARISON OF A MAXIMAL VOLUNTARY ISOMETRIC CONTRACTION AND A SUBMAXIMAL ISOMETRIC CONTRACTION TO NORMALIZE ELECTROMYOGRAPHY DATA DURING MANUAL HANDLING TASKS

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AIM: To compare two types of normalization contraction: a maximal voluntary isometric contraction (MVIC) and a submaximal isometric contraction (SIC) in order to determine which one is more adequate to normalize electromyography data of lumbar muscles during manual handling task (MHT). METHODS: Nine male healthy subjects (23.6±4.2 years, 73.6±13.8 kg, 1.8±0.1 meters) were selected from the university student's population. Muscular activity was recorded for the iliocostalis portion of erector spine (IL), rectus abdominis (RA) and lumbar multifidus (MU) muscles bilaterally (Wireless Trigno®, DelSYS®, Boston, USA), with an acquisition frequency of 4000 Hz. The MVIC for the MU and IL muscles were tested by raising the trunk from prone position with legs constrained. For RA, the subject tried to flex the upper trunk in the sagittal plane, with his chest manually restricted in a semi-seated position. MVIC was recorded for 5 seconds. The SIC was recorded for 15 seconds, with the subject in the standing position, knees slightly flexed, trunk at 45° of flexion, holding a box of 16 kg. Each contraction was repeated 3 times. Then, the subject performed 10 manual handlings of a box (11.3kg). Data were processed by calculating the root mean square (RMS) of the EMG signal. The 90^{th} percentile of the MHT was normalized by the maximal RMS of the 3 trials for MVIC and SIC. Data were analyzed by two-way MANOVA. RESULTS: There were no differences between trials for maximal and submaximal contraction (IL, p=0.575; MU, p=0.079; RA, p=0.282). There was statistically significant difference between MVIC and SIC (left and right IL, p=0.000; left MU, p=0.001 and right MU, p=0.000; left and right RA, p=0.000), being the MVIC greater than SIC for all muscles. The task normalized by MVIC did not exceed MVIC for any muscle. However, muscle activity during MHT was in average 2.2 times greater than the SIC signal. CONCLUSION: Both MVIC and SIC were reproducible between trials. However, the higher amplitude achieved by MVIC resulted in muscle activity during MHT lower than 100% when this reference contraction is used for electromyography normalization. Thus, MVIC seems to be more adequate to normalize electromyography data during MHT.

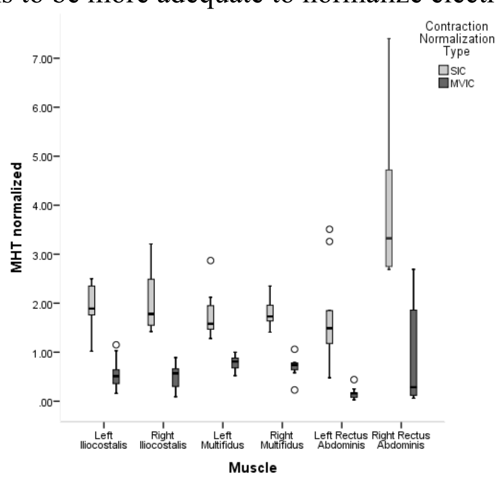

Figure 1 – MHT RMS for each muscle normalized by MIVC and SIC.

STRENGTH-INNERVATION RELATIONSHIP OF LOWER BACK MUSCLES – A GENDER COMPARISON

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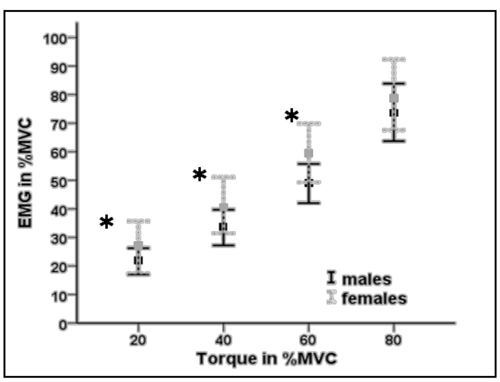
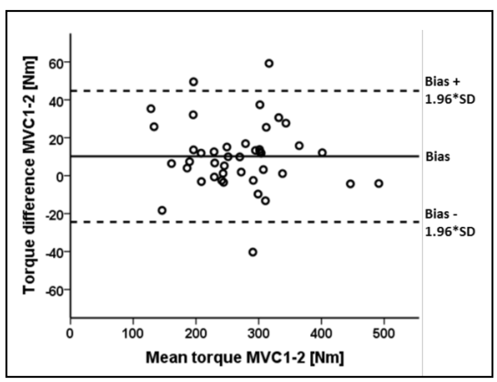
AIM: Measuring peak torque and/or innervation of trunk muscles is common in research and clinical application, e.g. in chronic low back pain. However, a variety of factors, e.g. motivation or pain, can influence maximum voluntary contractions (MVC). Combining a strength-innervation relationship (SIR) with submaximal voluntary contractions (subMVC) may be a relevant alternative. Despite well-known gender differences in strength, a comparison using a SIR protocol requires further confirmation. This study aimed to validate a subMVC protocol comparing healthy males and females for differences in SIR.
METHODS: Forty-two healthy subjects (21 males: 29±3yrs, 78±9kg, 1.82±0.07m; 21 females: 26±3yrs, 60±6kg, 1.67±0.05m) performed isokinetic trunk extension/flexion strength tests (Con-Trex MJ, TP-module, Physiomed AG, Germany). Equipped with a 4-lead bilateral sEMG (myon RFTD-32, myon AG, Suisse) on M. erector spinae (L3, Th9) they had to perform a test sequence (ROM: 45° flex to 10° ext; velocity: 45°/s: concentric) in standing position: 30 repetitions warm-up followed by 5 MVC and each 5 subMVC at 20, 40, 60 and 80% peak torque of MVC with bio feedback (monitor) and another 5 MVC for fatigue control. Peak torque for MVC (Nm, mean of 3 highest) and RMS for each subMVC (mV, mean of 5) were analyzed (mean±SD) and normalized to MVC. An unpaired t-test was used to determine statistical differences (α=0.05) between genders. Test-retest-variability (TRV, %) and Bland-Altman analysis (Bias and 95% Limits of Agreement (Bias±1.96*SD, LoA)) were calculated to compare both MVC trials.
RESULTS: MVC peak torque in males was higher than in females (315±65 to 212±54 Nm, p<.001). Relative EMG of the 4 subMVC trials was 22±5, 33±6, 49±7 and 74±10% in males, and 27±9, 41±10, 60±10 and 80±12% in females, being statistical significant different within subMVC of 20 (p=.034), 40 (p=.004) and 60% (p<.001). Reliability analysis of MVC trials revealed TRV 6.3±6.6%, and 10.2±34.5 Nm and 4±13% absolute and relative LoA.
CONCLUSION: The chosen subMVC protocol validly distinguished differences in SIR of back muscles between genders. Males revealed higher absolute but substantially lower relative innervation values than females. Differences in biometrics, e.g. skinfold or lever arm, and fiber type composition and intermuscular coordination have to be discussed. Basing subMVC loads on MVC makes normalization vulnerable to identification of the real MVC.





CAN HUMAN UTILIZE ELASTIC STRAIN ENERGY DURING SWIMMING?

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INTRODUCTION: The joint flexibility for swimmers is very high. Therefore, it is expected that their muscle and tendon can specifically play important roles during swimming, as shown by the mallard duck swimming (Biewener & Gillis 1999). On land, impact force can be utilized as the storage and release of elastic energy during terrestrial gait. Therefore, specific muscle-tendon interaction have been examined during human running and jumping (e.g. Ishikawa & Komi 2008). In swimming, however, it remains questionable whether elastic strain energy are utilized during swimming. Without impact forces, it is not clear how human can utilize the muscle and tendon elasticity during swimming.
AIM: The present study was to examine the muscle-tendon behavior together with EMG activities of vastus lateralis muscles (VL) during the human dolphin-kick of swimming.
METHODS: In the swimming pool, each subject (n=8) performed the 25 m dolphin-kick swimming. Surface EMGs in the VL and biceps femoris (BF) muscles as well as the knee joint angular data by goniometer were measured. In addition, fascicle lengths of VL were measured using ultrasonography. Instantaneous muscle-tendon unit (MTU) length of VL during swimming were estimated by knee joint angular data. The tendinous length of VL (Ltendon) was calculated by subtracting the horizontal part of fascicle length in the direction to the aponeurosis from the MTU length.
RESULTS: In the dolphin–kick swimming, stretching and shortening amplitudes of the VL L_{MTU} did not show any differences for both NORMAL and FAST conditions. The VL EMG was activated from the late MTU stretching and the early MTU shortening phases. The stretching and shortening amplitudes of VL Ltendon were increased significantly in the FAST condition than the NORMAL condition. Instead, the amplitudes of the VL Lfa was smaller in the FAST condition than the NORMAL condition.
CONCLUSION: During dolphin-kick swimming, the VL fascicles and tendon can perform a stretching-shortening action (Komi 1992). Therefore, the tendon elasticity might play important roles during human movements not only on land but also under water.

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TEST-RETEST RELIABILITY OF REAL-TIME ELASTOGRAPHY USING AN EXTERNAL REFERENCE MATERIAL: PRELIMINARY RESULTS.

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AIM: The aim of this study was to examine test-retest reliability of real-time elastography (RTE) using an external reference material.

METHODS: Six healthy subjects were recruited. Longitudinal RTE ultrasound (MyLab™ ClassC) images of the left and right Achilles tendon area were acquired in a test-retest session. An external reference material (Zerdine®, CIRS, Inc., Norfolk), with known elastic properties (first layer 93 kPa, second layer 10.5 kPa), was placed on the subject's Achilles tendon and included in the b-mode scans (Fig. 1). The reference material was used to normalize color scale among subjects. Different region of interest (ROI), including different human tissue (skin, Achilles tendon, Kager fat pad), were drawn in the images. The range between soft and hard (from red to blue) (Fig. 1A) was divided in 256 steps (0-255), according to the ultrasound image color depth.

The median and interquartile range of colors was computed. Test-retest reliability were calculated for the different tissues using Bland Altman plots mean difference and 95% Confidence Intervals (CI).

RESULTS: Bland Altman plots show a mean difference of 4.58(95%CI: -12.3 to 21.5) for the reference 93kPa, 9.17(95%CI: -12.8 to 31.1) for the skin, -3.75(95%CI: -24.5 to 17) for the tendon and -5.42(95%CI: -42 to 31.1) for the Kager fat pad.

CONCLUSION: Preliminary results shows good reliability of RTE using an external reference material especially on Achilles tendon.

ACKNOWLEDGEMENT: The study was supported by Thim van der Laan Foundation.

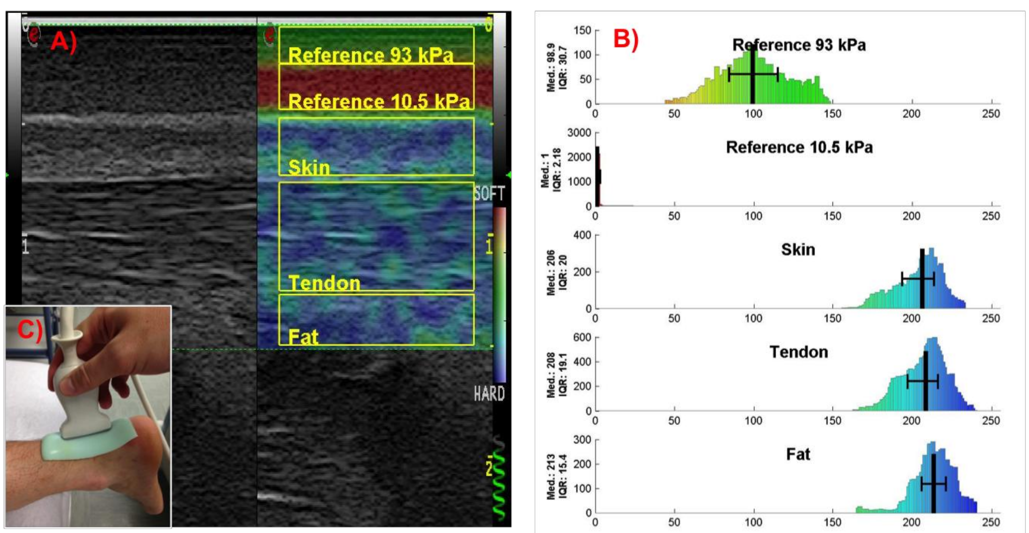

Figure 1: A) Elasto-Dual image, yellow boxes show the different tissues examinated. B) Show the color-histogram for the different tissues. C) Position of the probe during longitudinal scan of the Achilles tendon area.

EFFECTS OF THE MECHANICAL PROPERTIES OF HUMAN KNEE EXTENSOR MUSCLES ON DROP JUMP PERFORMANCE

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AIM: The purpose of the present study was to investigate whether the mechanical properties of human knee extensor muscles influence the type of drop jump performance.

METHODS: Six healthy male subjects performed maximal dynamic eccentric knee extension strengths (60, 120 and 180 $°s^{-1}$) using an isokinetic dynamometer. To examine the capability of eccentric loading resistance, the angle-specific joint torque-angular velocity curves were constructed. Based on their eccentric torque output relative to the isometric torque output, the subjects were categorized into the low eccentric (ECC/ISO < 1, L_{ECC}) and high eccentric (ECC/ISO > 1, H_{ECC}) strength group. Thereafter, they performed maximal-effort bilateral drop jump from a 50 cm-height platform. Motion data obtained from an 8-camera 3D motion capture system and ground reaction force from a force platform were employed to estimate kinematics and kinetics of the drop jump performance. Simultaneously, fascicle length of the vastus lateralis muscle (VL) using ultrasonography and muscle activation of the knee extensor muscles of the right leg using surface electromyography were recorded to evaluate the fascicle behavior and the effectiveness of the stretch-shortening cycle, respectively.

RESULTS: The mechanical characteristics of the knee extensors and drop jump performance for L_{ECC} and H_{ECC} groups were summarized in Table 1.

Table 1: Mechanical characteristics of two types of drop jump performance

Group	**Low_{ECC} (n=3)**		**$High_{ECC}$ (n=3)**	
Phase	**Braking**	**Propulsion**	**Braking**	**Propulsion**
Ground contact time (ms)	0.233 ± 0.058	0.298 ± 0.068	0.192 ± 0.031	0.202 ± 0.025
Jump height (m)	0.305 ± 0.011		0.395 ± 0.007	
Peak knee joint flexion angle (deg)	116.41 ± 14.31	-	96.83 ± 8.06	-
Peak knee joint power (W/BW)	-19.21 ± 1.18	10.68 ± 1.17	-25.19 ± 1.91	16.42 ± 3.63
Fascicle length change (%)	+20.4 ± 3.1	-4.8 ± 2.9	+15.5 ± 4.2	-6.1 ± 3.4
SSC_{EFF}(ratio) = EMG_{ECC}/EMG_{CON}	0.439 ± 0.076		0.852 ± 0.271	
Max. Eccentric torque (Nm/BW)	3.306 ± 0.439		3.002 ± 0.841	
Max. ECC / Max. ISO torque (ratio)	0.933 ± 0.051		1.105 ± 0.044	

CONCLUSION: The H_{ECC} jumpers showed less knee bending strategy and short ground contact time, higher rebound jump height than the L_{ECC}. In addition, the H_{ECC} minimizes the changes in muscle fascicle length and thus creates condition that is advantageous to utilize more elastic energy stored in the tendinous tissue during the stretching phase. Moreover, a high ratio of the eccentric to concentric phases of integrated electromyography data indicated that mechanical efficiency of pure positive work during stretch-shortening cycle exercise. Consequently, the H_{ECC} group jumpers are better to generate higher joint power during the propulsion phase than the L_{ECC} group jumpers. Higher capacity of resisting to eccentric loading may be an important factor to determine the type of drop jump performance.

TEST AND ELECTRODE BEST POSITION FOR SEMG ASSESSMENT OF ANTERIOR SERRATUS

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AIM: The purpose of this study was to evaluate which test and electrode position would provide better surface electromyography (sEMG) signal of anterior serratus muscle during maximal voluntary exertions (MVE). METHODS: Ten female students (24.2±1.8 years old, 60.6±6.7 kg, 166.7±5.8 cm) were evaluated regarding sEMG from their right/dominant anterior serratus using a portable device (Myomonitor IV, DelSys, Boston, USA). Active single differential electrodes were placed vertically along the mid-axillary line at rib levels 6–8 (electrode 1 – E1), and on the side of the body at xiphoid process level (electrode 2 – E2). Three MVE were performed in 4 different test positions (P): seated upright with scapula protracted at 90° of shoulder flexion (P1); dorsal decubitus with scapula protracted at 90° of shoulder flexion (P2); seated upright with shoulder flexed to 125°(P3); and standing facing the wall with scapula protracted at 90° of shoulder flexion and hands against the wall (P4). The signals were acquired at 1000 Hz and conditioned by the main amplifier, which provided a gain of 4000, frequency pass-band 20-450Hz, 16-bit resolution and noise of 1.2 microvolts (RMS). All signals were processed using MatLab. They were corrected for offset; band-pass filtered using a zero-lag 8^{th} order Butterworth filter at 30-450 Hz; RMS converted by means of 200-ms windows, 50% overlapped. The mean RMS amplitude obtained during rest was removed from the signals (noise level) in a power basis. The sEMG peak value obtained from the 3 MVE on each test position was calculated. Raw and normalized (the test position with no difference between E1 and E2 was used to normalize the other three positions) data were analyzed. Once all data attended the normality (Shapiro Wilk's test) and homoscedasticity (Levene's test) assumptions, data from E1 and E2 and the four test positions were compared through paired t-test and ANOVA one-way, respectively. All statistical tests were performed at SPSS software, with a significance level of 0.05 (5%). RESULTS: The sEMG peaks from the anterior serratus are expressed at Table 1. The raw peak of MVE was significantly higher for E1 in P1 (p=0.00), P2 (p=0.00), and P3 (p=0.02). Eight percent of the subjects had higher activation in E1 for P1 and P3, and 100% for P3. No difference between raw data from E1 and E2 was found in P4, therefore its values were used to normalize P1, P2 and P3. Considering the normalized data, none of the positions showed significant difference between E1 and E2. No significant difference was found among test positions for E1 and E2 in both raw and normalized sEMG peak. CONCLUSION: The recording of sEMG from the anterior serratus muscle is better performed when electrode is placed vertically along the mid-axillary line at rib levels 6–8, regardless the test position used to test MVE. Normalization procedure is able to eliminate differences between electrode positions.

Table 1. Mean and standard deviation of raw and normalized sEMG peak of anterior serratus, expressed on microvolts.

	Raw data		Normalized data	
	Electrode 1	Electrode 2	Electrode 1	Electrode 2
Position 1	85.38 ± 26.7	54.48 ± 21.4	1.55 ± 0.4	1.48 ± 0.4
Position 2	95.36 ± 46.0	43.79 ± 29.8	1.82 ± 1.0	1.19 ± 0.6
Position 3	76.42 ± 28.1	54.68 ± 29.9	1.43 ± 0.5	1.41 ± 0.4
Position 4	59.25 ± 26.0	40.30 ± 20.7	1.00	1.00

Electrode 1 = mid-axillary line at rib levels 6–8; Electrode 2 = side of the body at xiphoid process level.

EFFECTS OF SLEEP BRUXISM IN MASTICATORY EFFICIENCY

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AIM: Mastication is one of the most important functions of the stomatognathic system and many factors can influence the masticatory performance, such as the loss of teeth, restorations in posterior teeth, bite force, age, gender, occlusal contacts, motor functional changes, orofacial pain and parafunctional habits such as sleep bruxism. The aim of this study was to analyze the efficiency of the masticatory cycles, using the evaluation of usual and unusual mastication by the full envelope of the EMG signal obtained from the temporal and masseter muscles.

METHODS: 38 individuals of both genders, with an average age of 30.3 ± 5 years, matched individual to individual, divided into two groups, with 19 individuals each: G1. individuals with mild and severe sleep bruxism; G2. control individuals during the usual and unusual mastication. This study was previously approved by the Ethics Committee in Research of the School of Dentistry of Ribeirão Preto, University of São Paulo. All underwent electromyographic (EMG) evaluation in clinical conditions of chewing hard food (peanuts), chewing soft food (raisins) and non-habitual chewing (Parafilm placed on the molars) lasting 20 seconds each collection. Surface electromyography was performed using wireless EMG Delsys Trigno TM. Individuals with sleep bruxism were diagnosed by polysomnography using Polysomnograph Sonolab. The severity of sleep bruxism was evaluated by individual device BiteStrip®. The efficiency of the masticatory cycles between individuals was evaluated by the ensemble average of the electromyographic signal, and this value was obtained in microvolts/second, during the time. The values of ensemble average were normalized by the value of the electromyographic signal of maximum dental clenching, harvested by four seconds. The electromyographic means were tabulated and subjected to statistical analysis using independent *t* test (SPSS 19.0).

RESULTS: The result of the Student *t* test indicated no significant differences (p>0.05) between the normalized values obtained in masticatory cycles in both groups.

CONCLUSION: Based on the results, sleep bruxism did not promote significant alterations in efficiency of the masticatory cycles.

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CHANGES ON THE STOMATOGNATIC SYSTEM IN HYPERTENSIVE SUBJECTS

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AIM: This study aimed to analyze in individuals with hypertension, the electromyographic activity (EMG) in postural conditions of the jaw and masticatory cycles efficiency, of the masseter and temporal muscles.
METHODS: 56 subjects of both genders were selected to participate in this study, divided into two groups, Hipertensive Group, consisting of 28 subjects with a diagnosis of hypertension, and Control Group consists of 28 subjects without systemic abnormalities; being 17 women and 11 men in both groups. Measured to electromyographic activity of the masseter and temporal muscles in mandibular conditions of rest, right lateral and left, protrusion and clenching. We evaluated the masticatory cycle efficiency was measured by the ensemble average during mastication of peanuts, the raisins and the Parafilm M®. The EMG function was analyzed through electromyographic signal (Myosystem – BR3.5 – DataHominis Ltda - Brazil) with differential active electrodes. Surface differential active electrodes were placed on the skin, cleaned with alcohol, on both masseter and temporalis muscles. A ground electrode was fixed on the frontal region. The signals were digitally filtered using a bandpass filter of 10 to 500 Hz.Statistical analysis using SPSS 21.0 and Student's t test for independent samples ($p < 0.05$) was performed.
RESULTS: In the electromyographic activity of the clinical conditions of rest, protrusion, right and left lateral movement, clenching without and with Parafilm M® Hipertensive Group showed higher muscle activation. In mastication of soft food (raisins) or hard (peanuts) also showed that the EMG values of the masticatory cycle efficiency were lower for Hypertensive Group. The clinical condition of unusual mastication with Parafilm, there was a decrease of EMG activity in all muscles analyzed for the Hypertensive Group.
CONCLUSION: It was concluded that the disease hypertension interferes with the activation pattern of the masticatory muscles.
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THE EFFECT OF LUCIA JIG ON NEUROMUSCULAR RE-PROGRAMMING IN INDIVIDUALS WITH TEMPOROMANDIBULAR DYSFUNCTION

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AIM: The Lucia jig is a technique that promotes 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 in normal subjects or in patients with temporomandibular dysfunction (TMD). This research evaluated the electromyographically activity (RMS) of the masseter and temporal muscles in subjects with temporomandibular dysfunction during the use of the anterior programming device, the Lucia jig, in place for 0, 5, 10, 20 and 30 minutes to demonstrate its effect on the stomatognathic system.
METHODS: 42 dentate individuals (aged 21 to 40 years) with normal occlusion and temporomandibular dysfunction (RDC/TMD) were evaluated on the basis of the electromyographic activity of the masseter and temporal muscles, bilaterally, before placement of the neuromuscular re-programming device, the Lucia jig, on the upper central incisors in following time periods: I (without Lucia jig), II(0'), III(5'), IV(10'), V(15'), VI(20') and VII(30'). This study was previously approved by the Ethics Committee in Research of the School of Dentistry of Ribeirão Preto, University of São Paulo. Surface electromyography was performed using the EMG-Br1 Myosystem®. The values were normalized by the value of the electromyographic signal of maximum dental clenching, harvested by four seconds. The electromyographic means were tabulated and subjected to statistical analysis using repeated measures over the entire duration of the experiment (0 to 30 minutes) with the Lucia jig (SPSS 19.0).
RESULTS: There were no statistically significant differences (p<0.05) in the electromyographic activity of the muscles : right masseter [(I =0.06 ± 0.01), (II=0.09 ± 0.02), (III=0.08 ± 0.01), (IV=0.08 ± 0.01), (V=0.08 ± 0.01), (VI=0.09 ± 0.01), (VII=0.09 ± 0.02)]; left masseter [(I =0.09 ± 0.02), (II=0.11 ± 0.02), (III=0.10 ± 0.02), (IV=0.11 ± 0.02), (V=0.10 ± 0.02), (VI=0.10 ± 0.02), (VII=0.12 ± 0.03)]; right temporal [(I =0.16 ± 0.02), (II=0.16 ± 0.02), (III=0.16 ± 0.02), (IV=0.17 ± 0.02), (V=0.18 ± 0.02), (VI=0.19 ± 0.02), (VII=0.19 ± 0.02)] and left temporal [(I =0.12 ± 0.01), (II=0.12 ± 0.02), (III=0.12 ± 0.01), (IV=0.12 ± 0.01), (V=0.13 ± 0.01), (VI=0.13 ± 0.01), (VII=0.14 ± 0.02)].
CONCLUSION: Based on the results obtained, the authors conclude that the Lucia jig changes electromyographic activity and may thus lead to a neuromuscular reprogramming of the jaw.
ACKNOWLEDGEMENT: This study was supported by School of Dentistry of Ribeirão Preto, University of São Paulo.

CHANGES OF MASTIGATORY MUSCLES IN DIABETIC AND HYPERTENSIVE SUBJECTS – ELECTROMYOGRAPHIC ANALYSIS

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AIM: This study aimed to analyze the electromyographic activity of masseter and temporal muscles in subjects with diabetes and hypertension considering the postural conditions and masticatory cycle's efficiency.

METHODS: The study included 50 subjects divided into two groups : (1) without diabetes and / or hypertension - control group (n = 25) , (2) and with diabetes and hypertension - test group (n = 25) , selected by genre and pairing age, both being composed of 6 men and 19 women aged between 33-81 years (mean age 54 years) . The electromyographic activity was analyzed by means the electromyographic signal (Myosystem – BR3.5 – DataHominis Ltda - Brazil) with differential active electrodes. The electromyography recording evaluated the masseter and temporal muscles in mandibular conditions of rest, right lateral and left, protrusion (5 seconds each) and clenching (4 seconds). Masticatory cycle's efficiency was measured by the ensemble average of masseter and temporal muscles during chewing of parafilm M®, raisin and peanut (10 seconds each). Was applied student *t* test for independent samples considering the significance level of 5%.

RESULTS: The electromyographic activity of the clinical conditions of rest, protrusion, right and left lateral movement, clenching without and with Parafilm M® Hipertensive don't showed difference statistically significant between control and test group. Subjects with diabetes and hypertension showed lower means of masticatory cycle's efficiency than control group for the masseter and temporal muscles (Figure 1), with statistically significant difference ($p < 0.05$) in chewing parafilm M® and peanuts .

CONCLUSION: It was concluded that the chronic degenerative diseases, diabetes associated with hypertension, affect the function of masticatory muscles.

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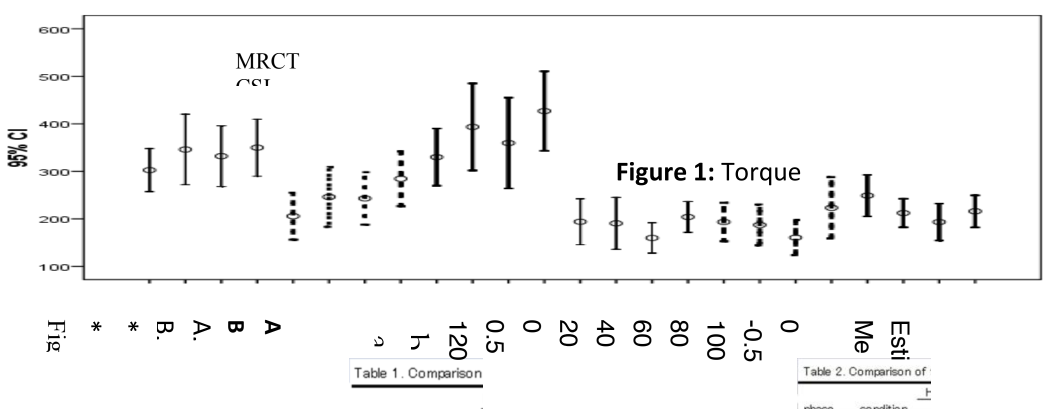

Figure 1: Confidence interval for the masticatory cycles's efficiency (RM – right masseter; LM – left masseter, RT – right temporal, LT – left temporal) during mastication of parafilm, raisins and peanuts, the control group and test group.

IMPACT OF SLEEP BRUXISM IN STOMATOGNATIC SYSTEM

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AIM: The harmonic development of the stomatognathic system has a fundamental role in the quality of human life. Amendments in this complex system cause serious physiological problems, promoting imbalance in the masticatory muscles. Sleep bruxism produces dysfunctional movements of the jaw, resulting from the rhythmic contraction of the masseter muscle, characterized by grinding and clenching of teeth associated with microarousals during sleep. This research evaluated the effects of sleep bruxism on electromyography activity of masseter and temporal muscles.
METHODS: 38 individuals of both genders, with an average age of 30.3 ± 5 years, matched individual to individual, divided into two groups, with 19 individuals each: G1. individuals with mild and severe sleep bruxism; G2. control individuals. This study was previously approved by the Ethics Committee in Research of the School of Dentistry of Ribeirão Preto, University of São Paulo. Assessment of muscle activity was performed by electromyographic recordings of the masseter and temporal muscles, bilaterally, during postural resting condition (4s), the clenching in maximum voluntary contraction (4s), maximum right and left laterality with dental contact (10s) and maximum protrusion with dental contact (10s). Surface electromyography was performed using wireless EMG Delsys Trigno TM. Individuals with sleep bruxism were diagnosed by polysomnography using Polysomnograph Sonolab. The severity of sleep bruxism was evaluated by individual device BiteStrip®. The values were normalized by the value of the electromyographic signal of maximum dental clenching, harvested by four seconds. The electromyographic means were tabulated and subjected to statistical analysis using independent *t* test (SPSS 19.0).
RESULTS: Electromyographic activity was significant (p <0.05) for protrusion: RM=[(I =0.15 ± 0.03), (II=0.33 ± 0.02)]; right laterality: RM=[(I=0.10 ± 0.02),(II=0.18 ± 0.02)]; RT=[(I = 0.18 ± 0.02), (II=0.35 ± 0.04)]; left laterality: RT=[(I=0.12 ± 0.01), (II=0.21 ± 0.03)].
CONCLUSION: Based on the results obtained, the authors conclude that alteration occurred in the pattern of activation of masticatory muscles in individuals with sleep bruxism, where they possessed it less muscle activity when compared to control individuals.
ACKNOWLEDGEMENT: This study was supported by FAPESP (grant n° 2012/10228-6).

THE INFLUENCE OF DIABETES DISEASES IN ELECTROMYOGRAPHIC ACTIVITY OF THE MASTICTORY MUSCLES

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AIM: The objective of this study was to analyze the electromyographic activity of masseter and temporalis muscles, both sides, in subjects with diabetes considering different clinical conditions.
METHODS: Twenty eight subjects (22-69 years) were divided into two groups: Group I (diabetic; n=14) and Group II (control; n=14). The electromyography recording was used to measure the rest, right and left lateral movement, protrusion and clenching conditions of mandibular; the masticatory cycle efficiency was measured by the ensemble average of masseter and temporal muscles during chewing of Parafilm M®, raisin and peanut. The electromyographic activity was analyzed through electromyographic signal (Myosystem – BR3.5 – DataHominis Ltda - Brazil) with differential active electrodes. Surface differential active electrodes were placed on the skin, cleaned with alcohol, on both masseter and temporalis muscles. A ground electrode was fixed on the frontal region. The signals were digitally filtered using a bandpass filter of 10 to 500 Hz. In comparison tests, the Student's t-test was applied for independent samples ($p < 0.05$).
RESULTS: Diabetics had lower muscle activation at rest for the right temporal and masseter muscles than the control group. Regarding protrusion clinical condition, diabetics showed the pattern of electromyographic expected to maintain this posture consisting of greater activation of the masseteric musculature compared with the activity of the temporal muscle. The pattern of right lateral movement was not maintained for diabetics, which showed greater muscle activation to almost every muscle was required when performing this task, when compared to the control group. During the execution of clenching clinical condition, with and without Parafilm M®, lower EMG activity was observed in all muscles for diabetics. Muscle activity during mastication for diabetics remained low activation of muscle fibers when compared with the normal pattern for all chews, unusual with Parafilm M®, or usual, with soft food, such as raisins or hard, as peanuts.
CONCLUSION: It was concluded that diabetes caused alterations in muscle fibers request during the masticatory process, highlighting the need for health professionals to be aware of this change in the stomatognathic system of individuals with this chronic degenerative disease.
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MAINTAIN A PROPER MUSCLE COORDINATION IS CRITICAL TO ACHIEVE MAXIMAL VELOCITY DURING A PEDALING CYCLIC TASK

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AIM: Pedaling is a multi-joint cyclic task requiring the coordination of numerous lower-limb muscles. Although some studies suggest that muscle coordination may represent a potential limiting factor for reaching fast cyclic movement (Neptune and Kautz 2001, Dorel et al 2012), it has never been demonstrated. The aim of the present study was to determine whether the coordination is altered when reaching the fastest possible pedaling movement and to discuss whether these alterations may exhibit some non-optimal characteristics limiting the maximal pedaling rate.
METHODS: 11 elite sprint cyclists (4 females, 21±3 years; 166±3 cm; 63±4 kg and 7 males; 25±5 years; 184±6 cm; 90±5 kg) were asked to perform two maximal cycling exercises (5-s): one at their optimal pedaling rate (V_{opt}: reached at maximal power output, ~120-130 rpm) and one at their maximal pedaling rate (V_{max}: ~210-240 rpm). Mechanical (pedal forces and velocity) and EMG signals for 8 lower limb muscles [(*gluteus maximus*, GMax, *biceps femoris*, BF, *tensor fasciae latae*, TF, *rectus femoris*, RF, *vastus lateralis*, VL, *gastrocnemius medialis*, GM, *soleus*, SOL and *tibialis anterior*, TA)] were continuously recorded. The mean and peak value of EMG RMS and the timing of activity were determined.
RESULTS: Neither RMS_{peak} nor RMS_{cycle} was different between the conditions, except for GMax (higher values during V_{max}, $P<0.05$). The analysis of EMG patterns (Figure 1) showed an earlier onset and/or offset of activity for all the thigh muscles during V_{max} (GMax, BF, TF, RF, VL; $P<0.01$; range: 14 to 48°), whereas no (SOL) or small opposite alterations were observed for lower leg muscles (i.e. later onset for TA, GM; $P<0.05$; range: 12 to 43°).
CONCLUSION: Despite the issue of activation dynamics, we showed an ability to maintain the mean and peak level of activity in V_{max} condition. Moreover the large muscle excitation phase advance of thigh muscles (~30-40° of the crank cycle) during V_{max} seems to be an interesting adjustment of coordination to address the effects of electromechanical delay and ~100 rpm increase. Nevertheless considering that leg muscles transmit the knee and hip extensors power and the energy of the segments to the crank, their opposite changes in timing of activity might be interpreted as a limiting factor for V_{max} (Neptune and Kautz 2001).

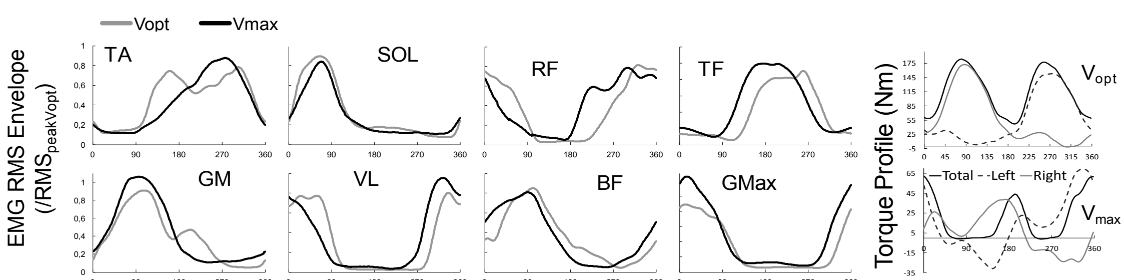

Figure 1: Mean RMS EMG envelopes for 8 lower limb muscles and typical torque profiles during cycling sprints at optimal (V_{opt}) and maximal (V_{max}) pedaling rates

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MASTICATORY MUSCLES COORDINATION INDEX OF HEALTHY CHILDREN AND WITH MALOCCLUSION

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AIMS: To investigate the masticatory muscles coordination of children with anterior dentoalveolar open bite (OB).
METHODS: Fifteen children with dentoalveolar open bite (OB) and no crossbite (7-12 years of age) were evaluated and compared to 15 children without malocclusion (controls, C) (7-11 years). All children were healthy and had Facial Height Ratio (FRH = Jarabak quotient) > 59%.
Surface electromyography (sEMG) of the masseter and temporal muscles were recorded during maximum teeth clenching either on cotton rolls between teeth or in intercuspal position (MVC). From the potentials recorded during the MVC tests, standardized by MVC on cotton rolls, the following standardized EMG indices (all in %) were calculated: POC (left and right side percentage overlapping coefficient that assess muscular symmetry), TORS (potential lateral displacing components due to unbalanced contractile activities of contralateral masseter and temporalis muscles), BAR (barycenter, anterior-posterior displacing component). Three more indices linked to the previous ones were computed: mean left-right asymmetry index (Asymmetry), mean momentum (Torque), most prevalent pair of masticatory muscles (Activity). Finally the standardized total activity (Std. IMPACT) was evaluated as the rate between the overall muscular activity performed in MVC and the one with cotton rolls.
Descriptive statistics were computed for all variables, which were normally distributed. Mean values were compared by Student's *t* tests for independent samples (the significance level was considered for P=0.05).
RESULTS: There were no significant differences between children with OB and those with normal occlusion. The observed indices values were respectively: masseter POC [%] (73.0±23.8% vs. 86.1±4.0%), temporal POC [%] (83.9±6.7% vs. 85.8±11.2%), TORS [%] (89.2±5.0% vs. 89.3±7.9%), BAR [%] (81.6±12.3% vs. 84.6±15.5%); Asymmetry [%] (13.8±15.3% vs. 7.3±11.0%), Torque [%] (7.0±6.7% vs. 6.2±9.4%), Activity [%] (15.5±14.5% vs. 11.4±17.5%); Std. IMPACT [%] (121±5% vs. 148±5%).
CONCLUSION: OB children had all mean indices worse than control children, but no significant differences were found because of the large inter-subject variability; an aspect that should be deepened in future studies.
ACKNOWLEDGEMENT: The first author received a fellowship from**:** The State of São Paulo Research Foundation (FAPESP) –Brazil. This work was supported by Provost's Office for Research of the University of São Paulo.

MANDIBULAR KINEMATICS IN DENTOFACIAL DEFORMITIES BEFORE ORTHOGNATHIC SURGERY

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AIM: Changes in facial morphology may cause disturbances in stomatognathic functions. The aim of the current investigation was to quantitatively assess the three-dimensional condylar paths during standardized mandibular movements in patients with dentofacial deformities before orthognathic surgery and in healthy subjects.
METHODS: Patients with dentofacial deformity were divided in two groups: DG-II (n = 15 with class II, mean age 26.3 years) and DG-III (n= 15 with class III, mean age 26.2 years), with 3 men and 12 women each, were assessed during the preoperative orthodontic treatment. Fifteen healthy young adults, paired for age and sex, were selected for control group. Mandibular kinematics were recorded during maximum mandibular border movements: mouth opening (MMO) and closing, lateral excursions and protrusion, using an infrared optoelectronic 3D-motion analyzer (BTS SMART System), with a 500 Hz sampling rate.
RESULTS: Patients and healthy subjects had similar age (1-way ANOVA, $p \geq 0.05$). The DG-II showed larger laterotrusion asymmetry than CG (Table 1). At MMO, the percentage of mandibular movement explained by condylar rotation was larger in the DG-III than DG-II (2-way ANOVA, $p=0.001$; Bonferroni post-hoc test, $p=0.045$, Figure.1).
CONCLUSION: The outcomes suggest that the proposed method could be a useful diagnostic tool to detect altered function in DG patients before orthognathic surgery.
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*The first author received a scholarship from CNPq (Science without Borders), Brazil.

Table 1: Kinematics indices of mandibular motion, mean±SD, 1-way ANOVA.

Measure	**Control**		**DG-II**		**DG-III**		***p-value***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Maximum opening – MMO (mm)	47.8	4.0	44.8	5.5	46.5	7.2	0.360
MMO deviation (mm)	2.7	1.1	3.6	1.6	3.4	2.3	0.358
Maximum laterotrusion	9.7	2.1	8.9	1.7	8.1	1.7	0.068
Laterotrusion asymmetry	0.7*	0.7	2.6*	2.6	1.1	1.1	0.011
Maximum Protrusion	7.7	1.7	7.4	1.6	6.5	2.0	0.196

*=Bonferroni post-hoc test, p=0.014.

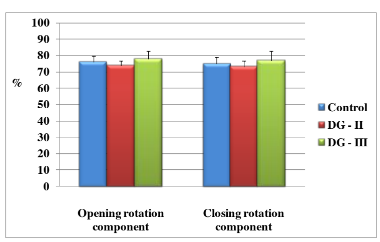

Figure 1: Percentage of mandibular rotation during mouth opening and closing, mean±SD, 2-way ANOVA.

BRAIN ACTIVATION DURING IMAGINED STANCE: AN FMRI STUDY ON BLIND AND HEALTHY SUBJECTS

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AIM: The integration of visual sensation with somatic sensation organizes body and kinesthetic imagery, which contributes to motor performance. To investigate whether the blind use different strategies for body and kinesthetic imagery, we compared brain activity during imagery between blind and healthy individuals.
METHODS: The study population comprised 6 blind individuals (congenitally totally blind, 3; amblyopic, 3) and 7 healthy individuals. they had no visual impairment and were otherwise healthy of any disease or disorder that could affect imagery. All 13 were right-handed. All subjects provided written informed consent, and the study protocol was approved by the Research Safety and Ethics Committee of Tokyo Metropolitan University. The subjects performed three tasks during which functional magnetic resonance imaging (fMRI) was performed: (1) imagining standing from a third-person perspective (visual imagery), (2) imagining standing from a first-person perspective (kinesthetic imagery). A complete session involved three repetitions of a block design. Cerebral neural activity was measured three times per session with a 30-s interval between the visual and kinesthetic imagery tasks. We used a Philips Achieva 3.0 T MRI scanner to study functional brain regions, and data were subjected to realignment, spatial standardization, and smoothing using the statistical analysis software SPM8 in MATLAB.
RESULTS: Activation of the paracentral lobule was observed in the healthy subjects, but not in the blind subjects, during visual and kinesthetic imagery. By subtraction analysis (blind minus healthy), brain activation was seen in the cingulate gyrus during visual imagery of stance, in the left primary motor area, bilateral premotor area, and right supramarginal gyrus during kinesthetic imagery of stance.
CONCLUSION: When blind people image visually and kinaesthetically, they may not utilize body representation. They might use different strategies for visual and kinesthetic imagery of standing.

ALTERED PROPRIOCEPTIVE POSTURAL CONTROL AS A RISK FACTOR FOR NON-SPECIFIC LOW BACK PAIN IN YOUNG ADULTS

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AIM: The aim of this study was to investigate if proprioceptive postural control, which is already demonstrated to be changed in people with non-specific low back pain (LBP), may play a role in the development of LBP.

METHODS: Proprioceptive postural control of 90 subjects was evaluated at baseline using a force plate and with application of vibration stimulation on ankle and back muscles. Spinal postural angles were measured with digital photographs. Psychosocial variables and physical activity was registered using questionnaires.

RESULTS: A more ankle-steered proprioceptive postural control strategy in upright standing increases the risk for developing or having recurrences of mild LBP within two years (Odds: 1.23; 95% CI: 1.06 – 1.44; p= 0.01). Increased postural sway, altered spinal postural angles and physical activity outcomes were not identified as risk factors for future mild LBP. Fear was identified as a risk factor; however absolute fear scores remained under the clinical relevant thresholds. (Table 1)

CONCLUSION: Increased reliance on ankle muscle proprioceptive inputs during standing on a stable surface increases the risk for future mild LBP in young individuals. This higher reliance on ankle muscle proprioceptive input was already demonstrated as a contributing mechanism in people with LBP in cross-sectional studies. However, current study identified this altered proprioceptive steering as a risk factor for future LBP. Therefore, addressing proprioceptive input may proof fruitful in both the prevention and rehabilitation of LBP.

Table 1: Logistic regression predicting NSLBP during follow-up.

	B	**S.E.**	**Wald**	**df**	**Sig.**	**Odds Ratio**	**95% C.I. for Odds Ratio**	
							Lower	**Upper**
Height	0.08	.04	3.38	1	.07	1.08	.99	1.18
PAI Sports	-1.18	.82	2.08	1	.15	.31	.06	1.52
PAI Leisure Time	-1.52	.86	3.16	1	.08	.22	.04	1.17
PAI Total Score	.87	.64	1.86	1	.17	2.39	.68	8.37
4DSQ Fear	**-.56**	**.21**	**6.91**	**1**	**.01**	**.57**	**.38**	**.87**
FABQ Physical activity	.07	.06	1.52	1	.22	1.07	.96	1.20
US MV soleus	**.21**	**.08**	**6.99**	**1**	**.01**	**1.23**	**1.06**	**1.44**
US foam RPW	-2.73	1.85	2.19	1	.14	.07	.00	2.43
Usit RPW	-1.53	1.15	1.78	1	.18	.26	.02	2.06

PAI = Physical Activity Index, 4DSQ = four-dimensional symptom questionnaire, FABQ = fear avoidance beliefs questionnaire, US = usual standing, MV = muscle vibration, RPW = relative proprioceptive weighting, Usit = usual sitting.

ELECTROMYOGRAM FEATURES DURING LINEAR TORQUE DECREMENT AND THEIR CHANGES WITH FATIGUE

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AIM: Surface electromyogram (EMG) spike shape analysis (SSA) has recently been proposed as an adjunct tool to EMG time and frequency domain analysis to increase our knowledge of motor unit (MU) control strategies. The study was aimed to understand more in MU deactivation strategy during torque decrement, and its possible changes in fatigued muscle, by using a combination of traditional time and frequency domain analysis and SSA techniques.

METHODS: EMG was detected from the biceps brachii of eleven untrained male subjects during static down going ramp contractions (90-0% of the maximal voluntary contraction, MVC) under non-fatigued (DGR) and fatigued (FDGR) conditions. The root mean square (RMS) and mean frequency (MF), as well as SSA parameters like mean spike amplitude (MSA), mean spike frequency (MSF) were calculated on 1 s EMG windows centred on each 10% MVC step for both conditions.

RESULTS: In both the DGR and FDGR the EMG-RMS, and mean spike amplitude decreased by 50% in the 90-60% MVC. The mean spike frequency also decreased by 50% in the 30-10% MVC.

CONCLUSION: The dynamics of EMG parameters during torque decrement would support a MU deactivation strategy which relies more on MU de-recruitment in the high %MVC range and more on firing rate reduction in the low %MVC range. The adopted integrated approach to EMG signal processing could indicate that SSA is an important tool to disclose alterations in motor control due to fatigue.

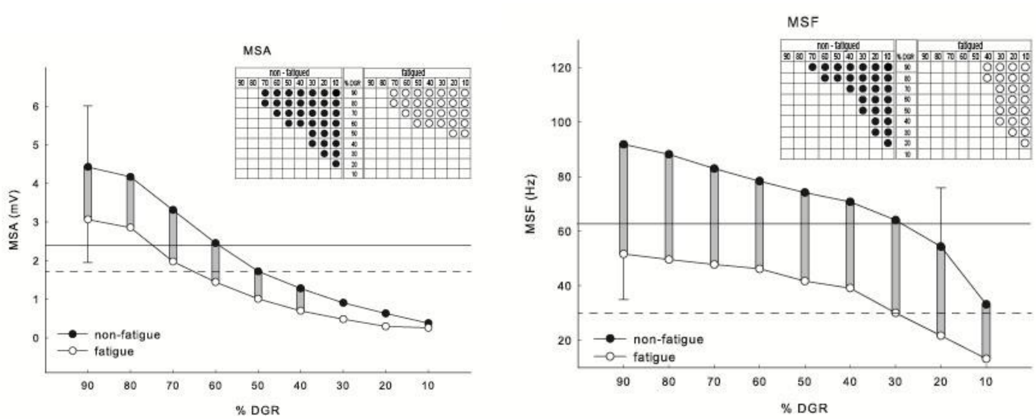

Figure 1: Spike shape analysis. Average values and biggest standard deviation of mean spike amplitude (MSA) – left panel and mean spike frequency (MSF) – right panel, during down going ramp (DGR) for non-fatigued (black circles) and fatigued muscle (white circles). The shaded areas indicate significant differences between the two muscle conditions. The inset in the upper right corner presents the location of the differences for effort level (%MVC) for non-fatigued and fatigued muscle. Line —— decrease by 50% in DGR, line – – decrease by 50% in FDGR.

ELEVATED MASTICATORY MUSCLE ACTIVITY DURING JAW CLENCHING IN PEOPLE WITH CHRONIC NECK PAIN

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AIM: Studies have shown that people with temporomandibular disorders display differences in neck muscle activity during tasks of the cervical spine compared to healthy controls. The aim of this study was to assess whether patients with chronic neck pain display evidence of altered masticatory muscle behavior during a jaw clenching task.
METHODS: Ten subjects (age: 28.9 ± 6.0 years) with a history of chronic non-specific neck pain (Neck Disability Index: 22.5 ± 7.1/100) greater than three months and 10 age and gender matched healthy controls (age: 27.2 ± 5.8 years) participated. Bite force was recorded via two flexible force transducers enclosed in a customized envelope and positioned in subject's mouth between the first molar teeth. Subjects performed two Maximal Voluntary Contractions (MVCs) of unilateral jaw clenching followed by 5 s submaximal isometric unilateral jaw clenching contractions at 10, 30, 50 and 70% MVC in a random order. Task performance during the submaximal contractions was measured by quantifying the Mean Distance (MD) and the Offset Error (OE) from the reference target as error indices and the Standard Deviation (SD) as an index of force steadiness. Surface electromyographic (EMG) signals were recorded from multiple locations over the masseter muscle bilaterally using 13×5 grids of electrodes. In addition, EMG was acquired from the anterior temporalis muscle bilaterally using bipolar EMG recordings.
The EMG root mean square (RMS) was computed for each location of the electrode grids to form a map of the EMG amplitude distribution and the average RMS was computed for each submaximal contraction. The RMS was also calculated for the anterior temporalis muscle for each submaximal contraction.
RESULTS: Both patients and controls performed the task with the same degree of accuracy. That is, no group differences were evident for MD (P=0.48), OE (P=0.37) or SD (P=0.82) at any of the force levels. However, higher values of RMS (averaged across the grid of electrodes) were observed for the patient group for both the contralateral and ipsilateral masseter during the submaximal contractions but only at the force targets of 30, 50 and 70% MVC (P<0.001). Furthermore, the patient group displayed higher values of temporalis RMS bilaterally at the force targets of 50 and 70% MVC (P<0.001).
CONCLUSION: Higher masticatory muscle activity was observed in a sample of patients with chronic neck pain during a unilateral jaw clenching task despite similarities in motor output. This study provides preliminary evidence of disturbed motor control of the jaw in patients with neck pain.

CHANGES IN CORTICOMOTOR PLASTICITY INDUCED BY TEN WEEKS OF EXERCISE IN SEDENTARY YOUNG ADULTS

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AIM: Recent studies have further elucidated the properties of cardiovascular and musculoskeletal exercise-induced changes in motor cortex (M1) plasticity (i.e. the strengthening and reorganization of neural connections). We now know that basal levels of brain-derived neurotrophic factor (BDNF), an integral protein associated with neuroprotection, neurite outgrowth, as well as synaptic plasticity, has been shown to increase in healthy young men after only 5 weeks of moderate-intensity endurance training. However, the degree of change in M1 plasticity following the completion of an exercise prescription remains unknown. The purpose of this study was to examine global changes in M1 plasticity of a small hand muscle in sedentary young adults following a 10 week exercise program.
METHODS: Electromyographic recordings were taken from the right abductor pollicis brevis (APB) muscle of 12 young subjects (5 women, 7 men; range 19-23 yrs). Subjects completed a 10 week exercise prescription consisting of two weekly resistance training sessions with a shorter aerobic session at the end, as well as a third aerobic session. Exercises were changed to avoid adaptation, and aerobic session workloads were determined by heart rate response. Transcranial magnetic stimulation (TMS) of the left hemisphere was used to assess changes in APB motor-evoked potentials (MEPs), input-output curve (IO curve) and short-interval intracortical inhibition (SICI). Changes in neural plasticity were induced using paired-associative stimulation (PAS), which consisted of 90 paired stimuli (0.05 Hz for 30 min) of median nerve electrical stimulation at the wrist followed 25 ms later by TMS to the hand area of the left M1.
RESULTS: There was an increase in slope of post-PAS IO curve after 10 weeks, indicative of increased cortical plasticity
CONCLUSION: Exercise appears to increase the capacity for plasticity in sedentary but otherwise healthy adults. Future analysis will include serum BDNF levels for correlation with our neurophysiological measurements.

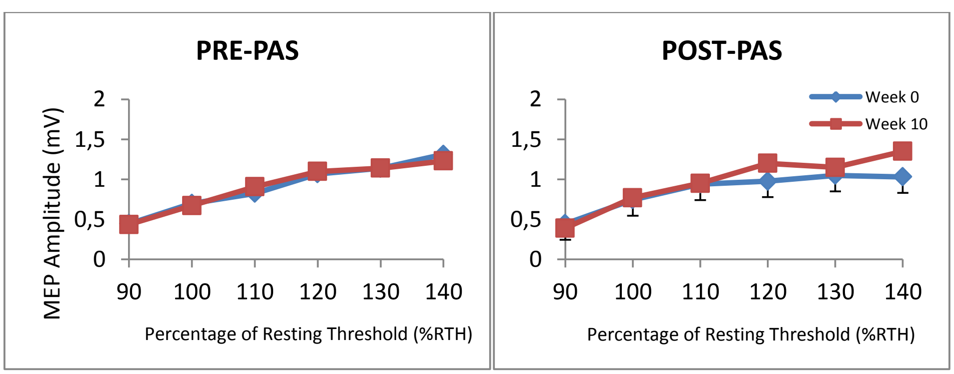

Figure. TMS Input Output (IO) curves taken prior to PAS indicate no change in slope whereas the 15 minute post-PAS IO curves show an increase in slope following 10 weeks of exercise.

CHRONIC NECK PAIN IS ASSOCITED WITH IMPAIRED KINEMATICS AND PROLONGED MUCSLE CO-ACTIVATION DURING FUNCTIONAL TASK

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AIM: The purpose of this study was to examine the influence of chronic neck pain on the three-dimensional kinematics and muscle recruitment pattern of the cervical and thoracic spine during an overhead reaching task involving a light weight transfer by the upper limb.
METHODS: Synchronized measurements of the three-dimensional spinal kinematics and electromyographic activities of cervical and thoracic spine were acquired during the performance of an overhead reaching task with the right hand. Thirty individuals with chronic neck pain and thirty age- and gender-matched asymptomatic controls were recruited for this study.
RESULTS: Neck pain group showed a significantly decreased cervical movement velocity and acceleration while performing the task (Figure 1). They also displayed a predominantly prolonged co-activation of cervical and thoracic muscles throughout the task cycle (Figure 2a-c).

CONCLUSION: The current findings highlighted the importance to examine differential kinematic variables of the spine which are associated with changes in the muscle recruitment in people with chronic neck pain. These results are produced during a dynamic movement that simulates daily functional activities. The results also provide an insight to the appropriate clinical intervention to promote the recovery of the functional disability commonly reported in patients with neck pain disorders.

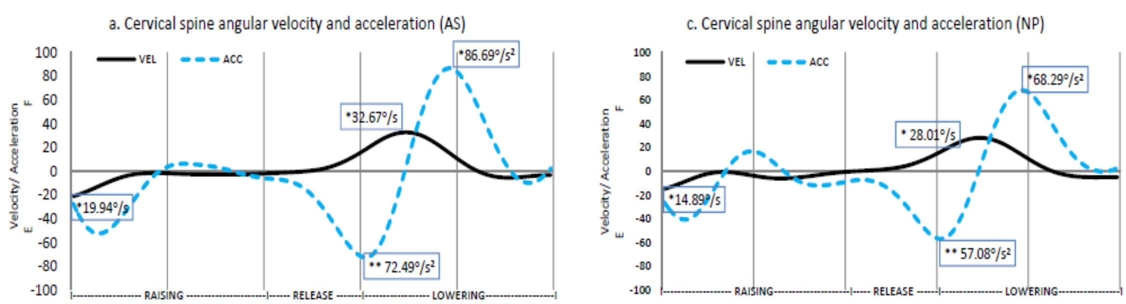

Figure 1. Cervical velocity and acceleration during functional task.

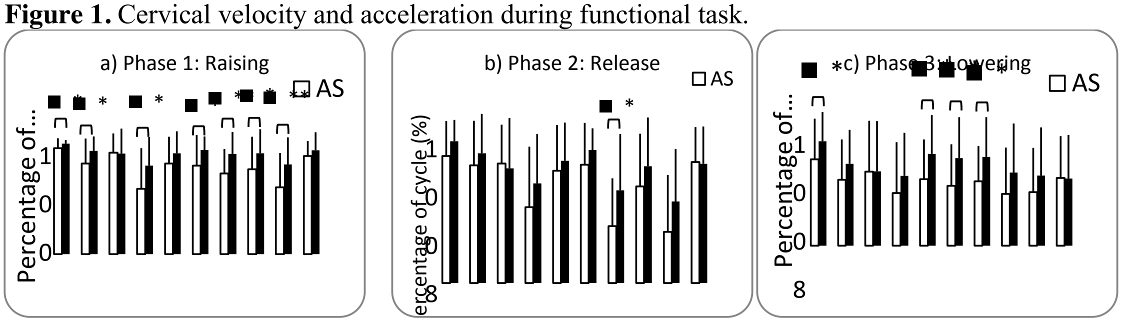

Figure 2 a-c. Percentage of activation duration of muscles during 3 phases of task cycle.

EFFECTS OF SCAPULAR POSITIONAL CONTROL ON NECK AND UPPER LIMB MUSCLE ACTIVITIES DURING STATIC AND DYNAMIC FUNCTIONAL TASKS

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AIM: The concept of scapular positional control (SPC) or “scapular stabilization” has been commonly adopted as a form of therapeutic exercise in physiotherapy for neck and upper limb disorders. This study examined the muscle activities of the neck and upper limb muscles, while individuals performed a static task as well as a dynamic functional task with and without maintaining the scapula in a controlled position.
METHODS: Twelve males and twelve females (mean age=28.0$\pm$4.5) who were symptom-free, participated in this study. Surface electromyography (EMG) was recorded while the subjects performed two sessions of 5-min typing task with and without SPC respectively. The muscles examined were the right upper trapezius (UT), lower trapezius (LT), anterior deltoid (AD), biceps (BR), triceps (TR), flexor carpi radialis (FCR) and extensor carpi radialis (ECR). A 3D wireless inertial sensor system (the X-bus System) was used to monitor the scapular position with reference to the thoracic spine during the functional tasks. The static functional task involved 5 min of copy typing on a desktop computer whereas the dynamic functional tasks involved 3 cycles of forward reaching with a 1-kg weight in hand.
RESULTS: The results revealed a significantly lower median muscle activity of UT and AD ($p<0.01$) and higher median activity of LT ($p<0.01$) when SPC was performed while subjects performed the static task. The amplitude ratios between pairs of synergistic muscles such as UT and LT, BR and TR also demonstrated significant differences ($p<0.01$) with SPC compared to without. In the dynamic task, significantly decreased UT activity and significantly increased activity in LT, TR FCR and ECR during the forward reaching phase ($p < 0.05$). In the backward phase, there was significant increase in LT, TR and FCR activity in the SPC condition ($p < 0.05$). There was also a trend showing decreased UT and AD activity in SPC condition in the backward phase. The scapular motion data confirmed that the scapula was well controlled in a retracted position in both the static and dynamic tasks during the SPC condition, however the other movements such as posterior tilt and rotation of the scapula showed lesser extent of change.
CONCLUSION: This study demonstrated that maintaining the scapula in a retracted position had significant effects to influence the neck and upper limb muscle activity. This finding provides evidence to support the use of scapular positional control as a form of exercise training for patients with neck and shoulder disorders. Currently, the scapular exercise intervention is being tested in a real patient group for comparison with the present results.

THE TIMING OF MUSCLE ACTIVITY BETWEEN THE RIGHT AND LEFT LEG DURING 180 DEGREES ROTATION JUMP LANDING

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AIM: The aim of this study was to investigate whether there were any significant differences in the timing of the muscle activities between the right leg and the left leg during 180 degrees rotation jump landing.
METHODS: The subjects were nine healthy females. The task was 180 degrees clockwise rotation jump landing. The electromyography (EMG) activity was recorded bilaterally for vastus medialis (VM), rectus femoris (RF), vastus lateralis (VL), semimembranosus (SM) and biceps femoris (BF). The ground reaction forces generated at landing were recorded using the force platforms. The initial ground contact was defined as the time when the vertical ground reaction force exceeded 10N. Paired *t* tests were used to determine whether there were any significant differences of onsets of muscle activity or the time of peak muscles activity, comparing the right and the left leg data. A one-way analysis of variance (ANOVA) and a post hoc Bonferroni test were used to identify the contractions timing differences among the five muscles of the right and the left leg data.
RESULTS: No significant differences between the right and the left leg were found in the onset times or peak times during 180 degrees rotation jump landing. However, for both sides of legs, onset times and peak times of the hamstrings resulted in significantly earlier than the quadriceps ($p < 0.01$).
CONCLUSION: Lower limb symmetry was observed in muscle activation data during 180 degrees rotation jump landing. And the timing of the hamstrings muscle activity was earlier than the quadriceps during jump landing. Our results were consistent with previous studies such as drop jump landing. In late years it may be suitable to adopt a rotation jump as training to prevent anterior cruciate ligament injury. Our results suggest that 180 degrees rotation jump landing was necessary to lead the similar muscle activity between the right and left leg and to increase the earlier hamstrings muscle activity than the quadriceps muscle activity.

Table 1: The timing of the onset muscle activity and peak muscle activity.

Group	Muscle	Onset	Peak
Right leg	**VM**	-40 ± 20 msec	90 ± 20 msec
	RF	-60 ± 20 msec	90 ± 20 msec
	VL	-50 ± 30 msec	80 ± 40 msec
	BF	-120 ± 40 msec	0.2 ± 40 msec
	SM	-120 ± 30 msec	-5 ± 50 msec
Left leg	**VM**	-30 ± 10 msec	100 ± 30 msec
	RF	-50 ± 30 msec	90 ± 20 msec
	VL	-40 ± 10 msec	90 ± 10 msec
	BF	-90 ± 20 msec	40 ± 70 msec
	SM	-110 ± 40 msec	30 ± 20 msec

THE EFFECT OF ORTHOTIC INTERVENTION ON NEUROMUSCULAR PERFORMANCE IN SUBJECTS WITH FUNCTIONAL ANKLE INSTABILITY: THE PRELIMINARY RESULTS

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AIM: Orthotics have been suggested to enhance sensorimotor function by placing the foot at the subtalar neutral position. Previous studies showed that orthotic interventions had effects on improving the muscle performance of foot and postural control. However, few studies examined the effects of orthotics intervention in the subjects with functional ankle instability (FAI). The purpose of the study was to determine if the orthotic intervention alter the neuromuscular control and perceived symptoms in subjects with FAI.

METHODS: The subjects with FAI were randomly assigned into the orthotic group (OR) and the control group (CO). The subjects in the OR group received four weeks intervention of semi-customized foot orthotics while the ones in the CO group received placebo insoles. Outcome measures were the double-to-single-limb stance test (DST) with eyes closed, and the Cumberland Ankle Instability Tool (CAIT). Onset time and electromyographic (EMG) activity of the peroneus longus (PL) and soleus (SO), area and velocity changes of center of pressure (COP) of the 20-second single-limb stance in the DST, and CAIT scores were measured before and after the orthotic intervention. The differences between the pre- and post-tests of each variable were analyzed with the two-tailed Mann-Witney U test using SPSS 19. The significant level was set at 0.05.

RESULTS: The differences of all variables were not showed to be significantly different between the OR (n=9) and CO groups (n=5), except the PL onset time in the DST with shoes (p=0.034). In the DST, the PL onset time of OR group (0.102s ± 0.089) were more prolonged compared to that of the CO group (0.005s ± 0.046) after 4 weeks of intervention. It might be caused by the stability support offered by the orthotics thus the subjects didn't have to prepare for imbalance occurred as changing the position from double-limb to single-limb stance. However, the CAIT scores of the OR group (6.44 ± 7.47) also tended to increased more than the CO group (1.00 ± 2.45; p=0.106) after the intervention, suggesting that the orthotic intervention might improve the perceived symptoms in FAI subjects.

CONCLUSIONS: Semi-customized foot orthotics might help improve subjective symptoms in FAI subjects. More subjects are still recruited to reach a more powerful conclusion.

NEUROMUSCULAR AND KINEMATICS ADAPTATIONS TO A SHORT TERM NORDIC HAMSTRING TRAINING

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AIM: To investigate the kinematic and neuromuscular adaptations to 4-week eccentric hamstring training using the Nordic hamstring exercise (NHE).
METHODS: Ten males (20.1 ± 1.7 years) completed 156 repetitions of the NHE over the intervention period. The angle at downward acceleration (angle at DWA), peak velocity (pVelocity), as well as activation of the biceps femoris (BF EMG) at different knee joint angle intervals during the performance of the NHE were the variables analysed. Peak torque, angle at peak torque and integrated EMG (iEMG) during a maximum eccentric voluntary contraction (MEVC) were also analysed.
RESULTS: The angle at DWA ($F = 8.5$, $\eta 2 = 0.49$, $p < 0.01$) and pVelocity ($F = 3.6$, $\eta 2 = 0.29$, $p < 0.05$) were significantly reduced following the 4-week intervention. A shift in the BF EMG was observed, with an increase in the activity in the early stages ($F = 3.19$, $\eta 2 = 0.23$, $p < 0.05$) and a decrease in the later stages ($F = 4.7$, $\eta 2 = 0.34$, $p < 0.05$) of the NHE, following the 4-week intervention. In addition, there was a significant decline in iEMG ($F = 5.4$, $\eta 2 = 0.38$, $p < 0.05$) during the MEVC, without a concomitant change in peak torque.
CONCLUSION: 4 weeks of NHE training significantly changed the kinematic variables associated with NHE performance. These changes, together with the observed shift in EMG activity during the NHE, could indicate an improvement in neuromuscular control induced by the NHE training. In addition, the observed EMG decline during the MEVC could be been explained as an increased pre-synaptic inhibition of BF α motoneuron activity induced as a result of repeated performance of eccentric exercise.

EVALUATION OF GLENOHUMERAL RANGE OF MOTION AND SCAPULAR/ROTATOR CUFF MUSCLES STRENGTHS IN COLLEGE OVERHEAD ATHLETES

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BACKGROUND: overhead athletes develop several adaptations in the shoulder complex being the most common glenohumeral internal rotation deficit (GIRD). Few studies have evaluated the strength of the rotator cuff and scapular muscles therefore the aim of this study was to evaluate the motion of the glenohumeral rotation and muscular strength in college handball athletes.
MATERIALS AND METHODS: internal and external rotation range of motion (ROM), GIRD, the total rotation motion were measured with a standard goniometer in 15 college athletes plus muscle strength of upper trapezius, lower trapezius, serratus anterior, rhomboids, internal and external rotators of the shoulder with a isometric manual dynamometer (Lafayette©). Differences were analyzed from the throwing and not-throwing shoulder.
RESULTS: Fifteen athletes were evaluated with a mean age 21 years. The athletes had significantly less internal rotation of the throwing arm (P=.004), greater external rotation of the throwing arm (P=.004), GIRD value: 12.66°±2.13. There were no significant differences in total rotation ROM and muscular strength.
CONCLUSION: This group of athletes showed greater external rotation, lesser internal rotation of the throwing shoulder and no differences in muscle strength.

Table 1 – Differences between Range of motion throwing and non-throwing shoulders

	Throwing	Non-throwing	P(.05)
Internal Rotation	74°	68°	.004
External Rotation	119°	108°	.004
Total rotation	186°	182°	.46

Table 2 – Differences between muscle strength throwing and non-throwing shoulders

	Throwing	Non-throwing	P (.05)
Shoulder Internal Rotators	24,2 ± 3,1	22,48 ± 4,1	.27
Shoulder External Rotators	17,7 ± 4,2	16,68 ± 3,5	.40
Upper Trapezius	24,9 ± 4,2	25,63± 4,9	.68
Inferior Trapezius	13,1 ± 2,8	13,65± 3,3	.68
Serratus Anterior	17,8 ± 5,0	18,58 ± 5,1	.68
Rhomboids	14,2 ± 4,3	13,95 ± 3,8	.84

ELECTROMYOGRAHIC ANALISYS OF QUADRICEPS MUSCLES IN DIFFERENT KNEE FLEXION ANGLES DURING ISOMETRIC AND DYNAMIC CONTRACTIONS

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AIM: The main goal of this study was to assess the electromyographic (EMG) signal amplitude when performing squat-jumps at different knee flexion angles (20º, 40º, 60º and 80º) and step-jumps with the dominant leg in boxes of different heights (10, 20, 30, 40 and 50 cm). Also, isometric actions was assess at different knee flexion angles (20º, 40º, 60º and 80º).
METHODS: Ten subjects (5 male and 5 female students) participated in this study. The EMG signal was evaluated using surface electrodes (BlueSensor, Medicotest) with bi-polar placement over the lower limbs' vastus lateralis (VL), vastus medialis (VM), internal gastrocnemius (GI), external gastrocnemius (GE) and biceps femoris (BF) muscles, according to SENIAM's guidelines. We focused on the analysis of the Average EMG full wave rectified signal (AvgEMG), as well as in its integral (iEMG).
For the evaluation of step and squat jumps, subjects performed two attempts of each predefined heights and knee flexion angle degrees. To evaluate isometric actions subjects performed the maximum strength, during 5 seconds, for each predefined knee flexion angle degrees.
To evaluate the muscle electrical activity, a pre-amplified telemetry system (Glonner) and *Simi Motion* software were used. The signal was recorded at a 2000 Hz frequency and filtered with a bandpass [10-600] Hz filter. One-way ANOVA was performed in order to compare the jumping heights and the different knee flexion angle degrees. These calculations were carried in SPSS Software (v20.0, IBM Corporation, USA).
RESULTS: No significant differences were found in the muscle EMG activation for the different heights (step-jump test), different degrees (squat-jump) and isometric actions. Generally, the VL and VM muscles presented higher values in all selected amplitude parameters.
CONCLUSION:
In the step jump, the flight time and duration of the contact phase progressively increased as the boxes' height was higher. However, no differences were found in the EMG signal. Regarding to squat-jump, the flight time and duration of the contact phase also increased as the knee flexion was higher (20º vs 60º and 10º vs 80º). The EMG signal slightly reduced when the knee flexion angles increased. Finally, the peak torque of the isometric actions increased in the higher angles of the knee flexion, but no differences were found in the EMG signal.

EFFECT OF PRE-ACTIVATION METHOD AND UNSTABLE SURFACE ON UPPER-BODY MUSCLE ACTIVATION

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AIM: The objective of this study is to evaluate the performance of the upper limb muscles in a session of resistance training, involving the pre-activation method and different types of surfaces.

METHODS: Pectoralis major, anterior deltoid, triceps brachial and serratus anterior muscle activation levels were determined by surface electromyography in 14 men (22.5 ± 2.4 years, 76.03 ± 9.03 kg, 173.64 ± 7.12 cm) with experience of at least six months of weight training and minimum frequency of 3 sessions per week. In the first session the subjects performed the 1-RM test for all exercises. The second visit was intended for experimental session that included the development of a series of the following conditions: 1) bench press, 2) stable crucifix + bench press, 3) unstable crucifix + bench press. The execution order was randomized and the rest interval was set at 10 minutes between each condition. The EMG signal was analyzed in routines developed in Matlab software 5.02c. All data were filtered using a moving 100 ms RMS window. Data were analyzed using a multivariate analysis of variance with repeated measures.

RESULTS: The stable and unstable pre-activation methods were effective to increase the level of activation of all muscles evaluated in comparison to the bench press task performed isolated. When comparing the different surfaces, the pre-activation method performed on unstable surface caused greater activation of the pectoralis major ($p = 0.004$) and serratus anterior ($p = 0.002$) muscles. No difference was found for the anterior deltoid ($p = 0.071$) and Triceps Brachial ($p = 0.391$) muscles.

CONCLUSION: The results show that using the method pre-activation was effective in increasing the myoelectric activity of the upper limb muscles. Furthermore, the use of an unstable surface while performing the single-joint exercise was effective in increasing the activity of the primary muscle (pectoralis major) as well as the stabilizer muscle of the scapula (serratus anterior). Therefore, the results indicate that performing the pre-activation method on an unstable surface can enhance muscle performance.

ACKNOWLEDGEMENT: This work was funded through grants from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

Table 1. Descriptive statistics of normalized EMG data of the four muscles during different methods of training.

Muscle	Mean (SD)			*p*-value
	Bench-press	Stable Pre-Activation	Unstable Pre-Activation	
Pectoralis major	45.00 (13.38)	48.93 (13.97)[a]	52.14 (15.00)[a,b]	0.001
Anterior Deltoid	43.07 (13.01)	46.71 (14.67)[a]	48.79 (14.97)[a]	0.001
Triceps Brachial	36.01 (8.13)	40.43 (8.11)[a]	41.64 (9.38)[a]	0.001
Serratus Anterior	40.21 (13.17)	44.93 (14.80)[a]	50.57 (16.73)[a,b]	0.001

a Significant difference compared to bench-press
b Significant difference compared to stable pre-activation

EMG ANALYSIS FOR CONTINUOUS STEERING MOVEMENT

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AIM: To elucidate the patterns of upper extremity (UE) muscle activation and the main contributing muscles during continuous steering movement (CSM) based on the steering movement measuring system we developed previously.
METHODS: The measuring system was designed to measure the position of the steering wheel, the steering torque and surface EMG (sEMG) signal during constant-velocity steering movement. We utilized a concept similar to the isokinetic dynamometer to study the UE muscle uses during constant-velocity CSM. With a hand switch device and eight-channel sEMG signals from elbow and shoulder muscles of dominant arm, we studied the muscle activation pattern under two different speeds (i.e. 60°/sec and 180°/sec) and two opposite directions of CSM (i.e. clockwise (CW) and counterclockwise (CCW)). SEMG signals from muscles of deltoid (anterior, middle and posterior fibers), biceps, triceps (long and lateral heads) and pectoralis major (clavicular and sternal parts) were processed as linear envelop (EMGLE) to calculate their activation level (normalized EMG amplitude, presented as % of amplitude during maximal voluntary isometric contraction) during stance phase of CSM (Fig.1).
RESULTS: Data from twelve normal young adults showed that most elbow and shoulder muscles exhibit the phasic contraction pattern rather than tonic pattern during CSM. As shown in Table 1, both 60°/sec and 180°/sec CSM favor posterior deltoid (PD) and long head of triceps (TO) as their main contributing muscles during clockwise CSM. In contrast, pectoralis major muscles (PC and PS) serve as the main muscles for counterclockwise CSM.
CONCLUSION: In this study, we investigate the muscles used during CSM and found four main contributing muscles. The information would be very helpful if CSM is used in UE exercise or training for rehabilitation of pathological patients in future.

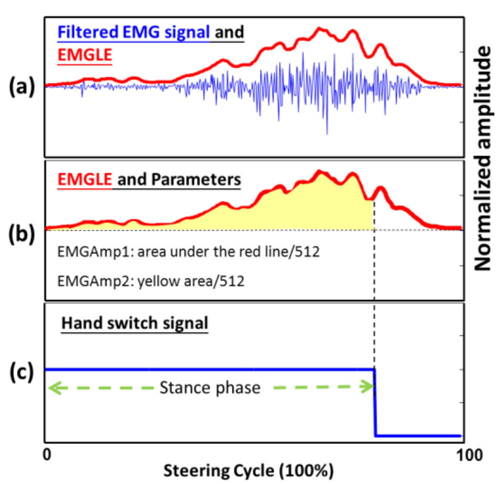

Figure 1: Example of processing of sEMG signal. (a)Filtered signal and its EMGLE; (b)Parameters of sEMG amplitude; (c)Hand switch signal during a steering cycle.

(a) 5×5 d-MMG array transducer (b) 5×5 d-MMG map (c) 64ch-EMG map

Figure: d-MMG array transducer, two-dimensional maps of d-MMG and 64-channnel EMG during isometric contraction.

NEUROMUSCULAR CONTROL IN IMPACT ROUNDHOUSE KICK IN JUNIOR AND SENIOR KARATEKA

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PURPOSE. Age-related adaptations in the neuromuscular control have been investigated mainly focusing on untrained populations, performing both isokinetic or complex exercises, reporting higher antagonist activation in adults with respect to adolescents. Despite specific adaptations have been demonstrated to occur following continuous training regimens, age-related differences in the antagonist activation of athletes have scarcely been investigated. This study aims at investigating the co-activation about the knee joint in two groups of elite karate athletes belonging to the Junior and Senior age categories during a specific task (roundhouse kick - RK) in order to possibly identify differences in the neuromuscular control strategies between groups.

METHODS. Six Senior (age 27.7 ± 2.6 years; stature 1.8 ± 0.1 m; mass 75.5 ± 8.4 kg) and six Junior (age 15.5 ± 1.0 years; stature 1.7 ± 0.1m; mass 57.5 ± 4.8 kg) elite karate practitioners were asked to perform three repetitions of the RK impacting on a punching bag. Kicking limb kinematics was recorded at 100 samples/s using stereophotogrammetry. Surface EMG signals were recorded from the Vastus Lateralis (VL) and Biceps Femoris (BF) of the kicking leg at 2000 samples/s. During knee flexion and extension, co-activation indexes (CI_F; CI_E), agonist and antagonist activation areas of VL and BF (I_{AGO-VL}; I_{ANT-VL}; I_{AGO-BF}; I_{ANT-BF}), knee peak angular velocity (${}^{Peak}\omega_F$; ${}^{Peak}\omega_E$), hip and knee angular displacement (during flexion, ${}^{H}\theta_F$; ${}^{K}\theta_F$ and during extension, ${}^{H}\theta_E$; ${}^{K}\theta_E$); were computed. Furthermore, the total angular momentum (${}^{t}H$) was computed as the sum of thigh angular momentum (${}^{th}H$) and shank angular momentum (${}^{sh}H$) about the vertical axis of the body; total, thigh and shank maximum angular momentum (${}^{t}H_{max}$; ${}^{th}H_{max}$; ${}^{sh}H_{max}$) during knee extension were detected and used to compare group means. Repeated measures analysis of variance was used to compare group means, statistical significance was set at $\alpha < 0.05$.

RESULTS. The Senior group was significantly heavier ($p = 0.001$) and taller ($p = 0.017$) than the Junior group. No difference between groups was observed in ${}^{Peak}\omega_F$, ${}^{Peak}\omega_E$ and in ${}^{H}\theta_F$, ${}^{K}\theta_F$,${}^{H}\theta_E$, ${}^{K}\theta_E$. During knee extension, the Senior group demonstrated higher CI_E, higher I_{ANT-BF} and higher ${}^{t}H_{max}$; ${}^{th}H_{max}$ and ${}^{sh}H_{max}$ with respect to the Junior group, whereas during knee flexion no difference emerged for CI_F and I_{ANT-VL}.

CONCLUSION. The higher $I_{ANT-BF,}$ with concurrent higher angular momentum (${}^{t}H_{max}$; ${}^{th}H_{max}$; ${}^{sh}H_{max}$), observed in the Senior group seems to be related to the joint protection upon impact. In addition, due to the very brief duration of the task, a feed forward mechanism modulating the antagonist activation based on the stress the impact imposes on the anatomical structures of the kicking limb could be hypothesized. This mechanism possibly involves skill dependent neural re-modelling of the peripheral and central nervous system.

Poster Session 5 (Poster Area 16.30)

EFFECT OF ELECTROMYOSIMULATION TRAINING ON ISOKINETIC STRENGTH, SPRINT TIME AND JUMP PERFORMANCE

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AIM: Electromyostimulation (EMS) is often used in strength training and multijoint EMS training doesn't induce sport performance adaptations according to some previous studies. Therefore the aim of this study was to evaluate the effects of a 6wk EMS training program on isokinetic knee strength, 40m sprint time and vertical jump performance.
METHODS: Twelve young healthy subjects (mean ± SD; age 22,5±1,8yr, height 176±7cm, mass 68±7kg, fat mass 14±6%) participated in this study. All subjects completed 12 sessions of isometric multijoint EMS training over 6 weeks. EMS trainings consisted of a three sets of 20 contractions (20conX3sets = 60 contractions, 5-s EMS, 10s rest, 100hz, 5min intersets rest time) with and were carried out 2 X wk^{-1} for 6 wk. The strip electrodes were placed on the area of thigh, calf and gluteal muscles. Then, EMS sessions was applied bilaterally with an EMS training device at the maximal tolerated comfortably current intensity according to VAS. The current was applied to 5s with 10s rest intervals with the specific current parameters was used to deliver biphasic symmetric rectangular-wave pulsed current with frequency 100Hz, pulse width 400µs, duty cycle %33 (5s on, 10s off). EMS was applied 120º knee joint angle on a seated leg press machine during maximal isometric voluntary contractions (Figure 1).
RESULTS: All of the measures showed no significant differences between before and after EMS training program ($p > 0.05$). As shown in Table 1, most of the performance values decreases non-significantly after exercise.
CONCLUSION: The main findings of the present study were no significant changes in any of measured parameters after 6 weeks of EMS. These results are similar to former experiments but our EMS training routines may inadequate to induce performance. Based on these results we can say that multijoint isometric EMS training doesn't effective as voluntary training.

Table 1: Means, Percentage of change, P values of pre- and post-test measurements.

Test Parameters	Pre-test	Post-test	%	p
Hamstring right 60°.s^{-1} (Nm)	135,3±37,9	125,4±29,6	-7,3	0,186
Hamstring left 60°.s^{-1} (Nm)	132,6±38,8	129,2±28,5	-2,5	0,632
Quadriceps right 60°.s^{-1} (Nm)	185,5±57,8	174,5±37,8	-5,9	0,255
Quadriceps left 60°.s^{-1} (Nm)	183,0±58,5	171,7±39,2	-4,6	0,220
Hamstring right 180°.s^{-1} (Nm)	102,5±27,2	95,4±22,8	-6,9	0,182
Hamstring left 180°.s^{-1} (Nm)	103,3±27,2	99,8±20,4	-3,3	0,463
Quadriceps right 180°.s^{-1} (Nm)	125,6±37,1	122,3±29,8	-2,6	0,504
Quadriceps left 180°.s^{-1} (Nm)	122,2±36,5	118,0±28,0	-3,4	0,383
Hamstring right 300°.s^{-1} (Nm)	83,6±21,6	82,6±16,5	-1,1	0,792
Hamstring left 300°.s^{-1} (Nm)	84,2±21,5	84,4±14,4	-0,2	0,966
Quadriceps right 300°.s^{-1} (Nm)	94,2±29,1	93,5±23,7	-0,7	0,905
Quadriceps left 300°.s^{-1} (Nm)	90,6±30,4	88,2±19,8	-2,6	0,637
Squat jump (cm)	29,6±5,2	30,3±5,1	2,3	0,276
Countermovement jump (cm)	33,8±6,7	33,6±6,7	- 0,5	0,851
40m sprint time (sc)	5,93±0,62	5,91±0,59	0,33	0,660

SPEED-DEPENDENT CHANGES OF LOWER LIMB COORDINATION IN CHRONIC STROKE PATIENTS WITH SLIGHT PARALYSIS DURING OVER-GROUND WALKING

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AIM**:** The purpose of present study was to assess whether any differences existed in motor coordination between stroke patients and healthy individuals during over-ground walking.
METHODS**:** Subjects were 10 stroke patients (mean age = 63 years) and 10 healthy subjects (mean age = 62 years). A 3-dimensional motion analysis device (Vicon MXT-20) was used to measure walking movement. The sampling frequency was set at 60 Hz. The subjects were asked to walk the distance of 10m barefoot. Maximum walking speed was predicted by Froude velocity (FV) considering walking with the inversed pendulum model. The measurement task consisted of over-ground walking at 3 different walking speeds; 20% (slow), 40% (moderate), and 60% (fast) of FV. The time series of walking data within a range of %FV ± 10% were analyzed, all other data were excluded. Walking speed, stride length, joint angle, and 5 relative phases (L-R shoulder, pelvis-thorax, hip-pelvis, knee-hip, and ankle-knee) were evaluated for stroke patients and healthy subjects.
RESULTS**:** The main findings of present study were: 1) there was no significant difference in walking speed at any %FV. Stride lengths at 20% FV and 40% FV in stroke patients were significantly smaller than healthy subjects. 2) Shoulder extension angle of paretic side at any %FV and pelvic rotation angle at 20% FV in stroke patients were significantly smaller than healthy subjects. 3) Hip-pelvis relative phases at 20% FV was significantly larger than healthy subjects. Ankle-knee relative phase at 60% FV in paretic side of stroke patients was significantly larger than healthy subjects. Hip-pelvis and ankle-knee relative phases at 40% FV in paretic side of stroke patients were significantly larger than healthy subjects.
CONCLUSION**:** Stroke patients with slight paralysis produced speed-dependent changes in lower limb coordination. At slow walking speed such as 20% FV, disorder of motor coordination in lower limb was more pronounced in proximal lower limb. On the other hand, at fast walking speed such as 60% FV, disorder of motor coordination was more pronounced in distal lower limb. 40% FV walking speed was most sensitive to detect the disability of motor coordination in both proximal and distal lower limb. These results of relative phase were useful information about rehabilitation program to get more coordination during over-ground walking.

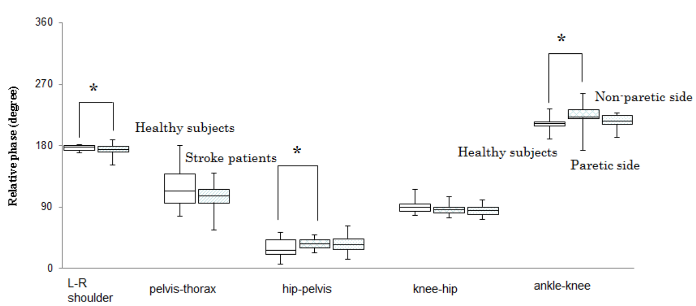

Figure 1: Relative phase at 40%FV in healthy subjects and stroke patients

ASSESING SPASTICITY VIA PATELLAR PENDULUM WHICH IS TRIGGERED BY PATELLAR T REFLEX.

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AIM: Spasticity is a movement disorder developing after upper motor neuron lesion. It is the tonus increase associated with movement velocity of extremity muscles. We aimed to develop a new parameter for assessing spasticity by electrophysiologically and kinesiologically.
METHODS: The electrophysiological characteristics of Patellar T reflex and patellar pendulum which triggered by patellar T reflex were defined. Spasticity changes the responses by utilizing movement features of knee joint during the reflex and pendulum. Angular changes and velocity during the reflex were also estimated with a goniometric approach. A new parameter which is obtained by dividing the angular velocity of the reflex to the frequency of the movement was used for the evaluation of muscle tonus. Medium and late latency EMG responses were examined in normal and spastic patients from effectors' muscle of Patellar T reflex that is m. Quadriceps femoris and its antagonist, m.biceps femoris muscles. The spasticity was evaluated in accordance with clinical Ashworth scale.
RESULTS: Medium Latency Late responses from biceps femoris muscle (BF-MLR) could not be obtained in normal cases, but it was established to be 54.73±10.18 msn latency in cerebral spastics. It was obtained in spinal spastics as 47.88±8.27 msn latency. When we applied the kinesiological records to the knee model (AnyBody®) we also observed biceps femoris late latency activity in spastic patients.
The parameter which obtained by kinesiological and electrophysiological methods was 69.61±32.56 in normal group, it had the value of 32.41±25.01 in cerebral spasticity group. In spinal spasticity group, the value 31.61±22.83 was obtained. The parameter can differentiate between normal and spastic groups. However, what is more important and determinative is its relation with Ashworth scale. The parameter that was 69.61±32.56 in normal cases decreased to 50.52±28.98 in Ashworth 1, to 32.00±14.90 in Ashworth 2, and finally to 14.48±22.83 in Ashworth 3, and these changes was statistically significant.
CONCLUSION:Consequently, the pendulum of patellar T reflex could differentiate between spasticity and normal by electrophysiological and kinesiological evaluation, and that it produced a rating for spastics in compliance with Ashworth scale.

MOVEMENT STRATEGIES DURING STAND-TO-SIT TRANSFERS IN CHILDREN WITH SPASTIC DIPLEGIC CEREBRAL PALSY: A PRELIMINARY STUDY

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AIM: This study aimed to assess stand-to-sit (STS) transfer movements in children with spastic diplegic cerebral palsy (CP). A better understanding of STS movements would be invaluable in rehabilitation of CP children.
METHODS: Three children with spastic diplegic CP (age range: 4–5 years), classified as Gross Motor Function Classification System (GMFCS) Level III (able to walk with assistive mobility devices), participated in this present study. Three children with normal development (NTC; age range**:** 4–5 years) were selected as controls, and each of the 3 CP subjects were compared to this group. This study was approved by the Osaka Prefecture University research ethics committee (2012-PT11). All CP subjects had difficulty standing independently, and therefore used a bar for assistance. To assess STS movements, a motion analysis system (Kinema tracer, Kissei Comtec, Matsumoto, Japan) with 4 cameras (30 Hz) synchronized with a pressure-sensitive trigger device was used. STS movements were performed bare foot with no time restrictions, and STS movement data, including the total duration of STS movement (from initial standing position to seated position with hip on the seat) and angular movement of each joint (trunk, hip, knee, and ankle) were collected and compared between each CP subject and the controls. No statistical analysis was conducted in this study.
RESULTS: The total duration of STS movement in 2 of 3 subjects with CP (range: 1.03– 2.13 seconds) was longer than that in the controls (mean: 1.01 ± 0.18 seconds). With regard to angular movement, all CP subjects maintained the flexed trunk position (Fig. 1A). Moreover, all CP subjects showed ankle plantarflexion, whereas the controls showed ankle dorsiflexion (Fig. 1 B).

CONCLUSION: These findings suggest that children with CP used a different strategy to perform STS movements.

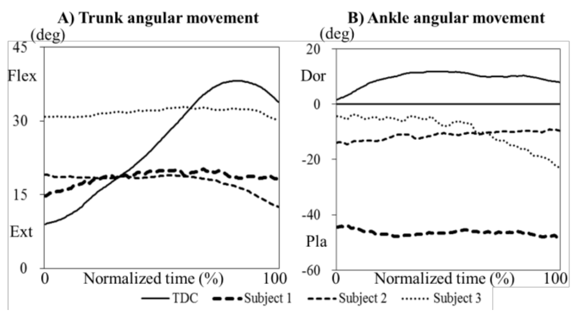

Figure 1. Angular movement of trunk (A) and ankle (B)

SURFACE EMG SIGNAL FEATURES IN ISOMETRIC MUSCLE CONTRACTION OF ARMS AND LEGS DURING THE ADJUSTMENT OF DEEP BRAIN STIMULATION SETTINGS IN ADVANCED PARKINSON'S DISEASE

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AIM: Deep brain stimulation (DBS) is effective treatment method for reducing motor symptoms in advanced Parkinson's disease (PD). However, its efficacy depends significantly on the settings of stimulation parameters such as the pulse amplitude, frequency and pulse width. The optimal adjustment of DBS settings is essential for the success of treatment but it can be difficult because objective methods for quantifying treatment efficacy are lacking. Surface electromyography (EMG) may be potential method for quantifying treatment effects in PD. However, it is unclear, how different stimulation parameters affect on the muscle activation and surface EMG of upper and lower limb muscles. This study aims to identify differences in the isometric surface EMG signals of PD patients between different settings of DBS and between upper and lower limb muscles.
METHODS: Surface EMG signals were measured from biceps brachii (BB) and tibialis anterior (TA) muscles of 13 PD patients during isometric muscle contraction. Measurements were performed during seven different settings of DBS treatment in a randomized order of setting states: a) chronic DBS settings (individual settings used for treatment), b) decrease and c) increase of 0.3 V in amplitude, d) decrease and e) increase of 30 Hz in frequency, f) increase of 30 μsec in pulse width and g) DBS-OFF. The EMGs were analyzed using methods based on signal amplitude, frequency, higher order statistics and nonlinear dynamics. Differences in the EMG signal characteristics were quantified with respect to chronic DBS settings. Signals were also compared between upper and lower limb muscles.
RESULTS: The results show significant differences (paired-samples T-test for normally distributed variables and Wilcoxon signed rank test for other variables, $p<0.05$) in the EMG signal peakedness and complexity and in the number of recurrent and deterministic structures between the chronic DBS settings and other settings for BB but not for TA muscles. In the EMG signal amplitude, the differences are significant only between the chronic DBS settings and DBS-OFF. In the median and mean frequencies, the differences are significant only between the chronic DBS settings and the increased pulse amplitude.
CONCLUSIONS: In isometric muscle contraction of BB, the muscle activation changes due to change in the DBS amplitude, frequency or pulse width. The change can be observed in the measured EMG signal morphology and complexity. The results indicate that the muscle activation of PD patients may be modulated in a different way for arm than for leg muscles during the DBS treatment.
ACKNOWLEDGEMENT: This study was supported by the Academy of Finland under project no. 252748.

ANALYSIS OF MASTICATORY EFFICIENCY IN PATIENTS WITH ACQUIRED IMMUNODEFICIENCY VIRUS

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AIM: AIDS (Acquired Immunodeficiency Syndrome), comes from the appearance of both the skeletal system disorders and systemic muscle caused by infection with the human immunodeficiency virus (HIV). The muscle and joint pains (myalgias and arthralgias) are the major musculoskeletal manifestations present in individuals infected by this virus. Currently the health professionals seek to investigate the contribution of variables of physical, biological and psychosocial order in the development of musculoskeletal disorders in HIV, often correlating these variables with the manifestation of symptoms. This study aims to evaluate the masticatory efficiency of patients with HIV subtype 1 (HIV-1).

METHODS: In this study 60 subjects were selected of both genders, with a mean age of 36.77 ± 9.33 years, were divided into two groups: Group 1 (G1), 30 individuals with HIV subtype 1 (HIV-1 group) and Group 2 (G2), 30 individuals with no medical diagnosis of infectious diseases, Ribeirao Preto of the community and region. The individuals were submitted to evaluation of masticatory efficiency by surface electromyography of the clinical conditions of Parafilm M ® Chew of raisins and peanuts, to the right and left temporal muscles (TD and TE), right and left masseter (MD and ME), right and left sternocleidomastoid (ECOMD and ecome) for 10 seconds each clinical condition. The EMG values were normalized by maximum voluntary contraction for 10 seconds. The final values were normalized linear envelope and analyzed statistically (t test - $p < 0.05$).

RESULTS: The results demonstrated significant values (t-test - $p < 0.05$) in the clinical condition of chewing Parafilm M ® for MD, ME, and ECOMD and ECOME muscles, the clinical condition of chewing raisins for TE muscles, ME, and ECOMD ecome and the clinical condition of chewing peanuts for TD, TE, MD, ME, and ECOMD and ECOME muscles.

CONCLUSION: Individuals infected with the human immunodeficiency virus had lower mean EMG for all muscles tested, which demonstrates a commitment masticatory function.

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EVALUATION OF POSTURAL CONDITIONS MANDIBLE OF PATIENTS WITH DUCHENNE MUSCULAR DYSTROPHY

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AIM: Dystrophin is a protein that is part of a protein complex that binds to contractile muscle portion. With the lack of this protein muscle tissue develops serious commitments engines unleash crippling muscle disorders that can lead to death the bearer of this disease. Duchenne Muscular Dystrophy is a fatal neuromuscular disorder linked to genetic inheritance in males, which has an incidence of 1:3500 boys. This observational cross-sectional study aims to analyze the pattern of electromyographic activity in the mandibular postural conditions in individuals with Duchenne muscular dystrophy.
METHODS: Were selected 40 male subjects, mean age 10 ± 4 years, divided into two groups matched for age, weight and height: GI - Carriers of Duchenne muscular dystrophy (n = 20), G2 - Control: individuals without a diagnosis of Duchenne Muscular Dystrophy (n = 20).
The individuals of this study were subjected to the stomatognathic system rating by surface electromyography during clinical conditions related to postural control of the jaw: resting (RP), protrusion (PR), right laterality (RB) and left (LE) of the right temporal muscles and left (TD and TE), right and left masseter (MD and ME), right and left sternocleidomastoid (ED and EE) for 4 seconds. The EMG values were normalized by maximum voluntary contraction for 4 seconds. The normalized values were statistically analyzed using SPSS 21.0 program using the Student t test ($p < 0.05$).
RESULTS: In this study we could notice significant changes in muscle activity in the clinical conditions of PR for TD, TE and EE muscles. Clinical condition in PR there were significant differences for the TD, TE and ED muscles. On the clinical condition of LD there were significant differences for the TD, TE and ED muscles. On the clinical condition of LE there
were significant differences for the TD and TE muscles.
CONCLUSION: This study demonstrates the heterogeneity of the results pertaining to the electromyographic averages fact that portrays the lack of an expected masticatory muscle activity related to the control of mandibular posture default.
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GIRLS WITH GENERALIZED JOINT HYPERMOBILITY DISPLAY CHANGED MUSCLE ACTIVITY STRATEGY DURING POSTURAL SWAY

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AIM: Generalized Joint Hypermobility (GJH) in children, defined by a Beighton score ≥ 6 positive joint tests out of 9, is a major criterion for Hypermobility syndrome (HMS). Reduced balance is reported in children with Hypermobility Syndrome [1]. The objective was to study knee muscle activation during postural sway in girls with GJH.

METHODS: A total of 16 girls with GJH and 11 girls with no GJH (NGJH), aged 14 years were recruited randomly from a Danish cohort of schoolchildren. Additional inclusion criteria for GJH were at least one hypermobile knee, while for NGJH it was at least one knee without hypermobility. Postural sway, as two-legged with eyes open and closed (EO, EC), and one-legged stance with eyes open (OLS), was measured on a force plate (60 s), and Rambling, Trembling medial-lateral (ML) and anterior-posterior (AP), and Center of Pressure Path Length (COPL) were calculated. Surface EMG was recorded (dominant leg) on the following muscles: quadriceps (Q), mean of vastus medialis and lateralis, hamstrings (H, mean of biceps femoris and semitendinosus), and gastrocnemius (G, mean of gastrochnemius medialis and lateralis), during all sway tests. EMG was normalized to isometric Maximum Voluntary EMG, expressed as %MVE, and co-contraction index (CCI) (EMG activity min/max) * (min+max), with minimum and maximum muscle activity determined based on mean Q-activity and mean H-activity, and the final CCI as the calculated mean over the number of trials. Self-reported knee related physical function was assessed with the Knee Injury and Osteoarthritis Outcome score for children (KOOS-Child). A general linear regression (mixed model) analysis was used to study between group differences.

RESULTS: GJH did not report lower knee function than NGJH, but GJH had generally larger sway, which was significant in EC (COPL 0.87 vs. 0.73m/min, p=0.001), and with a tendency to larger sway also in OLS (Trembling, ML, 5.27 vs 4.39mm, p=0.061). There was no group difference in completing the balance tasks.

During EO GJH had significantly lower muscle activity, seen in Q (1.29 vs 2.30%MVE, p=0.053), with a tendency also to lower activity in VM (1.15 vs 2.11%MVE, p=0.072). During EC and OLS GJH had significantly lower GL activity (EC: 2.45 vs. 3.55%MVE, p=0.005; OLS: 9.40 vs. 13.45%MVE, p=0.010), with a tendency to lower activity in G also in OLS (12.95 vs 15.71%MVE, p=0.068). There was a significantly lower CCI in EO (1.21 vs 2.53, p=0.041), and also a tendency to decreased CCI during EC (1.43 vs 1.73, p=0.062).

CONCLUSIONS: During static balance girls with GJH and at least one hypermobile knee performed with larger postural sway than NGJH, and stabilized with a lower muscle activity in knee extensors and plantar flexors, possibly relying more on the passive structures.

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MANDIBULAR MOVEMENT ASYMMETRY AND MASTICATORY MUSCLES INCOORDINATION IN PATIENTS WITH TEMPOROMANDIBULAR DISORDERS

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AIM: Temporomandibular disorders (TMD) consist of a number of clinical problems involving the masticatory system, particularly in women. The aim of the current study was to quantitatively investigate the asymmetry of jaw kinematics and the incoordination of muscles' activity during maximum voluntary contraction (MVC), in patients with moderate TMD and patients with severe TMD versus TMD-free subjects.
METHODS: Fifteen patients with moderate-TMD (13f, 2m; 19-45y), 15 severe-TMD women (14-45y) and 15 healthy volunteers (12f, 3m; 21-30y) were analyzed in this study. To be recruited in the pathologic group, patients had to present TMD according to the Research Diagnostic Criteria for TMD (RDC/TMD), then they were assigned to the moderate or the severe TMD group according to the level of perceived signs and symptoms (ProTMDmulti protocol). Free movements of mouth opening and mandibular laterotrusions were non-invasively recorded using an infrared optoelectronic 3D-motion analyzer (BTS SMART System). Temporalis and masseter muscles' EMG activity was recorded by a wireless device (BTS FreeEMG) during 5s of MVC. All signals were standardized as percentages of the potentials obtained during 5s of MVC with cotton rolls interposed between posterior teeth.
RESULTS: TMD patients showed larger jaw lateral displacement during mouth opening (healthy, 2.7±1.1mm; modTMD, 4.1±2.3mm; sevTMD, 4.3±2.2; 1-way ANOVA, p=0.071), and larger laterotrusion asymmetry (healthy, 0.7±0.7mm; modTMD, 1.6±0.9mm; sevTMD, 1.4±1.1mm; p=0.040). As shown in table 1, TMD patients also presented a pattern of muscular incoordination during MVC, with both asymmetry (POC, percent of overlapping coefficient, and Asymmetry) and latero-deviating couple (TORS and Torque) indices increasing with the severity degree.
CONCLUSION: Overall, TMD patients presented jaw movement asymmetry, incoordination between right and left muscle pairs, with a resultant latero-deviating moment on the mandible, all increasing with the severity degree.
ACKNOWLEDGEMENTS**:** Provost's Office for Research of the University of São Paulo, and Conselho Nacional de Pesquisa (CNPq), Brazil.

Table 1: EMG indices in MVC, mean±SD, 1-way ANOVA.

Measure	**Healthy**	**Moderate-TMD**	**Severe-TMD**	***p-value***
POC_temporalis [%]	87.7±2.4 *	84.5±6.2	82.0±7.1 *	0.029
POC masseter [%]	87.1±3.0 *	83.5±7.7	78.3±14.2 *	0.049
Asymmetry [%]	5.9±3.8 *	7.2±7.8 #	13.0±5.1 *#	0.004
TORS [%]	91.9±0.9 *	88.1±6.3	86.2±7.1 *	0.021
Torque [%]	3.1±1.8 *	8.5±8.0	10.7±9.1 *	0.015

*, # = Bonferroni post-hoc significant test.

UPPER TRAPEZIUS RELAXATION INDUCED BY TENS AND INTERFERENTIAL CURRENT IN COMPUTER USERS WITH CHRONIC NONSPECIFIC NECK DISCOMFORT: AN ELECTROMYOGRAPHIC ANALYSIS

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BACKGROUND**:** Recent studies have shown that a transcutaneous electrical nerve stimulation (TENS) and interferential current (IFC) application reduces pain in subjects with musculoskeletal disorders.

AIM: To compare the muscle relaxation of the upper trapezius induced by the application of TENS and IFC in females with chronic nonspecific neck discomfort.

METHODS: Sixty-four females between 18 and 40 years of age and a history of nonspecific neck discomfort were randomly assigned to a TENS or an IFC group. The women in the TENS (N=32; mean age 22 years) and IFC (N=32, mean age 23 years) group were submitted to current application during 3 consecutive days and were assessed by electromyography (EMG) in different times aiming to quantify the muscular tension of the upper trapezius. A visual analogue scale (VAS) was used as pain measure at baseline (before TENS or IFC application) and at the end of the study.

RESULTS: At baseline, demographic, pain, and EMG assessment data were similar between groups. Those in the IFC group had a significant trapezius relaxation after 3 IFC applications when compared to baseline and intermediate evaluations ($P<.05$). In contrast, the same analysis showed no significant difference between all assessments in the TENS group ($P>.05$). In relation to pain relief, both groups showed an improvement at the end of the study when compared to baseline (both, $P<.05$). The between-group analysis showed no difference for the subjects who received such IFC as TENS application ($P<.05$).

CONCLUSION**:** IFC induced the upper trapezius relaxation after 3 sessions in females with neck discomfort, but the TENS application did not change the muscular tension. However, these results should be carefully interpreted due to the lack of differences between groups. A significant pain decrease was found in the subjects of both groups, however, only the IFC application presented a clinically important improvement.

ANALYSIS OF ELECTROMYOGRAPHIC ACTIVITY AND BITE FORCE IN SUBJECTS WITH DENTAL ABFRACTION ASSOCIATED WITH TEMPOROMANDIBULAR DYSFUNCTION COMPARED WITH CONTROL SUBJECTS

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AIM: The aim of this study was to analyze and compare the activity of pairs of muscles through electromyography, during testing of dental clenching and analyze the performance of the masticatory muscles by measuring the bite force.

METHODS: The sample consisted of 06 subjects with dental abfraction associated with temporomandibular disorders (TMD) - G1, and 06 control subjects without signs or symptoms of TMD - G2 according to the classification proposed by the protocol of the Research Diagnostic Criteria for Temporomandibular Disorders - RDC / TMD , with a mean age of 52.5 years. The electromyographic examination and bite force were performed at the Laboratory of Research in Electromyography of the Stomatognathic System (LAPESE), the subjects were submitted to the examination of surface electromyography (EMG) of the anterior temporal and masseter masticatory muscles, using the Freely® electromyograph (from Götzen srl ; Legano , Milano, Italy) and measuring the bite force (Kratos® – Equipamentos Industriais, MOD:IDDK, SP-Brasil). With electrodes positioned, subjects were first submitted the standardization static tests, maximum voluntary contraction in normal maximum intercuspal and maximum voluntary contraction. Data were statistically analyzed using parametric statistics (Student's t) and descriptive (mean and standard deviation), adopting is the significance level of 5 % .

RESULTS: There was statistically significant difference when compared bite force between abfraction /TMD and control groups, but bite force values in control group was higher than the abfraction/TMD (Table 1). There was no statistically significant difference in these rates when compared between the study variables of electromyographic analysis. The values of the POC TA and POC MM of the subjects with abfraction / TMD were lower than the values considered normal (Table 2).

CONCLUSION: Considering the limitations of this study, it can be concluded that the dental condition abfraction/TMD is associated with reduced force of contraction of the masticatory muscles, but no difference in electromyographic activity of the same when compared to control subjects. More studies should be conducted for confirmation of these findings, including broader samples.

Table 1: Results of bite force analysis of groups in study. Table shows mean ± standard deviation, unit: kgf.

GROUPS	Right	Left
Abfraction/TMD	22,4 ± 10,74	24,0 ± 9,17
Control	49,46 ± 24,0	53,1 ± 21,81
p	0,02*	0,01*

Table 2: Summary of study variables of electromyographic analysis. Table shows mean ± standard deviation, unit: %.

GROUPS	POC TA	POC MM	TORS	ASS	ATIV	IMP
Abfraction/TMD	77,68 ± 11,78	66,46± 23,66	13,98±15,66	22,08 ± 18,25	20,15 ± 19,36	98,33 ±54,58
Control Group	84,08 ± 5,39	81,56 ± 9,06	5,35±3,23	9,37 ± 8,42	14,93 ± 7,78	84,0 ± 21,12

COMPARATIVE STUDY OF ELECTROMYOGRAPHIC INDICES OBTAINED FROM EQUIPMENTS WITH DIFFERENT TECHNOLOGIES

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AIM: To compare the electromyography indices of two equipments (BTS® and Freely®) in subjects with temporomandibular disorders (TMD) before and after treatment with Michigan's interoclusal splint in order to verify if the technological evolution of equipment interferes with the attainment of these indices.
METHODS: Composite sample of 8 female subjects with a mean age of 35 years with diagnosis of TMD, obtained by the RDC/TMD protocol (Research Diagnostic Criteria) were treated with Michigan's interoclusal splint and submitted to the examination of surface electromyography (EMG) of the anterior temporal and masseter masticatory muscles, using two different units: Freely® (De Götzen srl; Legano, Milano, Italy) and BTS® (BTS Bioengineering, Milano, Italy). With electrodes positioned, subjects were first submitted the static tests standardization, maximum voluntary contraction in maximum habitual intercuspal and maximum voluntary contraction with the splint positioned. The examinations were performed first with the BTS® and with no change of position of the electrodes were repeated with Freely®. The indices were calculated using the relevant software for each device and the data were comparatively analyzed using parametric statistics (Student's T), adopting the significance level of 5 %.
RESULTS: No statistically significant difference between the assessed parameters when comparing the electromyography were found. The mean (standard deviation) and p-values are shown in Table 1.
CONCLUSION: The studied electromyography bring similar results, no harm in choosing between one or the other, and the BTS ® system has the advantage of capturing wireless signals.

Table 1: Mean (standard deviation) and p-values of the comparison between the BTS® and Freely®.

	Without splint			**Splint**		
	BTS®	Freely®	***p-value***	BTS®	Freely®	***p-value***
POCT	84,4 ± 4,3	80,5 ± 15,2	**0,45**	81,4 ± 10,8	79,1 ± 11,5	**0,66**
POCM	76,7 ± 16,1	73,4 ± 15,8	**0,66**	79,1 ± 11,9	80,9 ± 12,8	**0,74**
AS	13,2 ± 11,6	14,8 ± 14,7	**0,79**	10,5 ± 14,9	9,9 ± 15,3	**0,95**
AT	8,7 ± 6,2	14,9 ± 12,8	**0,21**	14,7 ± 19,1	12,1 ± 18,5	**0,77**
TORQ	7,4 ± 7,5	8,9 ± 8,5	**0,71**	4,2 ± 4,1	4,7 ± 3,8	**0,86**
IMP	86,4 ± 34,1	83,5 ± 30	**0,85**	82,2 ± 35,1	75,4 ± 22,1	**0,63**

ALTERED CONTROL STRATEGIES DURING ISOMETRIC TRUNK EXTENSION FOLLOWING EXPERIMENTAL LOW BACK PAIN

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AIM: To investigate how multidirectional force variability and muscle activation is affected by low back pain during different levels of isometric trunk extensions.

METHODS: Twelve volunteers received intramuscular injection of hypertonic saline in the right m. longissimus (isotonic saline was used as control). A 10 cm electronic visual analogue scale (VAS) was used to assess the pain intensity (0 cm represented “no pain” and 10 cm “worst imaginable pain”). Subjects were seated on a custom designed chair with a 3-dimensional force transducer adjusted to the segmental height of T1. Surface electromyography (EMG) was recorded bilaterally from longissimus, multifidus, rectus abdominis, and external oblique muscles. Submaximal isometric trunk extensions were performed before, during, and after the saline injections at 5%, 10%, and 20% of MVC force, in random order. Subjects had a visual feedback of the requested anterior-posterior force during all submaximal contractions and were asked to be as accurate as possible. All analyses were performed over a steady epoch of 20 s (15 s after the first time the requested contraction level was achieved and ending 15 s before the contraction was stopped). Task accuracy, force variability and muscle activity were estimated.

RESULTS: Hypertonic injections induced higher average scores on the VAS compared with control injection (mean ± SD; hypertonic: 2.6 ± 1.4 cm, isotonic: 0.5 ± 0.7; $P < 0.05$). Pain reduced the muscle activity of the both rectus abdominis muscles during contractions at 10 and 20% of MVC levels ($P < 0.01$) although it did not affect force accuracy or tangential force variability. Subjects showed altered tangential force amplitudes (not controlled by feedback) during pain, which were different from non-painful conditions ($P < 0.05$).

CONCLUSION: Experimental low back pain caused immediate motor adaptations in the abdominal muscles. This new motor strategy was sufficient to maintain task performance although causing significant changes in the forces component intensities generated by the trunk in the directions not controlled by feedback. The long-term consequence of such adaptation is not known and could overload other relevant structures.

EFFECTS OF MUSCLE PAIN ON INTERLIMB COMMUNICATION: PRELIMINARY RESULTS

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AIM: The aim of the present study was to investigate the possible effect of muscle pain on human lower interlimb communication by quantifying the magnitude of short-latency crossed responses (SLCR) elicited by peripheral nerve stimulation before and after the induction of delayed onset muscle soreness (DOMS).
METHODS: Subjects (n=4, 2 females, age 28-33 years) participated to two recording sessions (>24h apart). At the end of the first session, DOMS was induced in one (randomly right/left) gastrocnemius muscle via eccentric exercise (3 sets of 15 repetitive ankle dorsiflexion movements carrying 20% body weight). Soreness was evaluated at the beginning of each session, using a 7 point Likert scale and assessment of pressure thresholds (PPTs) on gastrocnemius lateralis (GL) and medialis (GM). Electrical stimulation of the posterior tibial nerve (at 85% of maximal M-wave) was delivered while subjects were walking on a treadmill. Muscle activity of ipsilateral soleus (iSOL), contralateral GL (cGL) and GM (cGM) were recorded with surface EMG. SLCRs were quantified as the ratio between the root mean square (RMS) value of the averaged EMG in a time window from the onset of the response following stimulation (variable length of 20 to 30 ms) and the RMS of the control signals (average of gait cycle with no stimulation) in the same time window.
RESULTS: A reduction in PPT and increase in soreness was observed in the leg subjected to eccentric exercise 24h after the induction of DOMS (PPT cGL: - 28 ± 5 %, PPT cGM: - 23 ± 6 %; Likert scale: 3.6 ± 0.5, indicating moderate soreness during walking). One out four subjects did not show a SLCR, and was consequently excluded for further analysis. No changes in SLCR latencies were observed between day 1 and day 2 (cGL: 62.25 ± 4.04 ms; cGM: 62.25 ± 5.20 ms). All subjects showed an increase in the magnitude of SLCR after the induction of DOMS (see table 1) regardless of the muscle or side evaluated.
CONCLUSION: DOMS affects interlimb communication, leading to enhanced SLCR in the gastrocnemius muscle. An increased excitability of reflex pathways may enhance postural stability while walking in presence of acute muscle pain.

Table 1: Magnitude of the SLCR (expressed as a percentage of the control) elicited without (day 1) and with DOMS (day2).

	Day 1		**Day 2**	
	No DOMS leg	DOMS leg	No DOMS leg	DOMS leg
Subject 1	GL: 183 GM: 173	GL: 226 GM: 146	GL: 220 GM: 220	GL: 259 GM: 157
Subject 2	GL: 154 GM: 140	GL: 145 GM: 140	GL: 163 GM: 146	GL: 224 GM: 228
Subject 3	GL: 228 GM: 159	GL: 273 GM: 148	GL: 256 GM: 210	GL: 289 GM: 179

EFFECTS OF EXPERIMENTALLY INDUCED PAIN ON THE MODULAR CONTROL OF NECK MUSCLES

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AIM: To assess the modularity in the neural control of the neck region during an aiming task and to characterize the alterations of motor control at a multi-muscular level during experimentally induced neck muscle pain.

MATERIALS AND METHODS: Nine young, healthy individuals participated and performed multi-directional, multi-planar aiming movements of the head. Nine circular targets were placed on a white wall following a circular trajectory (8 peripheral and one central target). Subjects were asked to sit upright and wore a custom-made helmet equipped with a two laser pointers mounted parallel to the vision line. The task consisted of moving the head and neck to aim the laser pointers from the central target to each peripheral target (in clockwise or counterclockwise sequence; randomized) following a beat provided by a metronome. The task was performed in four conditions: at baseline (BASE), immediately after the injection of isotonic saline or (ISO) hypertonic saline (PAIN) into the right splenius capitis muscle (order of injection randomized), and 10 minutes after the end of pain following the last injection (POST). Tridimensional tracking of head and shoulder movement was achieved by means of stereo-photogrammetry and muscular activity was acquired via surface electromyographic signals, recorded from 12 muscles in the neck region. Data was segmented and motor modules from surface EMG were extracted by means of non-negative matrix factorization. Dimensionality was assessed by the variation accounted for each motor modules set. Motor modules were compared across conditions and individuals.

RESULTS: Subjects reported a peak pain intensity of 4.9 ± 1.2 out of 10 following the injection of hypertonic saline however the presence of pain did not affect the execution of the task ($P>0.05$ for maximal speed, time to peak speed, distance traveled). The PAIN condition was characterized by reduced activation of the injected muscle with variable adjustments in the other muscles, with variability observed across subjects. Compared to BASE, the ISO and POST conditions showed comparable motor module similarity (0.9 ± 0.09 and 0.9 ± 0.07 respectively, $P=0.93$) while for the PAIN condition, the level of similarity was significantly lower (0.77 ± 0.13, ISO vs PAIN $P=0.004$, POST vs PAIN $P=0.019$). Cross-reconstruction showed that BASE, ISO and POST motor modules differed from the PAIN motor modules yet were similar to one another.

CONCLUSION: Acute pain induced reorganized motor control of the neck region at a multi-muscular level, without an appreciable decrement of kinematic performance. Although the specific changes in the motor strategy were variable across subjects, subjects showed a decrement of similarity in motor modules for the painful condition, in agreement with the hypothesis that the individual muscle weights are adjusted in a dynamic task-dependent manner under the influence of afferent input.

INFLUENCE OF NEURAL MOBILIZATION IN FOREARM MUSCLES ACTIVITY AND GRIP STRENGTH

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AIM: Analyze the influence of neural mobilization in activation of the forearm muscles and grip strength.
METHODS: 12 healthy volunteers, male and female, with a mean age of 23.81 (± 3.48), participated in this study. All participants were evaluated by a blinded evaluator. Muscle activity was measured using surface electromyography (Miotec™) of the extensor carpi radialis, extensor carpi ulnaris and flexor digitorum superficialis and the signal was acquired at rest and through maximum grip strength, associated with a Jamar™ dynamometer. Standardization was performed by maximum voluntary excitation of the task performed before mobilization. For data analysis the software Miograph™ was used and the bandpass filter with a 10-500Hz. The participants underwent an initial evaluation with electromyography and grip strength. Subsequently, they were subjected to neural mobilization of radial, ulnar and median nerves by a trained physical therapist. After that, volunteers were evaluated again. Data for muscle activation (RMS) and grip strength (kgf) were statistically analyzed by student's t-test ($p<0.05$).
RESULTS: There was statistical difference before and after neural mobilization of the radial and median nerves after the task performed ($p<0.05$). During resting, statistical difference was observed only in the extensor carpi radialis muscle before and after mobilization of the radial nerve ($p <0.01$). There was also a statistical difference in grip strength when comparing pre and post mobilization of the radial nerve ($p <0.01$).
CONCLUSION: The results of this study suggests that neural mobilization can change grip strength and muscle activity of extensor carpi radialis and flexor digitorum superficialis.

EFFECT OF THE POSTOPERATIVE REHABILITATION ON TRIGGER FINGER

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AIM: The purpose of this study was to propose a postoperative rehabilitation protocol for trigger finger patients undergoing ultrasound-guided percutaneous pulley release surgery, and to provide quantitative evaluation of their finger function to investigate the effect of the postoperative rehabilitation on trigger finger.

METHODS: Patients suffering from trigger finger with joint contracture problems were recruited from the orthopedic clinics. The participants were divided into two groups, one was the intervention group and the other one was the control group. Both groups received the finger function evaluation before the pulley release surgery and one-month after the surgery. All the participants underwent the same surgical procedure performed by the same surgeon. A four-week postoperative rehabilitation program designed based on the wound healing process was proposed by this study. The intervention group received the postoperative rehabilitation after the surgery while the control group received no treatment after the surgery. The finger function was quantitatively evaluated by using a three-dimensional motion capture system. The fingertip workspace and joint range of motion (ROM) were evaluated while the participant was performing a required five-posture movement, including straight finger, intrinsic plus, straight fist, fist, and hook.

RESULTS: The intervention group presented significant better improvement than the control group in the fingertip workspace (49% vs. 17%), the ROM of the distal interphalangeal (DIP) joint (16% vs. 4%), the ROM of the proximal interphalangeal (PIP) joint (21% vs. 5%), and the total active ROM (17% vs. 5%).

CONCLUSION: This study proposed a postoperative rehabilitation protocol for trigger finger and demonstrated the benefits of the rehabilitation protocol for trigger finger after the pulley release surgery. Although both the intervention group and the control group showed improvement in the fingertip workspace and joint ROM at the one-month follow-up examination after surgery, the intervention group presented significant better improvement in the fingertip workspace, the ROM of DIP and PIP joints, and the total active ROM. These results may provide suggestions for the clinical treatment for trigger finger.

RELATIONSHIP BETWEEN CARDIOPULMONARY RESPONSES TO EXERCISE ONSET AND ANAEROBIC THRESHOLD IN PEOPLE WITH SUB-ACUTE MYOCARDIAL INFARCTION

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AIM: It has been demonstrated that higher aerobic capacity leads to decreased mortality. However, little is known about cardiopulmonary responses to exercise onset under the influence of aerobic capacity. Aim of this study is to investigate the relationship between cardiopulmonary responses to exercise onset and aerobic threshold in elderly people with sub-acute myocardial infarction.
METHODS: Twenty-Eight male subjects (mean age: 61.3 years; SD: 11.1 years; range: 36-79 years) with sub-acute myocardial infarction participated in this study. They had been admitted to hospital for cardiac rehabilitation due to their acute myocardial infarction. In the study, participants underwent a sub-maximal cardiopulmonary exercise test to determine oxygen uptake at their anaerobic threshold (AT), using cycle ergometry. Their increases in integrated value of oxygen uptake in four minutes from exercise onset were also calculated as cardiopulmonary responses. The Pearson product-moment correlation was used to assess the relationship between cardiopulmonary responses to exercise onset and oxygen uptake at participants' AT. All statistical tests with a P-value<0.05 were considered statistically significant using IBM SPSS statistics (version 20).
RESULTS: The average increase in oxygen uptake on exercise onset was 12.4 ml/kg (SD=1.3), and the average oxygen uptake at AT was 9.8ml/kg/min (SD=1.4). Oxygen uptake at AT was related to integrated value of oxygen uptake on exercise onset (r= 0.68, P<0.05).
CONCLUSION: These results suggest that an easily and safely obtained measurement of physical fitness is related to integrated value of oxygen uptake in four minutes from exercise onset. Therefore, integrated value of oxygen uptake in four minutes from exercise onset could be helpful to assess aerobic capacity in people with sub-acute myocardial infarction.
ACKNOWLEDGEMENT: Authors thank all subjects.

LOAD EFFECTS ON UPPER EXTREMITY MUSCLE ACTIVITY DURING A FUNCTIONAL TASK: A PILOT STUDY

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AIM: Compare the upper limb muscle activation during a loaded and unloaded functional task.
METHODS: A healthy female volunteer, 30 years old, right handed, without previous trauma participated in this pilot study. The chosen task was a simulated activity of daily living related to feeding/drinking. She had to pour water into a vessel using a 1 liter jar under two different conditions: the first condition being performed using an empty container and the second one with 1 liter of water. The task was repeated 3 times for each condition. Muscle activity was measured using surface electromyography (Trigno Wireless System, Delsys), collected at 2000 Hz upper trapezius muscles (TS), middle deltoid (DM), biceps brachii (BB), triceps brachii (TB) and pectoralis major (PM). Skin preparation and electrodes placement were performed according to SENIAM except for pectoralis major, which site was defined based on Perotto (2011). For the statistical analysis a t test, with significance level of 95% ($p < 0.05$) was used.
RESULTS: The RMS values obtained by surface electromyography are in Table 1. There was significant increase on muscle activity of the upper trapezius and biceps while performing the task with load (Figure 1). No significant changes were found on muscle activity of pectoralis major, middle deltoid and triceps. We observed a slight decrease on muscle activity of pectoralis major and triceps during the execution of the loaded task.
CONCLUSION: The findings of this study suggested that the main strategy used by top motor control to perform an upper limb functional task with load was the increased recruitment of upper trapezius muscle. Also, suggests a greater involvement of the elbow joint associated with load increasing, due to increased muscle activity of the biceps during the execution of the task in this condition.

Table 1: RMS values obtained for each muscle in millivolts (mV).

	Empty jar				Full jar (1Liter)			
	1st. Trial	2nd. Trial	3rd. Trial	Mean ± S. D.	1st. Trial	2nd. Trial	3rd. Trial	Mean ± S. D.
TS	3,013	2,957	2,646	2,87 ± 0,19	7,131	6,140	5,898	6,39 ± 0,65
DM	5,694	5,554	5,003	5,41 ± 0,36	5,215	5,671	5,652	5,51 ± 0,25
PM	8,787	7,658	7,113	7,85 ± 0,85	5,542	6,556	7,131	6,41 ± 0,80
TB	0,928	0,780	0,767	0,82 ± 0,08	0,618	0,818	0,842	0,75 ± 0,12
BB	3,724	4,251	4,542	4,17 ± 0,41	5,822	6,080	6,160	6,02 ± 0,17

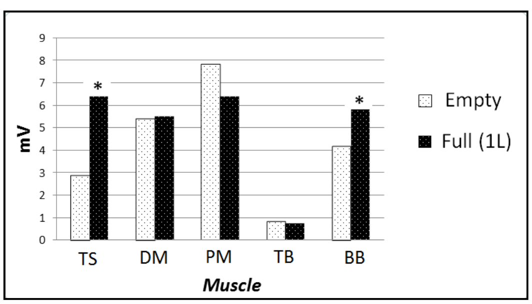

Figure 1: Comparison of muscle activity in different conditions. Average RMS values in millivolts (mV).
*Significance: $p < 0.05$

ANALYSIS OF HEART RATE VARIATION IN POSUTURE CONTOROL AND CONVERSION

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AIM: In physical therapy, physiotherapist uses some kind of postures subjects abilities and therapy purpose. At start and finish of therapeutic exercise and postural changing widely, they check a vital signs heart rate and blood pressure because risk management. The aim of this study was analyzing heart rate response at conversion of many postures that were useful in therapeutic exercise.
METHODS: Subjects were seven healthy adults women (average age: 20.4 years, average height (SD): 158.0 (4.7) cm, average weight (SD): 51.5 (6.9) kg. Subjects have kept and convert 5 positions (supine, side lying, prone, all four, kneeling), and posture-keeping time was supine for 4 minutes, the attitude of the other 3 minutes. We measured their heart rate [beats/ min] in each posture holding and posture conversion. We fitted a heart rate monitor (S810i, Polar) on them and recorded their heart rate. The following data was calculated: average heart rate at each posture keeping [beats/ min], time at heart rate being stable [sec]. Wilcoxon analysis was performed using IBM SPSS ver. 19, with $p < 0.05$ being considered significant.
RESULTS: Average heart rate in each position (SD) were supine: 59.5(5.2) beats/ min, side lying: 60.9(4.2) beats/ min, prone: 61.6(6.6) beats/ min, all four: 66.6(4.9) beats/ min, kneeling: 73.0(9.8) beats/ min, respectably. On the other hand, Average time at heart rate being stable were supine: 135 (102) sec, side lying: 98.0 (37.1) sec, prone: 98.0 (38.3) sec, all fours: 96.9 (28.6) sec, kneeling: 128 (43.9) sec, there was not the significant difference.
CONCLUSION: It is necessary to consider gravitational influence at the time of the physiotherapy enforcement with keeping and the conversion of the posture. There is little posture maintenance activity against gravity in the decubitus, but the activity of antigravity muscles is necessary to keeping standing position posture. In addition, I have venous return decrease of stroke volume, a blood pressure decline by body fluid accumulating in the body lower part under gravity with the standing position that is antigravity rank as a reaction of the circulatory system, and heart rates increase, and the adjustment of the circulatory system is done by heart and the lungs region and an arterial baroreceptor reflection. The heart rate increase rate with the standing position had the report with 30% in comparison with the face up position, but a knee stood in this result, and the heart rate in the rank compared it with face up position, a lateral decubitus position, abdominal position, and the increase of approximately 20% was seen. The knee which a support base side was large, and a center of gravity was low in stood, and, in the lying keeping, the thing that I influenced to a circulatory system by asthenia, the gravity of the sympathetic system by the antigravity muscles activity like a standing position was suggested. One another, supine, side lying, prone, the position of the heart was in a low position, and being circulation of against gravity. In addition, time before a heart rate being stable thought about there not having been a difference between each posture if circulation adjustment mechanism functioned normally that I showed that I had the ability that could maintain a steady state in both posture in around two minutes from 1 and a half minutes. This study examined the influence on heart rate posture kept and converted. As a result, supine, prone, side lying replied in the decubitus equally and assumed that a decubitus and a kneeling, and it was with the reply that was different in lying.

BILATERAL ALTERATION OF KNEE MUSCLE ONSET TIME SUBSEQUENT TO UNILATERAL ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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AIM: To compare the muscle onset of the Vastus Medialis (VM) and Semitendinosus (ST) muscles between the reconstructed knee of patients with anterior cruciate ligament reconstruction (ACLR) and a control knee of healthy subjects (HS), when undergoing a perturbation of the base of support. Also we compared the healthy knee of the ACLR group with the same knee side of the HS group.
METHODS: All Participants were amateur soccer players: 25 patients with unilateral ACLR (28.3 ±7.8 years) that underwent a unilateral arthroscopic reconstruction with the same surgeon at least 7 months before the evaluation, using ipsilateral semitendinosus and gracilis graft; and 25 HS (24.2 ±2.9 years). All subjects underwent a sudden perturbation of the base of support in a controlled laboratory environment. Electromyography (EMG) of the VM and ST muscles was registered bilaterally. Muscle onset was defined as the time between the perturbation and the muscle activation, detected through the EMG analysis, and was determined as the time in which the EMG amplitude was equal or higher to the product between the average amplitude of rectified values of 500 ms previous to perturbation multiplied by three times the value of standard deviation of the same time window (Hodges & Bui, 1996). Several repetitions were recorder and averaged.
RESULTS: Significant differences for VM and ST muscle onset were observed when comparing ACLR vs. HS for both knees (Table 1)
CONCLUSION: Bilateral modification of muscle onset timing could be related to a bilateral modulation of neuromuscular control by the gamma system, in response to an altered propioceptive input (Johansson et al., 1991, Fonseca et a1., 2004). This should be considered in the evaluation and rehabilitation programs of the reconstructed patients.

Table 1
Muscle onset (ms) timing after postural perturbation in control (n=25) and ACLR (N=25) groups

	HS		ACLR	
	Reconstructed Control	Healthy Control	Reconstructed knee	Healthy knee
Vastus Medialis	67.1(±12.1)*	73.5(±13)$^{\#}$	99.9(±30.3)*	100.4(±25.9)$^{\#}$
Semitendinosus	74.5(±9.1)**	72.2(±9)$^{\#\#}$	101.7(±28.1)**	104.7(±28.1)$^{\#\#}$

Values are mean (SD)
ACLR: anterior cruciate ligament reconstruction; *p=0.007;**p=0.009; $^{\#}$=0.01;$^{\#\#}$=0.006

COMPARISON BETWEEN DOUBLE-LEG HEEL RAISE AND WALKING IN ANKLE PLANTAR FLEXOR ACTIVITY

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AIM: The purpose of this study was to determine a difference of muscle activity between double-leg heel raise (DHR) and treadmill walking.
METHODS: Thirty health males with an age of 21.5 ± 1.6 yr. (mean ± SD), a body mass of 63.6 ± 9.3 kg and a height of 171.0 ± 4.5 cm participated in this study. All subjects provided written informed consent prior to participation, and approval was granted by the Tohoku Bunka Gakuen University's Human Subjects Ethics Committee. The EMG data were acquired simultaneously from both heads of the gastrocnemius and the soleus of right side during DHR and treadmill waking. DHR conditions were maximum plantar flexion (MPF), 3/4MPF, 2/4MPF and 1/4MPF, and then walking speeds were 20, 40, 60, 80 and 100 m/min. The analog EMG signal and a foot-switch data were passed through the 16 bit A/D board and all signals were sampled at 1 kHz. EMG data were filtered with a 10Hz high-pass IIR digital filter and the zero-phase filtering approach was adopted. After the signal was full-wave rectified, moving average was calculated at 89 ms windows. For EMG data during DHR, the peak values were detected. On the other hands, we standardized EMG data in treadmill walking by each walking cycle. After calculating arithmetic mean, the peak value was detected at each subject. We compared the muscle activity of treadmill walking with DHR.
RESULTS: The muscle activity in DHR and walking significantly increased with the increment in height of heel-raise and walking speed, respectively. In the comparison between 1/4MPF and each walking speed, although it was 26.7 % that the activity of the soleus in 100 m/min walking exceeded it in DHR, the gastrocnemius lateral head was 80.0 %. The ratios, however, decreased to 23.3 % in the comparison between MPF and 100 m/min walking. In addition, in the comparison between MPF and each walking speed, it was below 3.3 % that both the activity of the soleus and the gastrocnemius medial head in walking exceeded it in DHR.
CONCLUSION: The heel raise test is often used in clinical conditions for evaluating the function of the calf muscle. The single-leg heel raise, however, were difficult for elderly persons because they decrease balance function. Therefore, double-leg heel raise was useful for the evaluation of ankle plantar flexors at clinical situation. The results of this study indicated that DHR was useful for an evaluation of the ankle plantar flexor activity necessary for walking.

Table 1: Percentage of persons above EMG activity of each plantar flexion. (n=30)

	20 m/min			40 m/min			60 m/min			80 m/min			100 m/min		
	So	Gm	Gl	So	Gm	Gl	So	Gm	Gl	So	Gm	Gl	So	Gm	Gl
1/4 MPF	6.7	0.0	6.7	3.3	3.3	20.0	3.3	6.7	30.0	10.0	3.3	56.7	26.7	20.0	80.0
2/4 MPF	0.0	0.0	6.7	0.0	0.0	10.0	3.3	6.7	13.3	6.7	6.7	36.7	23.3	10.0	70.0
3/4 MPF	3.3	0.0	3.3	0.0	3.3	6.7	0.0	3.3	10.0	0.0	3.3	23.3	10.0	3.3	33.3
MPF	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	3.3	0.0	3.3	10.0	3.3	3.3	23.3

MPF: maximum plantar flexion. So: soleus. Gm: medial head of gastrocnemius. Gl: lateral head of gastrocnemius. (%)

THE EFFECT OF CHEST WALL-STRETCHING EXERCISE ON THE HARDNESS OF INTERCOSTAL MUSCLES -EVALUATION USING SHEAR WAVE ELASTOGRAPHY-

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AIM: The chest wall-stretching exercise is a technique to reduce the hardness of the chest wall muscles, mainly the intercostal muscles (ICM), in subjects with respiratory and shoulder disorders. The aims of this study were to estimate the validity and reliability of measuring shear elastic modulus of ICM on the chest wall, and to investigate the effect of the chest wall-stretching exercise on changes in shear elastic modulus.
METHODS: 15 healthy male subjects participated in this study. The shear elastic moduli of ICM on the second and sixth intercostal space were measured using ultrasonic Shear Wave Elastography (SWE) at 6 levels of lung volume. Additionally, the chest expansion was measured at the levels of the axilla and xiphisternum. All subjects received five maneuvers of chest wall-stretching exercises. Lung volume capacity (VC) and the shear elastic modulus of ICM were measured before and after these exercises. The repeatability of measurement using ultrasonic SWE was assessed using the intra-class coefficient correlation (ICC). The relationship between the shear elastic modulus of ICM and the chest expansion was evaluated using Pearson's product-moment correlation coefficient. The Student paired t-test was used to test the differences in VC and shear elastic modulus of ICM before and after stretching exercise. Statistical significance was set at $p<0.05$.
RESULTS: The within-examiner repeatability of measuring shear elastic modulus of ICM at each intercostal space was excellent (ICC: 2nd 0.779-0.915, 6th 0.769-0.976). We found significant negative correlations between the shear elastic modulus of ICM on the second intercostal space and the chest expansion at the levels of the axilla, and between the shear elastic modulus of ICM on the sixth intercostal space and the chest expansion at the levels of xiphisternum. The shear elastic modulus of ICM at the maximal inspiratory level decreased significantly by the chest wall-stretching exercise in both second and six intercostal spaces. Additionally, these exercises increased VC significantly.
CONCLUSION: The results suggested that the measurement of shear elastic modulus of ICM using ultrasonic SWE was highly-reproducible and that the evaluation using this measurement can be a useful index for the chest wall flexibility. Moreover, the stretching exercise used in this study was shown to be effective in improvement of the hardness of ICM.

THE EFFECT OF TRANSCRANIAL DIRECT CURRENT STIMULATION ON MOTOR RELATED AREAS DURING MOTOR IMAGERY

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AIM: Previous studies have shown that anodal transcranial direct current stimulation (tDCS) modulate cortical excitability in focal areas of the brain and facilitate motor performance. However, it has remained unclear whether tDCS affect motor imagery ability. The purpose of this study was to investigate the effect of tDCS on motor related areas during motor imagery.

METHODS: Eighteen right-handed volunteers were participated in this study. Both anodal and sham tDCS was applied to left primary motor cortex (M1) with a current of 1mA for 10 min. The participants performed hand mental rotation task as motor imagery task before and after tDCS. Reaction time and error rate were analyzed and compared between before and after tDCS.

RESULTS: Reaction time after anodal tDCS was significantly shorter than before anodal ($p<0.01$) and after sham tDCS ($p<0.05$). However, reaction time between before and after sham tDCS was not significantly different. Error rate of both anodal and sham tDCS was not significantly different between before and after tDCS.

CONCLUSION: These findings suggest that anodal tDCS on motor related areas is an effective technique to modulate the cortical excitability and affect motor imagery.

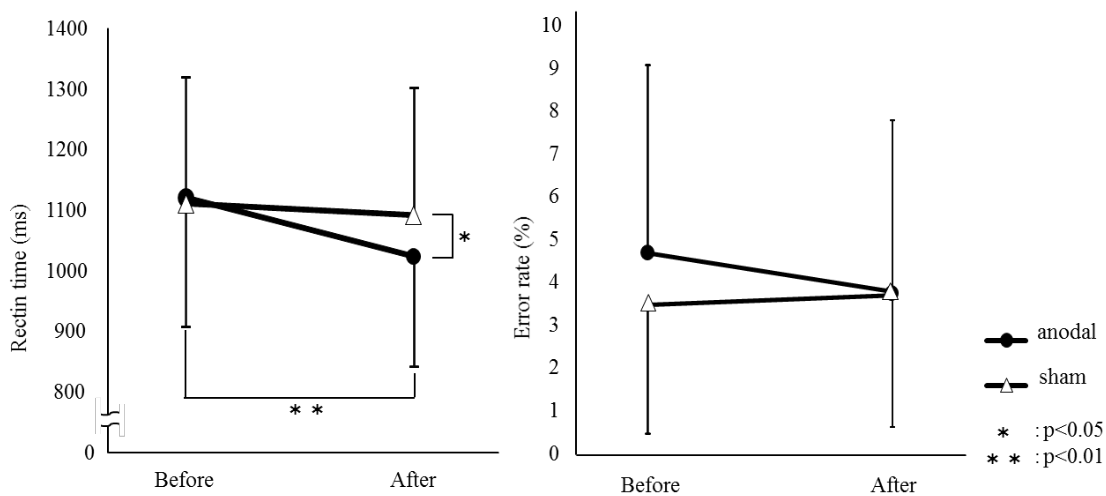

Figure 1: Reaction time and error rate of mental rotation task.

IDENTIFICATION OF MAIN FORCE DIRECTIONS OF HUMAN TRUNK MUSCLES

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AIM: The aim of the study was to identify main force directions of trunk muscles. This is of particular interest if specific training of trunk muscles is to be applied. Diagnostically, such data could also be used to identify trunk muscle co-ordination deficits and could therefore help to improve trunk muscle training of low back pain patients.
METHODS: 20 healthy men (age 35.4 ± 8.2 years) performed static isometric tests of their trunk muscles. The applied load levels were 9, 17, 34, 50, 71, 87, and 100% of their upper body weight (UBW) in 45° increments of a complete rotation (i.e. 0°: forward tilt, 45°, 90°, 135°: left sided tilt, 180°: backward tilt, -45°, -90°, -135°: right sided tilt), resulting in 56 single tasks per subject. The investigation was performed in a computerized test and training device (CTT Centaur) which allows whole body tilts up to horizontal position at any rotational angle. During the tests the upper body remains free while the lower body is secured up to pelvic height. Correct position of the subjects was controlled by using a rigid harness over the subject's shoulder that was equipped with strain gauges for visual feedback. Surface EMG (SEMG) was taken from five trunk muscles from both sides: rectus abdominis (ra), internal oblique (oi), external oblique (oe), lumbar multifidus (mf), longissimus (lo), and iliocostalis (ico) muscle (AD: 2000/s, resolution: 24 bit). The primarily polar data of each muscle were converted into Cartesian coordinates for the calculation of center of gravity co-ordinates. These rectangular co-ordinates were then transformed back into polar data, containing exact angular information for every muscle. This was done separately for every tilt angle, considering all rotation angles. The found data were compared with the expected angle of main force directions, based on muscle fiber directions underneath the electrodes which were placed according the SENIAM recommendations.
RESULTS: The calculated main force directions for all investigated trunk muscles deviate from the expected angles. For ra we expected (e) the maximum to be found at 180° rotation angle but it was found (f) at ± 170° rotation angles (10° deviation from sagittal plane, (dsp)). The other trunk muscles revealed the following data: oi e: ±90° vs. f: ±141° (39° dsp), oe e: ± 135° vs. f: ±153° (27° dsp), mf e: 0° vs. f: ±48° (32° dsp), lo e: 0° vs. f: ±44° (36° dsp), and ico e: ±45° vs. f: ±104° (76° dsp).
CONCLUSION: In part, the found differences from the expected main force directions are considerable, requiring modification of established training regimes. Nevertheless, if forces in sagittal plane are applied most trunk muscles can be trained at reasonable levels, but ico requires separate force directions, i.e. forces acting almost in frontal plane. If trunk muscle training also includes sideways directions the found main force angles should be considered.

RELATIONS OF FORWARD INCLINATION ANGLE OF THE LEGS AND CENTER OF GRAVITY MOVEMENT DURING SIT-TO-STAND

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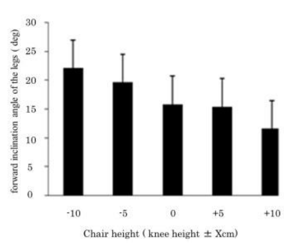
OBJECTIVE: The motion of standing up from a chair affects the act of standing up because the forward inclination angle of the legs at the start of the movement determines the base of support. This forward inclination angle of the legs is also known to vary according to the chair height. This study examines the selection criteria for standing strategies on the basis of changes in the center of gravity trajectory and forward inclination angle of the legs when the chair height is changed.

METHODS: Ten young subjects participated in this study. The subjects were asked to stand up from a chair that had no backrest or armrests. The chair height was determined on the basis of the knee height (KH) when the forward inclination angle of the legs was 0°. The subjects were asked to stand up from the chair at their preferred speed at five different heights (KH +0 cm, + 5 cm, + 10 cm, −5 cm, −10 cm). The initial forward inclination angle of the legs was the angle at which it was easiest for the subjects to stand. The central position of the joint was recorded using a three-dimensional motion analysis system (MA-5000 ANIMA), and the data were used to calculate inclination angles of the trunk and legs and center of gravity. The center of gravity was calculated from 10 points on the body using a four-segment rigid link model.

RESULTS: The forward inclination angle of the legs tended to be larger with a lower chair height (fig 1), indicating that the chair height was the main factor. However, a change in the chair height did not cause any change in the trajectory of the center of gravity. Strategies were divided into three patterns on the basis of the maximum horizontal movement, namely a stabilization pattern, a momentum transfer pattern, and a pattern corresponding to the maximum amount of forward movement of the center of gravity and chair height. No significant correlation was observed between the chair height and maximum horizontal movement, indicating that the forward inclination speed of the trunk and knee extensor strength tend to exhibit effects.

CONCLUSION: The forward inclination angle of the legs changes in response to the chair height; however, the standing strategy tended to change on the basis of the height at which it was easy for the subject to stand, suggesting that the optimal standing movement according to the chair cannot be determined from the forward inclination angle of the legs alone. There are limitations to the maximum displacement of the forward inclination angle of the trunk if the chair is low even when the forward inclination angle of the legs is large and a stabilization strategy can be easily selected. This suggests that people are forced to adopt a momentum transfer strategy when the knee extensor strength and forward inclination speed of the trunk are increased.

Figure 1: forward inclination angle of the legs at different chair height.



ACUTE EFFECT OF KINESTHETIC ILLUSION INDUCED BY VISUAL STIMULATION ON THE UPPER-LIMB VOLUNTARY MOVEMENT AFTER STROKE: 2 CASE REPORTS

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AIM: We have demonstrated that a kinesthetic illusion (KI) can be evoked by means of a visual stimulation. Furthermore, the corticospinal tract excitability is facilitated and motor associated cortex activation during KI was revealed. Movements of the paretic hand are associated with unbalanced interhemispheric inhibition, we applied KI to the two stroke patients. Therefore, the present study reported the acute effect on a movement function in those patients.
METHODS: Two patients with cerebral infarction participated in this study (Table 1). The subjects were instructed to watch a monitor, which displayed a movie that repeatedly showed an inverted non-paretic finger movement (flexion and extension) for 20 minutes. The monitor was placed on the subjects' distal forearm to induce a KI. The starting position angle, the maximum flexion, and the extension angle of metacarpophalangeal joint, the proximal, and distal interphalangeal joints of the paretic index finger were measured, with all measurements obtained before (pre-test) and after (post-test) the KI intervention. The angle of movement arc (AMA) were obtained from those angles. In addition, subjects were asked about the vividness of the illusory sensation evoked by the visual stimulation.
RESULTS: In both subjects, post-test AMA was greater than pre-test AMA. Additionally, the subjects reported that watching the movie induced a vivid kinesthetic sensation of finger movement.
CONCLUSION: The KI induced by watching a movie is apparently similar to movie observation; however, our previous research showed that the motor-related areas of the frontoparietal cortex, insula, and striatum are more markedly activated during KI than during simple movie observation. Furthermore, the subjects reported a strong feeling as if they were moving their own hand while watching a movie that induced KI. Hence, we hypothesize that cerebral network activation during the induction of the KI possibly promotes the voluntary movement of a paretic finger after stroke.

RT

	Parafilm Mastication	Parafilm Mastication	Raisins Mastication	Raisins Mastication	Peanuts Mastication	LM	Peanuts Mastication	RM
Fig. 2: Bland-Altman plot for MVC extensions.	RT	LM	LT	RM	RT	LT	RM	RM
Fig. 1: SIR of subMVC (mean±SD, * p<0.05).	LT	RT	LM	RT	RT	RM	LM	LM

LT

EFFECT OF WEIGHT-BEARING STANDING-SHAKING-BOARD EXERCISE IN COMBINATION WITH ELECTRICAL MUSCLE STIMULATION ON MUSCLE STRENGTH, GAIT AND BALANCE IN ELDERLY SUBJECTS

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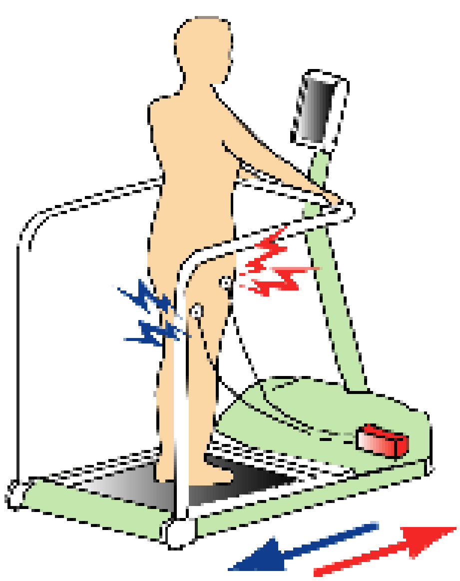
AIM: The purpose of this study was to investigate the effect of weight-bearing standing-shaking-board exercise in combination with electrical muscle stimulation on muscle strength, gait, and balance in elderly subjects.
METHODS: The subjects included in this study were 10 adults. They were divided into training and control groups. The training group performed the combination training using a shaking board device (Shaking Board, OG Giken Co. Ltd., Okayama, Japan) and electrical stimulation. During the exercise, low-frequency stimulation waves were applied to the anterior region of the thigh at anterior turning point and to the posterior region of the thigh at posterior turning point (Fig. 1). Electrical stimulation was given for 20 min per session, 3 times a week for 3 months. The subjects were tested before the trial, at the end of the trial, and 4 months after the trial for muscle strength of the lower extremity, gait ability, and standing balance.
RESULTS: At the end of the trial, the training group showed improved performance in all the tests. Four months after the trial, the training group showed decreased performance in all the tests and the results were same as before the trial(Fig. 2). In contrast, there were no significant improvements in performance in any of the tests in the control group.
CONCLUSION: These results suggest that weight-bearing standing-shaking-board exercise in combination with electrical muscle stimulation can improve muscle strength of the lower extremity and improve gait and balance in elderly subjects.
ACKNOWLEDGEMENT: Supported by Grant-in-Aid for Scientific Research (B) 25282180



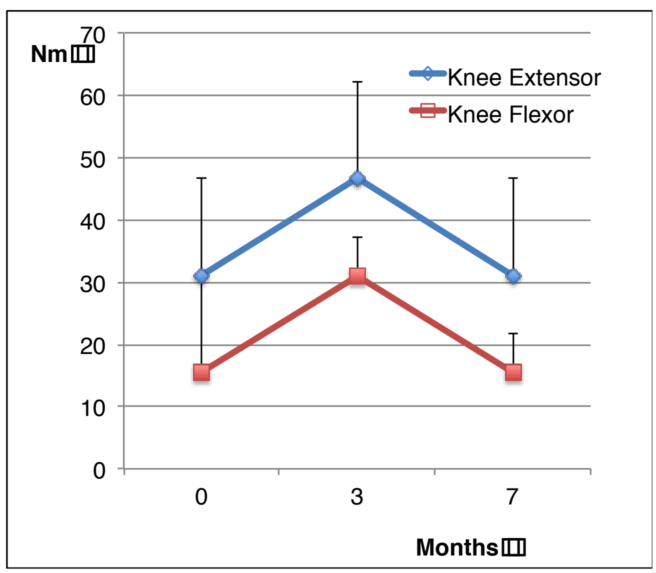


Figure 1: Shaking board device **Figure 2:** Muscle strength measurement

ISOGAI DYNAMIC THERAPY MODIFIES HEALTHY YOUNG ADULT'S SPINAL LORDOSIS ANGLE IN STANDING

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AIM: Isogai dynamic therapy is a Japanese manual therapeutic method. The therapy assumes that an abnormal orientation of the pelvis is one source of various health conditions, including such as headache, neck pain, and low back pain. A key tenet of Isogai dynamic therapy is that an anterior adjustment of a posteriorly tilting pelvis would modify the spinal curvatures, resulting in an improved body balance [1]. Although the Isogai dynamic therapy has been practiced for over 70 years, quantitative evidence for its effectiveness is still lacking. Therefore, the purpose of this initial study in healthy individuals was to quantify the effect of the anterior tilt of the pelvis on the angle of the spinal curvatures.
METHODS: Nine healthy male adults (Age: 29.3 ± 8.1years; Height: 1.75 ± 0.1m; Mass: 70.0 ± 9.7kg) participated in this study. First, the subjects were instructed to assume a normal, erect standing position, and the spinal curvatures, i.e., the thoracic kyphosis and lumbar lordosis, were measured three times using Spinal Mouse (Idiag AG) [2]. Next, a certified Isogai dynamic therapist with 12.5 years of clinical practice adjusted the subject's pelvic position one time each with four different types of manual manipulations to make the pelvis more anteriorly tilt. The same technician then re-measured spinal curvatures. The thoracic kyphosis and lumbar lordosis angles were averaged across the three trials. A paired sample t-test was used to determine the effects of the manipulations on the thoracic kyphosis and lumbar lordosis.
RESULTS: Isogai dynamic therapy increased lumbar lordosis to 25.1° (± 5.9) from 21.2° (± 6.9) ($p < 0.05$) but did not affect thoracic kyphosis (before: 36.8 ± 6.9°; after: 36.1 ± 6.5°).
CONCLUSION: These findings show that the Isogai dynamic therapy can increase the lumbar lordosis angle by tilting the pelvis anteriorly in healthy young adults. The increase in the lumbar lordosis angle can shift the body's center of the mass posteriorly [3]. A more anteriorly tilted pelvis is associated with lower activation of the trunk extensor muscles that support the trunk during standing [2]. Presumed benefit of a reduction in back extensor muscle activity is a delay in the onset of fatigue during prolonged standing and an improved ability to maintain balance during gait [2].
ACKNOWLEDGEMENT: Funded by the JSPS KAKENHI Grant-in-Aid for Challenging Exploratory Research 24650451.

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ARE THERE DIFFERENCES IN MUSCLE ACTIVITY IN VARIED LOWER LIMB POSITIONS DURING THE PELVIC DROP EXERCISE?

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AIM: Evaluate the effect of lower limb rotation on the recruitment of the gluteus medius muscle during the pelvic drop exercise.
METHODS: Seventeen healthy subjects (age = 24.4 ± 2.8 years) performed the pelvic drop exercise with the lower limb positioned in lateral, medial and neutral rotation. The electromyographic activity of the gluteus medius muscle (GM), tensor fascia latae (TFL) and quadratus lumborum (QL) was assessed using surface electromyography. The data were synchronized with an electrogoniometer.
RESULTS: Analysis of variance with repeated measures (ANOVA) showed a significant increase in activity of GM in medial and neutral rotation when compared with lateral rotation. Between the medial and neutral rotation, there was no difference. The GM activity was not higher than TFL activity (GM / TFL) in any of the evaluated rotations. When compared to QL, the GM (GM / QL) showed significant increase in muscle activity in medial and neutral rotation.
CONCLUSION: Pelvic drop exercises are more efficient to activate the gluteus medius muscle when the lower limb is in neutral position and medial rotation.

EFFECTS OF REHABILITATION TRAINING WITH A WEARABLE ASSIST TYPE ROBOT ON BASIC MOVEMENT ABILITIES OF HEMIPLEGIC PATIENTS AFTER STROKE

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AIM: In recent years, robot assisted technologies have gathered attention in rehabilitation fields, especially for patients with disabilities related to walking after stroke. Hybrid Assisted limbL(HAL®) is a biological electrical potential triggered wearable assist type rehabilitation robot. The evidence for therapeutic effects of HAL are gradually being recognized. The previous study focused on chronic patients and walking or daily living ability, however, it is unclear regarding the kinematic data of hemiplegic patients' movements. The purpose of this study is to clarify the effects of basic movement training with HAL for hemiplegic patients after stroke in restorative stage and analyze the kinematic data.

METHODS: Six hemiplegic patients after stroke in a rehabilitation hospital participated in this study after giving their written informed consent to this research. A randomized crossover design was used in this research. We gave basic movement training (sit to stand, standing balance, and walking) with HAL(60 minutes per day, 2 times per week) instead of the usual physical therapy (+HAL phase) and only conventional rehabilitation therapy (RH phase) 1 week respectively. We evaluated the speed of the basic movement (sit to stand and 10 m walking) and maximum amount of loading pressure (kg/cm2) on the affected limb (during sit-to-sand task and lateral weight shifting with standing) before and after each phase. The Mann–Whitney U test was used to compare the improvement ratio between each phase. The experimental protocol was approved by the medical-ethical committee at the hospital participants stayed in.

RESULTS: Regarding parameters of the basic movements, sit-to-stand speed and maximum amount of loading pressure on the affected limb (during sit-to-stand and lateral weight shifting) were more improved at the + HAL phase than at the RH phase ($p<0.05$). There are no different between each phase about the effect of the walking speed. At the +HAL phase, two patients became able to do the standing balance tasks without standing aid anew. The other two patients became able to mount and descend stairs with a normal step pattern from by one step at a time pattern.

CONCLUSION: The present study revealed the training with HAL affected the sit-to-stand movement speed and load carrying ability. It could be considered HAL has an assisting or stabilizing function against the loading. Patients after stroke with hemi-paralysis easily get into a pattern that avoids loading on the affected lower limb. Their causes are impairment of the paretic lower limb and its weakness. Whereas, HAL assists extension torque at the knee and hip joint against the loading. These functions enable patients to complete the tasks smoothly and facilitate the motor learning. On the other hand, the cause of the effect on the walking ability decreasing was walking ability needs not only the function of loading on the paretic limb but also complex weight shift ability. Further studies are needed in order to improve walking ability, besides loading ability.

EFFECT OF TOE CONTACT WITH THE GROUND ON KNEE AND TRUNK MOVEMENT DURING WALKING: A PRELIMINARY STUDY

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AIM: Reduced toe function during walking may affect an individual's gait pattern and increase mechanical stress on the knee and trunk. This study aimed to investigate the effect of toe contact with the ground on knee and trunk movement during walking.

METHODS: Nine healthy volunteers (6 men, 3 women; age, 21.2 ± 0.7 years) who participated in the study were asked to walk barefoot at a preferred but constant speed along a linear pathway under 2 conditions: normal gait (control), and with inhibited toe flexion to prevent weight bearing on toes (intervention). Accelerations at the knee (Kn) and lumbar (Lx) spine were assessed using triaxial accelerometers, which were mounted on the right fibular head and the spinous process of L3. Acceleration vectors were oriented such that the cranial, anterior, and right-sided deviations were positive in the vertical, forward, and lateral axes, respectively. Heel strike was confirmed with the use of pressure sensors applied under both heels and toe flexion was inhibited with use of kinesiology tape applied along the toe extensors at the terminal extension position. Reduced weight bearing on the toes was confirmed using a force platform. The participants were instructed to initiate walking with the left foot and data from the sixth and eighth steps, both of which were in the stance phase on the right, were recorded. The same protocol was repeated 3 times for each condition. The sampling rate was 1 kHz. Peak accelerations in the positive and negative directions (vertical: PAv+/PAv-, forward: PAf+/PAf-, lateral: Pal+/Pal-) and the root mean square (RMS; vertical: RMSv, forward: RMSf, lateral: RMSl) were calculated, and mean values of these parameters were calculated over the 3 trials for each condition. Between-condition differences were assessed using the Wilcoxon signed-rank test. This study was approved by the local ethics committee.

RESULTS: The walking speed of the participants during the control and intervention conditions was 4.33 km/h ± 2.71% and 4.29 km/h ± 2.65%, respectively. The LxRMSv and LxRMSl for the intervention condition [median, 1.038 (maximum, 1.766; minimum, 0.674) m/s^2; median, 0.854 (maximum, 1.196; minimum, 0.729) m/s^2, respectively] were higher than those for the control condition [median, 0.858 (maximum, 1.438; minimum, 0.644) m/s^2; median, 0.821 (maximum, 1.166; minimum, 0.646) m/s^2 (p = 0.046 and 0.013, respectively)] and the LxPAf- [med, 5.940 (maximum, 13.777; minimum, 2.950) m/s^2)] for the intervention condition was lower than that for the control condition [median, 4.708 (maximum, 10.569; minimum; 2.313) m/s^2) (p = 0.050)]. The KnRMSv for the intervention condition [median, 2.127 (maximum, 3.931; minimum, 1.707) m/s^2] were higher than that for the control condition [median, 2.051 (maximum, 3.568; minimum, 1.471) (p = 0.055)].

CONCLUSION: Insufficient toe contact resulted in increased vertical stress and lateral perturbation of the low back during walking, suggesting that it leads to increased mechanical stress on the facet joints and low back muscles, and possibly causing low back pain. Further, it may cause increased vertical stress at the knee joint. These results may provide further insight into factors associated with osteoarthritis.

DEVELOPMENT OF A GAIT ASSISTANCE SYSTEM FOR PARKINSON'S DISEASE SUFFERERS

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AIM: It has been recognized that movements of Parkinson's disease (PD) sufferers are characterized by the loss of smooth shift of their weights. Most of PD sufferers with this phenomenon need assistance with walking. It has been believed that this phenomenon is attributed to his/her weight, which is left in the rear during movements. This study was designed to develop a system, which senses postures of a person who uses it and assists his/her movements.
METHODS (OUTLINE OF SYSTEM): As a drive system, a commercially available electric wheelchair was altered. The user puts his hands on the grips in the rear of the system when walking. His postures with gait were measured by means of two laser range finders (LRFs), which were furnished with the rear of the system. LRF, a two-dimensional measuring area sensor, enables information about the distance to objects to be acquired at a wide viewing angle. The data collected with LRFs are transmitted to a personal computer (PC) via USB and given feedback to the drive control program. The LRF measuring period was 100 msec. One of the LRFs was put perpendicular to the floor for the measurement of postures of the upper half of his/her body, and the other was put at a level with the floor for the measurement at his/her foot down. The LRF put at the user's foot down detected his/her foot when he/she took a step forward. The system was designed to move the distance forward, which he/she stepped into. To avoid a violent fall, the system was designed to stop drive when he/she failed to catch his/her front foot in. When he/she caught his/her front foot slipping out on either side of the system, the system was designed to go round in the opposite direction to that in which he/she caught his/her front foot; the system was designed to constantly catch him/her right behind the system.
This study was performed under approval from the Ethics Committee, Tokyo Metropolitan University.
RESULTS: The two PD sufferers enabled the attainment of a stable gait.
CONCLUSION: Although muscle strength was maintained in PD sufferers, it is frequently difficult for them to change movements and to shift their weights. It was considered that the present system enabled gait assistance by facilitating smooth shift of PD sufferers' weights.

A GAIT ASSISTANCE SYSTEM

CONTROL OF AN ARM ROBOT USING DECODED MUSCLE ACTIVITIES FROM ELECTROCORTICOGRAMS

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AIM: We proposed the neuro-muscular interface is a method to control a robot arm using electromyograms (EMG) decoded from electrocorticograms (ECoG) in Primate Primary Motor Cortex.
METHODS: We used sparse linear regression to find the best fit between the band-passed ECoGs and EMGs. We also predicted 4 DOF angle of arm from the decoded 8 EMGs using 3-layer neural networks.
RESULTS: The correlation coefficient (CC) and normalized root-mean-square error (nRMSE) between the actual and predicted EMGs were used to quantify the information extracted directly from ECoGs related to muscle activity. Grand averages and standard error of the mean for each muscle ranged between 0.88 ± 0.009 for CC and 0.42 ± 0.007 for nRMSE. Average and standard error of CC for reconstruction of trajectories using the predicted EMG signals were 0.82 ± 0.12. Average and standard error of nRMSE for each angle ranged 0.12 ± 0.01. The reconstructed trajectories showed good correlation with the actual arm movement (Fig. 1).
CONCLUSION: This study describes a novel attempt to predict joint angles and multiple muscle activities from a small number of ECoG signals. This approach offers important insight regarding the presence of ample information in ECoGs to predict time-varying muscle activities, whereas previous ECoG-based studies have tried to classify direction or intention of movement. The results clearly demonstrate that muscle activities time series and trial-to-trial variations of finger, hand, and arm muscles can be predicted from ECoG signals. Finally, joint angles can also estimated from the predicted EMG signals. This creates remarkable benefits, which would contribute to the realization of ECoG-based prosthetics.
ACKNOWLEDGEMENT: This study was 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.

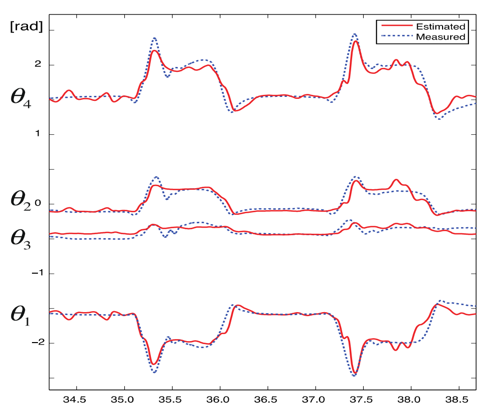

Figure 1: Estimated joint angle using decoded EMGs from ECoGs

Friday July 18th 2014

Oral Sessions

Electromyography and kinematics of the upper extremity in a clinical perspective

Biomechanics and electromyography have for the lower extremities to some degree been standardized and are well incorporated in clinical settings mainly as gait labs that are of great value for many specific patients groups. In contrast, such clinically relevant and standardized equipment and protocols for kinetics and motor control of the upper extremity are currently scarce. However, this is a growing research area that attracts attention within both ISB and ISEK oriented research groups.

Stability of the shoulder girdle is mainly provided by the scapula stabilizing muscles and affect both head and shoulder stability and thereby precision of visions and upper extremity kinematics. Therefore scapula stabilization and its underlying role in development of symptoms in the upper extremities is a major focus area. Naturally, it is also a large part of this ISB/ISEK session dedicated to invited presentations which together provide a multidisciplinary approach to current clinically relevant upper extremity research.

NEUROMUSCULAR FUNCTION IN PATIENTS WITH SUBACROMIAL IMPINGEMENT SYNDROME AND CLINICAL ASSESSMENT OF SCAPULAR KINEMATICS

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AIMS: The aims were to understand potential mechanisms for impairment in the neuromuscular function of the scapular stabilisers in a general patient sample with SIS, and to assess the clinimetric properties of clinical assessment methods of scapular kinematics as important aspects for optimising effect measures of treatment in order to improve clinical guidelines in this area.
METHODS: Scapular muscle activity was examined, 1) during a voluntary arm movement task and 2) selective activation tasks during sessions with and without on-line biofeedback, in a general population consisting of 16 SIS patients and 15 controls (No-SIS). Furthermore, 3) a systematic review was conducted of all available clinical scapular assessment methods and their associated clinimetric results, and the **CO**nsensus-based **S**tandards for the selection of health **M**easurement **IN**struments (COSMIN) checklist was used to critically assess the quality of the involved studies for each measurement property.
RESULTS: 1) In spite of a general tendency for higher scapular muscle activity among SIS patients, between-group differences were not significant, either in activity level, ratio of activation between muscles or in the time of activity onset of the muscles, 2) Using the defined criteria of: (i) a selective activation above 12% of maximum activation during which other muscle parts were below 1.5% activity or (ii) an activation ratio above 95% of the total activity of all muscles, significantly fewer SIS subjects than No-SIS subjects achieved selective activation of individual scapular muscle compartments without on-line biofeedback of muscle activity from each muscle compartment of the trapezius muscle, 3) On the basis of 46 included articles, a total of 55 names of clinical assessment methods were identified. Thirty-one of the studies included in the quality assessment of the reliability and validity domains were classified as 'fair' (55%) to 'poor' (45%), with only one study being rated as 'good'. Few of the assessment methods in the included studies with 'fair' or 'good' measurement property ratings demonstrated acceptable results for reliability and validity. Responsiveness was not investigated.
CONCLUSION: 1) No between-group differences of SIS and No-SIS subjects in neuromuscular activity of scapular stabilising muscles were observed, 2) and when provided with visual EMG feedback, the SIS group performed equally well as the No-SIS group, However, when assessing the neuromuscular function with and without the use of biofeedback, the findings show that without biofeedback, the SIS group had a lower scapular muscle control, 3) When addressing the possibility for measuring scapular kinematics clinically, the findings show a substantially larger number of clinical assessment methods for scapular position and function than previously reported. None of the included clinical assessment methods had been examined for all three domains: reliability, validity (diagnostic accuracy), as well as responsiveness. Based on these results, the current findings question the generalisability of current rehabilitation guidelines to the general population with SIS, however, SIS patients may benefit from biofeedback training. Lastly, these results indicate that very few clinical assessment methods have sufficient clinimetric properties that can be recommended for clinical use.

INCREASED WRIST MUSCLE ACTIVATION IN STROKE PATIENTS AT REST

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AIM: Spasticity after a stroke is a common and disabling condition in which the inability to reduce muscle activation at rest may play a key role (Burne et al. *JNNP*, 2005). Quantification of increased muscle activation at rest by EMG alone is difficult because of absence of an absolute reference. In this study we identify increased muscle activation in stroke patients at rest, by differentiation of EMG-noise, i.e. a part that <u>does not</u> relate to the joint moment and true muscle activation that <u>does</u> relate to the joint moment, using an EMG driven biomechanical model of the wrist.
METHODS: Subjects and patients were instructed to relax. Flexion and extension rotations were imposed at the wrist over the full range of motion in 32 chronic Stroke patients (58.5 years, SD 13.1) and 14 healthy subjects (49.4 years, SD 15.1). Wrist position, wrist torque and surface EMG (Delsys Bagnoli-8) of the flexor carpi radialis (*FCR*) and the extensor carpi radialis (*ECR*) were recorded at 2048 Hz. EMG was off-line rectified. All signals were low pass filtered (20Hz, 3rd order Butterworth). Wrist velocity and acceleration were derived from wrist position. A non-linear neuromuscular model including passive visco-elasticity and an active Hill-type muscle model (De Vlugt et al. *J. Neuro. Eng. Rehab.* 2010) was used to predict *FCR* and *ECR* muscle force from EMG simultaneously. Thirteen model parameters (6 for each muscle and wrist inertia) were optimized by fitting the estimated wrist torque to the recorded wrist torque.
RESULTS: In relaxed conditions, the *ECR* force was increased in stroke patients when compared to controls (Fig. 1). The *FCR* force was equal in both stroke patients and controls.
CONCLUSION: *ECR* and *FCR* forces at relaxed conditions can be quantified separately from voluntary and reflexive muscle forces to wrist joint torque. The *ECR* activation at relaxed conditions was found to be increased in the stroke patient group. Increased muscle activation in relaxed conditions is responsible for increased wrist stiffness. For the clinician the application of an EMG driven biomechanical model of the wrist offers a quantitative means for targeted treatment of joint stiffness for each patient.
ACKNOWLEDGEMENT: This research is supported by The Netherlands Organization for Health Research and Development and the Dutch Technology Foundation. We thank the Explicit-Stroke group for sharing their data.

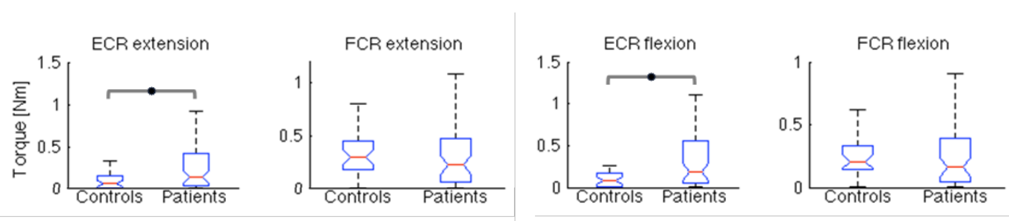
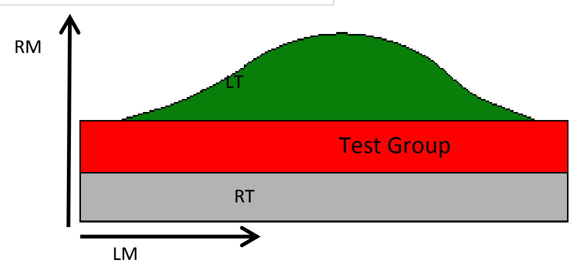


Fig
distribution at relaxed conditions of the *ECR* and the *FCR* during a Ramp and Hold *extension* or *flexion* over the full range of motion. Significant differences between controls and patients indicated by black dot



MOTOR CONTROL OF THE SHOULDER GIRDLE

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AIM: The objectives are to review motor adaptations of the shoulder region in a clinical perspective. The focus is put on work- and sports-related musculoskeletal disorders bridging the gap between ergonomics and sports science.
METHODS: Surface electromyography (SEMG) from the trapezius muscle (upper, middle and lower part), surrounding muscles (deltoideus anterior, deltoideus medialis, infraspinatus, serratus anterior) anterior and 3D kinematics of the upper arm were recorded in static and dynamic conditions in pain-free as well as painful conditions. Experimental pain was induced exogenously (eccentric exercise) and endogenously (injection of hypertonic saline). Further, patients suffering from sub-chronic/chronic shoulder pain were investigated in cross-sectional and prospective designs. Both induced and voluntary muscle activation were performed, i.e., H reflex and bipolar/high-density SEMG recordings. Linear and non-linear analyses of the changes in motor control were conducted to assess motor adaptations in relation to soreness and pain stages.
RESULTS: The trapezius H reflex is inhibited and the spatial activation of the trapezius sub-divisions is changed (increased amplitude and normalized mutual information) in presence of delayed onset muscle soreness. The spatial activation of the upper trapezius is also changed (shift towards caudal part) in presence of experimental muscle pain. The synergistic action of neck-shoulder muscles is altered in elite swimmers suffering from shoulder pain. In chronic pain condition, a more static activation and less variable activation ratio of the muscles of the shoulder girdle is found among butchers. For the upper arm, larger range of motion is reported in acute and chronic pain conditions. On the contrary, the size of variability is respectively smaller and larger in presence of experimental and chronic pain.
CONCLUSION: The assessment of motor adaptations in work and sports-related conditions can be used to benchmark the pain status and identify early signs indicating the development of musculoskeletal disorders. Further, motor variability is found to be an important parameter in ergonomics and sports. Future studies should investigate the potential benefit of inducing motor variability in occupational and sport settings as a mean to prevent disorders in the shoulder girdle.
ACKNOWLEDGEMENT: This work was partly supported by grants from the Ministry of Culture Committee on Sports Research in Denmark and the Danish Rheumatism Association.

SHOULDER MUSCLE FUNCTIONAL CONNECTIVITY IN PEOPLE WITH CHRONIC NECK/SHOULDER PAIN AND HEALTHY CONTROLS DURING A REPETITIVE POINTING TASK

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AIM: Describe relationships between activation patterns of neck/shoulder muscles during a repetitive upper limb task in persons with chronic neck/shoulder pain and healthy controls.
METHODS: A group of adult volunteers with chronic neck/shoulder pain (intensity > 3/10, duration > 3 months) and a matched control group (n=16 each) participated in the study. They performed a repetitive forward-backward pointing task (one movement/s) at shoulder height, while seated. Bipolar surface electromyography (EMG) was recorded during the last 30s of the 1min task. Data was sampled at 1080Hz from the Upper and Lower Trapezius (UT, LT), Infraspinatus (IN), Supraspinatus (SU) and Anterior Deltoid (AD). Functional connectivity between pairs of muscles was computed over consecutive 500ms blocks using the Mutual Information technique, and averaged over the 30s trials. Group comparisons were statistically assessed using independent t-tests with significance set at $p < 0.05$.
RESULTS: As indicated in Table 1 with values of Mutual Information, the Pain group displayed significantly lower SU-UT functional connectivity and conversely, significantly higher SU-IN functional connectivity.
CONCLUSION: The behavior of the supraspinatus is different in people with neck/shoulder pain. We have previously shown that during the same experimental task performed while standing, SU activity amplitude was greater in the Pain group, suggesting an increased attempt to stabilize the painful shoulder. This is supported by results of the present study, where lower SU-UT and higher SU-IN functional connectivity could indicate that the supraspinatus' role as a rotator cuff and shoulder joint stabilizer is prioritized over assisting scapula elevation and abduction during shoulder height tasks in people with pain.
ACKNOWLEDGEMENT: This study was supported by the Canada Foundation for Innovation and the Quebec Institut de recherche Robert-Sauvé en santé et sécurité du travail.

Table 1. Functional Connectivity (Mutual Information) in the 10 neck/shoulder muscle pairs during a repetitive pointing task in Control and Pain groups (mean (SD)). *: $p < 0.05$

Muscle pair	Mutual Information (mean (SD))		Group effect (p-value)
	Control	Pain	
SU-AD	0.024 (0.015)	0.025 (0.026)	0.977
SU-UT	0.172 (0.108)	0.043 (0.03)	0.0001*
SU-LT	0.036 (0.013)	0.036 (0.031)	0.965
SU-IN	0.027 (0.009)	0.071 (0.069)	0.023*
UT-AD	0.016 (0.004)	0.019 (0.020)	0.554
UT-LT	0.034 (0.018)	0.038 (0.033)	0.667
UT-IN	0.028 (0.021)	0.029 (0.012)	0.964
LT-IN	0.032 (0.019)	0.031 (0.02)	0.914
LT-AD	0.024 (0.017)	0.026 (0.021)	0.783
IN-AD	0.021 (0.024)	0.035 (0.088)	0.536

FATIGUE RELATED CHANGE IN ACTIVATION RATIO BETWEEN PARTS OF TRAPEZIUS IN SUBJECTS WITH AND WITHOUT PAIN

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AIM: This study evaluated, in subjects with or without shoulder neck pain, load sharing among the scapula stabilizing parts of the trapezius muscle and the effect of fatigue induced by a submaximal shoulder elevation maintained to task failure.

METHODS: Ten cases suffering from shoulder neck pain and ten healthy controls, group matched on age and gender, were included in the study. Surface electromyography (EMG) was recorded unilaterally from the upper, middle and lower sections of the trapezius. Subjects were seated in a rigid frame and shoulder elevation force was recorded by transducers, applied over the acromion of both shoulders. Force and EMG signals were sampled at 2000 Hz, stored and force provided as visual feedback to the subject. Shoulder elevation maximal voluntary contraction (MVC) was recorded. Subjects then maintained a bilateral 30% MVC contraction until task failure. During the 30% MVC, perceived exertion (RPE) was rated and a brief MVC was performed each minute. Shoulder pain was rated on a 10 cm visual analogue scale (VAS) before and after the sustained contraction. EMG for all three muscle parts was analyzed for 20-s periods between the MVCs. Root mean square (RMS) and mean power frequency (MPF) were calculated. Ratios of upper to middle and upper to lower trapezius RMS EMG were calculated and normalized to the first minute values. Time to task failure was normalized as 100%.

RESULTS: Cases and controls had a mean (SD) age of 36.2 (12.5) years and 38.5 (15.7) years, and a Body Mass Index of 23.5 (2.0) and 23.2 (2.3), respectively. Mean (SD) of VAS was significantly higher and MVC significantly lower for cases (16.0 (14.4) mm and 546 (162) N, respectively) compared to controls (2.1 (3.9) mm and 667 (194) N, respectively).

Endurance time was similar for cases and controls (7 and 8.5 minutes, respectively) and mean RPE at task failure was 10 for both groups, while pain increased to significantly higher level for cases (54.8 (29.0) mm) than for controls 14.1 (12.2) mm). RMS EMG in upper trapezius showed a significant increase from 169 (76) μV at start to 251 (133) μV at task failure, while it remained unchanged for middle and lower trapezius. In accordance, the normalized activation ratios for both upper/middle trapezius and upper/lower trapezius increased significantly for the whole group. However, there were no differences between cases and controls. Similarly, for the whole group MPF decreased significantly in upper trapezius from 58.8 (7.4) Hz at start to 54.3 (9.9) Hz at task failure while no change was seen for middle and lower trapezius or between cases and controls.

CONCLUSION: The main finding in the study was the selective signs of fatigue development in the upper trapezius with a decrease in MPF and an increase in activation resulting in a changed activation ratio between parts of trapezius. Surprisingly, no evidence was found of an influence of pain status on spatial activation or temporal development of fatigue.

Special Session: Neuromechanics of muscle coordination (Sala 1LM 09.00-11.00)

Organizer:

François Hug, CCRE Spine, The University of Queensland

The redundancy of the musculoskeletal system implies vast degrees of freedom. Consequently, a given joint moment can be theoretically produced by an infinite number of muscle force combinations. The question of how the central nervous system controls movements that require coordinating a large number of degrees of freedom is central to the understanding of motor control, for design robotic and prosthetic systems that mimic or restore human movement, and for the improvement of rehabilitation programs.

In this session, muscle coordination will be discussed from both a neural control perspective (muscle synergies) and a biomechanical perspective (load sharing strategies between muscles). Our contention is that the control of movement can be better understood by combining information about the neural command and the result of this command in terms of muscle force and load sharing strategies.

MUSCLE SYNERGIES FOR MOTOR CONTROL

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A fundamental challenge in neuroscience is understanding how the central nervous system (CNS) controls complex motor skills that require coordinating a large number of degrees-of-freedom. A long standing hypothesis is that the CNS relies on a modular architecture to simplify motor control and skill learning. In the last 15 years evidence for modularity has come from the identification of muscle synergies in different species, behaviors, and conditions. Muscle synergies, extracted from multi-muscle EMG recordings using multidimensional decomposition algorithms such as non-negative matrix factorization, factor analysis, principal component analysis, and independent component analysis, capture regularities in the spatial, temporal, and spatiotemporal organization of the muscle activation patterns. Such muscle synergies do not represent stereotyped muscle activation patterns due to loss of independent control but coordinated recruitment of groups of muscles that can be flexibly combined to achieve adequate, yet potentially suboptimal, control with a limited number of building blocks. For example, the linear combination of a small number of muscle synergies explains a large fraction of the variation in the muscle patterns recorded in human subjects during reaching, catching, and force generation. These results suggest that muscle synergies are basic modules providing a low-dimensional representation of the motor commands that exploits the inherent structure of the musculoskeletal system and of the motor tasks to simplify control.

MUSCLE SYNERGIES DETERMINE THE ADAPTABILITY TO NOVEL VISUOMOTOR TRANSFORMATION

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AIM: A long standing hypothesis is that the CNS generates motor output via flexible combinations of muscle synergies. However, to date, evidence for modularity is indirect because it derives mainly from the observation of low-dimensionality in the motor commands. Stronger evidence requires testing a causal prediction of a modular architecture. As modularity allows efficient learning by reducing the number of parameters it also constrains the control policies that can be learned with the modules. Here we relate failure of motor adaptation to synergies by characterizing adaptation to different types of virtual surgeries which are either compatible or incompatible to the subject-specific synergies. That novel approach allows to reveal whether muscle synergies determine the feasibility of motor learning.
METHODS: Subjects sat with their hand and forearm in a splint attached to a force transducer positioned on a desktop in front of them. The subjects' view of their hand was occluded by a LCD monitor displaying a virtual scene with a desktop and a spherical cursor matching the position of the hand. The task required moving the cursor to reach a target in one of eight directions in the horizontal plane. Cursor displacement was computed either from the recorded forces (force control) or the forces estimated with a linear EMG-to-force mapping of the EMGs recorded from several shoulder and elbow muscles (EMG control). Data collected from an initial block in force control were used to estimate the EMG-to-force matrix used for EMG control in the rest of the experiment and to extract time-invariant muscle synergies. Virtual surgeries were constructed by introducing a rotation in muscle space and did not affect the forces that could be generated by activation of individual muscles. However, only incompatible surgeries remapped forces associated with the synergies along a single direction in force space, thus affecting the force generation capability of a synergistic controller.
RESULTS: We found that subjects with practice significantly increased the number of successful trials during the compatible surgery but not during the incompatible one. The average initial angle error immediately after each virtual surgery was not significantly different between compatible and incompatible cases, indicating that the perturbations were properly matched. However, the learning rate after the compatible surgery was significantly higher and led to significant less errors at the end of the perturbation.
CONCLUSION: We have shown that in a virtual environment subjects were adapting significantly faster to perturbation which were compatible to the initially extracted synergies, then if they were incompatible. Thus our study has shown that muscle synergies determined the feasibility of movements in human subjects thereby providing strong support for the synergy hypothesis. In contrast to previous studies of muscle synergies reporting low-dimensionality in the motor output, we provide evidence for modularity from testing the prediction that a truly modular controller cannot easily adapt to perturbations which are incompatible with the modules. These results provide, for the first time, a validation of the prediction of a modular control architecture on learning difficulty.

SYNERGY ANALYSIS OF PRE-TREATMENT EMG DIFFERENTIATES RESPONDERS AND NON-RESPONDERS TO REHABILITATION POST-STROKE

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BACKGROUND: At least 50% of individuals post-stroke fail to respond to therapies that target walking recovery. Intrinsic physiologic differences in the capacity for motor recovery are likely present in persons post-stroke. However, currently used clinical assessments are not able to differentiate this capacity and predict response to rehabilitation.

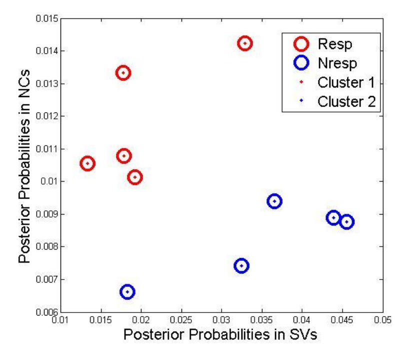
AIM: Here we explored the potential for information contained in muscle synergies constructed from EMG signals measured prior to treatment to differentiate therapeutic responders (RES) from non-responders (NRES) among persons post-stroke.

METHODS: Thirty-five individuals post-stroke participated in an 8-week rehabilitation program targeting walking recovery. Self-selected walking speed and EMG data from eight paretic leg muscles were collected pre and post-treatment. Participants were categorized as either RES or NRES based on pre-to-post-treatment changes in walking speed. Data from the five highest RES and lowest NRES were analyzed. We developed novel synergy analysis methods that investigated cycle-to-cycle variability in synergy vectors (SVs) and neural commands (NCs): 1) as a function of EMG normalization method (i.e., magnitude per trial, maximum value over all trials, unit variance per trial, and unit variance over all trials) and 2) whether or not SV weights were held constant across walking cycles. Variability in NCs was calculated after phase shifting to achieve optimal alignment. Both baseline differences and pre-post treatment changes were tested using non-parametric statistics.

RESULTS: On average, only two synergies were required to reach 90% VAF overall and three to reach 95%. For pre-treatment analysis, RES showed higher variability in phase-shifted NCs for two synergies when using magnitude per trial normalization and constant or varying SVs ($p = 0.004$). For three synergies, RES showed a tendency toward lower variability in SVs using any normalization method except maximum over all trials ($p = 0.055$). For pre-to-post-treatment changes, RES showed larger shape changes in phase-shifted NCs regardless of synergy analysis method ($p = 0.032$). Using Gaussian mixture mode distribution with only pre-treatment data, we were able to correctly classify all individuals as either RES or NRES (Figure 1).

CONCLUSION: The majority of the significant differences were revealed using the magnitude normalization per trial method with varying SVs. Our findings suggest that individuals post-stroke with the greatest ability to modulate the shapes of their pre-treatment NCs may be those most likely to respond to rehabilitation.

ACKNOWLEDGEMENT: This work supported by the Department of Veterans Affairs, Rehabilitation R&D Service (Merit Review #B29792R, Research Career Scientist #F7823S – Patten, PI) and NSF CBET 1159735 (Fregly & Patten, Co-PIs).



Control

ESTIMATION OF INDIVIDUAL MUSCLE FORCE USING ELASTOGRAPHY: NEW INSIGHTS INTO UNDERSTANDING OF LOAD SHARING STRATEGIES

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The estimation of the force produced by individual muscles remains one of the main challenge in biomechanics. To solve the muscle redundancy problem, several modelling approaches have been proposed in the literature. However, due to the lack of experimental and non-invasive methods, these models cannot be validated (Erdemir et al., Clin Biomech 2007). This presentation will aim to: 1) review a recent series of studies that aimed to estimate individual muscle force using elastography and 2) present recent works performed using elastography to provide new insight into understanding of load sharing strategies.

Elastographic techniques will be introduced. Thus, the technique called supersonic shear imaging (SSI, Bercoff et al., IEEE Trans Ultrasoun Ferroelectr Freq Control, 2004) seems particularly interesting for muscle studies performed during contraction (Shinohara et al., Muscle & Nerve, 2010).

Using tasks that mainly involve one muscle (i.e., index and little finger abduction), a study showed that the shear elastic modulus measured by SSI is linearly related to the muscle force during isometric contractions (Bouillard et al., Plos One 2011). It suggests that this measurement can be accurately used to estimate changes in muscle force. Taking advantage from this technique, load sharing strategies were analyzed among elbow flexors during isometric elbow flexions (Bouillard et al., J Biomech 2012). The increase in isometric torque was mainly explained by an increase in the muscle force of the *brachialis* for low torque levels, while it is mainly explained by an increase in muscle force of the *biceps brachii* for higher torque levels.

In addition, a further study demonstrated that fatigue does not influence the ability to estimate muscle force using elastography (Bouillard et al., J Appl Physiol 2012). Then, evidence of changes in the load sharing among quadriceps muscles was demonstrated during a prolonged isometric knee extension at a constant torque level. A high inter individual variability was found, indicating that subjects did not use the same strategy for this task. Another study investigated the effects of selective fatigue (induced by muscle stimulation of the *vastus lateralis*) on the load sharing strategies during submaximal knee extensions (Bouillard et al., J Neurophysiol 2014). It induced a decrease in the muscle force produced by this muscle to sustain a constant sub-maximal torque. However, the strategy used to compensate for this decrease differed between participants. These results are discussed in respect to the strategies used by the central nervous system to control muscle coordination during a fatiguing task.

Several experiments are currently ongoing to quantify fatigue of individual muscles within a muscle group, or to analyze the load sharing between muscles in the presence of acute pain. The next steps required to extend these works to dynamic contraction will also be presented as perspectives.

MOTOR ADAPTATIONS TO PAIN AIM TO ALTER LOADING IN PAINFUL TISSUE: IS IT TOO SIMPLISTIC?

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The effects of pain on movement have been widely studied during acute experimental pain and in clinical population. This work underpins the conclusion that we move differently when we are in pain. A basic assumption underpinning our understanding of the adaptation to movement during pain is that the aim of altered movement control is to modify the load on painful tissue to protect from further pain and/or injury. However, because of technical limitations related to the quantification of tissue load (stress), this fundamental assumption has not been directly tested. Here, we will present a comprehensive series of studies that aimed to test this assumption using an elastographic technique (Supersonic Shear Imaging, SSI). SSI was used to measure muscle shear elastic modulus as this is considered to be an index of muscle stress. The first study explored motor adaptations in response to an acute noxious stimulation during three tasks that differed in the number of available degrees of freedom. Fifteen participants performed 3 isometric force-matched tasks (single leg knee extension, single leg squat, and bilateral leg squat) in 3 conditions (Control, Pain and Washout). Pain was induced by injection of hypertonic saline into the vastus medialis (VM; left leg). During tasks with fewer degrees of freedom (knee extension and single leg squat task) there was no change in VM EMG amplitude or VM shear elastic modulus. In contrast, during the bilateral leg squat, VM EMG amplitude decreased during Pain (-32.9±15.8%; $P<0.001$). This decrease in activation was associated with reduced VM shear elastic modulus (-17.6±23.3%; $P=0.029$). This work provides evidence that when an obvious solution is available to decrease stress on painful tissue, this option is selected. The lack of adaptation observed during tasks with fewer degrees of freedom might be explained by the limited potential to redistribute stress while maintaining the same force output. In other words, it is possible that the ability to alter the load sharing between the synergist muscles (and thus to reduce stress within the painful muscle) is constrained by this task objective. To test this hypothesis, we performed a second study to determine whether stress is reduced within VM or rectus femoris (RF) during isometric knee extensions with homonymous pain, when the activity of the test muscles are theoretically not constrained by the task goal (i.e. during a vastus lateralis (VL) EMG matched task rather than force-matched task). Thirteen participants matched VL EMG amplitude corresponding to the activity recorded at 20% of MVC. Pain was induced into either VM or RF. Stress in the VM was not systematically altered when pain was induced in this muscle during the isometric VL EMG-matched knee extension task. However, stress was significantly reduced in RF (-13% compared to Control; $P=0.017$) when pain was induced in this muscle during the same VL EMG-matched knee extension task. These results highlight between-muscle differences in neuromechanical adaptation to experimental pain that are likely explained by neurophysiological constraints. In conclusion, reduced load within the painful tissue is likely to the goal of adaptation in movement during pain; but this is not always an achievable goal.

NHMRC fellowships (PH: ID401599, KT: ID1009410), Program grant (PH:ID631414)

Posture and Balance 2 (Sala 2LM 09.30-11.00

CO-ACTIVATION OF ANKLE MUSCLES DURING QUIET STANCE BEFORE AND AFTER A BOUT OF HIGH INTENSITY INTERVAL TRAINING IN SENIORS AND ADULTS

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AIM: Increased antagonist muscle co-activation in the elderly is considered to provide mechanical stability via stiffening joints and reducing degrees of freedom of postural control. However, the acute impact of a single bout of high intensity interval training (HIIT) on ankle muscle co-activation during mono- and bipedal stance has not yet been addressed.
METHODS: Twenty healthy seniors (age: 70 (SD: 4) y; BMI: 25.0 (3.6); VO2max: 30.2 (6.1)) and twenty young adults (age: 27 (SD: 3) y; BMI: 22.4 (2.2); VO2max: 46.6 (7.2)) were examined on three days. After assessing maximal heart rates (HRmax) via exhaustive treadmill testing, either a 4 × 4 HIIT at 90% of HRmax or a control condition was randomly performed. Subjects executed single limb-eyes opened (SLEO) and double limb-eyes closed (DLEC) standing before (pre), immediately after (post), 10’, 30’ and 45’ after the HIIT as well as control conditions, respectively. Surface EMG signals were measured above the soleus (SO) and tibialis anterior (TA) muscles of the dominant leg, which served for the Co-activation index (CAI = 2 × TA / TA + SO) averaged over three trials performed.
RESULTS: Data are presented in Figure 1. With basically higher CAI values for seniors independently from the condition (HIIT vs. control), repeated measures ANOVA (2 “group”: seniors vs. young adults × 2 “condition”: HIIT vs. control × 5 “time”: pre, post, 10’post, 30’post, 45’post) only revealed strong main effects of “time” ($F=4.2$, $p=0.003$, $\eta_p^2=0.11$) and “group” ($F=39.6$, $p<0.001$, $\eta_p^2=0.53$) during SLEO. Post-hoc analyses for “time” showed a significant decrease from pre to 45’post ($p<0.01$) for either group. No significant main or interaction effects were observed for DLEC ($0.28<p<0.96$).
CONCLUSION: The present study revealed evidence that notably higher ankle co-activation pattern only occurred during SLEO in seniors. HIIT does not relevantely affect co-activity in both groups. By getting more familiar with the postural tasks, seniors as well as adults decreased their CAI from pre to 45’post. Thus, it seems plausible to assume that acute intense exercise does not require a more stiffened joint by increasing co-activation.

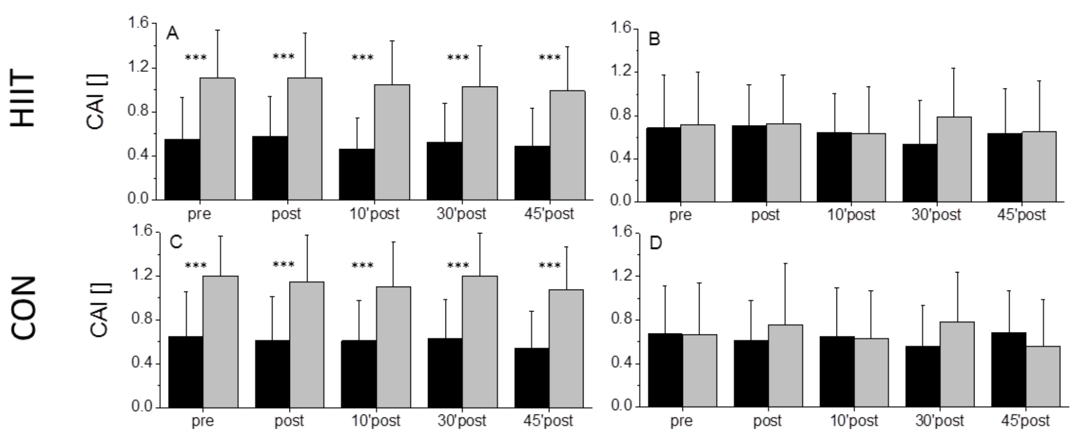

Table 1: Average of normalized sEMG amplitude (% of EMG_{MVIC}) of eight muscles during two speeds of CSM (n=12).

	60°/sec		180°/sec	
Muscle	cw	ccw	cw	ccw
AD	1.49	7.65	1.86	7.98
MD	3.54	3.35	4.16	4.74
PD	**10.36***	2.96	**12.40***	5.92

STRATEGIES TO BALANCE MAINTENANCE DURING SINGLE LEG STANDING AND SINGLE LEG STANDING ON WOBBLE BOARD

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AIM: Compare strategies used to maintain balance during standing on a wobble board (WB) and its relation to single leg standing (SLS) performance.
METHODS: Seventeen healthy men performed 15-second SLS followed by a 60-second WB test. In order to assess strategies used in both tasks the middle 5-second period of SLS and a 5-second balance period from WB test were used for analysis. Kinematic data were collected from the WB, trunk and lower limbs. Kinetic data were used to calculate center of pressure (CoP) for SLS test. Total excursion and velocity of displacement were calculated for the trunk and the contralateral leg, for both tests, CoP for SLS and WB angles for WB test. Average rectified values (ARV) were calculated from electromyographic signals from eight muscles of the supporting limb: Tibialis Anterior (TA), Peroneus Longus (PL), Soleus (SOL), Gastrocnemius Medialis (GM), Rectus Femoris (RF), Vastus Lateralis (VL), Semitendinosus (ST) and Biceps Femoris (BF). One-way ANOVA was used to compare ARV between tests for each muscle. Pearson's coefficient of correlation was used to test associations of CoP and WB variables retrieved from each test. Stepwise multiple regressions were employed toevaluate possible relationships between CoP_{VEL} for SLS and WB_{VEL} for WB with trunk and leg displacement and muscle ARV. For all analyses the significance level was set to $p<0.05$.
RESULTS: Significant differences for ARV values were found between tests. Tukey post-hoc analysis revealed that ARV for ST and BF were significantly smaller for SLS test when compared to lower leg muscles ($p<0.001$), while ARV for TA, PL and BF was higher in comparison to SOL, RF, VL and ST during WB test ($p<0.01$– Figure 1). CoP excursion (CoP_{EXC}) for SLS correlated with WB_{EXC} t ($r=0.75$, $p=0.004$). Soleus ARV, frontal plane WB angular velocity and SLS CoP velocity (CoP_{VEL}) were significantly correlated ($r=0.45$, $p<0.05$). Multiple regression analyses revealed that trunk displacement and SOL and BF muscle activation significantly contributed to the sagittal plane control of the WB_{VEL} ($r^2=0.94$), while

Patient 1

lower leg However, no significant contributors were found for CoP_{VEL} during SLS.
CONCLUSION: The higher demand the WB test imposes is reflected by the higher overall muscle activation found for WB test, with higher activity for muscles to control frontal plane board movements and decelerate the trunk. Higher activations were found for lower leg muscles of SLS supporting that an ankle strategy may be the mechanism of balance maintenance. These results suggest specific strategies to maintain equilibrium for SLS and WB tasks, in which compensatory movements are specifically required during WB test based on its inherently more unstable nature.

THE EFFECT OF LUMBAR POSTURE AND PELVIC FIXATION ON BACK EXTENSOR TORQUE AND PARAVERTEBRAL MUSCLE ACTIVITY DURING MAXIMAL LIFTING

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AIM: Lumbar posture is considered to be important risk factor for lifting-related back injuries, and has been shown to affect trunk extensor torque and back extensor muscle recruitment. To date, most studies have investigated the influence of lumbar posture on extensor torque and paraspinal muscle activity at a single muscle level using pelvic and/or lower limb fixation devices, rather than in functional positions such as lifting. The aim of this study was to investigate the effect of lumbar posture and pelvic fixation on back extensor torque and paravertebral muscle activity during a simulated lifting task.
METHODS: Twenty-six healthy participants aged between 18 and 35 years adopted a posture for lifting a box with the hands 30cm above the floor. Three lumbar spine postures (lordotic, flexed and mid-range) were studied while exerting a five second maximal isometric lift. The muscle activity of three paravertebral muscles (UES, LES, and multifidus) was recorded in each posture using electromyography (EMG) and expressed as a percentage of maximal voluntary contraction in the Biering-Sorensen position. A chest harness connected to a 3D floor mounted force gauge (AMTI, USA) via a metal chain provided a measure of maximum isometric voluntary trunk extensor force. A nine-camera motion analysis system (Qualysis Medical AB Sweden) recorded body position, which was used in conjunction with kinetics to estimate trunk extensor torque. Neuromuscular efficiency was calculated as a ratio of the torque produced divided by the level of activation of the paravertebral muscles.
RESULTS: Lumbar posture was found to have a significant effect on trunk extensor torque ($P<0.0001$), with torque increasing from lordotic to flexed postures. In contrast, a flexed lumbar posture produced less muscle activity than a lordotic posture ($P<0.001$). Consequently, a flexed posture was considered to have a higher neuromuscular efficiency ratio (torque/activation). All divisions of the paravertebral muscles behaved similarly, despite changes to lumbar posture. Fixation had no effect on the ability to produce extensor or paraspinal muscle activity.
CONCLUSION: When moving from a lordotic to flexed posture maximal extensor torque increased whilst paraspinal muscle activity decreased when performing maximal trunk extension in a lifting position. This led to significantly greater neuromuscular efficiency in the full flexed posture, and was not influenced by pelvic fixation. The combination of high extensor torque and low levels of paraspinal muscle activity in the flexed posture has important implications for low back injuries and the education and training of those involved in manual handling tasks

ACKNOWLEDGEMENT: Physiotherapy New Zealand Scholarship Trust Fund

RELATIONSHIP BETWEEN TRUNK STABILITY VARIABLES OBTAINED BY UNSTABLE SITTING AND SUDDEN LOADING PROTOCOLS

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AIM: The importance of trunk stability (frequently referred to as core stability) in athletic function and injury prevention is being increasingly recognized. However, the assessment of trunk stability is very complex as it seems to require the combination of different measurements, such as, trunk balancing and trunk responses against sudden perturbations in static and dynamic conditions. The aim of this study was to analyze the relationship between all these variables.

METHODS: 37 recreational male athletes took part in this study (age: 26.7±4.2 years; mass: 71.7±6.6 kg; height: 177.1±6.4 cm; trunk moment of inertia: 5.4±1.1 kg*m^2). Trunk balancing was assessed using a battery of tests performed sitting on an unstable seat placed on a force plate (Kistler 9286A). Sway was assessed by analyzing the mean radial error and mean velocity of the centre of pressure (COP) displacements. Sudden and unexpected trunk loads in anterior, posterior and lateral directions, were applied to the thorax by a pneumatic actuator while the subject was seated with the pelvis fixed. Thorax angular displacement was measured and the damping and stiffness coefficients of the trunk were calculated from the first 120 ms of data.

RESULTS: No significant correlations were found between variables (Table 1).

CONCLUSION: The lack of relationship between the variables that have been associated to trunk/core stability confirms the complexity of its evaluation and indicates that it is task/context dependent. Therefore, different measures appear to be necessary to fully characterize trunk stability in recreational athletes.

ACKNOWLEDGEMENT: Research supported by *Ministerio de Ciencia e Innovación* of Spain (DEP2010-16493).

Table 1. Bivariate correlations between trunk angular displacement (θ), trunk stiffness (K) and trunk damping (β) over the 120 ms after loading in the anterior, posterior and lateral directions and mean radial error (MRE) and mean velocity (MV) of the centre of pressure displacement during unstable sitting.

		Anterior Loading			Lateral Loading			Posterior Loading		
		K	***β***	***θ***	***K***	***β***	***θ***	***K***	***β***	***θ***
MRE	**USNF**	.061	.216	-.199	.257	-.076	-.106	.169	-.006	.033
	USWF	.037	.210	-.131	.058	.009	.078	.161	-.220	-.123
	USML	.196	.149	-.203	.199	.098	-.086	.178	-.171	-.086
	USAP	.076	.136	-.187	.002	.149	-.045	.142	-.128	-.023
	USCD	.229	.204	-.284	.062	.089	-.017	.303	-.100	-.226
MV	**USNF**	.077	.251	-.124	.033	.178	-.208	-.028	-.104	.231
	USWF	-.027	.137	.119	-.048	-.003	.132	-.035	-.257	.115
	USML	.025	.167	.068	.204	.176	-.080	.017	-.261	.148
	USAP	-.166	.014	.046	.124	.037	.011	-.036	-.235	.246
	USCD	-.003	-.053	.038	.105	-.047	.043	-.077	-.260	.204

Unstable sitting tasks: without feedback (USNF); with feedback (USWF); performing medial-lateral displacements with feedback (USML); performing anterior-posterior displacements with feedback (USAP); performing circular displacements with feedback (USCD).

ESTIMATING CENTER OF PRESSURE AND CENTRE OF MASS PATTERNS IN STROKE SUBJECTS DURING ACTIVITIES OF DAILY LIVING USING FORCE SENSING SHOES

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AIM: Stroke is associated with impaired balance control, which may decrease the performance of activities of daily living (ADL). Up till now, balance control often is assessed in the clinical setting using standardized clinical tests (like the Berg Balance Scale) or using force plates in the laboratory setting. However, these tests provide limited information about the performance of stroke patients during ADL. Recent developments in sensor technology enable the measurement of relevant balance parameters like center of pressure (CoP) and center of mass (CoM) using special shoes containing force sensors and inertial sensors. This way, balance parameters can be assessed while performing ADL without the restrictions of a lab environment.

The aim of this study is to evaluate CoP and CoM movement patterns in stroke patients, during activities of daily living while wearing instrumented shoes containing force sensors and inertial sensors.

METHODS: Currently, nine individuals with a history of stroke have been included. Subjects walked in a straight line over 10 meters and performed a predefined ADL task while wearing the instrumented shoes. The ADL task was defined as a sequence of the following activities: sitting, rising up from a chair, walking to another room, opening a door, manipulating an object while standing and finally returning to the start position.

The instrumented shoes included two force sensors and two inertial sensors per shoe (ForceShoes™ - Xsens, Enschede, the Netherlands). The position of the CoP, relative to the position of both feet (in the frontal plane) was measured at 50 Hz. The position of the CoM was estimated by low-pass filtering the CoP position at a cut-off frequency of 0.4 Hz.

RESULTS: The CoP patterns vary per individual and per task. During stance and walking in a straight line, individuals generally show a small shift of the mean CoP position and CoM position to their non-affected side. While performing the more difficult predefined ADL task, the mean CoP position and the CoM position shifts more towards the individual's non-affected side.

CONCLUSION: The use of force shoes enables the measurement of balance parameters during ADL tasks without being restricted to a laboratory environment. CoP and CoM movement patterns measured during ADL tasks can give more insight in balance control of individuals than current clinical tests or lab measurements with force plates. Results indicate that in more demanding tasks, the mean CoP and CoM position shifts more towards the non-affected side compared to walking in a straight line.

ACKNOWLEDGEMENT: This study is part of the INTERACTION project, which is partially funded by the European Commission under the 7th Framework Programme (FP7-ICT-2011-7-287351)

LIMITS OF STABILITY OF MIGRAINE PATIENTS – A PILOT STUDY

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AIM: The aim of this study is to evaluate the limits of stability in patients with migraine with aura (MA) and controls (CG).
METHODS: It was evaluated 10 patients in MA group, with 41,7 years old (SD: 7,9), and 10 control subjects (CG), with 31,9 (SD: 8,4). They had no systemic diseases, history of vestibular diseases or other types of headache and were screened from a headache outpatients clinic, diagnosed by neurologists experts on headache according to ICHD-II (2004).
A blind examiner assessed the limits of stability on a Balance Master System (Neurocom®) and the patients were oriented to displace intentionally their Center of Pressure (COP) without changing their base of support to the maximum distance in eight directions: Forward (F), Right Forward (RF), Right (R), Right Back (RB), Back (B), Left Back (LB), Left (L) and Left Forward (LF). The limits of stability were computed as the reaction time after the equipment command (sec), average of movement velocity (deg/sec), maximal COP excursion (%) and end-point COP excursion (%) in each direction. A Student t-test was applied to contrast the groups and a significant level of 5% was adopted.
RESULTS: The reaction time was higher in MA group in relation to the CG in the directions: F (P=0.001), RF (P=0.01), R (P=0.002), RB (P=0.02) and LF (P=0.002). The mean velocity to perform the task was lower in MA group in the directions: F (P=0.02), RF (P=0.002), R (P=0.0005), RB (P=0.01), L (P=0.04) and LF (P=0.008). MA had lower endpoint of the excursion in the directions: F (P=0.002), RF (P=0.006) and LB (P=0.03), and lower maximal excursion in the directions: F (P=0.01), RF (P=0.03), R (P=0.005), L (P=0.01) (Figure 1).
CONCLUSION: These preliminary findings highlight the impairment of patients with migraine, especially in the reaction time and movement velocity, increasing the postural instability.

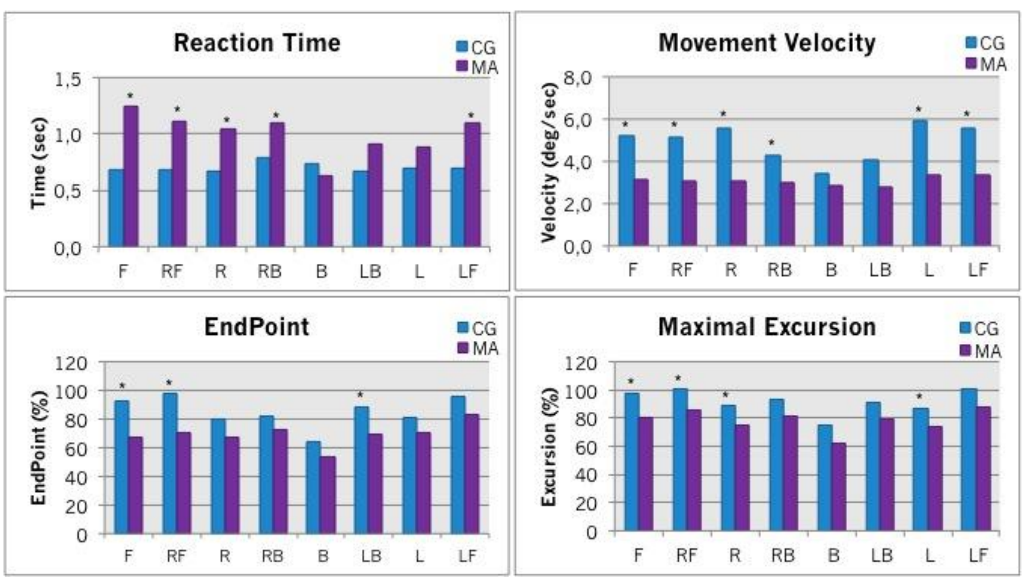

Figure 1: Reaction time, Movement Velocity, Endpoint and Maximal Excursion of Limits of Stability Test in Migraine with Aura Patients *versus* Controls. *P<0.05.

COMPARISON OF THE DEEP TRUNK MUSCLE ACTIVITY DURING SINGLE LEG STANDING WITH AND WITHOUT LIFTING A WEIGHT

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AIM: Lifting is a general movement in daily life. While lifting a weight, trunk muscle activity, (including that of deep trunk muscles,) helps maintain posture. However, the activity pattern of deep trunk muscle while holding a weight is not clear. Therefore, the purpose of this study was to clarify trunk muscle activity during single leg standing with a weight.
METHODS: Eight healthy men participated in the study. We measured trunk muscle activity during static standing, right single leg standing, and left single leg standing with and without a weight (2 kg) in the right hand. The participants elevated their right hand with the shoulder joint in a 90 degree abduction position.Wire electrodes were inserted in the bilateral transversus abdominis (TrA) and lumbar multifidus (MF), and surface electrodes were attached to the bilateral rectus abdominis (RA), external obliques (EO), and erector spinae (ES). The root-mean-square was calculated for 1 s when each posture was stable. Wilcoxon signed-rank test was used to compare muscle activity (%MVC) of each task between the posture with and without the weight.
RESULTS: The activities of the bilateral RA, left EO, right TrA, and right MF were significantly greater in the standing position with the weight than without the weight. Similar results were obtained for single leg standing
CONCLUSION: he activities of the trunk muscles were significantly greater in single leg standing with the weight than without the weight. This study suggested that trunk muscle may be important , when they move with a something.

Physical Rehabilitation & Medicine 3 (Sala 4LM 9.30-11.00)

ASSOCIATION BETWEEN PSYCHOSOCIAL FACTORS AND TRAPEZIUS ACTIVATION IN COMPUTER-INTENSIVE OFFICE WORKERS

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AIM: The aim of this study was to investigate the association between psychosocial factors and muscular rest (by means of RRT and gap frequency) obtained during regular office work. METHODS: Thirty-six office workers (29 females and 7 males; age 42±7 years; weight 72±6 Kg; BMI 26±4) from a public university participated. These workers completed the Utrecht Work Engagement Scale (UWES) and the short version of the Job Content Questionnaire (JCQ). The UWES contains 17 questions and is divided into 6 items related to vigor, 5 items related to dedication, and 6 items related to absorption; the total score reflects the worker's engagement. The JCQ analyzes the relationship between demand and control, and is also based on 17 questions (five to evaluate demand, six to evaluate control and six to evaluate social support). The scores are used to measure the high-demand/low-control/low-support model of job strain development. Recordings of surface electromyography (EMG) were obtained from the dominant upper trapezius (UT) muscle for approximately 2 hours of each worker. They were instructed to perform their usual tasks during a regular working day. The signals were RMS-converted and normalized (%MVE – maximal voluntary exertion). Muscular rest was evaluated by means of gap frequency, expressed as number of gaps per minute (RMS<1%MVE, longer than 125ms) and Relative Rest Time – RRT, obtained for the entire recording. The association between psychosocial factors and trapezius EMG was tested using Spearman's correlation coefficients (r_s).

RESULTS: No significant correlation was observed when all the domains of UWES and JCQ were correlated with gap frequency and RRT recorded for the dominant UT (Table 1). Considering the job demand evaluated through the JCQ, a borderline p-value were found for the association with UT RRT, indicating a possible negative moderate correlation. Therefore, higher values of demand can lead to lower RRT. However, larger samples should be assessed in order to verify this association.

CONCLUSION: We suggest that these psychosocial indicators can act as complementary factors to predispose the development of musculoskeletal disorders. Furthermore, we believe that factors related to biomechanical exposure such as low-level and sustained muscle activation, little variation and constrained movements, associated with poor ergonomics may be more relevant risk factors for the development of musculoskeletal disorders in offices workers.

Table 1. Spearman correlation coefficients (r_S) and p-values (r_S; p) between psychossocial factors (UWES and JCQ scores) and upper trapezius activation (gap frequency and RRT.

	UWES				JCQ		
	VIG	DED	ABS	ENG	DEM	CTR	SOS
Gap frequency (min^{-1})	-0.04; 0.80	0.10; 0.53	0.00; 0.99	0.01; 0.93	-0.11; 0.54	0.50; 0.77	-0.18; 0.30
RRT (%)	-0.21; 0.21	-0.09; 0.56	-0.19; 0.26)	-0.19; 0.24	-0.32; 0.06	0.71; 0.68	-0.09; 0.59

VIG: vigor; DED: dedication; ABS: absorption; ENG: engagement; DEM: demand; CTR: control; SOS: social support.

REAL-TIME DETECTION OF GAIT EVENTS FOR STROKE REHABILITATION BASED ON INERTIAL AND MAGNETIC SENSORS

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AIM: To develop and validate on pathological gait patterns a real-time, adaptive algorithm for gait-event detection based on inertial and magnetic sensors.
METHODS: Two sensors placed on the external part of each shank were used to detect the initial contact (IC), the mid-swing (MS), and the end contact (EC) events of each leg. The algorithm core was a state machine that defined the gait events as the minimum of the shank flexion/extension angle (IC), and the minimum (EC) and maximum (MS) of the shank angular velocity in the sagittal plane (Fig. 1). The algorithm parameters were initialized on each subject by means of a calibration procedure and updated every step. To validate the algorithm, ten stroke patients with three different levels of impairment were asked to walk twelve times at a self-selected speed. Reliability of the algorithm was assessed against the GaitRite system by means of Precision (P), Recall (R), and F1-score; the timing agreement between the two measurements was computed through the Bland-Altman method.
RESULTS: F1-scores of 0.998 (P=0.998, R=0.997) and 0.944 (P=0.948, R=0.941) were obtained for IC and EC, respectively (number of steps = 1137). Mean detection delays [95 % confidence interval] with respect to the GaitRite system varied between subgroups, being higher for patients with severe impairment. The mean delay obtained for the subgroup with mild impairment was 20.11 ms [17.62, 22.60] for IC and 3.50 ms [0.32, 6.68] for EC. On the other hand, the mean delays for the severely-impaired subgroup were 52.37 ms [46.50, 58.24] for IC and 15.78 ms [8.21, 23.35] for EC.
CONCLUSION: The real-time algorithm performed positively when tested on a heterogeneous sample of stroke patients. Results proved that the algorithm is suitable to provide in real time accurate information related to gait, which is crucial for the design of gait interventions for stroke patients.

ACKNOWLEDGEMENTS: Partially supported by MIUR (grant no.: 2010R277FT).

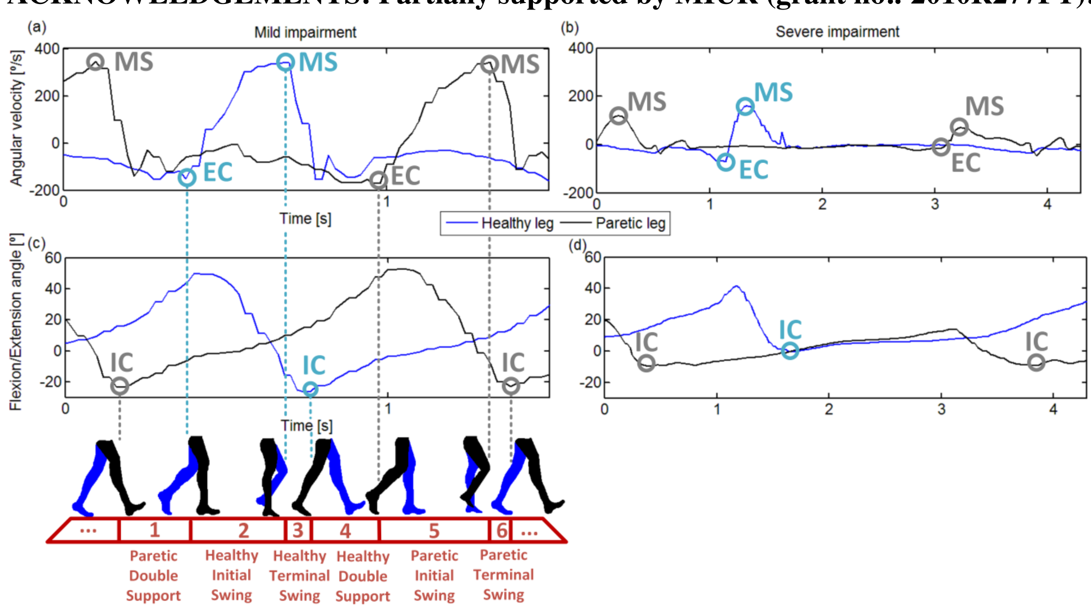

Figure 1: Walking patterns of stroke patients, divided by their level of impairment: mild (speed >0.8 m/s) and severe (speed <0.4 m/s). One stride of the shank sagittal-plane angular velocity (a,b) and the shank flexion/extension angle (c,d) are shown. IC, EC, and MS defined the 6 gait phases.

THE INTRA-SESSION RELIABILITY IN DEFINING THE EXTENT AND THE LOCATION OF PAIN DURING ULNT1: A STUDY ON HEALTHY VOLUNTEERS

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AIM: Despite pain drawings (PDs) have been widely used in research and clinics, to our knowledge no studies explored the reliability of reporting the extent and the location of pain. The aim of this study was to investigate the intra-session reliability of healthy volunteers in reporting the extent and location of pain after the upper limb neurodynamic test 1 (ULNT1).
METHODS: Forty-four healthy volunteers (29 female, 15 male) participated to the study. An electromagnetic device (Polhemus-G4) was used to control the joint position of the shoulder during the test. PDs were shaded with a stylus pen on an iPad®. A custom designed software was used to quantify the pain extent and analyze the pain overlap (Fig 1). The ULNT1 was performed twice, the first time stopping at pain onset (PO) and the second at submaximal pain (SP). After each test the volunteers shaded two consecutive PDs with an interval of one minute. The test re-test reliability of pain extent was examined using intraclass correlation coefficient (ICC) and Bland-Altman plots. Pain location reliability was investigated calculating the pain overlap and estimating the Jaccard similarity coefficient.
RESULTS: The ICC values for PO and SP were 0.980 (95% CI: 0.963-0.989), and 0.976 (95% CI: 0.956-0.987) respectively. Values of the Bland-Altman plots are reported in Figure 2. The mean Jaccard similarity coefficient was 0.67±0.17 for PO, and 0.71±0.12 for SP.
CONCLUSION: The intra-session reliability of healthy volunteers in reporting the extent of pain using the PDs is high. Good reliability values were found also for pain location. Further research could be useful to investigate the reliability of PDs in different patient populations.
ACKNOWLEDGEMENT: Supported by a grant from the Thim van der Laan Foundation.

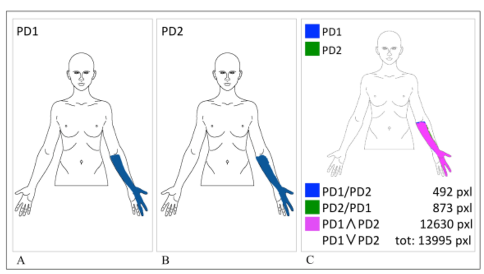

Figure 1: Two consecutive pain drawings of the same participant (A, B), and the overlap analysis (C)

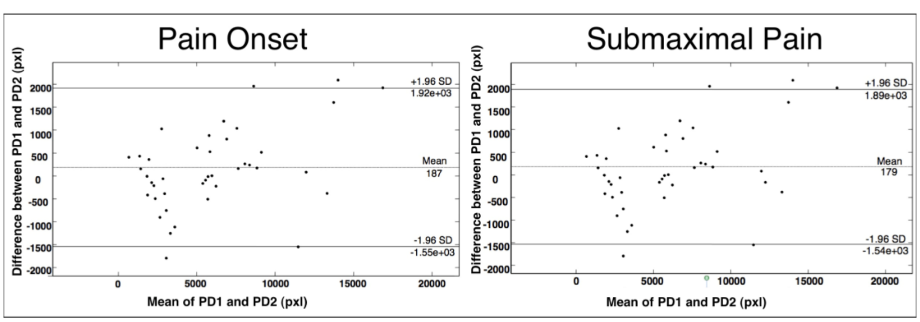

Figure 2: The Bland-Altman plots with values of mean difference and the 95% limits of agreement

ELECTROSTIMULATION IN PREFRAIL OLDER ADULTS LEADS TO IMPROVE THE CONTROL OF CHALLENGING POSTURAL SITUATION THROUGH MUSCULOTENDINOUS ADAPTATIONS.

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AIM: In order to counteract strength decline in (pre)frail older adults, neuromuscular electrostimulation (NMES) training is a common and relevant clinical tool. But its impact on the musculotendinous (MT) stiffness and the postural control is not well documented. Thus the current study aimed to investigate the effects of NMES training of the Triceps Surae muscle on MT stiffness and balance performance during a challenging postural task in prefrail institutionalized women.

METHODS: Nine prefrail institutionalized elderly women have performed four weeks of high-frequency NMES training and seven healthy non institutionalized control elderly (no training protocol) took part for this study. During an incremental plantarflexion maximal voluntary contraction (MVC), MT stiffness was assessed before and after the conditioning period, by measuring the displacement of the MT junction with an echography device and the ankle torque. The limit of stability (LoS) in forward direction was determined through the maximal anterior position of the Center of Pressure ($dCoP_{max}$) and the related CoP sway parameters (frequency and amplitude) were computed during the 2 seconds prior the LoS.

RESULTS: The NMES training induced an increase in MVC, MT stiffness and LoS (+26.2%, $p<0.01$, +44%, $p<0.01$, and +22.3%, $p<0.05$ respectively). Interestingly, the CoP sway frequency and amplitude changed significantly as a result of NMES training, with values close to those of the healthy control group (see Figure 1).

CONCLUSION: High-frequency NMES training seems to be an efficient clinical tool to promote the recovery of challenging balance control through an improvement of strength capacity / MT stiffness. The mechanisms underlying this relationship will be discussed from an integrated approach.

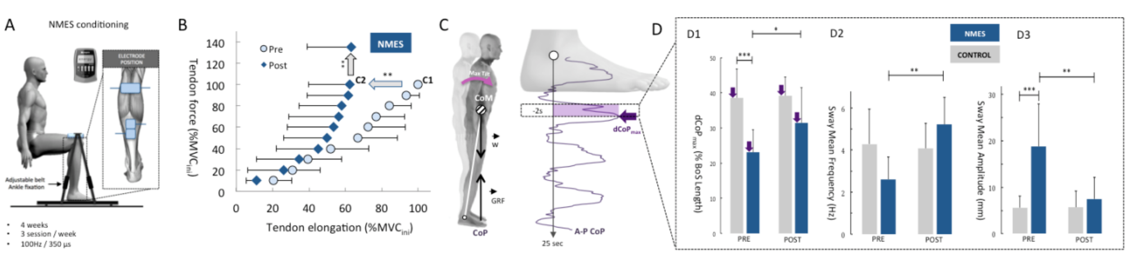

Figure 1:(A), Subject's position during the NMES session and main parameters of the NMES training / electrodes placement on the Triceps Surae. (B) Relation between the tendon elongation and force during the incremental MVC before and after the training for the NMES group revealing higher MT stiffness and force after the conditioning period. (C) Challenging postural task set-up and representation of the anteroposterior CoP displacement during a trial. (D) Results for the LoS (D1) and mean sway frequency (D2) and amplitude (D3) computed from the 2s prior the LoS.

SCAPULAR MUSCULAR ACTIVATION AND KINEMATICS IN PATIENTS WITH DIFFERENT PATTERNS OF SCAPULAR DYSKINESIS

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AIM: We investigated whether specific patterns of scapular dyskinesis have related alterations of scapular kinematics and associated muscular activation.
METHODS: Seventy-eight subjects with unilateral shoulder pain were recruited. A visual-based palpation method classified the scapular movements during arm raising/lowering movements in scapular plane as single abnormal scapular patterns [inferior angle (pattern I)/ medial border (pattern II)/ superior border (pattern III) of scapula prominence and normal movement (pattern IV)] or mixed abnormal scapular patterns. Alternations of the scapular kinematics and associated muscular activation were assessed by surface electromyography and electromagnetic motion-capturing system.
RESULTS: In kinematics part, more scapular internal rotation was found in patients with pattern II (4°) and pattern I+II (5°) compared to normal pattern (pattern IV) during arm lowering. In EMG part, there was less activation of middle trapezius in pattern I+II group (5%) compared to normal pattern group during arm lowering. Additionally, decreased activation of serratus anterior was found in pattern II (8%) and pattern I+II (8%) group compared to normal pattern during arm lowering. Besides, increased activation of upper trapezius was shown in pattern II group (14%) during arm lowering from maximal to 120 degree arm angle.
CONCLUSION: Specific alterations of scapular muscular activation and kinematics were found in pattern II and pattern I+II. In addition, all changes occurred during arm lowering phase. As a result, evaluating scapular dyskinesis pattern is more important in arm lowering phase. Inhibiting upper trapezius and activating middle trapezius and serratus anterior may be essential in restoring normal scapular movements, especially in pattern II and pattern I+II scapula dyskinesis.

Table 1: Serratus anterior activation (% MVIC) in scapular dyskinesis during arm lowering phase.

Dyskinesis	Max~120°	120°~90°	90°~60°	60°~30°	30°~0°
Medial border	45% ± 12%	36% ± 15%	26% ± 10%	12% ± 6% *	5% ± 2%
Inferior angle and Medial border	38% ± 11%	31% ± 7%	21% ± 6%	12% ± 6% *	5% ± 2%
Normal	49% ± 15%	42% ± 13%	32% ± 14%	20% ± 8%	9% ± 6%

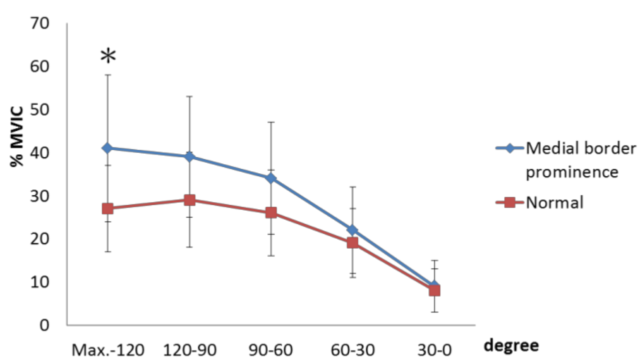

Figure 1: Upper trapezius activation in scapular dyskinesis during arm lowering phase.

THE TESTING MECHANICS OF MUSCLE EXPOSED TO BTX-A FOR A RANGE OF LENGTHS SHOW NEW EFFECTS, INDICATED AND CONTRAINDICATED

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AIM: Botulinum toxin type A (BTX-A) is used widely in treating muscle spasticity. It is applied to decrease muscle tone, to increase the joint range of motion, and to improve function. BTX-A is known to have effects beyond the injection side [e.g., 1]. However, little information is available on its effects on muscular mechanics tested for a range of muscle lengths, instead of a few selected lengths. The goal of this study was to quantify the effects of exposure to BTX-A of muscles of the intact anterior crural compartment of the rat on their mechanical and structural properties. We expected to find new effects of BTX-A on determinants of muscle force-length characteristics.

METHODS: Five days following injections of 0.1U BTX-A in 20µl of saline (BTX-A group) or only 20µl of saline (control group) into the mid-belly of the tibialis anterior (TA), the effects were tested on the TA, as well as the extensor digitorum longus (EDL) and extensor hallucis longus (EHL). The active and passive forces of muscles kept at constant length were measured simultaneously with those of the lengthened muscle, in two experiments [1-2]: (i) the TA was lengthened (BTX group, n=8, body mass 312.5±14.6g, control group, n=8, body mass 318.5±12.5g); or (ii) the EDL was lengthened both proximally and distally (BTX group, n=8, body mass 315.0±6.3g, control group, n=8, body mass 300.0±6.9g). Histological analyses: glycogen staining was done with periodic acid-Schiff to test for muscle paralyzation, and Gomori trichrome stain was used to assess intramuscular tissue content.

RESULTS: Exposure to BTX-A causes (1) substantial force decreases (peak force drops range from 47.3% to 85.6%) for all compartmental muscles, (2) length dependent force reductions such that more pronounced reductions are found at shorter lengths (e.g., for the TA, force reductions increase from 46.6% to 55.9% with decreasing length), (3) a narrower length range of force exertion (for the EDL both proximally and distally, by up to 26.1%), and (4) increased passive forces (for all lengthened muscles, minimally three-fold). Histological examinations show (i) presence of partial paralysis, and (ii) a significant increase in the ratio of intramuscular collagenous tissue content for the TA, EDL, and EHL muscles. The latter is in concert with the passive force increases shown.

CONCLUSION: Our results do indicate that the effects of BTX-A on muscular mechanics are more complex than the weakening of the affected muscle as characterized by active force reduction. Such effects may be clinically relevant since, as some are additional to the intended ones, others may be unintended. More pronounced active force reductions shown at shorter lengths may sustain indicated effects, as spastic muscle is considered to resist motion forcefully in flexed joint positions. In contrast, the narrowed length range of active force production and increased passive forces appear contraindicated. The former may worsen the already limited range of motion and the latter may compromise passive resistance to stretch.

REFERENCES:

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[2] Ates, F. et al., 2013, Muscle Nerve, in press, doi: 10.1002/mus.23993.

ACKNOWLEDGEMENT: The Scientific and Technological Research Council of Turkey (TÜBİTAK) (grant 108M431), and the Boğazici University Research Fund (grant 6372).

REFLECTION AND VIDEO FEEDBACK IN ERGONOMIC EDUCATION - A MODEL FOR MOVEMENT ANALYSIS AND LEARNING

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AIM: The aim of the present study was to explore the initial phase of a model for movement learning used in an ergonomic learning situation.
METHODS: A model for movement analysis and learning was developed including instructions, video recordings, viewing and discussing the recordings in an iterative process of app. 45 min. Sixteen undergraduate nursing students from the end of years two and three participated. The model entails several individual sessions over time and in the present study the initial session was in focus. Together with a facilitator the students were to perform pre-selected movements and a computerized video analysis program was used to provide feedback of the performed movements. The focus was on movement initiation, force application and quality of the movement. The role of the facilitator was to achieve a safe and flexible learning atmosphere and to continuously invite the students to reflect. Pre-recorded videos of a role model (video modelling) were also presented to the learner to provide an example of how the movement could be performed in an ergonomic way with efficient force application and low level of musculoskeletal load. Audio recordings during the first of three video sessions were analysed with qualitative content analysis.
RESULTS: The qualitative content analysis resulted in an overall theme; Self-reflection facilitated by interaction and encountering one's own movement. The three sub-themes were: Reflected visualizing, Self-adjustment through reflection and Reflected experiences.
CONCLUSION: The learning model appears to provide an instrument for stimulating reflection and movement awareness as a basis for understanding how to refine movements. This learning model may contribute to enhance reflection in the process of movement learning, not only among nursing students but also in other movement learning situations. We suggest that the presented learning model support increased motivation in individual movement learning and could be valuable in rehabilitation processes.

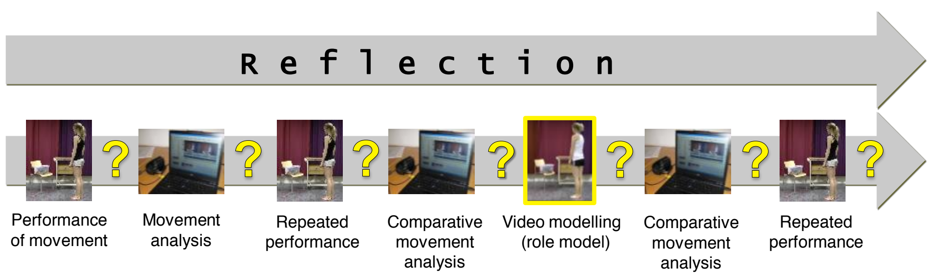

Figure 1: The iterative process of the learning model. The question-marks represent the facilitator's input with open-ended questions

Modelling & Signal Processing 4 (Sala Cesarea 12.00-13.00)

BAYESIAN FILTERING IMPROVES PROPORTIONAL MYOELECTRIC PROSTHESIS CONTROL

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AIM: Myoelectric signals are studied in order to enable robust and intuitive control of myoelectric prostheses. Regression algorithms provide a promising way to achieve simultaneous and proportional control (SPC) of multiple degrees of freedom. However, current regression algorithms all use root mean square (RMS) as the amplitude detector for surface EMG. RMS lacks smoothness because of the intrinsic fluctuations of the myoelectric signals. By increasing the time window length of feature computation, these fluctuations can be reduced. However, long time windows increase the control delay in the operation of the prosthesis, rendering it unresponsive. Here we aim at achieving a stable and responsive control of a hand prosthesis based on regression algorithms.

METHODS: Myoelectric signal amplitude is the feature we use for our SPC system. For a correct amplitude estimation based on RMS, stationarity within the time window of estimation is demanded. Given the non-stationarity of myoelectric signals during dynamic contractions we propose an evolution-observation model following a Bayes-Fokker-Planck (BFP) approach (Sanger 2007), in which the evolution of the prior of a Bayesian filter is given by a Fokker-Planck equation that is solved numerically. In an offline evaluation, we compare BFP to RMS in terms of amplitude estimation quality. Here we collect 126 signals with two high density electrode arrays positioned on the upper forearm. To put theory to practice, we also assess control quality in an online evaluation. The control of two degrees of freedom is performed by common spatial patterns based regression using signals from 16 electrodes positioned on the upper forearm.

RESULTS: Amplitude estimation using BFP is compared to RMS with a 200 ms time window. First we compare performance on simulated myoelectric signals and find that BFP yields a 3.7 fold better signal amplitude estimation quantified by root mean square deviation. Second, for measured myoelectric signals we find that BFP outperforms RMS by 4.3 fold in terms of signal-to-noise ratio. Finally we performed an online assessment of control quality for proportional control of two degrees of freedom. The results show a clear superiority of BFP, which achieves low noise, i.e. stable control, with no perceivable control delay. RMS, on the other hand, reaches the low noise regime only for time window lengths that result in impractical control delays.

CONCLUSION: We find that an advanced amplitude estimation algorithm, the Bayes-Fokker-Planck amplitude estimator, provides an envelope detector for regression algorithms. Indeed, we achieve a robust yet responsive simultaneous and proportional control of two degrees of freedom. Planned follow up studies will extend the approach to more degrees of freedom as well as compare different regression algorithms.

ACKNOWLEDGEMENT: The project is supported by grant #01GQ0811 within the National Bernstein Network Computational Neuroscience.

EMG WHITENING IMPROVES PATTERN RECOGNITION IN PROSTHESIS CONTROL

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AIM: A common method for controlling powered upper-limb prostheses is via EMG-based motion classification. We improved classification accuracy by applying whitening as an EMG preprocessing step. Whitening decorrelates the EMG signal and has been shown to be advantageous in related problems such as EMG-force processing.
METHODS: Previously collected EMG data from ten intact subjects and five amputees were reanalyzed, with and without EMG signal whitening. A linear discriminant classifier was employed. Up to 11 motion classes and ten electrode channels were examined, using both time- and frequency-domain EMG features.
RESULTS: Whitening increased the statistical bandwidth of the EMG signal, on average, by 65–75%. Whitening significantly reduced the coefficient of variation of time-domain features (mean absolute value, average signal length and normalized zero crossing rate). Whitening increased classification accuracy approximately five percentage points at small window lengths (< 100 ms), with smaller gains found at longer window lengths.
CONCLUSION: Whitening the EMG signal prior to its use in classification analysis increased the statistical bandwidth of the signal, decreased the coefficient of variation of extracted features and increased classification accuracy at short window lengths.
ACKNOWLEDGEMENT: Amputee data provided by G. Li and the Neural Engineering Center for Artificial Limbs, Rehabilitation Institute of Chicago.
REFERENCE: Liu et al., Electromyogram Whitening for Improved Classification Accuracy in Upper Limb Prosthesis Control. IEEE Trans Neural Sys Rehab Eng 2013; 21(5):767–774.

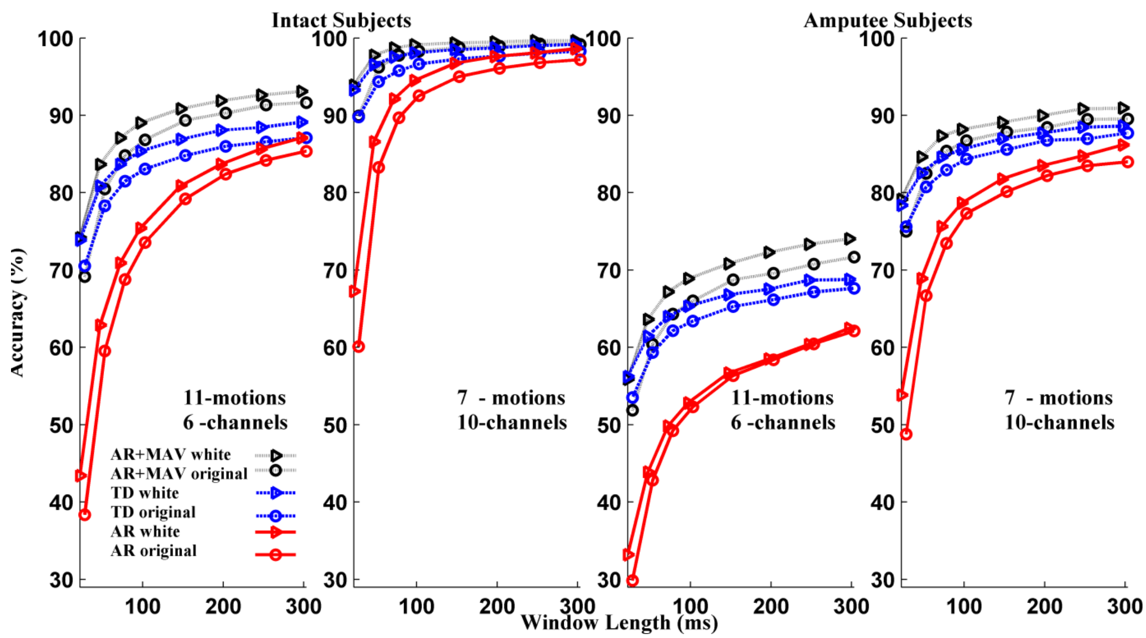

Figure 1: Average classification results with vs. without EMG signal prewhitening.

AUTOMATED TRACKING OF DIAPHRAGMATIC EXCURSION VIA M-MODE ULTRASOUND IMAGING

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AIM**:** The use of m-mode (sequential, single line, depth scans) ultrasound (US) for the investigation of diaphragmatic excursion (DE) is well established, but manual mark-up of m-mode sequences is time consuming and must be performed post-hoc. The ability to track diaphragm movement in real time would allow for instantaneous feedback to patients, opening the opportunity for novel performance enhancement and rehabilitation techniques. Here we present a simple, computationally inexpensive method by which m-mode sequences of DE can be accurately tracked in real-time.

METHODS**:** M-mode US data (25Hz) were collected from 8 healthy subjects, under two conditions; Normal breathing, or tidal flow, (TF) and extended flow (EF) where participants were asked to increase their inhalation and exhalation levels. A convex probe (2.5MHz, Shimadzu Medical Corporation), was placed subcostally on the right sagittal plane, in line with the anterior iliac crest, and aligned vertically. Recordings lasted 30 seconds. Each m-mode sequence was marked manually to establish the movement of the diaphragm. A polynomial interpolation fit across the entire m-mode sequence was applied to generate 16 independent m-mode sequences of diaphragm movement.

MODEL**:** Data were separated into 5 test and 3 training subjects (two items per subject). Centred on each manually marked point on the diaphragm in the training set, 31 pixel contours were sampled (subsections of vertical lines in Fig 1). This results in a database of unique contours, describing the appearance of the diaphragm. The mean ($\overline{m}$) is calculated, and subtracted from each contour. The eigenvectors and values of these data are calculated, and the most significant eigenvectors (ε), and values (ε_v) are selected, these describe 99.3% of the variance in the database of contours. These vectors and values were used as a statistical contour model that describe the appearance of the diaphragm.

ANALYSIS**:** The first identification of diaphragm position checks the entire m-mode line for the best match. Each possible fitting point is checked, by extracting the contour about that point (c). The level of fit is then calculated as $\min\{(c - \overline{m}) \times \varepsilon\}$, and the minimum fit in the first m-mode line is selected. In all following m-mode lines in the sequence, only the closest 5 positions around the previous fit are tested.

RESULTS**:** The test set were analysed as above, and a comparison with manually marked data were made. Across the dataset, the absolute tracking error per m-mode line was 1.4±1.2 mm. If we separate our data into TF and EF, the error is evenly distributed between the TF (0.85±2.83mm) and EF (0.87±2.86mm). The average processing time per m-mode line was found to be 0.12ms, significantly less than the 40ms frame processing time.

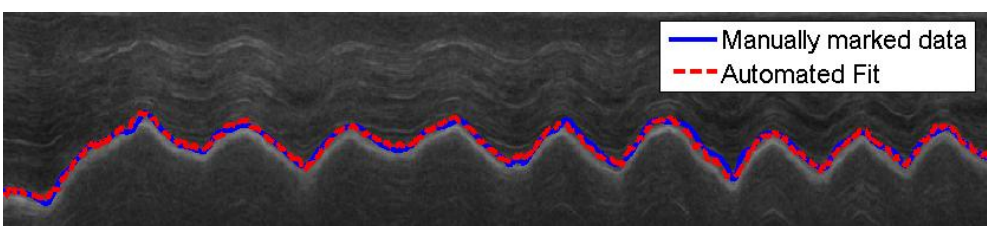

Fig 1 - M-mode sequence of DE as marked manually (blue line) and automatically (red line).

CONCLUSION**:** The preliminary results of a simple, yet effective, algorithm capable of tracking DE in real time have been show. The results show a good accuracy is achieved, with low overhead, allowing for multiple m-mode lines to be analysed simultaneously.

A B-MODE ULTRASOUND MUSCLE MODEL FOR HYPOTHESIS TESTING

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AIM: Ultrasonography (US) is capable of non-invasively imaging large cross-sectional areas of muscle tissue, revealing fascicle curvature, and strong indicators of activation. While methods exist which aim to extract these properties automatically, little is known regarding how to interpret them physiologically. A Restricted Boltzmann Machine (RBM) is used to build a US texture model of human Gastrocnemius Medialis (GM). Via Principal Components Analysis, the model is capable of generating probabilistic images of GM under specified isometric and/or passive strain, which can be used to test physiological hypotheses.
METHODS: 18 Participants were asked to stand on programmable foot pedals while strapped upright to a flat backboard. They then performed a series of ankle rotations designed to exploit skeletal muscle properties under 3 conditions: isometric contraction, passive ankle rotation, and combined contraction and ankle rotation, while US of the GM was recorded.
An Active Shape Model was used to automatically extract images of GM from each frame of US, and a large database of images was created. Each image was down-sampled to an 80x80 matrix. Then a RBM was used to create a graphical model of the muscle from that database, leaving out a random participant's data for validation. The RBM yields a 1536 point feature vector, from which the RBM can approximately reconstruct the original image.
Given the feature vectors of images from two sequences (isometric and passive) in the model data-set we can capture the covariance using PCA. Then we can take a static frame from the validation data-set, produce a feature vector, and add a linear combination of the eigenvectors to the feature vector. Given the feature vector, the RBM can construct probablistic examples of images depicting how the muscle would likely look under some passive ankle rotation, and/or isometric contraction. This can be achieved by constructing isometric/passive signals to be used as coefficients to each respective eigenvector.
RESULTS: Figure 1 shows generated images (bottom) using the validation participant's data. These images were generated using the signals (top: isometric coefficient is blue, passive coefficient is red). These coefficients multiply the eigenvectors of their respective classes, which are then added to the feature vector generated from the image at $t = 0$.

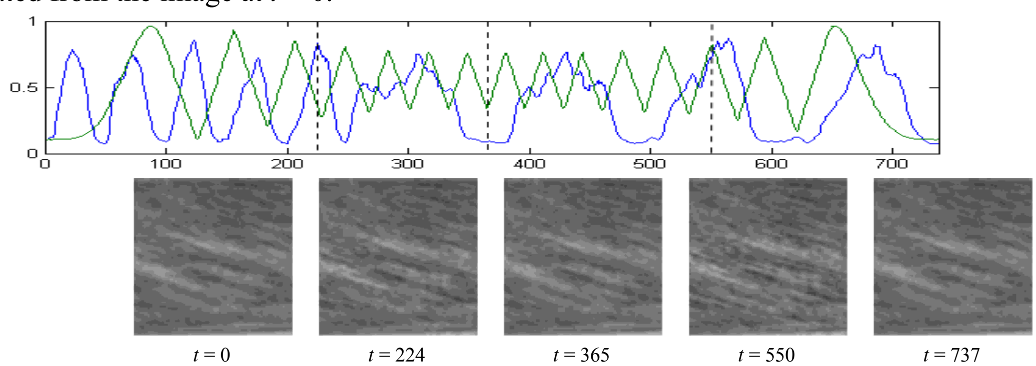

Figure 1: Generated US images from the model.

CONCLUSION: This paper sets groundwork for testing new hypotheses about muscle tissue behavior under strain. By taking the accumulated difference between a generated image for a desired activation, and relaying this information back to a patient, and since US is known to be more sensitive to activation than EMG, we also have a potential method of biofeedback for patients - for example - with spinal cord injury.

ALGORITHMS FOR AUTOMATIC PROGRAMMING OF DEEP BRAIN STIMULATION FOR PARKINSON'S DISEASE

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AIM: Recent studies have shown that certain motor symptoms of Parkinson's disease (PD), specifically bradykinesia, akinesia and rigidity, are correlated with oscillatory beta-band (12-30 Hz) activity in the basal ganglia. Deep brain stimulation (DBS) is an established therapy for PD and has a demonstrated ability to reduce these symptoms. Suboptimal device settings and infrequent postoperative programming of stimulus parameters, however, can weaken the clinical success and overall efficacy of the therapy. Realization of electrophysiological biomarkers for PD symptoms allows for the possibility of implementing automatic device programming algorithms. The aim of this study was to use a computational model to implement, test and evaluate two types of automatic algorithms.
METHODS: A physiologically based computational model of the thalamo-cortico-basal ganglia network was developed to employ two distinct automatic initial device programming algorithms. The first algorithm varied stimulus parameters systematically, similar to the current clinical practice of manual programming[1]. The second approach used the Nelder-Mead simplex optimization algorithm to find the ideal stimulus parameter set. Stimulation amplitude, pulse width and frequency were identified using both methods for a range of target levels of beta-band oscillation suppression, as a benchmark for effective therapy.
RESULTS: Pathologic beta-band oscillations, similar to those observed experimentally, were generated in the model using simulated dopamine depletion conditions. Both algorithms successfully identified a set of stimulation parameters that reached the target level of beta oscillation suppression, Table 1. The number of steps indicates how many calculations each algorithm had to execute to identify the effective parameter settings. In practice, this would be directly related to stimulator programming time. The Nelder-Mead method required less steps, by an order of magnitude, for each target of beta band suppression.
CONCLUSION: The results show that both the commonly employed manual algorithm for setting DBS parameters and the optimization based approach proposed here can automatically determine stimulation parameters based on a given biomarker. The optimization algorithm can further be extended to include minimization of power consumption as well as other electrophysiologic biomarkers, such as tremor.
ACKNOWLEDGEMENT: This research was supported by the GREP ENG funded under the Programme for Research in Third-Level Institutions (PRTLI) administered by the Higher Education Authority and co-funded under the European Regional Development Fund (ERDF).

Table 1: The stimulation settings as determined by both types of algorithms for a given level of beta-band oscillation reduction.

% Reduction	Current Clinical Practice				Nelder-Mead			
	Amp (nA/cm2)	Freq (Hz)	Pulse Width (µs)	# Steps	Amp (nA/cm2)	Freq (Hz)	Pulse Width (µs)	# Steps
80	150	145	60	101	300	140	70	11
78.5	100	145	60	100	200	137	65	16
75	300	135	60	29	150	135	65	5

[1] Montgomery, E.B. (2010). *Deep Brain Stimulation Programming: Practices and Principles*. New York: Oxford University Press.

Motor Control 3 (Sala 1LM 12.00-13.00)

ELECTROCORTICAL RESPONSES IN VOLUNTEERS WITH AND WITHOUT SPECIFIC EXPERIENCE WATCHING MOVIES INCLUDING THE EXECUTION OF COMPLEX MOTOR GESTURES

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AIM**:** EEG registration during the execution of a movement is a difficult task because of the numerous artifacts generated by the movement itself. The analysis of electrocortical activity during motor imagery or while watching an action made by an athlete can be more easily carried out. According to the theory of mirror neurons, in fact, there is an overlapping in some cortical activation during the execution of a motor gesture and during the observation of the same gesture made with the same purpose by an other person. Therefore it is possible to record cortical activity generated exclusively by the vision of a motor action. The analysis of electrocortical activity as a result of visual stimuli may reveal a statistically significant difference in the signal of expert subjects, compared to non-experts, while watching a movie commensurate to the field of expertise.

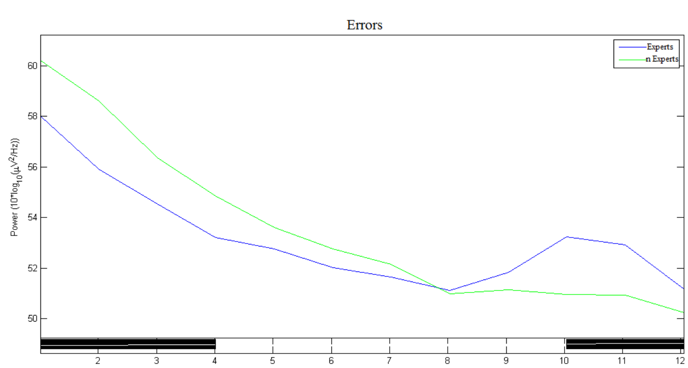
METHOD**:** Fourteen volunteers, 7 belonging to the expert group (high experience in the field of acrobatic gymnastics) and 7 to the control one took part in the study; EEG was recorded using a prototype of a wireless amplifier during the vision of 10 movies (5 containing evident technical errors and falls and 5 without errors or falls) containing executions of specific technical gestures of acrobatic gymnastics. EEG was analyzed in Delta, Theta, Low and Intermediate Alpha bands using the International 10–20 system, the EEG was monitored over eight scalp locations (F3, F4, C3, C4, P3, P4, O1, O2). All leads were referenced in CZ, and a grounding electrode was applied with a strap on the wrist. For statistical analysis the ANOVA test to intra-group analysis was performed. For inter-group analysis Independent t-test was performed evaluating separate contributions of each identified ICA (1-8).

RESULTS**:** No statistically significant differences were found between groups at baseline in the analyzed spectrum. Statistically significant difference ($p<0,05$) emerges in EEG power spectrum, comparing the two groups, in Delta and partially in Alpha bands.

CONCLUSIONS AND DISCUSSIONS**:** The statistically significant differences between expert and controls during the vision of complex motor gestures could indicate a difference in the brain activity during the recognition of motor programs related to the acrobatic gymnastic. These findings confirm the relationship between EEG activity and vision of specific motor gestures and extend knowledges on the electrocortical response to visual stimuli emphasizing the difference between experienced and inexperienced subjects, relative to the field analyzed.

ACKNOWLEDGEMENT**:** M. Ivaldi was funded by a grant from the Lagrange Project – Crt Foundation.

Fig. Power spectrum in experts and non experts groups during the vision of a movie containing evident technical errors and falls (blue line for experts group, green line for non experts group). A statistically significant difference ($p<0.05$) was found in Delta and Intermediate Alpha band. The black bar indicates statistical significance differences ($p <0.05$).



Motor Control 3 (Sala 1LM 12.00-13.00)

GOAL-RELEVANT AND NON-GOAL-RELEVANT VARIABILITY IN A REAL AND A VIRTUAL SIMULATED ASSEMBLY TASK

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AIM: We used the uncontrolled manifold (UCM) approach to study joint coordination underlying the control of task-related variables in a real and a virtual environment. The UCM approach is based on such a premise that the motor control system does not look for an optimal solution when it faces with a motor redundancy problem. Instead, it invokes a family of solutions that are equally capable of solving the problem. The UCM approach may potentially determine what control variables are of primary importance and how attributes of a task such as precision, complexity and timing regime may interact with the control variable.
METHODS: Sixteen novice subjects performed the task within 2 different platforms: real (RE), virtual (VE) with 2 precision demands, complexity and timing regimes. The task was repeated 12 times (i.e., 12 cycles). The joint angles of a simplified whole body model were computed over a cycle in 3D. The center of mass (CM), the head and hand positions as putative control variables were computed as a function of joint angles. The mean of the controlled variables across the cycles were considered as desired trajectory. The variability of joint angle combinations was partitioned into 2 components with respect to assumed control variables. The first component, goal-equivalent (GE) component, equals the variability of joint angles in a subspace that has minimal effect on deviation of the controlled variables from the desired trajectory. Alternatively, the non-goal-equivalent (NGE) component leads to deviations away from the desired controlled variables. The ratio of GE and NGE was used as an index of stability of the controlled variables.
RESULTS: Among the putative control variables, only CM showed a more stable pattern within the RE compared with VE. Additionally, the interaction of timing regime and the platform type played a significant role on the stability index of CM. High timing pressure only increased the index in the RE.
CONCLUSION: We found that, for the simulated assembly task, the CM was more stable in the RE compared with the VE. The head and hand positions were less stably controlled. The present study underlines the challenges inherent to the current VR platforms when assessing the biomechanics of a task.
ACKNOWLEGMENTS: The authors wish to thank Marwan Badawi, Quentin Avril and Bruno Arnaldi for their kind support. This work was supported by the European Project VISIONAIR (grant agreement 262044) and the Danish Council for Independent Research | Technology and Production Sciences (FTP) Grant number: 10092821.

EVOLUTION OF MOTOR PLANNING IN THE PRESENCE OF UNCERTAINTY

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SIGNIFICANCE: The ability rapidly and correctly respond to environmental cues, including sounds or postural disturbances, is critical for many activities of daily life such as skillfully catching a ball or recovering from a trip on the sidewalk. Knowledge of how we handle uncertainty about if and when a cue will arrive is important for understanding the mechanisms contributing to our ability to respond appropriately, and how that is influenced by cognitive and motor impairment.
AIM: To determine how uncertainty about when movement cue will occur influences planning process and the efficacy of the eventual motor response.
METHODS: Data were collected from 12 healthy, seated subjects. The right arm was attached to a rotary motor used to apply elbow flexion perturbations, eliciting a reflex response to probe the motor system. Each trial began with an auditory WARNING tone, cueing the subject to prepare an elbow extension movement, followed by an auditory GO cue, indicating that the movement should executed as rapidly as possible. Timing between the WARNING and GO cues was varied across blocks of trials to provide three levels of temporal certainty. For the low-certainty and medium-certainty conditions, time between the WARNING and GO was a randomly varied between 5-12 s, and and 2.5-3.5 s, respectively. For the high-certainty condition, the time was fixed at 3 s. Furthermore, an analog countdown clock was visible allowing the subject to know precisely when the GO cue would arrive. Probe perturbations of 100°/s and 100 ms were presented in 20% of the trials to evaluate the state of motor planning and efficacy of the motor response. These were applied before the WARNING, to quantify reflex responses in the absence of a motor plan, and at various times before GO, to assess time course of the planning process. Reflex responses were quantified by the average rectified electromyogram (EMG) recorded from the lateral head of the triceps (Tri_Lat). Results described here are for the period 75-100 ms after perturbation onset.
HYPOTHESIS: Our hypothesis was that uncertainty in the timing of GO cue would 1) increase the time that a motor response is planned in advance and 2) decrease the effectiveness of the response triggered by an unexpected postural perturbation.
RESULTS: Uncertainty about when a movement should occur greatly prolonged the planning process. In the highly uncertain condition, the plan was fully prepared for periods of up to 1000 ms prior to the GO, and unchanged within this period. In contrast, motor responses in the medium and high certainty conditions continued to evolve within this period. The responses in the highest certainty condition were nearly absent 1000 ms prior to the GO cue, but very large (relative to both uncertain conditions) and rapid for perturbations arriving close to the GO. All of these reported differences between conditions were significant at a level of $p<0.05$.
CONCLUSION: Uncertainty about when movement cues will occur greatly influences the planning process and the efficacy of the eventual motor response. Postural perturbations can be used to study this process, and may be a useful tool for assessing how motor planning is affected by various cognitive and motor disorders.
ACKNOWLEDGEMENT: Funding provided by NIH R01 NS053813 and T32 EB009406.

A MOTOR CONTROL-LEARNING MODEL FOR REACHING MOVEMENTS IN 3-DIMENSIONAL SPACE

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AIM: Human's musculoskeletal has many degrees of freedom and is actuated by dozens of muscles. The neural motor control system has to learn how to control such complex dynamics in a trial-and-error manner. In this study, we applied the motor control-learning model to reaching movements of upper limb moving in three-dimensional space. The motor control-learning model is based on the reinforcement learning algorithm that enables trial-and-error learning and is proposed as the learning model in the basal ganglia. We tested whether accurate reaching movements of complex musculoskeletal system can be acquired in a trial-and-error manner by reinforcement learning algorithm.

METHODS: The musculoskeletal of the upper limb was modeled as the two-link dynamical system composed of the shoulder joint with three degrees of freedom, the elbow joint with one degree of freedom, and twenty muscles with viscoelastic property. The feedback command signals to each muscle are learned by reinforcement learning algorithm. The value of reward signal in the reinforcement learning is determined under the tradeoff between movement accuracy and energy consumption.

RESULTS: Figure 1 shows the results of computer simulation of reaching movement learning. Total of 75,000 reaching trials were simulated where the target positions of reaching were determined randomly in each trial. The increase in the amount of reward signal gained in each trial suggests the progress of motor learning. In addition, the distance between target position and hand position at the end of each trial became smaller as the number of trial increased.

CONCLUSION: The results of our computer simulation suggests that reaching movements of the upper limb with complex dynamics like biological musculoskeletal system could be trained in a trial-and-error manner with the reinforcement learning algorithm.

ACKNOWLEDGEMENT: A part of this study was supported by SRPBS of MEXT. This study was also supported by JST of CREST.

Patient 2

Figure 1: Progress in reaching movement learning simulation. Left panel: Amount of reward signal gained in each trial. Right panel: Distance between target position and hand position at the end of each trial.

Multichannel EMG 3 (Sala 2LM 12.00-13.00)

INCREASE IN HOMOHGENEITY OF BICEPS BRACHII MUSCLE ACTIVITY WHEN ADDING SUPINATION/PRONATION TORQUES DURING AN ISOMETRIC ARM FLEXION

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AIM: The current study investigated if the muscle activity of biceps brachii (BB) measured with multi-channel EMG becomes more or less homogeneous when supination/pronation torque is added during an isometric arm flexion.
METHODS: Eight healthy men had to generate three types of isometric contractions at 50%-MVC (force feedback, ~5s duration) with the elbow flexors: 1) only flexion, 2) flexion+supination, 3) flexion+pronation. We measured flexion force and supination-pronation torque at the wrist as well as surface EMG with 49±8 electrodes homogeneously distributed over the entire BB. The monopolar EMGs were high-pass filtered, processed with principal component analysis (PCA), rectified and smoothed to obtain representative EMG amplitudes. Mean and standard deviation (SD) of flexion force (EMG amplitudes) and peak supination/pronation torques were determined. PCA was further used to quantify the degree of homogeneity of the multiple EMG amplitudes over BB.
RESULTS: The mean flexion force showed no significant effect on contraction type (169±20N; p=0.07), whereas SD showed a significant effect (2.3±0.8, 4.7±2.4, 4.4±1.7N; p=0.04). The mean and SD EMG amplitude of BB showed a significant effect on contraction type (27±5, 50±3, 15±5%-MVC; p<0.01). The first PC of the EMG amplitudes over BB also showed a significant effect on contraction type (52±8, 89±3, 89±7; p<0.01; Fig.1).
CONCLUSION: Despite the same mean flexion force was realized for the three contraction types, the last two contraction types (2 and 3) showed about twice as large variations in flexion force. The muscle activity was 50%-MVC for the contraction type *2* and substantially lower for the other contractions (1: 23%, 2: 35%). The arm flexion synergists of BB appear to be mainly responsible to realize the desired arm flexion force. It was found that compared to pure flexion torque the muscle activity of BB became substantially more homogeneous when a supination/pronation torque was added during the flexion (see Fig.1).

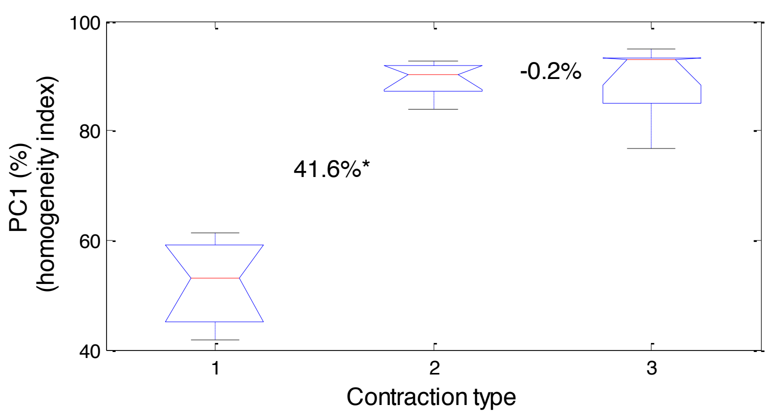

Figure 1: First principal component (PC1) of the EMG amplitudes over BB of the three contraction types. Note the substantial increase in homogeneity of BB muscle activity for contraction types 2, 3.

TOPOGRAPHICAL CHARACTERISTICS OF MOTOR UNITS OF THE UPPER MUSCULATURE DETERMINED BY MEANS OF HIGH-DENSITY SURFACE EMG.

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INTRODUCTION: The upper facial musculature (Fig. 1A) is significantly involved in the mediation of emotional and affective states. Functional investigation of these musculature by means of conventional surface EMG techniques is relevant e.g. in psychophysiology for emotion recognition and in human-machine interaction. Systematic topographical data on this musculature at a single motor unit (MU) level could contribute significantly to improving electrophysiological investigation (Lapatki 2010). However, such data are not yet available.

AIM: To topographically characterize the MUs of the upper facial muscle subcomponents.

METHODS: Signals were recorded in two separate measurements using 0.3mm-thin electrode grids (256 channels). Ten healthy adult subjects performed slight to moderate voluntary contractions of the Mm. frontalis (FRO), orbicularis oculi (OOC), corrugator supercili (CSC) and procerus (PRO). Multichannel motor unit action potentials (MUAPs) were decomposed by convolution kernel compensation technique (Holobar 2007). For each MUAP, the initiation and propagation of the potential were topographically identified in the time sequence of the interpolated monopolar amplitude maps to determine motor endplate zones and muscle fiber directions.

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 muscles. In the OOC (Fig. 1B) and the other three muscle subcomponents (Fig. 1C) we found widely distributed motor endplate locations. In general, results showed relatively high inter-individual variability.

CONCLUSIONS: Our findings add substantially to the sparse neurophysiological and anatomical knowledge on the upper facial musculature on the MU level. Such information is indispensable for the establishment of objective placement guidelines for conventional (surface and needle) EMG electrodes in the upper face.

REFERENCES: Lapatki BG et al., Psychophysiol 2010;47:299-314. Holobar A, Zazula D, IEEE Trans Signal Process 2007;55:4487–4496.

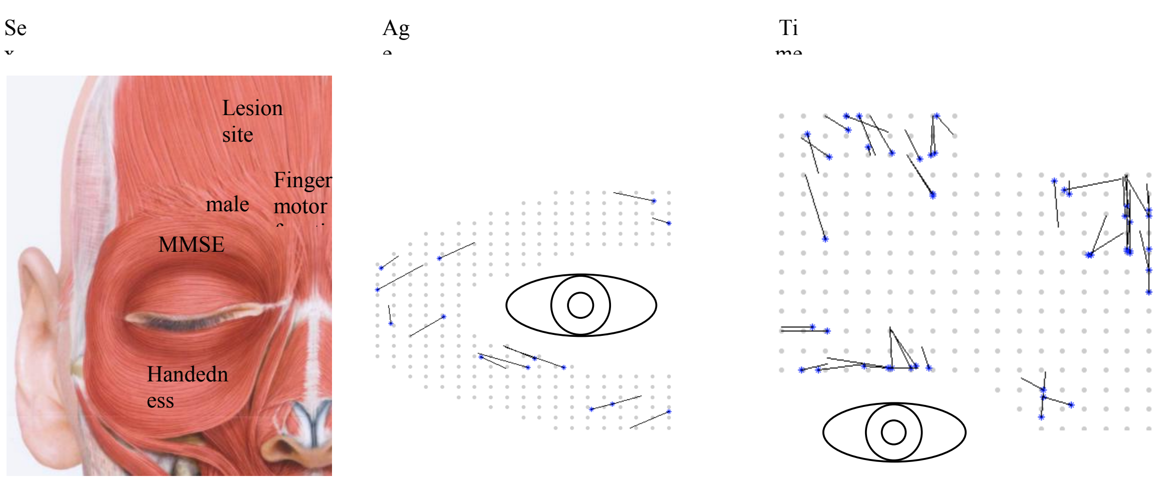

Fig. 1. A) Anatomical situation. B) Recording from the right OOC using an electrode grid with 2.5mm inter-electrode distances; blue dots: motor endplate positions; black lines: muscle fibre orientations. C) Recording from the right upper facial muscles (FRO, PRO, CSC, OOC) using two grids with 4mm inter-electrode distances.

ANATOMICAL FEATURES OF VASTUS MEDIALIS MOTOR UNITS

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AIM: The aim of this study was to investigate the anatomical properties of vastus medialis (VM) motor units (MUs). For this purpose, we: i) validated a method to estimate MU fiber orientation and territory size; ii) extracted these parameters and correlated them with the position of the MU from real EMG signals from VM.

METHODS: One hundred MUs were simulated at two different depths (8 and 18 mm) and with territories of different transverse sizes, from 10 to 60 mm. Fibers were simulated in oblique directions, from 20 to 80º inclination with respect to the femoral axis. Fiber orientation was determined by tracking the travelling action potential in consecutive time instants. The width of the representation of MU surface potentials was calculated on the axis perpendicular to such orientation (standard deviation of the Gaussian curve best fitting the distribution of peak amplitude). The relation between the transverse size of simulated MU territory and the width of the MU surface representation was described by two regression equations, one for each depth. These equations were considered to estimate the territory transverse size of MU decomposed from monopolar EMGs collected from the VM muscle (16x8 electrodes grid) while ten participants performed knee extensions at 60% and 20% of their maximal isometric effort. Besides fiber orientation and MU territory size, the position of VM MUs was determined as the coordinates of the center of the MU representation.

RESULTS: Simulated and estimated fiber orientations were highly correlated ($P<0.001$; $R>0.97$, mean square error<2.97°, N=100). Simulated and estimated territory sizes were highly correlated ($P<0.001$; $R>0.96$, mean square error<0.64 mm). The 121 MUs identified from the VM muscle were oriented 33-57° (10^{th}-90^{th} percentiles) and the width of their surface representation was 15-26 mm (10^{th}-90^{th} percentiles); this corresponds to estimated territory size not larger than 70 mm. More obliquely oriented MU fibers, located prevalently in the distal VM portion ($P<0.001$; $R=0.42$), were associated to narrower, estimated territories ($P<0.001$; $R=0.44$, figure).

CONCLUSION: Our results suggest the fibers of VM motor units distribute locally within the transverse direction of VM width. The narrower territory observed in the most oblique fibers might be related to more precise direction of force production in the distal (patellar tracking) vs. proximal (knee extension) portions of VM.

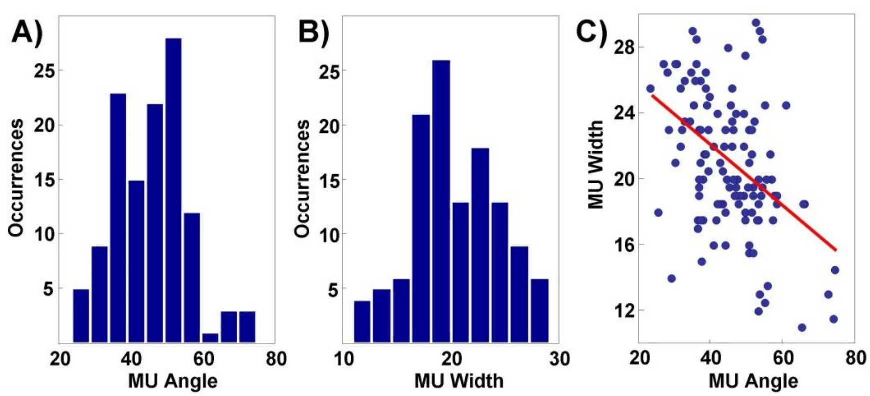

Figure: A) MU Fiber orientation; B) Width of the surface representation MUs; C) Correlation between A and B. N=121 MUs.

A NON-INVASIVE METHOD TO MEASURE REFLEX RESPONSE OF LARGE POPULATIONS OF MOTOR UNITS

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AIM: The estimation of reflex responses in single motor units (MUs) is one of the fundamental methods to investigate neuromuscular pathways. However, this is commonly performed using invasive intramuscular EMG (iEMG) for the precise detection of single motor unit activity. In this study, we proposed and validate a new method that enables the accurate detection of the discharge times of a relative large population of motor units from high-density surface electromyography (HDsEMG).

METHOD: Seven healthy participants (male, age: 24-35 year) attended the experiments. HDsEMG and intramuscular EMG (as control) were recorded from the tibialis anterior muscle during ankle dorsiflexions performed at the 5%, 10% and 20% of the maximum voluntary contraction (MVC) force. The tibial nerve (inhibitory reflex) and the peroneal nerve (excitatory reflex) were stimulated with constant current stimuli of 500 μs duration. The HDsEMG was decomposed by the gradient Convolution Kernel Compensation (CKC) technique [1]. The intramuscular EMG was decomposed using the EMGLAB tool [2]. Identical motor units decomposed from HDsEMG and iEMG signals were found calculating the normalized cross-correlation with a threshold of 0.7. The reflex responses of the MUs were analyzed using the peri-stimulus time histogram (PSTH) [3] and the peri-stimulus frequency gram (PSF) [4]. The similarities of reflex responses estimated from HDsEMG and iEMG for the identical MUs were tested calculating the normalized difference between peri-stimulus time for both PSF and PSTH.

RESULTS: Forty-six common MUs were identified in total. The average agreement was 0.90±0.05 for inhibitory and 0.89±0.07 for excitatory reflex responses. There was no statistically difference between latencies, amplitudes and durations of the reflex responses for the common MUs that were detected using the two techniques. The average normalized difference for PSTH was 10.7±3.5% for inhibitory and 17.3±7.0% for excitatory reflexes. The percentage errors were found to be similar for all contraction levels, except for 20% MVC in the excitatory reflexes.

CONCLUSION: The proposed non-invasive approach for the investigation of single MU reflex responses is an accurate way to study neural circuitries. However, the error for the peri-stimulus time increases for high contraction forces when MUs discharge synchronously for excitatory reflexes.

ACKNOWLADGEMENT: This study was supported European Research Council (ERC) via the ERC Advanced Grant DEMOVE (No. 267888).

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DETECTION OF MULTI-INNERVATION ZONES FROM HIGH-DENSITY SURFACE EMG USING THE GRAPH-CUT SEGMENTATION ALGORITHM

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AIM: This work presents a new method, based on machine vision and image processing techniques, to find the location of multi-innervation zones (IZs) and also local conduction velocity (CV) of Motor Unit Action Potentials (MUAPs) in high-density surface EMG (HD-sEMG) signals.
METHODS: HD-sEMG signals were mapped into image space, and then the 2-d propagation patterns were identified by the following procedure: 1) identification of propagating patterns using the graph-cut segmentation algorithm (Salah et al, 2011), 2) morphological signal processing to exclude outliers (standing potentials), and 3) extraction of coordinates of IZs and related CV. RESULTS: Figure 1 shows the result of the proposed algorithm on 60 ms simulated multi-IZ HD-sEMG with 20dB SNR. The surface EMG signal was simulated using a cylindrical model of the sphincter muscle EMG (Farina et al, 2001). Propagating patterns were identified and then located (Figure1a) while IZ locations and propagations were returned in the time space and visualized in the original signal (Figure 1b). The coordination of IZs and related CV were automatically calculated by the algorithm (Table 1).
CONCLUSION: In this paper, a new method for the identification of multi-IZ locations was proposed that could be potentially used as a part of the TASI (investigation of pelvic floor muscle) project. Locating the IZs of the external anal sphincter could assist the surgeon not to cut the innervation area that possibly leads to faecal incontinence in episiotomy.
ACKNOWLEDGMENT: ERC Advanced Grant DEMOVE (No. 267888).

Table 1: The output of the algorithm (simulated CV's were 4 m/s for all MUs)

Time (ms)	**IZ Channel**	**CV**(m/s)
6.8	12.5	4.37
6.9	20.7	3.37
28.5	8.7	4.37
31.6	20.6	3.43
38.4	10.8	4.33

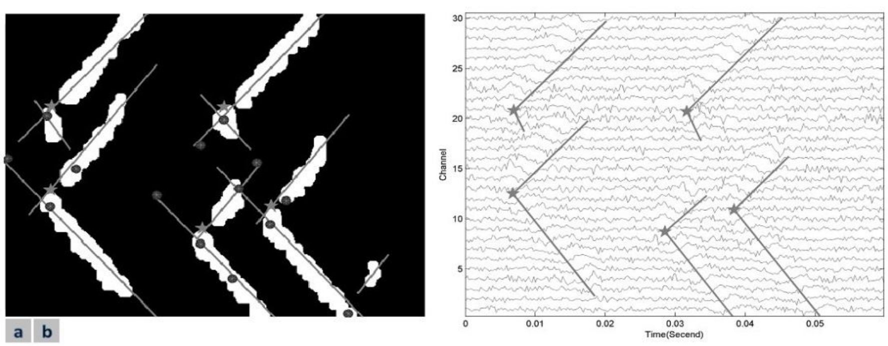

Figure 1: The result of the algorithm on a noisy signal. (a) image space and (b) original signal.

Motor Performance and Sport Science 3 (Sala 4LM 12.00-13.00)

ASSESSMENT OF A "CLASSIFICATION MODEL" FOR ATHLETES WITH MOTOR IMPAIRMENT COMPETING IN CLAY TARGET SHOOTING

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Olympic trap clay target shooting (CTS) consists of a complex sequence of minute movements performed in less than 1 second aimed at killing flying clay targets thrown at varying speeds, angles and elevations in a randomized order. The present research project is aimed at including individuals with motor impairments (IMI) in CTS competitions under the International Paralympic Committee (IPC) endorsement. To accomplish this goal, the study is aimed at providing data and evidences to support the development of a classification model for standing (St) and sitting (Si) IMI by minimizing the impact of eligible types of motor impairments on the outcome of competition, following the guidelines of both the IPC Classification Code[1] and the IPC "Position Stand" on classification[2]. In a preliminary laboratory 3D kinematic study[3] carried out on able-bodied clay target shooters (CTSh) we demonstrated that a wide movement of the pelvis (about 70% of the total range of movement –ROM- of the gun), aimed at stabilizing as much as possible the upper part of the body to minimize the movement of the gun barrel (as typically occurs in a successful performance[4]), is the usual way to shoot. We hypothesized that two classes, one for St-CTSh and one for Si-CTSh, should be allowed for IMI competing in this sport. Indeed, wheelchair-bounded Si-CTSh, being obliged to perform all the CTS movements only with the upper part of the body, would have a worse performance than St-CTSh. Thirty-three male St-CTShs (8 amputees, 3 with spinal cord injury, and 22 with other motor disorders/impairments) and 24 male Si-CTShs (2 amputees, 19 with spinal cord injury, and 3 with other motor disorders/impairments) who competed in at least one of the 4 international CTS competitions carried out in Italy in the last 3 years gave their informed consent to participate in the present study. In each CTSh all motor functions were evaluated through standardized techniques of manual examination of muscle strength, ROM and hypertonia, to assess a motor functionality score (MFS) of 85 points for each upper limb, 25 points for each side of the trunk and 60 points for each lower limb with a total MFS, correspondent to that of an able-bodied individual, of 340 points. A mean of the percentage of hit clays in each race was used as performance score (PS%). St-CTShs and Si-CTShs had the same age (48.9±13.15 *vs* 47.9±8.98 y), the same training status (3.8±1.69 *vs* 4.0±1.95 hours per week) and the same CTS experience (15.2±14.02 *vs* 9.6±9.53 y, as total, and 10.2±10.31 *vs* 9.3±8.22 y, as IMI). St-CTShs had a significantly greater MF (299.3±27.54 points) than Si-CTShs (216.6±40.38 points). St-CTShs had a significantly greater PS% (74.5±13.44%) than Si-CTShs (PS% 63.0±13.67). In conclusion, this study showed that the capability of competing in a standing posture, determining greater degrees of freedom and therefore possibly a more accurate gun movement, allows a better performance than when CTS movement is carried out on a wheelchair. Based on these results we propose two separate medal events for St-CTSh and Si-CTSh.

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LEVER WHEELCHAIRS: DOES LEVER'S AXIS OF ROTATION POSITION INFLUENCE HUMAN WORK CONDITIONS?

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AIM: Present day lever wheelchairs vary strongly in design of lever propulsion mechanisms. In order to assess if differences in these designs influence human work conditions during wheelchair propulsion experimental studies on a dedicated test stand were carried out.
METHODS: 10 healthy, young, male subjects with similar anthropometry carried out tests which consisted of performing wheelchair propulsion work with levers in 2 different lever's axis of rotation positions. During experiments measurement of: 6 muscles EMG activity was carried out in order to assess local muscle fatigue, oxygen consumption to assess human work efficiency and pulse for overall work difficulty assessment. The tests were carried out on a dedicated test stand which allowed individualization of load during experiments as well as measurement of external work carried out by the subjects. In both examined cases human work conditions were the same except for the lever's axis of rotation position.
RESULTS: Since all subjects were similar from the anthropometric point of view, the results were averaged over subjects and are presented in Table 1. Changes in parameters derived from EMG measurements (MNF and RMS) show 2 different patterns of muscle activity for the 2 examined lever's axis of rotation positions. Also, the averaged human work efficiency calculated for these cases vary significantly ($p<0,05$). Assessment of maximum pulse achieved in both trials also allowed the conclusion, that 2 analyzed cases were significantly different ($p<0,05$).
CONCLUSION: Human work conditions during lever wheelchair propulsion are significantly influenced by the design of lever's axis of rotation position. Proper design of lever mechanism can improve human performance.
ACKNOWLEDGEMENT: Here presented research was financed from ECO-Mobility project WND-POIG.01.03.01-14-154/09. Project co-financed from European Regional Development Fund within the framework of Operational Programme Innovative Economy.

Table 1: Summary of the results. All data was averaged over subjects (n=10).
EMG MNF change [%] = (MNF value from the end of the 8-minute test) divided by (MNF value averaged from the first 60 [s] of the test); since there were 6 muscles assessed, in each case there are 6 values indicated (from left to right the values represent muscles: LT ant. deltoid; LT pect. major; RT lat. triceps; LT lat. triceps; RT ant. deltoid; RT pect. major). RMS values are presented analogically.

Parameter	**First lever's axis of rotation position**	**Second lever's axis of rotation position**
EMG MNF change [%]	80; 97; 91; 85; 86; 90	95; 113; 97; 96; 96; 98
EMG RMS change [%]	190; 280; 230; 260; 180; 340	150; 155; 180; 190; 180; 150
Human work efficiency[%]	25,4	31,3
Maximum pulse [bmp]	146,1	125,2

OPTIMUM CONDITIONING FOR MAXIMUM POSTACTIVATION POTENTIATION IN HUMAN PLANTAR FLEXION TWITCH TORQUE

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AIM: An intense muscle contraction prior to a subsequent resting twitch evoked by an electrical stimulation increases twitch amplitude compared to twitch force without conditioning. This is referred to the phenomenon of post activation potentiation (PAP). The aim of this study was to gain more detailed information about the influence of the level of intensity of voluntary isometric conditioning on PAP. In addition, conditioning beyond isometric maximum, i. e. eccentric and post-eccentric muscle action, is of special interest in this work (ongoing study). Results can be of high interest for optimum conditioning for sport performance or when resting twitches are used for the evaluation of muscle function (i.e. assessment of maximum voluntary muscle activation using twitch interpolation technique).
METHODS: N=8 subjects performed sub-maximal and maximal isometric plantar flexion conditioning contractions (CON) using feedback control at levels of 50% to 100% of maximum voluntary contraction (MVC) in steps of 10%. In addition, at 100% MVC, eccentric (ω = 5°/s, 20°) and post-eccentric (ω = 20°/s, 20°) contractions of 4s duration are used for conditioning. Each CON was preceded and followed by supra-maximal percutaneous tibial nerve stimulation using a high voltage stimulator (DS7A, Digitimer, GB). ANOVA statistics and post-hoc comparisons were used to identify significant results ($p < 0.05$).
RESULTS: We found significant differences between twitches before and after CON for each conditioning intensity. Increasing the level of isometric conditioning intensity, a significant increase of PAP from 13.6 ± 2.0 to 16.6 ± 2.3% MVC could be observed (Fig. 1). Additionally, preliminary data points to further potentiation of twitches when using maximal voluntary eccentric or post-eccentric muscle action for conditioning (Fig. 2).
CONCLUSION: Insufficient conditioning intensity does not evoke maximum PAP, although 90% seems to be the critical level for optimal conditioning. As conditioning for PAP always interacts with fatiguing effects, further work is needed to identify optimum strategies for maximum performance enhancements in sports. Eccentric or post-eccentric contraction forms might help to increase PAP while decreasing or maintaining the level of fatigue.

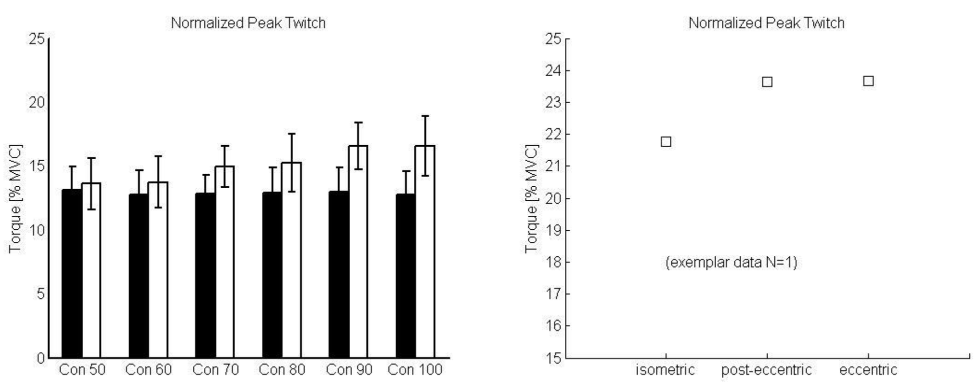

Figure 1/2: Normalized twitches before (black bars) and after (gray bars) conditioning with 50 to 100% of MVC and exemplar data (□, n=1) of conditioning beyond isometric MVC.

SIMULTANEOUS MEASUREMENT OF A MECHANOMYOGRAM AND AN ELECTROMYOGRAM USING AN MMG/EMG HYBRID TRANSDUCER

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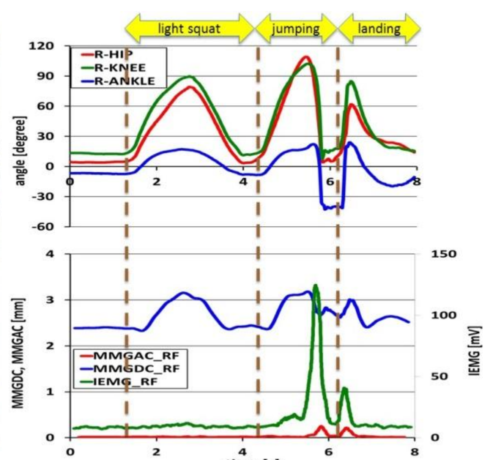
AIM: We previously proposed a wireless displacement-mechanomyogram (d-MMG) transducer with electromyogram (EMG) electrodes that can measure both MMG and EMG signals simultaneously. In this study, the transducer was applied to the simultaneous measurement of d-MMG and EMG during a subject's light squat movement and jumping.
METHODS: The developed wireless MMG/EMG hybrid transducer (45 mm long × 16 mm wide × 12 mm high, 2.5 g) is composed of a small photo-reflector, two EMG electrodes, and a wireless transmission module. During a subject's light squatting and jumping, we measured the d-MMG, the integrated EMG and the joint angles of the hip, knee and ankle. Four hybrid transducers were placed on the rectus femoris, vastus lateralis, hamstrings and gastrocnemius (lateral head), respectively of the subject's right leg. The d-MMG signal includes a large transformation of the skin surface (MMG_{DC}) and a slight vibration (MMG_{AC}) added to the MMG_{DC}. In order to calculate the joint angle, the reflection markers were placed on five body surfaces. The experiment was performed with approval of the ethic committee of Okayama University.
RESULTS: The Figure shows the three joint angles, the d-MMGs and the integrated EMG (IEMG) of the vastus lateralis during a light squat and jumping. When the subject's knee began to bend, the IEMG increased slightly because of the eccentric contraction. The maximum IEMG was reached at the maximal flexure, and the MMG_{DC} then increased (the skin surface swelled) moderately. When the knee began to extend, the IEMG decreased but the MMG_{DC} later decreased moderately. When the subject prepared to jump, the MMG and EMG increased simultaneously, and when he finally jumped, the IEMG suddenly increased because the vastus lateralis contracted strongly at the knee extension, and the MMG_{DC} decreased. In the air, both the IEMG and the MMG_{DC} became zero, and they increased similarly to the case of the light squat when the subject made his landing. These results suggested that the d-MMG corresponded to the passive cross-sectional changes of muscle and voluntary muscle contraction.
CONCLUSION: The wireless d-MMG/EMG hybrid transducer was used for the measurement of light squatting/jumping, and the relationship between d-MMG and EMG was examined. In the future, this transducer could be applied successfully in the rehabilitation field.
ACKNOWLEDGEMENT: This research was partially supported by a Grant-in-aids for Scientific Research (23650263) from Japan Society for the Promotion of Science.

male



ALTERED MUSUCULAR ACTIVITY AND MOVEMENT PATTERNS DURING SINGLE AND DOUBLE LEG SQUATS IN INDIVIDUALS WITH KNEE INJURY

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AIM: To assess specific altered movement patterns in leg and/or trunk during the performance of Single Leg Squat (SLS) and Double Leg Squat (DLS) and the simultaneous, bilateral muscular activity in six muscles of the hip, thigh and shank in individuals with a unilateral, total ACL rupture, and to assess the associations between these specific altered movement patterns and muscular activity on injured and non-injured sides.
METHODS: Sixteen participants (10 women), mean age 29.5 years, with a total, unilateral, ACL rupture, performed SLS and DLS and were scored for altered movements in leg and trunk according to Test for Substitution Patterns (TSP). Surface Electromyography was recorded bilaterally for six muscles in hip, thigh and shank and evaluated at movement initiation, middle and end.
RESULTS: More pronounced altered movement patterns were observed on participants' injured side, in agreement with previous studies of the TSP. Asymmetries in muscular activity, in general lower activity on injured as compared to non-injured side, were found during both SLS and DLS. Correlations between individual altered movement patterns and asymmetries in the activity of specific muscles at specific times were seen, not only in muscles acting directly on the knee joint, but also in muscles primarily acting on adjacent joints. These correlations indicated; the more deviating muscle activity in the injured side, the more pronounced altered movement pattern; "knee medial to the supporting foot" correlated to lower activity of the gluteus medius muscle on injured side ($r_s= -0.73$, $p=0.001$), "lateral displacement of hip-pelvis region" to a lower activity in quadriceps muscle on injured side ($r_s=-0.54$, $p=0.03$) and "displacement of trunk" to higher activity of gluteus medius muscle on injured side ($r_s=0.62$, $p=0.01$).
CONCLUSIONS: The specific asymmetries found in activity of individual muscles between injured and non-injured sides, and associations between these asymmetries and specific altered movement patterns during SLS and DLS, suggest that altered movement patterns, as measured with SLS and DLS, can be interpreted as an indication of impaired sensorimotor control, and that quantitative assessments of altered movement patterns ought to be advocated as a complement to commonly used assessments in ACL rehabilitation.

Motor Control 4 (Sala Cesarea 15.30-16.30)

NECK MUSCLE STRAIN DURING PARACHUTE OPENING SHOCK IN SKYDIVERS

Lo Martire R[1], Gladh K[1], Gunhammar K[1], Richert E[1], Westman A[1,2], Lindholm P[2], Nilsson J[1], Müller M[1], Äng BO[1]

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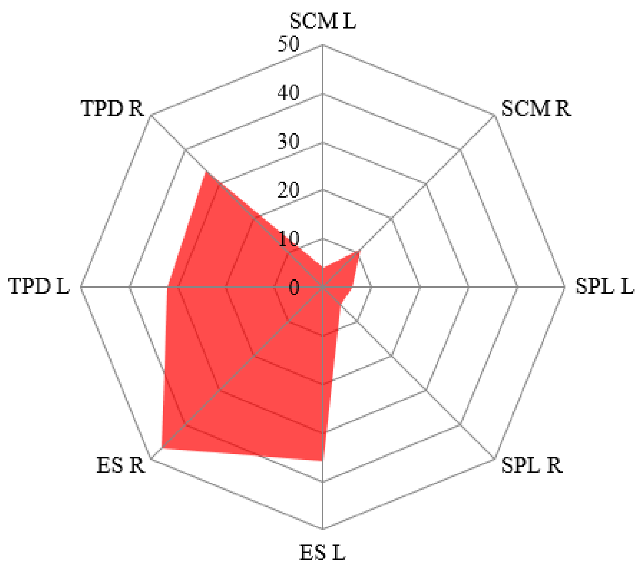
AIM: This study's objective was to investigate neck muscle strain during parachute opening shock (POS), an event during which falling speed is reduced from about 210 km/h to 30 km/h within a few seconds. Neck pain episodes related to POS has recently been found to be significant among skydivers, and peaks strains of muscle activity have previously been found to cause neck pain. However, such data on peak activity is absent in the skydiver community. METHODS: In this empirical observation, 20 experienced skydivers each performed two consecutive skydives with ram-air parachutes. During POS, muscle activity was obtained bilaterally from the sternocleidomastoids (SCM), the splenius capitis (SPL), the cervical erector spine (ES) and trapezius descendens (TPD) with the use of an established surface electromyographic measuring protocol, and data was normalized against pre-test isometric maximum voluntary electricity contraction (%MVE). Two triaxial accelerometers were used to map decelerations. Muscle activity peaks surpassing reference values of a minimum of 50 ms latencies were identified for each muscle using a Matlab-script. RESULT: Analysis revealed ES and TPD to have significantly more supramaximal peak muscle activities than SCM and SPL (83 and 86 vs. 15 and 11; $p<0.001$), with Figure 1 displaying the sum of peak muscle activities for each muscle. CONCLUSION: A high amount of peak muscle activities were found in erector spine and trapezius descendens during POS, suggesting these muscles to be the most vulnerable to neck pain during POS deceleration. Further studies elucidating preventive measures in the skydiving population is encouraged.



Motor Control 4 (Sala Cesarea 15.30-16.30)

MUSCLE ACTIVATION WITHIN EQUINE GLUTEUS MEDIUS IS ASYNCHRONOUS STARTING LATERAL IN WALK AND TROT

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AIM: To describe the intramuscular pattern of muscle activation in walk and trot at three areas of the equine gluteus medius muscle, one of the largest unsegmented muscles of horses.
METHODS: Surface electromyography (sEMG) measurements were taken in fourteen horses without lameness, walking and trotting on a treadmill. Three electrodes were placed over both the left and right gluteus medius muscle at roughly the midpoint between origin and insertion about 5cm apart on the lateral (GM1), middle (GM2), and medial (GM3) part of the gluteus medius muscle. The resulting EMG signal was rectified and sampling rate was reduced to 120 Hz. A Butterworth low-pass filter was applied (fourth order; cut-off frequency, 20 Hz). Occurrence of the maximum muscle activation within the motion cycle was determined for each electrode as a percentage of the total duration of the respective motion cycle. The time points of the occurrence of the maximum activities of GM1, GM2 and GM3 were then ranked within each muscle during each motion cycle. For each horse a minimum of ten motion cycles was considered for each gait. An average rank of each area was then determined for each electrode of each horse at both gaits, and only these ranks were further considered.
RESULTS: There was a similar ranking pattern in walk and trot, with GM1 as first maximum peak activity (walk left in 10 out of 14 horses, right 7/14; trot left 7/14, right 6/14), GM2 as the second peak activity (walk left 7/14, right 8/14; trot left 6/14, right 6/14), and GM3 as the third peak activity (walk left 8/14, right 6/14; trot left 9/14, right 6/14).
CONCLUSION: The small but distinct time delay in maximum sEMG activity of different areas may serve to optimize the function of the gluteus medius muscle, which is the stable extension of the hip joint. Also the staging of muscle contraction may reduce the potential detrimental effect of simultaneous contraction of such a large muscle mass.

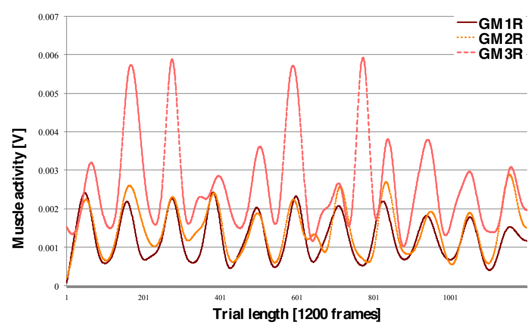

Figure 1: In Horse 3 muscle activity of the right lateral (GM1R), the right middle (GM2R) and the right medial (GMR3) gluteus medius muscle in walk throughout one trial.

ARE SURFACE ELECTRODES A VALID EMG RECORDING TOOL FOR GLUTEUS MEDIUS?

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AIM: Dysfunction of gluteus medius (GMed) has been associated with a range of injuries from the lumber spine to the ankle joint. Exercise interventions of GMed are therefore an important component of lumbar spine and lower limb rehabilitation. Surface electrode EMG investigations have recently been used to quantify muscle activity of GMed across a range of rehabilitation exercises for the purpose of directing targeted rehabilitation programs. However, GMed is covered by gluteus maximus (GMax) posteriorly and tensor fascia lata (TFL) anteriorly; and this may potentially result in contamination of surface electrode signals with cross-talk, a known limitation of surface electrode recordings. The purpose of this study was therefore to investigate the validity if using surface EMG electrodes to record activity from GMed.
METHODS: EMG activity was compared between surface and intramuscular EMG electrodes on 9 healthy adults free of hip pain or pathology. The intramuscular electrode was inserted 3cm distal to the midpoint of the iliac crest, along a line towards the greater trochanter. The surface electrode was positioned approximately 1cm posterior to the intramuscular electrode insertion site. Participants were positioned in side-lying, with the testing leg upper-most and were asked to perform three maximum voluntary isometric contractions (MVICs) across three different actions. The testing actions consisted of hip internal rotation, hip abduction and hip external rotation. The EMG signals were filtered and processed to generate a linear envelope, and normalized to the maximum value recorded across all three actions. The normalized value recorded from all three actions was compared between electrode type (surface vs intramuscular) using Mann Whitney *U* tests ($\alpha = 0.05$).
RESULTS: Results are presented in Table 1. In positions that evoked a high intensity of muscle activity (internal rotation and abduction) there was no significant difference between electrode types. However, during external rotation, when the intensity of muscle activity was low, surface electrodes recorded additional myoelectric activity, potentially representative of cross-talk from surrounding muscles.
CONCLUSION: At low levels of muscle activity, in actions where GMed is not considered a prime mover, surface electrodes may be vulnerable to contamination of cross-talk from surrounding muscles. Studies that use surface electrodes to quantify activity from GMed may therefore potentially misdirect clinical interventions.

Table 1: Comparison between surface and intramuscular recordings of gluteus medius

Action	**Electrode median (inter-quartile range) %MVIC**		*U* statistic	*p*-value
	Intramuscular	**Surface**		
External rotation	4.2 (6.4)	18.3 (13.2)	81	**0.002**
Abduction	100.0 (NA)	100.0 (19.8)	24	0.277
Internal rotation	77.0 (14.0)	82.2 (25.7)	52	0.604

FASCICLE MOVEMENT IN A BIARTICULAR MUSCLE: IS LENGTH CHANGE JOINT DEPENDANT?

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BACKGROUND: The human medial gastrocnemius (MG) is biarticular and crosses both the knee and ankle joints. Rotations of both the ankle and knee joints may contribute differently to changes in the MG tendon unit (MTU) and fascicle lengths, and also i) the mechanical factors influencing muscle force production and ii) the potential for sensory feedback (e.g. from muscle spindles). Patterns of muscle fascicle length change can differ from MTU length changes during different motor tasks; however it is unknown whether the relationship is differentially influenced by knee or ankle joint angle changes.
AIM: To investigate the relationship between muscle fascicle and MTU length changes in MG during passive rotation of the ankle or knee joint.
METHODS: B-mode ultrasound images were collected from the right MG of seven participants (Mean±SD Height: 1.78±0.08m, Weight: 73.07±10.61kg). The ultrasound probe was aligned over the muscle to provide a clear image of complete fascicles and secured in the same position for the duration of the experiment using elasticated bandage. Participants laid prone on an isokinetic dynamometer and were placed in two positions, to enable either passive rotation of: i) the ankle joint (-15^{o} dorsiflexion to +30^{o} plantarflexion) or ii) the knee joint (180^{o} extension to 90^{o} flexion). During knee rotation the ankle joint was fixed at 90^{o} using a customized brace. The ranges of motion ensured MTU length change was similar in each condition (knee: 0.450-0.426m; ankle: 0.451-0.420m, calculated with OpenSim [1]).
Muscle fascicle lengths were calculated from analysis of collected ultrasound image sequences, which were processed in a fully automated manner using the methods of [2]. MTU length change was calculated using the equations provided by [3], using angle data recorded from the dynamometer during each trial.
RESULTS: Preliminary analysis of data revealed that in all participants the largest fascicle length changes occurred during rotation of the ankle joint, although changes in MTU length were similar between conditions. A strong linear relationship was found between MTU and fascicle length change during ankle joint rotations ($0.55 \leq r^2 \geq 0.97$, median: 0.91). During knee joint rotation the relationship was significantly better described by a quadratic fit (linear: $0.36 \leq r^2 \geq 0.86$, median: 0.65; quadratic: $0.61 \leq r^2 \geq 0.98$, median: 0.75).
CONCLUSION: Knee and ankle joint rotations lead to different responses in muscle fascicles of human MG. Differences could have implications for the potential for sensory feedback during postural control and may be due to differences in properties of elastic structures in proximal/distal regions of the muscle, association(s) with other muscles (e.g. soleus spanning the ankle joint) and/or geometric properties of muscle fascicles.
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THE RELATIONSHIP BETWEEN JOINT PHASE TRANSITION AND MUSCLE ACTIVITIES DURING TIPTOE STANDING IN BALLET DANCERS

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AIM: We aimed to investigate the contributions of muscle activities to the phase transitions between angular displacements of lower limb adjacent joints during tiptoe standing in ballet dancers. This is for understanding how their joint coordination is generated by muscle activations.
METHODS: Seven female ballet dancers performed tiptoe standing with three kinds of ballet specific foot positions (1st, 5th, and 6th positions) for 10s, during which kinematics data of metatarsophalangeal (MP), ankle, knee, and hip in anteroposterior direction and surface electromyograms (EMG) over 13 muscles of lower limb were recorded. Next, we calculated the phase difference between adjacent joints' angular displacements (that is, MP-ankle, ankle-knee, knee-hip) by Hilbert transformation and detected the time when each phase difference changes from in- to anti- phase (A) or from anti- to in- phase (B). Then low-pass filtered phase difference and EMG data at the detected time were used to compute the cross-correlation. Mean values of cross-correlation for all events during each foot position were calculated for each participant, pair of joint, and the phase transition pattern (A or B).
RESULTS: For every participant, some muscles showed high correlation with phase difference. There were five types of cross-correlation; A and B have 1) positive and negative correlation, respectively, 2) negative and positive correlation, respectively, 3) positive correlation, 4) negative correlation, and 5) no correlation with EMG signals (Figure 1). Most of the correlation belonged to type 1 and 5 and some muscles of some participants had type 2 to 4. The relationship between phase and muscle activities was different between leg positions and participants.
CONCLUSION: Phase transitions in ballet dancers' joint coordination were accompanied by muscle activations. Some muscles were activated when the phase was turning to either in-phase or anti-phase in specific leg positions and dancers.

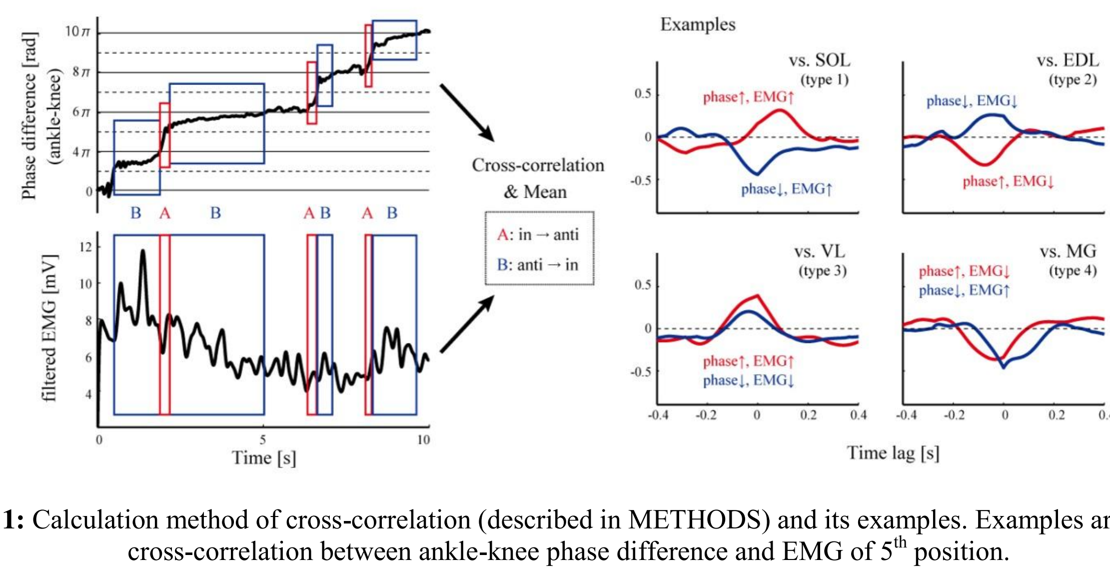

Figure 1: Calculation method of cross-correlation (described in METHODS) and its examples. Examples are of mean cross-correlation between ankle-knee phase difference and EMG of 5th position.

Clinical Neurophysiology 2 (Sala 1LM 15.30-16.30)

CHARACTERISTICS OF MOTOR UNITS OF THE STERNOCLEIDOMASTOID MUSCLE DURING CERVICAL ISOMETRIC FLEXION

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AIM: To clarify the relationship between firing rate and recruitment threshold of motor units in the bilateral sternocleidomastoid (SCM) muscles during isometric cervical flexion in healthy populations.
METHODS: Twelve healthy subjects (6 males & 6 females, 27.30±4.31 years) participated in the study. Surface electromyographic signals from bilateral SCM muscles were detected at 25% and 50% of the maximum voluntary contraction (MVC) during isometric cervical flexion and then decomposed into individual motor unit action potential trains. Subsequently, the relationship between firing rate and recruitment threshold of motor units was identified using linear regression analysis.
RESULTS: The linear slope coefficients for these relationships between firing rate and recruitment threshold of motor units were -0.56±0.04 (P<0.01) for right SCM muscle at 25% MVC, -0.60±0.06 (P<0.01) for left SCM muscle at 25% MVC, -0.30±0.02 (P<0.01) for right SCM muscle at 50% MVC and -0.34±0.02 (P<0.01) for right SCM muscle at 50% MVC, respectively. In addition, the y-intercepts were 25.72±0.54 (P<0.01) for right SCM muscle at 25% MVC, 25.22±0.77 (P<0.01) for left SCM muscle at 25% MVC, 22.62±0.56 (P<0.01) for right SCM muscle at 50% MVC and 25.60±0.53 (P<0.01) for right SCM muscle at 50% MVC.
CONCLUSION: For SCM muscle, the present findings support the "onion skin" property, demonstrating the lower the recruitment threshold of motor unit was, the higher firing rate of motor unit sustained and vice versa. Further knowledge of characteristics of motor units, such as firing rate or recruitment threshold would make it possible to refine the potential mechanism underlying painful musculoskeletal conditions.
ACKNOWLEDGEMENT: The project was supported by National Health Research Institutes (NHRI-EX102-10204EI), Taiwan.

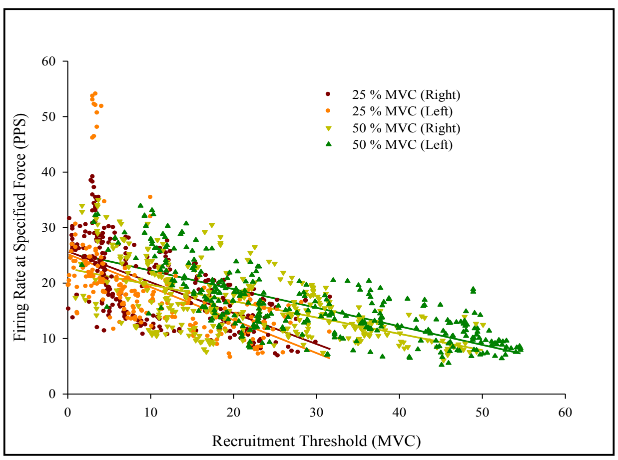

Figure 1: Relationship between firing rate and recruitment threshold of motor units in the bilateral SCM muscles

BENEFITS OF THE HBP EXOSKELETON ON WALKING AND COGNITIVE BRAIN FUNCTIONS IN MULTIPLE SCLEROSIS PATIENTS

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AIM: We investigated the effect of a passive and fully articulated exoskeleton (the Human Body Posturizer, HBP) on multiple sclerosis patients by means of behavioural and Event-Related Potentials (ERPs) analysis.
METHODS: Six multiple sclerosis patients and six healthy controls performed two sessions of the Go/No-Go task with a 64-channel EEG cap mounted on the scalp. At the end of the first session, the HBP was mounted on the patient's body; after 60 minutes the exoskeleton was removed and the second session of the task was repeated. The Expanded Disability Status Scale (EDSS) was fully administered before and after the treatment. The healthy controls executed the same tasks as the patients (expect for the HBP and EDSS) with the same timing.
RESULTS: One hour of HBP-treatment was able to reduce the EDSS score of 0.5 point. The EEG analysis of the premotor brain activities revealed an increased prefrontal cortex activity in the patients group after the HBP application.
CONCLUSION: A single HBP application was able to improve mobility and ambulation in all tested patients. These effects were associated to enhanced activity in the prefrontal cortex indicating a strong compensatory action on high-level executive functions that are able to increase the motor control of patients.

EFFECT OF TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION ON PRIMARY MOTOR CORTEX TO MODULATE CORTICAL EXCITABILITY DURING IMPLICIT SEQUENTIAL MOTOR LEARNING

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AIM: The relationship between cranial transcutaneous electrical nerve stimulation (TENS) stimulation and cortical excitability change during motor learning process is unknown. This study aims to find out the effects of cranial TENS application on cortical excitability of primary motor cortex (M1) during motor learning process in normal subjects.
METHODS: Twenty-four volunteers were recruited from colleges and communities. Exclusion criteria were contraindications of TMS, poor skin condition and neurological disorder. Subjects were randomized into TENS stimulation group (G1) and TENS combined with serial reaction time task (SRTT) group (G2). Subjects in both groups need to accomplish two trials (TENS or sham stimulation), the interval between trials was 1 week. Motor evoked potential (MEP), intracerebral inhibition (ICI) and intracerebral facilitation (ICF) were measured at baseline, immediately after stimulation, and at 30 and 60 minutes follow up.
RESULTS: Group effect (P=0.005), time effect (P=0.001) and interaction (P=0.016) found in normalized MEP (nMEP). In G1, nMEP after TENS stimulation were higher than sham condition, but not reach significance (P=0.278). In G2, nMEP after TENS stimulation were significant higher than sham condition (P=0.011). In SRTT performance, reaction times significantly improved after TENS stimulation and sham stimulation. However, there were no significant difference of reaction time between TENS and sham stimulation. In 30 and 60 minutes follow up, SRTT performance after TENS stimulation were better than sham stimulation, which indicated better consolidation of the task. There were no significant change in ICI and ICF.
CONCLUSION: Cranial TENS enhanced excitability of M1. According to previous study (Lin et al., 2011), increasing excitability of M1 indicated improvement of motor memory retrieval, but our results did not found significant difference on SRTT performance. More subjects were required for further study.

Muscle Fatigue (Sala 2LM 15.30-16.30)

LOCALIZED MOTOR UNIT TASK GROUPS IN THE MASSETER MUSCLE

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AIM: We investigated whether differential activation behavior can also be detected in small muscle sub-volumes at the level of single MUs. METHODS: Two bipolar fine-wire electrodes and an intraoral 3D bite-force transmitter (Fig. 1) were used to record intramuscular electromyograms (EMG) resulting from controlled bite-forces of 10 healthy human subjects (mean age 24.1 ± 1.2 years). Two selected masseter regions were simultaneously recorded under a constant resultant bite force vector of 20N performed in four different loading directions for 20 seconds each. The recordings were sampled with 20 KHz and decomposed with the software EMGLAB into the contribution of single MUs to the localized EMG activity. RESULTS: The selected masseter regions showed significant ($p < 0.01$) task dependent recruitment changes of the 217 MUs observed. Depending on the bite force direction, MU derecruitment, additional recruitment, or no recruitment at all could be found. Proportions of MUs involved in one, two, three, or four examined tasks were 46%, 31%, 18%, and 5%, respectively (Table 1). CONCLUSION: This study provides evidence of the ability of the neuromuscular system to modify the mechanical output of small masseter sub-volumes by differential control of adjacent MUs belonging to distinct task groups. Localized differential activation behavior of the masseter may be the crucial factor enabling highly flexible and efficient adjustment of the activity the muscle in response to complex local biomechanical needs, for example continually varying bite-forces during the demanding masticatory process.

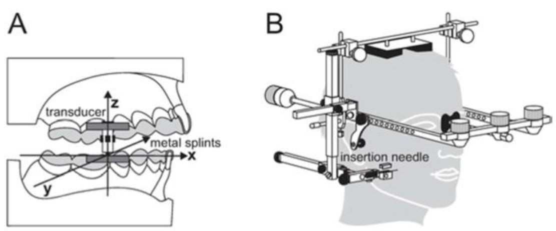

Fig. 1: A: Intraoral force-measurement device. B: The stereotactic instrumentation used for placement of the fine-wire electrodes in predetermined masseter sub-volumes.

Table 1: MU numbers and proportions for the different grades of task specificity

Task per MU	Unimodal	Bimodal	Trimodal	Quadrimodal	*N*
Deep MUs	47(41%)	33 (28%)	28 (24%)	8 (7%)	116
Superficial MUs	54 (53%)	34 (34%)	10 (10%)	3 (3%)	101
Total	101	67	38	11	217
Proportion	46%	31%	18%	5%	

3D KINEMATIC ANALYSIS OF RUNNING MECHANICS DURING A MARATHON TO OBJECTIFY THE INFLUENCE OF FATIGUE; PRELIMINARY RESULTS

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Purpose: Running is associated with high incidence of running related injuries. The etiology of running related injuries is assumed to be multifactorial. Fatigue can be considered an important factor in the development of these injuries, although its exact influence is not fully understood. Studying the influence of fatigue on running mechanics is difficult in the lab setting but recent developments in sensor technology allow continuous 3-d kinematic analysis of running mechanics outside the lab. This study was a first step towards objectifying the influence of fatigue on the running technique in the sport specific setting of an actual marathon

Methods: One trained male runner (31 yrs, 78 kg, 182 cm) was equipped with 8 wireless inertial Xsens MTw ce motion sensors (containing an accelero-, magnetometer and gyroscope) on the feet, lower and upper legs, sacrum and sternum. Data was gathered with a sample frequency of 60Hz throughout the 42,2 km of the Enschede Marathon and transmitted wirelessly to a tablet pc carried by an accompanying cyclist. Fatigue was expressed as the ratio between Heart Rate (HR) and velocity. Raw sensor data was processed and segment calibration was performed off line. At three stages during the marathon (at 13.6, 33.9 and 39.0 km), where the runner was running on level ground in a straight direction, hip, knee and ankle angles, stride length and step frequency were calculated. Joint angles were normalized to cycle length and averaged over 200 gait cycles per stage.

Results: Fatigue increased during the marathon since the ratio between HR and velocity increased. Step frequency remained constant while stride length decreased from an initial 2.59 meters to 2.15 meters per stride. Ankle plantar flexion and knee peak flexion decreased during (mid-) swing and ankle plantar flexion decreased at toe-off. No changes were witnessed in hip angle.

Conclusion: This pilot study showed the possibility of performing a continuous 3-d kinematic analysis of the running technique during an actual marathon and of objectifying the influence of fatigue on this technique.

Table: 1 Results

Stage	1	2	3
Kilometers at the marathon	13,6	33,9	39
MeanVelocity (km/h)	13,6	12	11,2
Stride Length Mean (m)	2,59	2,31	2,15
Step Frequency (cycli/min, Left & Right Leg)	172	174	173
Ratio Heart Rate(Beats/min) & Velocity (km/h)	10.9	13.1	13.8
Peak Knee Flexion during Swingphase (degrees)	103	97	89
Ankle Plantarflexion at Toe Off (degrees)	35	28	21
Ankle Plantarflexion at midswing (degrees)	12	12	2

Muscle Fatigue (Sala 2LM 15.30-16.30)

NEUROMUSCULAR ADAPTATIONS TO FATIGUE: COMPARISON BETWEEN ISOLOAD VERSUS ISOKINETIC CONCENTRIC TRAINING

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AIM: Isoload (IL) and isokinetic (IK) contractions are commonly used in strength training and rehabilitation protocols. However, little knowledge is available to trainers and practitioners for specifically prescribing one or the other contraction modality. Previous studies conducted in our laboratory and using a standardization procedure showed specific neuromuscular adaptations to IL *vs* IK low repetitions resistance training. The aim of the study was to compare neuromuscular adaptations induced by IL *vs* IK medium resistance/medium repetitions training program.
METHODS: Thirty-four healthy men were randomly assigned to a training (IL or IK) or control (C) group. IL and IK training programs consisted of 16 training sessions comprising 2 sets of concentric fatiguing leg extensions (48.6±6.3 and 31.3±4.3 repetitions on average respectively), during an 8-wk period. For each subjects, sets of the first session were work- and velocity-matched from a standard IL exercise performed during the pre-tests. Thereafter, the training load was adjusted to the performance development of each subject. All participants were tested before (PRE) and after the 8-wk training or control period (POST), through two separate test sessions. One session consisted of repetitive concentric IL contractions, performed against a predetermined 50-RM load. The other session comprised a block of 50 maximal voluntary isometric contractions (MVICs; 3-s contraction, 2-s rest) followed by 2 MVICs performed respectively 30-s and 3-mn after the last contraction. Each 10 MVICs, single and double-pulse stimulations were delivered during the torque plateau and at rest. During both sessions, mechanical data and EMG signal of agonist and antagonist muscles were recorded. During data processing, the parameters of interest were averaged in sections of equal number of repetitions.
RESULTS: Considering a 3-way ANOVA (group (IL, IK, C) × time (pre, post) × section), preliminary results showed a main effect of “time” on mechanical performance for both dynamic and isometric test sessions. During POST isometric fatigue protocol, mean voluntary torque was significantly higher than at PRE (+7.9% for the two group pooled; $p<0.005$). The increased torque could be related with increased voluntary activation (+4.8%; $p<0.01$). Surprisingly, the fatigue-induced torque decrease was larger during POST (-38.1 *vs* -31.9%; $p<0.01$). However, we observed faster voluntary torque recovery (+41.2%; $p<0.005$) that could be partly explained by faster rest twitch torque recovery (+29%; $p<0.005$). No main effect of “group” was found for isometric test session. On the other hand, dynamic test sessions revealed a main “group × time” effect on mechanical performance. Total number of repetitions, mean angular velocity and total amount of work performed at POST were higher for IL group ($p<0.05$). After training, fatigue-induced torque and peak torque angle changes were also specific to the training group ($p<0.005$).
CONCLUSION: IL and IK medium resistance/medium repetitions training program lead to performance improvements related to both specific and transferable neuromuscular adaptations. Further analyses of mechanical data combined with ultrasonography images and EMG signal processing will provide an accurate insight into the training-induced adaptations.

HAS INTERPRETATION OF THE MOTOR ADAPTATION TO PAIN BEEN TOO SIMPLISTIC?

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AIM: During pain it is proposed the nervous system searches for less painful movement strategies. We investigated whether participants searched for a new, less painful movement strategy during acute experimental pain.
METHODS: In 3 experiments (Exp), participants performed 2 trials of 60 radial-ulnar deviation wrist movements between two target regions. Motion of the right wrist and forearm were recorded with a 3D motion sensor. In all experiments variation in flexion-extension angle range during the task was determined in trial 1. For Exp1-trial2, the control condition was repeated. For Exp2–trial2 and Exp3–trial2 wrist extensor muscle pain was induced by electrical stimulation when the wrist crossed neutral radial-ulnar deviation. Stimulation intensity was determined by wrist flexion-extension angle. Exp2 – painful stimulation (~5/10) for two-thirds flexion-extension range, and less painful (~1/10) for one-third. Exp3 – painful stimulation (~5/10) for two-thirds flexion-extension range and no pain for one-third. The proportion of movements performed in the less/non-painful flexion-extension angle range was recorded. Vector lengths between average wrist-angle of trial1 and wrist-angle for each repetition of trial2 quantified change in wrist-angles relative to baseline. Vectors were summed (*Total vector length*).
RESULTS: *Total vector length* was greater (Exp2; $p=0.03$) or tended to be greater (Exp3; $p=0.08$) during pain indicating a change in movement strategy. Although the new wrist-angle was perceived as less painful, this did not correspond to the region with less intense stimulation. The less/non-painful region was not used more often in Exp3 ($p=0.90$) and even used less in Exp2 ($P<0.03$).
CONCLUSION: A less painful strategy was found, but it was not the solution with complete or near complete pain reduction.

Muscle Fatigue (Sala 2LM 15.30-16.30)

THE EFECT OF FATIGUE ON EMG ACTIVITY AND LEG KINEMATICS IN DANCERS AND NON-DANCERSPERFORMING DROP LANDING

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AIM: Previous studies have reported that fatigue alter landing biomechanics including muscle activity which could result in increased injury risks. McEldowney et al. recently reported that quadriceps and hamstrings co-contraction ratios in dancers were substantially greater than previously reported in other athletic populations. However, it is still unknown if the changes in landing biomechanics after fatigue are similar between dancers and non-dancers. So the purpose of this study was to compare changes in landing performance and activation patterns of the leg during fatigue that could result in increased injury risk in dancers and non-dancers.
METHODS: Ten dancers with ballet experiences more than ten years and ten controls who had no regular athletic training participated in this study. They performed nonfatigued and fatigued drop landings (0.30 m), while ground reaction force (GRF), electromyographic (EMG) activity of rectus femoris, biceps femoris, medial gastrocnemius, and tibialis anterior muscles, and kinematics of hip, knee and ankle joint were recorded.
RESULTS: Fatigue increased significantly peak GRF and time between initial contact to peak GRF for both groups, while there was no significant difference between groups in each conditions. Knee flexion and ankle dorsiflexion at contact were significantly greater during fatigued condition. After fatigue, EMG activity of biceps femoris muscle significantly increased, while there was no significant change in EMG activities in other muscles.
CONCLUSION: .Fatigue elicited a similar response in dancers and non-dancers in biomechanical landing performance, while dancers showed increased muscle activity in biceps femoris after fatigue.

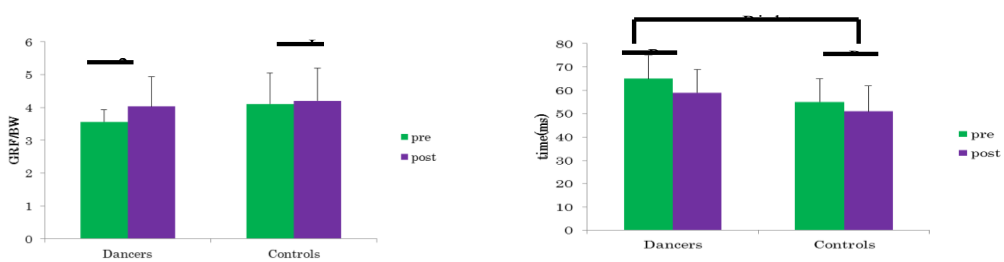

Figure 1: Peak GRF and time between initial contact to peak GRF during non-fatigued and fatigued conditions.

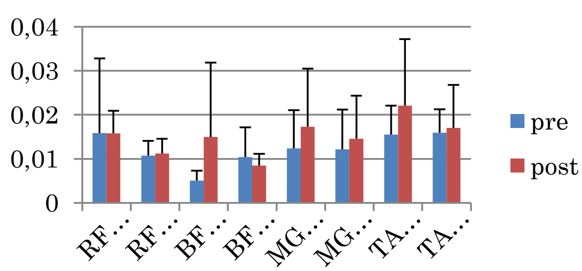

Figure 2: EMG activity level during non-fatigued and fatigued conditions.

Neuromechanics of muscle coordination (Sala 4LM 15.30-16.30)

TRUNK MUSCLE ACTIVITY DURING DIFFERENT TYPES OF STABLE AND UNSTABLE SQUATTING

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AIM: Squat exercises are widely used in rehabilitation, fitness, and strength training to improve or maintain individual performance levels. In this exercise, trunk muscles are also considered a key factor to support the load. However, it remains unknown to what extent different types of squatting, under stable and unstable conditions, affect trunk muscle activation.
METHODS: Twelve healthy females (N = 6, age: 29.4 (SD 9.0) y, height: 168.5 (6.0) cm, body mass: 64.0 (7.1) kg) and males (N = 6, age: 28.8 (8.0) y, height: 178.3 (3.1) cm, body mass: 76.2 (6.6) kg) randomly completed four repetitions of each squat type (back squat (BS), front squat (FS) and overhead squat (OS)) under stable and unstable conditions with additional external loads (female 12.5 kg / male 20 kg) barefoot. A knee angle of 100^{o} at the lowest point and a timing of 2 s down and 2 s up were enforced. After the stable trials were completed, unstable trials with a reduced base of support were performed by standing with the ball of the foot on a 1.6 cm high wooden board and the heels off the ground. Surface electromyography of internal (OI) and external oblique (EO), rectus abdominus (RA) and erector spinae (ES) was collected during each squat and normalised against a maximal voluntary isometric contraction performed in a crunch and prone plank position. 3D position and motion of the participants was captured using 56 reflective markers placed on lower limbs, hip, spine, thorax, shoulder and hands. Two (condition: stable vs. unstable) × three (type: BS, FS, OS) repeated measures ANOVAs were separately calculated for each muscle. The included outcome measure was to evaluate trunk muscle activity for the different squat types.
RESULTS: Statistically significant type-effects ($p<0.001$) with large effect sizes ($0.54<\eta_p^2<0.77$) were observed for all squat types. Post-hoc tests are separately shown above each chart-box (Figure 1). A significant type × condition interaction was only observed for OI. Post-hoc tests showed significant differences between stable and unstable conditions for BS and OS (Figure 1, OI). Significant condition effects were only found for OI ($p=0.03$, $\eta_p^2=0.35$) and ES ($p=0.03$, $\eta_p^2=0.34$).
CONCLUSION: The type of squatting exercise seems to have a greater affect on trunk muscle activation than the stability condition. However, the deeper stabilising OI seems to respond with higher muscle activation also under unstable standing conditions. The results have significant implications for the prescription of squat exercise to be performed when considering trunk loading and trunk muscle activation.

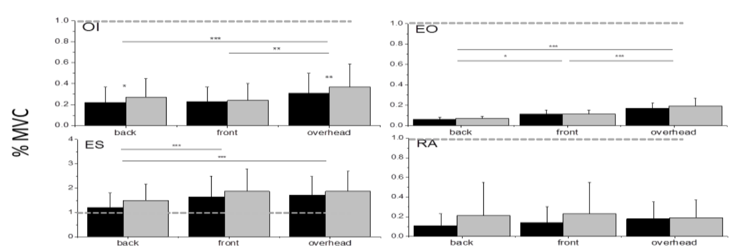

Figure 1: Trunk muscle activation shown as means and standard deviations in stable (black) and unstable (grey) standing conditions

MOTOR MODULES IN ASSISTED-PEDALING: PRELIMINARY RESULTS ON HEALTHY SUBJECTS

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INTRODUCTION: Motor modules underlying different motor tasks have been recently evaluated to understand how the central nervous system controls muscle coordination. Assisted-pedaling represents a safer and economic alternative for locomotor interventions in neurological patients. This study aimed at the assessment of modular muscle coordination underlying assisted-pedaling to eventually improve cycling-based interventions.
METHODS: Seven healthy subjects (age of 27.9 ± 3.8) were tested. The protocol consisted of pedaling for 3 minutes on a recumbent motorized cycle-ergometer (MOTOmed; Reck GmbH) at three cadences: 20, 40, and 60 rpm. The motor always maintained 10 rpm less than the target cadence. EMG signals of 18 lower limb muscles (gluteus maximum, biceps femoris long and short head, gastrocnemius lateralis, soleus, tensor fasciae latae, rectus femoris, vastus lateralis, , tibialis anterior of both legs) were acquired at 1024 Hz. Motor modules for each subject and cadence were extracted by applying Nonnegative Matrix Factorization to a set of 30 consecutive pedaling cycles.
RESULTS: Four motor modules underlie the task execution for all the pedaling conditions (Variance Accounted For > 0.9 for each muscle). The spatial structure of the extracted modules, W, was robust across subjects and cadences, and modules temporal activation, H, can be related to different biomechanical functions during task execution.
CONCLUSION: Pedaling at different cadences did not affect the spatio-temporal features of the modular motor control, with the extracted modules being the same as those underlying upright pedaling. Moreover, some of the extracted modules were shared with those typical of locomotion, further supporting the use of cycling trainings in the recovery of gait. Future studies will be performed to assess the effect of voluntary pedaling augmented by electrical stimulation based on modular muscle coordination in post-stroke patients.

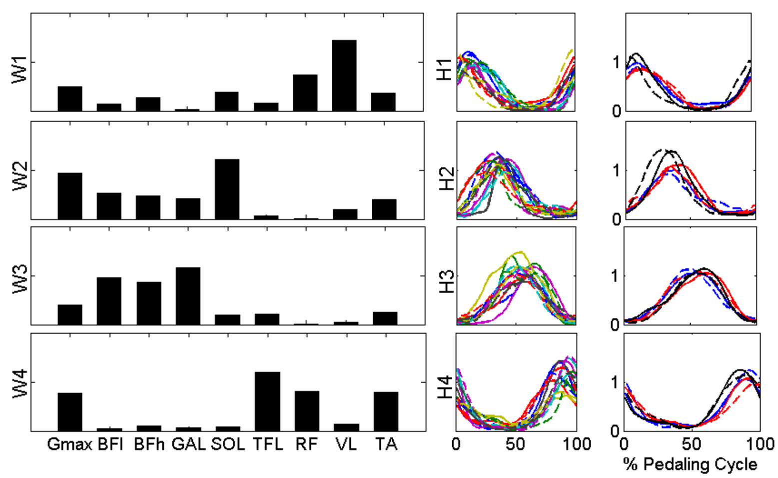

Figure 1: Average motor modules (bar plots on the left), subject-specific synergy activation coefficients H (each color represents a different subject, middle plot), and condition-specific synergy activation coefficients averaged across subjects (solid line = right, dashed line = left, blue = 20 rpm, red = 40 rpm, black = 60 rpm)

MERGING A LIBRARY OF BASIC MOTOR MODULES AS A GENERAL MODEL FOR LOWER LIMBS MUSCLE COORDINATION

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INTRODUCTION: Muscle synergies have been proposed as the building blocks according to which the central nervous system orchestrates a variety of movements. The aim of this study is to assess whether a library of basic modules is able to represent the muscle coordination for different motor tasks involving lower limb muscle coordination.

METHODS: 4 subjects (24-28 years) performed 7 different tasks (walking, backward walking, jogging, high knee running in place, heels to back running in place, jumping in place and pedaling). EMG activity was recorded from 8 muscles of the right leg (gluteus maximus, biceps femoris, gastrocnemius medialis, soleus, rectus femoris, vastus medialis, vastus lateralis and tibialis anterior). For each task and subject, modules were extracted through Nonnegative Matrix Factorization applied to all the consecutive movement cycles. Shared and specific muscle synergies were firstly identified from the tasks with a higher number of more sparse modules (i.e. walking and pedaling) and they were used as a basic library W_{LIB}. Synergy vectors W extracted from all the other tasks were then reconstructed from W_{LIB} using a synergy merging model adapted from (Cheung et al. PNAS 2012) and based on a linear least squares with non-negativity constraints. Reconstruction quality was assessed through the scalar product *r* between the original W and the reconstructed one. Significance of each reconstruction was assessed by comparing the obtained *r* with that obtained by 100 surrogates of W_{LIB} with shuffled muscle components.

RESULTS: 3 synergies shared between walking and pedaling, plus a specific muscle synergy for each task, were used to form a library W_{LIB} of 5 synergies (Fig.1). Merging these library accounted for the muscle coordination of all the other tasks, with a high reconstruction quality significantly higher than that expected from chance.

CONCLUSION: A set of basic sparse motor modules, mainly deriving from the coordination of walking and pedaling, is able to account for the muscle coordination of various motor tasks. Future studies will seek to extend the validity of the model through the monitoring of trunk and upper limb muscles. The biomechanical contribution of each individual merged module to different tasks should also be taken into account.

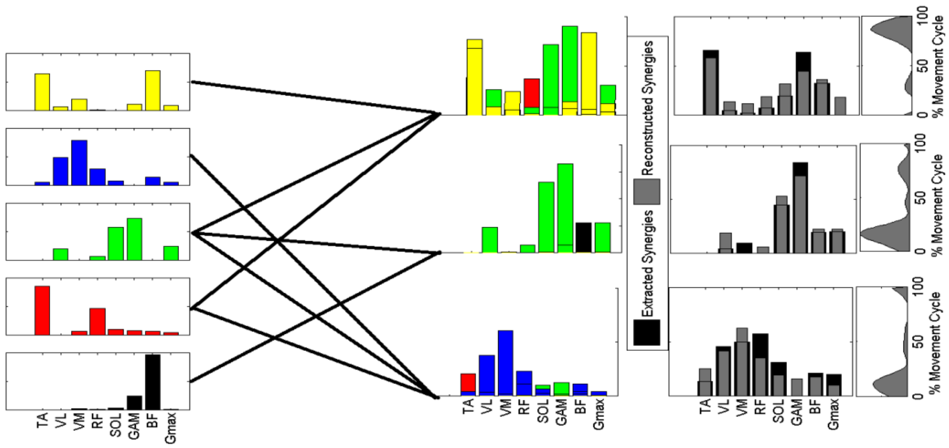

Figure 1: Example of reconstruction of the jumping modules W_{JUMP} of one subject by using the merging of W_{LIB}. Left: W_{LIB}. Middle: contribution of each W_{LIB} component to W_{JUMP}. Right: extracted and reconstructed W_{JUMP} modules, together with synergy activation coefficients H.

MUSCULAR SUPPORT AGAINST INJURY INDUCING MOMENTS

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AIM**:** To evaluate differences in muscle activation strategies of anterior cruciate ligament (ACL) deficient and healthy subjects while generating voluntary frontal plane loads.
METHODS**:** ACL deficient individuals and matched controls (CON) stood with the knee of interest flexed to 30° and the foot fixed to a force platform. Surface electromyography (EMG), kinematics and kinetics were recorded while subjects generated various combinations of medial-lateral-anterior-posterior ground reaction forces (GRFs) at 60% of their maximal efforts with equal body weight on each leg.
PRELIMINARY RESULTS**:** ACL showed greater levels of activation compared to CON ($p<0.05$). Rectus femoris (RF), tensor fascia lata (TFL), semitendinosus (ST), biceps femoris (BF) exhibit preferential activation during anterior, lateral, posterior, and postero-medial loading directions, respectively (Fig 1A-E). Vastii muscles of CON were equally active in all load directions, while ACL had higher activation during postero-lateral loading. Peak abduction and adduction moments of 0.6 Nm/kg were accompanied by peak internal/external rotation moments of 0.37 and 0.24 Nm/kg at lateral and medial loading directions (Fig 1F).
DISCUSSION**:** Knee abduction moments are important components of the ACL injury mechanism. However, individual knee joint muscles lack sufficient mechanical advantage to oppose these moments (Buchanan 1997 J Orthop Res 15:11-17). Based on our results, we suggest the vastii are important stabilizers, contracting to compress the joint while bi-articular muscles preferentially activate to facilitate respective moments: TFL-abduction; ST and BF-flexion; RF-extension. ACL loads can peak when abduction is combined with external rotation (Shimokochi 2008 J Athl Train 43:396-408). However, our voluntarily generated moments couple abduction with internal rotation, perhaps to minimize ACL strain. Due to its moment arm and activation, we also suggest the BF contributes to these external rotational forces.

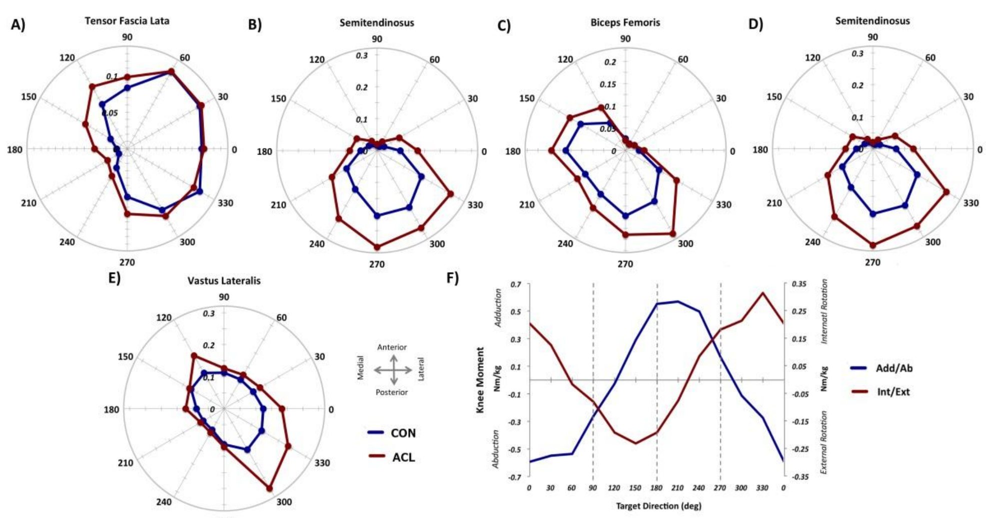

Fig 1: A-E) EMG polar plots of 13 CON and 7 ACL, normalized to % maximum voluntary isometric contraction. Each radii represents GRFs loading direction (°) **F)** Knee joint frontal and transverse moments (Nm/kg) of 2 CON subjects at each target location.

CAN ACTIVATION ONSET IN GLUTEUS MINIMUS BE DETECTED NON-INVASIVELY USING M-MODE ULTRASOUND IMAGING?

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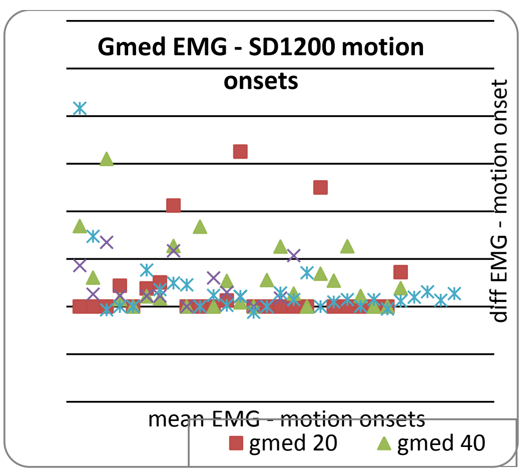
BACKGROUND: Chronic spinal and joint pain are associated to a changed timing of deep muscle activation. Initial evidence indicates that therapy of impaired deep muscles is effective against pain symptoms. Knowledge on dysfunctional deep hip muscle activity may improve the conservative treatment of hip joint pain. A clinical assessment of deep muscle activity requires non-invasive methods, e.g. ultrasound imaging (US). Studies on the agreement of EMG and US activation onsets indicated that activity-related muscle motion may occur before local excitation. To distinguish electrically passive muscle motion from active motion, this study proposed M-mode high-energy motion onsets, based on energy detection with the Teager-Kaiser Energy Operator.

METHODS: Onset of deep gluteus medius and gluteus minimus activity during isometric hip abduction was probed in 10 subjects with fine-wire EMG and M-mode US.

RESULTS: In gluteus medius, high-energy onsets indicated electrically active motion correctly in 100%, in gluteus minimus in 89%. M-mode reflected the same activation sequence as EMG. Latencies between excitation and high-energy onset were median 17-46 ms and highly variable (IQR 53-98 ms).

CONCLUSION: M -mode high-energy motion reflects a mechanical phenomenon which is closely related to muscle excitation. Due to in-vivo variation, single high-energy onsets cannot substitute EMG. The clinical value of high-energy onsets needs further research.



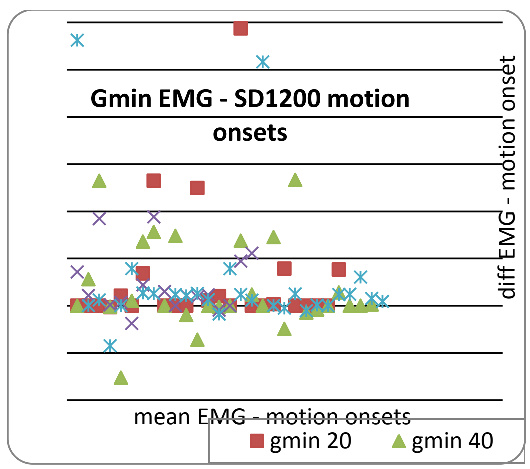


Figure 1: Bland-Altman plots of the agreement of fwEMG and M-mode US high-energy motion onsets of glutues medius and minimus activity; 100% correct recognition of electrically active muscle motion in gluteus medius, 89% correct recognition in gluteus minimus.

Poster Sessions

Poster Session 6 (Poster Area 11.00)

Poster Session 6 (Poster Area 11.00)

SPATIAL CHARACTERISTICS OF LUMBAR FATIGUE DIFFER WITH AGE

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AIM: The segmental innervation of the lumbar muscles suggests a spatial organization. Muscular fatigue is quantified by simultaneous change of amplitude and frequency characteristics. Although strength attributes decrease with age, especially the submaximal endurance capacity is less affected. The aim of this study was to assess possible spatial characteristics of lumbar muscular fatigue in different age-groups.

METHODS: A total of 66 symptom-free young (YO: N=32, 24 years (SD: 2)) and middle-aged (MA: N=34, 55 years (SD: 3)) men was examined. Surface EMG (SEMG) signals were recorded bilaterally from lumbar erector spinae muscle at levels L4, L3, L2 and L1. The endurance task was a 10-minute modified Sorensen test with 50% support of the previously determined upper body mass (Centaur, BfMC). Relative changes of amplitude (RMS%) and mean frequency (MF%) at the end of the test compared to baseline values were calculated. Four group-specific and SEMG parameter-independent repeated measures ANOVAs (Side(2)×Level(4)) were conducted. Further, effect sizes (partial eta squared, η_p^2) are reported ($\eta_p^2 \geq 0.01$ indicates small, ≥ 0.06 medium and ≥ 0.14 large effects).

RESULTS: Five of MA (15%) did not finish the endurance task and were therefore excluded from further analyses. The ANOVAs of both groups revealed a significant main effect of “Level” (YO: $P<0.01$, MA: $P<0.05$), while “Side×Level” and “Side” failed to reach significance. This could be proven for RMS% with a large ($\eta_p^2=0.180$) effect size in YO, but for MF% with a medium ($\eta_p^2=0.105$) effect size in MA.

CONCLUSION: Independent of age, the electrophysiological assessment of fatiguing trunk extension tasks has to consider spatial differences. When quantifying lumbar fatigue by utilizing MF%, a segment-specific application of the surface electrodes in YO seems redundant. In contrast, in MA a segment-specific organization of MF% can be verified, which therefore has to be considered. The opposite should be taken into account if RMS% is examined.

ACKNOWLEDGEMENT: This study was supported by the Deutsche Forschungsgemeinschaft (DFG), grant SCHO 451/8-1.

ASYNCHRONOUS ALTERATIONS OF MUSCLE STRENGTH AND TENDON STIFFNESS FOLLOWING 8-WEEK RESISTIVE-LIKE EXERCISE WITH WHOLE-BODY VIBRATION IN ELDERLY.

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AIM: The aim of this study was to investigate whether muscle strength and tendon property in a muscle-tendon complex alter synchronously following the 8-week resistive-like exercise in elderly.
METHODS: Twenty five elderly women (69.01 ± 3.95 yr, 155.15 ± 4.9 cm, 60.05 ± 7.45) were recruited and participated in the resistive-like exercise (3 days a week) with whole-body vibration for eight weeks, followed by the 4-week detraining period. The baseline measurements prior to the training session included the maximum isometric ankle plantarflexion torque at a 10-deg plantarflexed position using a custom-built dynamometer and the elongation of the medial gastrocnemius (MG) aponeurosis and the Achilles tendon unit by monitoring the musculo-tendinous junction using a real-time ultrasound imaging machine with a linear probe. The stiffness of the tendon unit was estimated from the MG muscle force and the MG tendon unit elongation. The same measurements were performed 4 and 8 weeks after the training period and after the detraining period.
RESULTS: During the training period, MG muscle forces significantly increased after four and eight weeks of training (234.56 ± 55.01 N, 255.89 ± 50.70 N) from pre measurement (214 ± 52.93 N, $p<.05$). Compared with the baseline value (20.53 ± 7.95 N/mm), tendon stiffness was maintained for the first four weeks (19.89 ± 6.36 N/mm) but increased significantly after eight weeks of training (25.83 ± 8.82 N/mm, $p<.05$). MG muscle force (236.74 ± 48.35 N) and tendon stiffness (22.64 ± 6.66 N/mm) were maintained following the 4-week detraining period.
CONCLUSION: Changes in muscle force and tendon stiffness during the training period were asynchronous; changes in tendon stiffness were significant after 8 weeks of training while muscle force continuously increased throughout the training period. The asynchronous alterations in muscle strength and tendon mechanical property might play as an important factor to induce muscular injuries during the early phase of resistance training.
ACKNOWLEDGEMENT: This work was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (MEST) (NRF-2010-0024090).

MUSCLE ACTIVITY IN LOWER LIMB MUSCLES DURING GAIT IMAGERY AND OBSERVATION

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AIM: The aim of our study was to compare lower limb muscle activity during gait imagery and gait observation tasks from first person perspective in standing default position with respect to rest standing position without any mental or voluntary activity.
METHODS: 32 subjects participated in our study. Electomyographic (EMG) activity was recorded by the Noraxon® system from the dominant lower limb muscles participating in gait execution: tibialis anterior, gastrocnemius lateralis, gastrocnemius medialis, biceps femoris (BF), semitendinosus (ST) and rectus femoris (RF). The raw EMG signals were full wave rectified and the root mean squared value of EMG signals were calculated using a time averaging period of 25 ms (MyoResearch®). EMG data were collected in standardized standing position in 1) rest without any voluntary activity or motor imagery (reference value), 2) gait imagery and 3) gait observation for 60 seconds. EMG activity within imagery and observation condition was expressed as a percentage of a reference value. The non-parametric Wilcoxon matched paired test was performed for the statistical analysis (Statistica 9.0).
CONCLUSION: In the standing position, the rhythmic gait imagery task resulted in an increased EMG activity ($p<0.05$) in the BF, ST and RF compared to the resting position. Motor imagery and action observation have been widely studied over the last few years, particularly in the context of its effect on movement recovery. There is wide evidence, that motor performance improvement is enhanced either by mental training in patients with neurological or traumatic movement disabilities, not just by practice itself. Facilitated muscle activity has been previously demonstrated during both motor imagery and action observation compared to resting conditions during upper limb task. Studies on gait imagery or gait observation mostly focused on the activity of neural structures, which are similar to those active during real gait execution. In our study the increased EMG activity of proximal tested muscles during gait imagery might reflect enhanced ability of the cortex to control the muscles with mostly monosynaptic corticospinal innervations compared to the distal leg muscles which mostly have polysynaptic corticospinal pathways. This might be even more pronounced in standing because this is a position congruent with walking and thus offers a more appropriate somatosensory feedback compared to incongruent positions with walking, such as sitting or lying. These findings may contribute to futher understanding of gait control mechanisms and mental learning processes.
ACKNOWLEDGEMENT: This research was supported by grant “Support of Human Resources in Science and Research in Non-medical Healthcare at the Faculty of Health Sciences at Palacký University Olomouc“, CZ.1.07/2.3.00/20.0163.

ELECTROMYOGRAPHIC STANDARDIZED INDICES IN HEALTHY BRAZILIAN CHILDREN AND ADULTS

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AIM**:** We aimed to (a) determine values of the electromyographic (sEMG) standardized indices for the assessment of muscular symmetry (left and right side, percentage overlapping coefficient, POC), potential lateral displacing components (unbalanced contractile activities of contralateral masseter and temporalis muscles, TORS), anterior-posterior displacing component (barycenter, BAR), relative activity (most prevalent pair of masticatory muscles, ATTIV), and standardized total activity (IMPACT) in healthy Brazilian children; (b) compare children to health adults.

METHODS**:** We analyzed 19 healthy children (6-12 years, mean age 9.5, SD 2.0), 11 male and 8 female, 19 healthy adults (19-30 years, mean age 25.2, SD 3.5), 3 male and 16 female. All subjects had normal natural dentition for age and normal dental occlusion, and no temporomandibular or craniocervical disorders. Additionally, children had Facial Height Ratio (FRH = Jarabak quotient) > 59% and no previous or current orthodontic treatment.

sEMGs of masseter and temporal muscles were performed during maximum teeth clenching either on cotton rolls between teeth or in intercuspal position (MVC). EMG indices were calculated with the potentials recorded during the MVC tests standardized by MVC with cotton rolls. Descriptive statistics were computed for all variables that were normally distributed. Mean values were compared by Student's *t* tests for independent samples ($P < 0.05$).

RESULTS**:** Children showed adequate neuromuscular coordination, with mean values similar to those of the adults: POC [%] masseter (85.9±4.0% and 86.2±3.9%), POC [%] temporal (86.4±10.0% and 87.4±2.5%), TORS [%] (89.6±7.1% and 91.8±0.9%), BAR [%] (86.1±8.5% and 87.4±7.1%), and ATTIV [%] (9.4±15.9% and 10.3±8.4%). Because children showed higher activity during MVC than during MVC with cotton rolls, their Impact index [%] (total muscular standardized activity) was higher than in adults (142±51% and 100±31%) $p = 0.005$. The values obtained for healthy adults were in accordance with literature data.

CONCLUSION**:** The current study was the first to evaluate these EMG indices in Brazilian children. Overall, these findings in healthy subjects with normal occlusion may be interpreted as muscular coordination, independent of dentition stage and craniofacial development.

These children data may be used as reference values.

ACKNOWLEDGEMENT**:** This work was supported by Provost's Office for Research of the University of São Paulo, and the first author received a fellowship from**:** The State of São Paulo Research Foundation (FAPESP) -Brazil.

PRIMITIVE NEONATAL POSTURAL MOTOR PATTERNS EVOKED BY FOCAL SENSORY STIMULATION IN HEALTHY ADULT HUMANS

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Despite recent accounts of philogenetically retained postnatal motor synergies in stepping, evidence for primitive patterns in adult humans remains debated. Here we characterize the kinematic and electromyographic signature of postural motor synergies evoked by sensory inputs in adult humans. These responses were systematically evoked during rest in populations of healthy participants; they appeared as involuntary motor patterns evolving across several minutes in response to sustained sources of focal sensory stimulation applied to specific body regions; most importantly, muscle and kinematic activity patterns were dramatically facilitated in amplitude and latency by repeated stimulation. Interestingly, the kinematic features of these responses strongly resembled primitive postural reactions reported in healthy newborn humans at specific developmental stages. Our observations suggest that the basic patterns underlying postnatal postural reflexes are retained at further developmental stages and support our ability to manipulate their excitability for future investigational and therapeutic purposes.

THE EFFECT OF ISOMETRIC CONTRACTION ON THE REGULATION OF FORCE TREMOR IN THE CONTRALATERAL LIMB

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AIM: When performing isometric voluntary contractions, the force exerted by the muscle is not entirely steady. Instead, small fluctuations exist that are dependent on the intensity and duration of contraction. Although it is clear that variability in force production in a single limb is enhanced during submaximal isometric contractions, little is known about how force tremor is regulated in the opposite limb during this task. This study determined how force tremor in a single limb is altered when the opposite limb is engaged in a force generating task.
METHODS: Index finger abduction force and first dorsal interosseous (FDI) activity were assessed in thirteen healthy (23 ± 4 yrs) at target forces of 5, 10, 15, 20 and 60% MVC for the non-dominant limb (unilateral task). Force tremor was again quantified in the non-dominant limb when the dominant limb generated a sustained submaximal abduction force at 60% MVC (bilateral task). Force tremor was quantified as the coefficient of variation of abduction force, and frequency parameters of force and EMG data were examined using power spectral analysis.
RESULTS: When the non-dominant limb generated force at 20% MVC, tremor was greater during the bilateral task compared with the unilateral task; a finding reflected in the amplitude of peak power of force (Figure 1). In contrast to the task differences observed for abduction force tremor, no FDI EMG differences were detected between the unilateral and bilateral tasks.
CONCLUSION: The process of performing a bilateral isometric task invoked tremor-related changes in the non-dominant limb at selective force targets. It is possible that some feature of common drive to the motoneuron pool, or the proportion of the pool that is activated at 20% MVC, may have contributed to the task differences observed at this moderate force output during a bilateral isometric contraction.

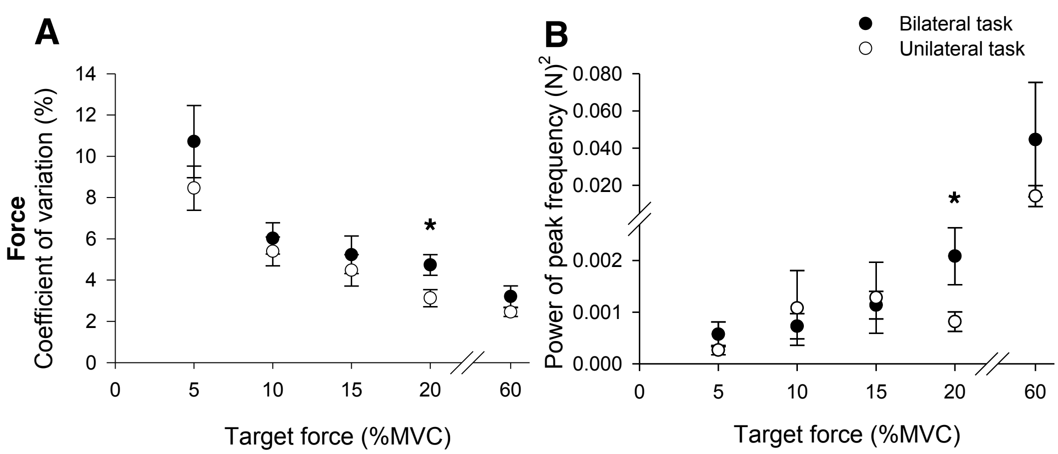

Figure 1: Index finger abduction force tremor, measured by **A** Coefficient of Variation and **B** Power of Peak Frequency of force.

ANALYSIS OF THE ONSET OF TURNING DURING WALKING AFTER STROKE

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Background: Turning during walking is a complex task involving maintaining balance and anticipatory orienting for future motor and sensory events. How these mechanisms are affected by stroke remains unknown.
AIM: To investigate the onset of turning during walking between stroke and healthy individuals.
METHODS: Nine stroke hemiplegic patients, 6 age-matched healthy older people and 10 healthy young people were visually cued to turn 90° to the left or right on the non-paretic stance (healthy individuals : on the right stance) after steady walking. The onset time and the sequence of Head, Thorax and Pelvis in response to the turning cue were examined by using the inertial sensor (tri-axial acceleration / angular velocity meter). And the subsequent contralateral foot contact (CFC) was recorded, too.
RESULTS: Stroke patients had later onset time of Head than healthy individuals. And the behavior strategies were different between the stance leg direction and the swing leg direction. On the stance leg direction, this meant on the non-paretic direction (healthy individuals: right direction, Figure 1), the sequence of Head, Thorax and Pelvis were not observed and the each segments started to turn before CFC in healthy individuals. On the other hand, in stroke patients, Pelvis started to turn late to Head and at the same time as CFC. On the swing leg direction, this meant on the paretic direction (healthy individuals: left direction, Figure 2), the sequence of segments were observed and started to turn before CFC in healthy young people. On the other hand, in the elderly and stroke patients, the sequence of Head and Thorax, or Head and Pelvis were observed and Pelvis started to turn at the same time as CFC.
CONCLUSION: The results suggest that it should be separately to analyze of turning direction. Stroke patients are behind with the onset of turning during walking in response to the visually cue than healthy individuals. These are caused by a combination of biomechanical and defective sensorimotor integration.

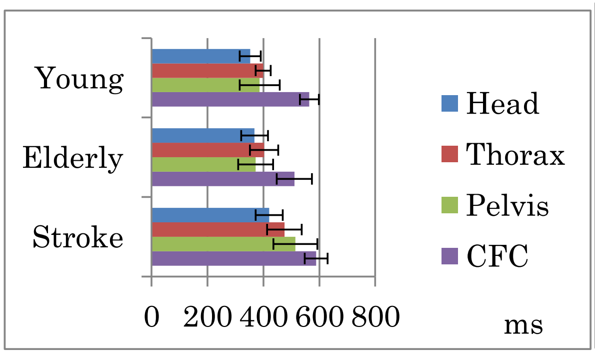

Figure 1: Latency of turning to the stance leg direction

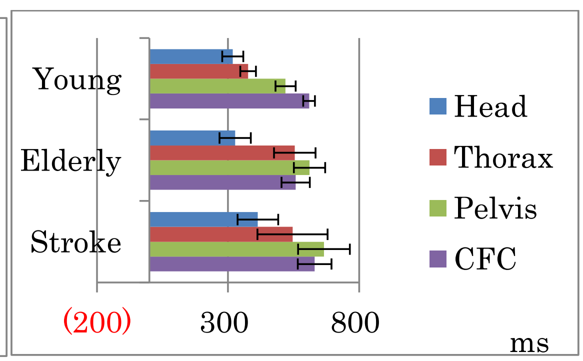

Figure 2: Latency of turning to the swing leg direction

NEUROMOTOR RESPONSES TO CONSECUTIVE DAILY DOSING OF ANTIHISTAMINES

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AIM: The cholinergic and histaminergic systems play important roles in the regulation of movement. These systems can be selectively altered following ingestion of different classes of antihistamines. This study examined how sedating antihistamines (strong anticholinergic effects) and non-sedating antihistamines (increased antihistaminergic effects) influence day-time drowsiness, voluntary movement, and involuntary movement when administered on consecutive days.
METHODS: Ten healthy young subjects were recruited into a double blind, placebo-controlled, three-way crossover study. Subjects ingested either the sedating promethazine, the non-sedating loratadine, or a placebo. Subjects then ingested the same drug 24 hours later. Measures of drowsiness, simple reaction time (SRT), choice reaction time (CRT), and postural tremor were obtained pre-ingestion, 1 hour post-ingestion and 2 hours post-ingestion on each day.
RESULTS: As expected, promethazine increased drowsiness and loratadine had no significant impact on drowsiness. However both classes of drug affected movement. Consecutive daily doses of each antihistamine affected SRT and CRT, whereby reaction time deficits were less pronounced following the repeat dose. A reduced tremor response was also observed following consecutive daily dosing of promethazine. This was in contrast to loratadine which caused an increase in tremor amplitude with the consecutive daily dose.
CONCLUSION: Mechanisms associated with reaction time are strongly influenced by both central cholinergic and histaminergic pathways. Tremor mechanisms appear more complex, whereby decreased activity in cholinergic systems decreases the amplitude of postural tremor, and decreased activity in histaminergic systems increases the amplitude of postural tremor.

THE EFFECT OF WORKING MEMORY TRAINING ON DUAL UPPER AND LOWER LIMB TASK PERFORMANCE

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AIM: Humans perform two or more tasks at a time (dual task) during many daily activities (e.g. walking and talking). The quality of each task is influenced by how attention is allocated at the same time. Unfortunately, we have a limited attention capacity and are therefore unable to give adequate attention to each task simultaneously. Previous studies have shown that this limitation is determined by working memory capacity. Working memory is the cognitive system that retains information for short periods of time. Recently, it was found that working memory capacity could be improved through working memory training. However, the effect of increment of working memory capacity on dual-task performance remains unknown.
METHODS: Thirty healthy men participated in this study. Participants were assigned randomly to either the working memory training group (WG), dual-task training group (DG), or control group (CG). WG subjects participated in working memory training and DG subjects executed dual-task training for 2 weeks (15 min, 4 times a week). We evaluated dual-task performance and working memory capacity before and after training. The dual task we adopted included an isometric knee extension task (task 1) and an elbow reaction task (task 2). At first, subjects performed a right knee extension task (task 1). Subjects modulated their movements to keep a target torque (20% or 40% peak torque). While performing task 1, subjects executed task 2; for this, subjects were instructed to flex the left elbow as hard and fast as possible at the moment the signal lamp changed from red to blue. Electromyographic (EMG) signals were recorded from the *biceps brachii* muscle by using surface electrodes. We calculated reaction time as the duration between the lamp change and the onset of EMG activity in the *biceps brachii* muscle. We then drew a scatter diagram for both task 1 and task 2 performance. We defined dual-task performance as a change of plot in the scatter diagram. To measure working memory capacity, the detection paradigm published by Luck and Vogel (Luck and Vogel, 1997) was employed. Working memory training was modified using the working memory training method described in a previous study (Westerberg and Klingberg, 2007). Dual task training used the same way to evaluate. dual-task performance we adopted. The number of plot changes in each scatter diagram was compared using a chi-square test. Working memory capacity was compared using a paired *t*-test. Differences were considered significant at $p < 0.05$.
RESULT: Working memory capacity significantly increased in the WG after training. In contrast, there was no significant difference in working memory capacity between the CG and DG. Dual-task performance improved significantly in the WG, DG, and CG in the 20% peak torque condition. In the 40% peak torque condition, the CG showed no significant change in dual-task performance. Otherwise, in the 40% peak torque condition, the WG and DG showed significant change in dual-task performance.
CONCLUSION: We present new evidence indicating that increases in working memory capacity have positive effects on the dual-task performance.

MUSCLE SYNERGY ANALYSIS REVEALS QUICK SHIFTS IN MODULER CONTROLERS OF HUMAN LOCOMOTION DURING SPEEDING UP

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AIM: To reveal the shifting pattern in modular controllers of human locomotion during acceleration using muscle synergy analysis. A muscle synergy represents a control module of movement.
METHODS: 8 healthy volunteers walked or ran on a treadmill linearly increasing speed from 0.3 to 5.0 m/s (ramp speed condition, acceleration was set to 0.001m/s^2). Subjects were instructed to either walk or run on the basis of their preference under the given speed. Surface EMG activity was recorded from 16 muscles on the one side of the trunk and leg. Using non-negative matrix factorization (NMF), we extracted muscle synergies from data matrix of EMG recordings. Then we determined the number of muscle synergies at different walking or running speeds (slow walk: 0.4m/s, moderate walk: 1.1m/s, fast walk: 1.8m/s, slow run: 2.3m/s, moderate run: 3.55m/s, fast run: 4.8m/s) and that of shared muscle synergies between adjacent speeds. Furthermore, EMG data were reconstructed in all speed ranges by modified NMF algorithm. The algorithm firstly assigned muscle synergies extracted previously and optimized only synergy recruitment coefficients. Variance accounted for (VAF) were calculated by comparing reconstructed EMG data and original EMG data.
RESULTS: The number of muscle synergies at slow walk condition was significantly smaller than all conditions except fast run, and that of slow run was significantly smaller than moderate run (Table1). Components of muscle synergies were found to be different from the number of shared muscle synergies between adjacent conditions (Table 1). High VAF area took square form and shifted with speeding up (Figure 1).
CONCLUSION: Differences in the number of muscle synergies and in components of these indicates control modules of human locomotion shift with speeding up. Square-like form of high VAF area suggests the shifting pattern of human locomotion is thought to be not gradual change but quick change.

Table 1: Number of muscle synergies used in each condition and number of similar muscle synergies used between adjacent conditions. *: $p<0.05$ vs. slow walk,†: $p<0.05$ vs. slow run.

Number of muscle synergy	Slow walk (0.4m/s)	Moderate walk (1.1m/s)	Fast walk (1.8m/s)	Slow run (2.3m/s)	Moderate run (3.55m/s)	Fast run (4.8m/s)
Identified per condition	3.25(±0.46)	* 4.88(±1.13)	* 4.88(±0.99)	4.25(±0.71)	* † 5.25(±0.46)	* 4.63(±0.52)
Shared with adjacent conditions	3.12(±0.33)	3.50(±1.00)	3.00(±0.60)	3.88(±1.11)	3.63(±1.05)	

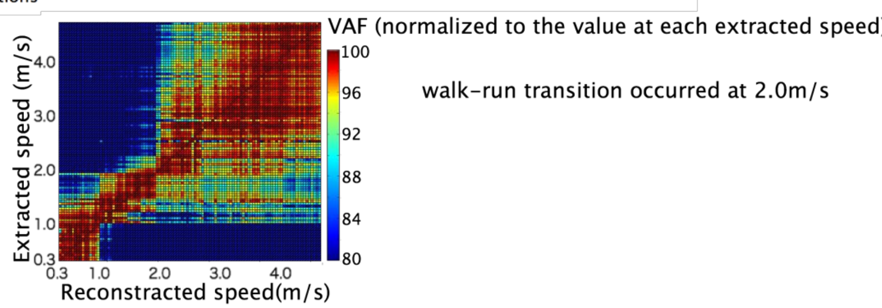

Figure 1: An example of VAF between reconstructed EMG data and original EMG data.

ALTERATIONS OF CORTICAL CONTROL OF SCAPULAR MUSCLES IN PATIENTS WITH SHOULDER IMPINGEMENET SYNDROME

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AIM: To examine the cortical representation of trapezius muscles and serratus anterior muscles in individuals with shoulder impingement syndrome (SIS).
METHODS: The study is an exploratory and cross-sectional study. We plan to recruit in total 20 subjects with shoulder impingement syndrome and 20 healthy controls by the time of conference presentation. So far, we have finished data collection on 2 patients (2 females, age: 23 years, BMI: 21.6±0.05) and 6 control subject (4 females and 2 males, age: 23.29±0.82 years, BMI: 22.42±2.03). The cortical representation of trapezius and serratus anterior muscles was examined while the subjects were seated with arm elevation to 90 degrees in the scapular plane (to examine injured arm in patient group and the control arm in the healthy subjects). We used transcranial magnetic stimulation (TMS) (MagStim 200 stimulator, MagStim Company, UK) to find the hot spot of the target muscles and the active motor threshold (aMT), motor evoked thresholds (MEPs) and the response latency were recorded using Neuropack M1 MEB-9200 (Nihon Kohden, Tokyo, Japan). After finding hot spot of the target muscles, we also facilitated the sites around the hotspot to make mapping area and calculated the center gravity of mapping area (COG) of each target muscle.
RESULTS: Upper trapezius had the lowest active motor threshold among the three scapular muscles. Patients with shoulder impingement seemed to have higher stimulation thresholds particularly for the lower trapezius and serratus anterior muscles. In addition, the patients had a trend of showing longer response latency then the healthy controls for the lower trapezius and serratus anterior muscles (Table 1). The location of COG of each target muscle seemed no obvious difference between patients and healthy subjects so far (Figure 1).
CONCLUSION: Cortical presentation of the scapular muscles seemed to alter in patients with shoulder impingement. However, we need a larger sample size to confirm our preliminary findings.

Table 1: Threshold, MEP and latency of trapezius muscles and serratus anterior in the 2 groups

Group	**Patient group (n=2)**			**Control group (n=6)**		
	aMT (%MSO*)	**MEP (mV)**	**Latency (ms)**	**aMT (%MSO)**	**MEP (mV)**	**Latency (ms)**
Upper trapezius	51%±0.01	0.83±0.74	75.09±42.86	49%±0.06	1.35±0.89	76.5±24.66
Lower trapezius	61%±0.08	0.89±0.37	104.68±16.33	51%±0.07	0.39±0.12	74.81±27.96
Serratus anterior	58%	0.33±0.13	109.79±24	54%±0.06	0.35±0.19	90.03±12.84

***MSO: maximal stimulation output of the TMS**

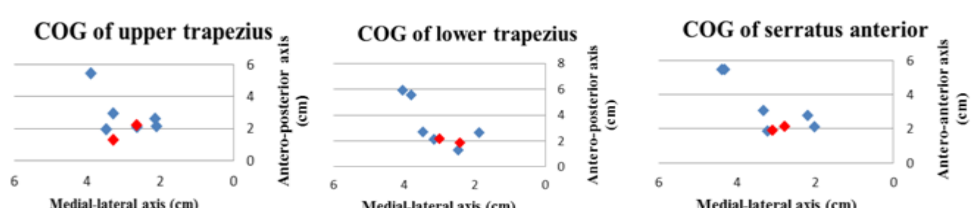

Figure 1: Distribution of center gravity of mapping area (COG) of upper trapezius, lower trapezius and serratus anterior in healthy subjects and patients with shoulder impingement syndrome. (Red color: patients; blue color: healthy subjects)

BRAIN ACTIVITY DURING DUAL-TASK COMPRISING COGNITIVE MOTOR TASKS: AN FMRI STUDY

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AIM: The aim of the present study was to examine cerebral activity during a DT comprising of two different cognitive task involving the perception of the somatic change during the movement by using fMRI. We predicted that it seem to be the base of evidence for recovery of motor behavior.
METHODS: Sixteen healthy subjects (9 men, 7 women) participated in the study. The subjects performed the following six tasks during which 3-T fMRI was carried out. Task 1: Calculation (1-back). Task 2: Carrying out up-and-down movement of the left lower limb. Task 3: Performing a dual task by combining tasks 1 and 2. Task 4: Perceiving the hardness of a sponge by the soles of the feet. Task 5: Moving the left lower limb to one of five different positions. Task 6: Perceiving the hardness of the sponge in the sole of the feet while performing Task 5.
RESULTS: During Task 3, activation of the motor area, supplementary motor area, and cerebellum was observed. During Task 6, in addition to the vermis of the cerebellum, the middle frontal gyrus and basal ganglia were active.
CONCLUSION: During Task 3, the vermis of cerebellum played a role of motor control by feedback control. During Task 6, not only the cerebellum but also the basal ganglia played a role in motor control which was needed cognitive processing. Further, activation of the middle frontal gyrus may be involved in co-ordination between performing the motor task and paying attention to sensory information. Our findings suggest that such an exercise might expand the selectivity of motor behavior.

Table 1: Significant activation during Task 6.

Brain region	BA	L/R	MNI Cordinate			Voxels	T-value
			x	y	z		
Middle frontal gyrus	10	L	-32	56	6	35	5.86
Orbitofrontal cortex	11/12	R	30	28	-10	169	6.36
Inferior frontal gyrus	44/45	R	60	14	4	192	7.58
Premotor area	6	R	24	-4	70	122	4.88
Supplementary motor area	6	L	-4	-12	72	68	5.52
	6	R	18	-18	74	346	5.77
Primary motor cortex	4	R	10	-28	70	163	8.17
Inferior parietal lobule	40	L	-48	-28	36	180	5.30
	40	R	64	-14	22	77	6.10
Superior parietal lobule	5/7	R	10	-48	74	55	7.13
Insula	13	L	-42	-2	0	647	7.45
	13	R	42	0	-4	658	6.53
Vermis of cerebellum			-2	-50	-14	378	11.86
Thalamus		L	-18	-24	16	776	7.63
		R	18	-22	16	899	7.80
Pallidum		L	-20	-6	-4	291	6.82
		R	18	-4	-8	280	8.36

P < 0.001 (uncorrected for multiple spatial comparisons), BA: Brodmann area, t-value (t≥4.10), and voxel (kE ≥10).

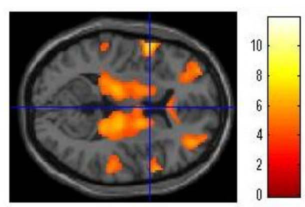

Figure 1: Significant activation during Task 6 (Z=8).

METHODOLOGICAL CONSIDERATIONS WHEN DETERMINING THE MOTOR UNIT NUMBER INDEX IN THE BICEPS BRACHII OF HUMANS

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BACKGROUND: The motor unit number index (MUNIX) provides an index value relative to motor unit number from surface electromyography (EMG). It has been used in investigations of larger muscles, although in some instances very large ranges of values have been reported (Neuwirth et al, 2011). The MUNIX calculation relies on the surface interference pattern (SIP) from voluntary contractions and the compound muscle action potential (CMAP) from a supra-maximal stimulation of the nerve, both of which may vary when measured at different sites across a muscle.
AIM: Investigate the effects of electrode position on SIP and CMAP area and power, and resulting MUNIX values from the BB muscle in healthy adults.
METHODS: A 4-channel linear array surface EMG electrode was placed on both the medial and lateral heads of the BB of 10 participants, 9 young 24.8(4.2) yrs and 1 old 70 yrs. EMG signals were recorded during maximum voluntary isometric contractions and at 5, 10, 20, 30, 40, and 60% of the maximum. The CMAP was obtained with a supramaximal stimulation of the musculocutaneous nerve. SIP and CMAP area and power, and MUNIX values were calculated for each of the 8 channels.
RESULTS: MUNIX values differed significantly across different proximal-distal locations of the BB ($p<0.001$), but did not differ between sites side by side on medial and lateral heads ($p=0.532$). Mean MUNIX across all channels was 131.
CONCLUSIONS: Site selection is important when obtaining a MUNIX from the BB. Medial-lateral variations are less important than proximal-distal variations when considering a recording location. Similar values can be obtained from the same locations on the medial and lateral heads.
Acknowledgements: The work was partly funded by MRC grant MR/K025252/1
References: Neuwirth, C., Nandedkar, S., Stålberg, E., Barkhaus, P. E., Carvalho, M., Furtula, J., Dijk, J. P., Baldinger, R., Castro, J., Costa, J., Otto, M., Sandberg, A. and Weber, M. (2011) 'Motor Unit Number Index (MUNIX): a novel neurophysiological marker for neuromuscular disorders; test-retest reliability in healthy volunteers.' *Clin Neurophysiol*, 122(9), Sep, pp. 1867-1872.

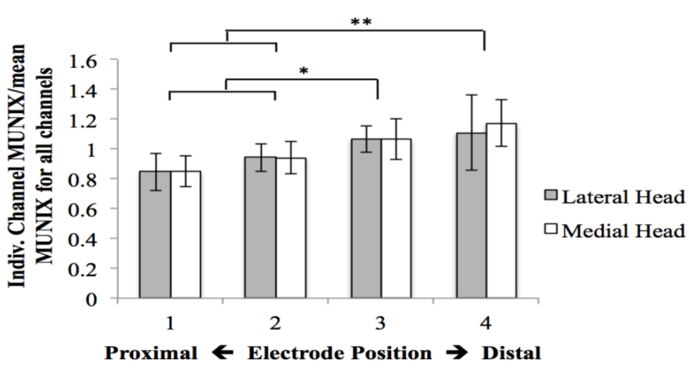

Figure 1 – MUNIX values across 8 separate channels on the medial and lateral heads of the BB (*p<0.05, **p<0.001).

REPEATABILITY OF UPPER TRAPEZIUS EMG IN VDU OPERATORS WITH NECK-SHOULDER COMPLAINTS

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AIM: To assess the between-day MVIC of upper trapezius of VDU operators with neck-shoulder complaints.
METHODS: 10 VDU operators with neck-shoulder complaints participated in two testing sessions separated by three to seven days. sEMG was recorded on right upper trapezius muscle during the performance three MVIC. Reliability indices calculated were: the standard error of measurement (SEM) and intra-class correlation coefficients (ICC).
RESULTS: Data were analyzed by way of intraclass correlation coefficients (ICC). The peak rms EMG ICC (95%CI) was 0.93(0.75,0.98). The median frequency ICC (95%CI) was 0.94 (0.79,0.99).
CONCLUSION: sEMG from MVIC can be measured with sufficient reliability for the assessment of upper trapezius muscle in g Projects (#12).

PRACTICAL EXAMINATION ON PLACEMENT OF SURFACE ELECTRODES FOR EMG MEASUREMENT

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AIM: The aim of this study is to improve the accuracy and flexible of surface electromyography (SEMG). Placement of surface electrodes on the target muscle is generally determined in terms of topography. However, in order to obtain further accurate information, surface electrodes must be placed on the proper position to avoid the influence of innervation zones. Therefore, with widely measurable surface electrodes, we estimated suitable SEMG indices in relation to the placement during sustained and dynamic contractions.
METHODS: Participants were asked to extent the knee joint with a maximally voluntary contraction (MVC). After a sufficient rest period, each participant performed a sustained contraction at 30% of MVC (sustained cont.) then squat contractions (dynamic cont.). SEMG signals were recorded at the vastus lateralis (VL) muscle. This approach was confirmed by comparing four types of electrode (concentric, two-bar, array and matrix) in terms of the muscle fatigue related variation in SEMG indices including the average rectified value (ARV), the mean power frequency (MPF) and muscle fiber conduction velocity (MFCV). In sustained cont. and dynamic cont. four type electrodes and matrix electrode (ELSCH064R3S, OT Bioelettronica, Torino, Italy) were used, respectively.
RESULTS: SEMG signals measured by the matrix electrode were displayed by the spatial distribution pattern of SEMG indices (ARV, changing ratios of ARV and MPF, and MFCV). In the knee joint side at the VL, ARV and the changing ratios showed a large value and varied greatly, respectively. Namely, an increase in ARV and compression toward lower-frequencies in MPF occurred. Besides, MFCV decreased with respect to time. ARV showed the significant difference ($p < 0.01$) with two types of electrodes (concentric and two-bar) between the hip and knee joint side. Such the results were also confirmed with array and matrix electrodes. For dynamic cont., the movement of innervation zones in relation to squat exercise was confirmed by MFCV in the hip joint side (upper side (Fig.1)).
CONCLUSION: Recognizing the muscle fatigue related variation in SEMG indices, the placement of surface electrode was not restricted at the VL. Thus seeking more accurate measurements, the knee joint side at the VL would be suitable because the influence of displacement due to dynamic contractions was less. As a result, knee joint side at VL was appropriate for the practical placement of popular surface electrodes such as concentric and two-bar ones.
ACKNOWLEDGEMENT: This work was supported by JSPS KAKENHI Grant Number 23650341,

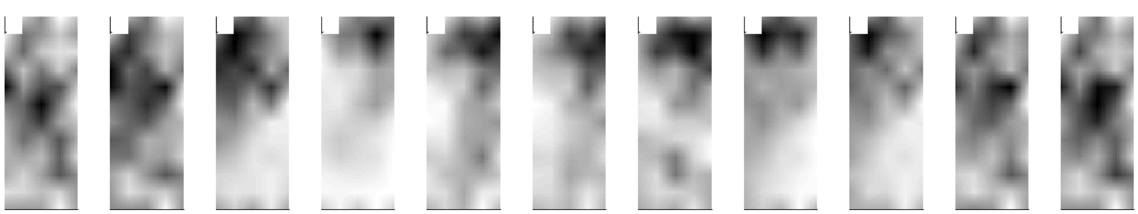

Figure 1: Movement of innervation zones by MFCV in squat exercise.

EFFECTS OF LOW LEVEL LASER THERAPY IN THE QUADRICES FEMORIS FATIGUE IN ELDERLY WOMEN

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AIM: To analyze the effects of low level laser therapy (LLLT) in the quadriceps femoris muscle fatigue during sustained maximal isometric contractions performed by elderly women.
METHODS: Six females [mean (standard deviation) 68.7(6.97) years; weight 64.25 (8.30) kg; and height 1.58 (5.96) m] were randomized in one Active Laser Group and in one Placebo Laser Group in one session experimental procedure. Previously to surface electromyography (SEMG) data collection, LLLT [cluster with 14 diodes (7 with 850nm wavelength (GaAlAs), 7 with 630nm wavelength (GaAsInP), 100 mW output power, and 4 J per diode)] was applied in the quadriceps femoris muscle of dominant lower extremity, according to group randomization. Due to cluster´s size, 4 LLLT applications were necessary to have all superficial quadriceps covered, totalizing 120 seconds of LLLT application and 158J for all diodes. After, SEMG was recorded from rectus femoris (RF), vastus lateralis (VL), and vastus medialis (VM) muscles by simple differential surface electrodes during sustained maximal isometric contractions performed until muscular exhaustion with subject sit in a leg extension chair with hip, and knee at 90° of flexion. SEMG data collection were made in the dominant lower limb. Sensors location and placement were set according to SENIAM recommendations. A load cell was used to have force exhaustion interval (FEI) as reference to data analysis. Signal from sensors and load cell were acquired synchronously at a frequency of 2000Hz. Muscular exhaustion was considered when force was 20% lower than the highest force value (HFV) obtained in the beginning of muscular contraction. Thus, FEI interval was determined as [FEI=(HFV-20% of HFV)]. SEMG raw data of FEI interval were digitally filtered at frequency bandwidth of 20–1000 Hz. After, a first five-seconds window following the start point of FEI interval and a second five-seconds window preceding the end point of FEI interval were obtained. MDF raw values of RF, VL, and VM obtained from first and second FEI windows were used for analysis. Normalized Ratio of MDF for each muscle was obtained by the ratio of FEI second window divided by FEI first window for VL, RF and VM. Because of sample size, just exploratory data analysis was done among groups.
RESULTS: Active Laser Group results showed greater values of normalized MDF for VL [mean (standard deviation) 0.95 (0.10)], RF [0.86 (0.04)] and VM [1.08 (0.19)] muscles in comparison to values of VL [0.82 (0.03)]; RF [0.81 (0.07)] and VM [0.83 (0.15)] of Placebo Laser Group.
CONCLUSION: Although these results to be just exploratory and from a small sample size, it is possible to observe that Active Laser Group results showed greater values of normalized MDF for all muscles, suggesting that quadriceps femoris irradiated with active LLLT had a tendency toward minimizing muscle fatigue in elderly women.
ACKNOWLEDGEMENT: Authors would like to thank FAPESP for the financial support of this research (2012/12472-1).

A SINGLE SET OF EXHAUSTIVE EXERCISE BEFORE RESISTANCE TRAINING IMPROVES NEUROMUSCULAR ENDURANCE

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AIM: The purpose of this study was to examine the effects of an additional set of exhaustive exercise before traditional hypertrophic training on quadriceps endurance.
METHODS: Twenty-seven men volunteers [mean (SD): age 20.6 (1.9) yr, height 174.8 (6.0) cm, and body mass 72.7 (9.7) kg] participated in the study. Subjects performed maximal dynamic strength (1RM) and endurance tests before and after an 8-wk hypertrophic training program using a knee extensor machine. After baseline testing, the subjects were divided randomly into 3 groups: untrained control (CO, n = 9), traditional training (TR, n = 9), and prior exhaustive training (PE, n = 9). Both the TR and PE groups trained using the same training protocol (2 d·wk-1; 3 sets of 8-12 repetitions at 75% of 1RM); the only difference was that the PE group performed an additional set of exhaustive exercise at 20% of 1RM before each training session. For the quadriceps endurance test, all subjects were instructed to perform as many repetitions as possible at 60% of 1RM until failure (No of repetitions used as endurance mechanical index), while surface electromyography (EMG) signals were also recorded at the right vastus lateralis muscle using active surface electrode. A moving EMG-RMS method was computed across time-series and normalized by the maximal number of repetitions during endurance test. The %RMS values were then used as neuromuscular endurance work index.
RESULTS: After 8 wk, the PE group experienced a greater ($P < 0.05$) increase in endurance than TR and control groups (Figure 1A e B). Lower %RMS values during the endurance test, after PE training, indicated greater neuromuscular efficiency to support the functional demand of exercise up exhaustion (Figure 1B).
CONCLUSION: A single set of exhaustive exercise at 20% of 1RM before traditional hypertrophic training can be a suitable strategy for inducing additional beneficial effects on quadriceps endurance in young men.

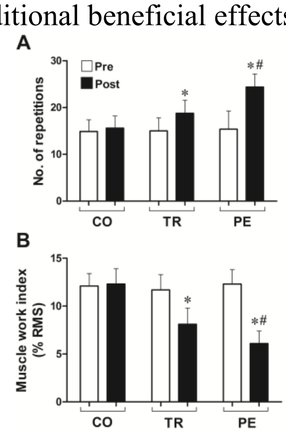

Figure 1: No of repetitions (A) and neuromuscular work index (%RMS) mean values. *$P < 0.05$ significance between pre- and post-training. # $P < 0.05$ significance between PE and CO.

DETECTION OF MUSCLE FATIGUE USING EMG-MMG COUPLING INDEX

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AIM: The purpose of this study is to assess the performance of cross fuzzy entropy between simultaneously recorded electromyography (EMG) and mechanomyography (MMG) signals during sustained isometric contraction for monitoring local muscle fatigue.

METHODS: The EMG and MMG signals analyzed were recorded during the voluntary isometric contractions of 12 healthy human subjects (eight males and four females, age: 30.2 ± 4.9). A pair of surface EMG self adhesive conductive gel electrodes (Axon Systems, Inc., New York, USA), with their centre 25 mm apart from each other were placed on abrased, clean skin longitudinally, immediately under the thickest point of the Biceps. The accelerometer (EGAS-FS-10-VO5, Entran Inc, Fairfield, NJ) was placed as close as possible to the EMG electrodes so as to record the MMG on the axis orthogonal to the muscle from the same motor territory. The subject was asked to perform an elbow flexion against the lever arm to 80% of his/her maximal voluntary contraction (MVC) and maintain this value through visual feedback of the torque reading on the screen. The test was stopped when the torque dropped to approximately 70% of the MVC, which indicates the muscle is fatigued. The gain of the EMG signal was 2000 with a 10–400 Hz bandwidth and that of the MMG signal was 5000 with a bandwidth 5–400 Hz. Signals from the EMG electrodes and accelerometer were acquired at 1 KHz per channel and stored in computer for further C-FuzzyEn analysis. The mean frequency of EMG was also estimated for comparison.

RESULTS: The C-FuzzyEn and MNF were calculated and normalized by their respective first epoch value. A least-square error linear regression was fitted to each normalized C-FuzzyEn and MNF over the period of contraction to obtain the slope and intercept respectively. Fig. 4(a) shows the time course of the C-FuzzyEn and MNF for subject 3. The Mann–Whiteney U test compared the slope and intercept of normalized C-FuzzyEn and MNF obtained from all the subjects. The test results demonstrated that there is no significant difference for both slope and intercept between the C-FuzzyEn and MNF. The results suggested that C-FuzzyEn may potentially become a new alternative method for muscle fatigue assessment.

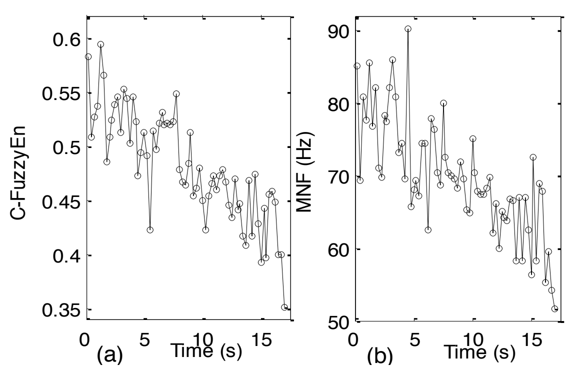

Figure 1: Time courses of EMG-MMG C-FuzzyEn (a) and EMG MNF (b) of subject 3. The duration of the analysis window is 500 ms.

CENTRAL AND PERIPHERAL MYOELECTRIC MANIFESTATIONS OF FATIGUE IN A FACIOSCAPULOHUMERAL MUSCULAR DYSTROPHY PATIENT

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INTRODUCTION**:** In facioscapulohumeral muscular dystrophy (FSHD), the third most common muscular dystrophy, fatigue is a critical and early symptom flag of the pathological processes leading to muscle wasting and to the incurable decline of the subjects' quality of life. Notwithstanding the clinical importance of fatigue in FSHD, the relative contribution of central and peripheral mechanisms to perceived fatigue is currently unknown, neither if it may temporally precede the appearance of detectable alterations in skeletal muscles.
AIM**:** Aims of the present study were: 1) to examine the myoelectric manifestations of central (FD, fractal dimension) and peripheral (CV, conduction velocity) fatigue of a FSHD patient (Score 1, according to Lamperti et al. 2010); 2) To assess whether myoelectric manifestations of fatigue precede or follow detectable muscle alterations by magnetic resonance imaging (MRI).
METHODS**:** Surface EMG signals were recorded with linear adhesive arrays in biceps brachii short head during isometric contractions at 20% and 60% of the maximum voluntary contraction (MVC) for 1 min and 20 s respectively at 90 degrees knee joint angle. Initial values and rate of change (slope) of mean frequency of the power spectrum (MNF), CV and FD of the EMG signal were calculated. Total body muscle MRI was also obtained.
RESULTS**:** MRI revealed, among others, abnormalities on T1-weighted sequences corresponding to marked atrophy and fatty fibrous replacement in trapezius muscle bilaterally. No abnormalities in biceps brachii bilaterally were found. A modification of CV slope was observed at 20% MVC in the right biceps brachii (0.0014 vs 0.0021 %/s) compared to the left, thus suggesting the presence of peripheral fatigability at low force output. This alteration was associated with a higher initial value and positive MNF slope, and equal initial value and unchanged FD slope, suggesting higher muscle fibers recruitment and unchanged central fatigue at low force development. On the contrary, all estimated parameters displayed a significant slope variation at 60% MVC in the right biceps only. No slope changes were observed in the contralateral biceps.
CONCLUSION**:** These results seem to highlight the arising of central and peripheral myoelectric manifestations of fatigue and a progressive reduction of fibers recruitment at higher force output only in the right muscle. Importantly these changes seem to precede phenotypical alterations detectable by muscle MRI.
REFERENCE**:** Lamperti et al., (2010). A standardized clinical evaluation of patients affected by facioscapulohumeral muscular dystrophy: The FSHD clinical score. *Muscle & Nerve* 42, 213-217.

EVALUATION OF CENTRAL AND PERIPHERAL FATIGUE USING FRACTAL DIMENSION AND CONDUCTION VELOCITY

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AIM: Over the past decade, several surface EMG descriptors for central and peripheral fatigue have been developed. We tested fractal dimension (FD) as an indicator of central fatigue, and conduction velocity (CV) as an indicator of peripheral fatigue. The aim of the study was to analyze the vector (FD, CV) as a bi-dimensional index for central and peripheral fatigue in healthy subjects.
METHODS: 29 female subjects performed two isometric knee extensions at 20% and 60% MVC. Surface EMG signals were detected from the quadriceps muscle using bi-dimensional arrays. FD was computed with a numerical algorithm using non-overlapping signal epochs of 1s, whereas CV was estimated with a multichannel algorithm on single differential signals.
The index was then tested in two elite female athletes, with different training backgrounds.
RESULTS: Central and peripheral fatigue were observed, respectively as a decrease of FD and CV. The slopes of FD and CV were also analyzed in the athletes, showing different behavior during the high force contraction. (Figure 1) The power athlete showed mostly central fatigue, while the endurance athlete mostly peripheral fatigue.
CONCLUSION: These results suggest that the vector (FD, CV) could be used to differentially characterize central and peripheral components of muscle fatigue, with potential application in both clinical and sport sciences.
ACKNOWLEDGEMENT: This study was supported by the Thim van der Laan Foundation, Landquart, Switzerland.

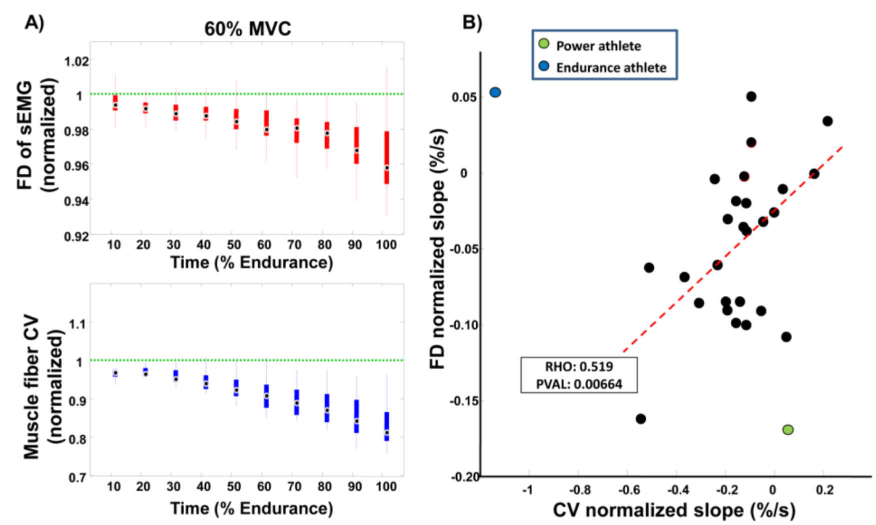

Figure 1: A) Time course of FD and CV in the vastus medialis muscle during 60% MVC isometric contractions. B) Scatter plot of the normalized slopes of FD and CV during the same contraction. The power and endurance athletes are superimposed with different colors.

MEASUREMENTS AND MECHANISMS OF CUMULATIVE NECK/SHOULDER FATIGUE DURING A SIMULATED DAY OF CAR ASSEMBLY WORK AT SHOULDER HEIGHT

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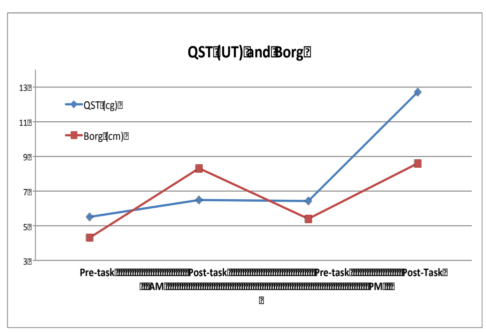
AIM: This project was designed to determine key manifestations of fatigue due to a day of simulated car assembly work at shoulder height. The long-term goal is to bring valid and reliable devices in workplaces to detect premature biomechanical signs of accumulated fatigue in order to prevent work-related musculoskeletal disorders (MSD).
METHODS: Fifteen healthy, adult participants completed two same-day sessions (morning: AM, afternoon: PM) of a drilling task using an electric right angle tool performed to exhaustion (Borg CR10 8/10). Neck/shoulder quantitative sensory testing (QST) and pain outcomes were collected before and after the task, and performance (number of bolts screwed), perceived difficulty, vascular, biomechanical and proprioceptive outcomes were collected throughout the task. The task comprised of 4min work blocks interspersed with 1min of quiet static data collection (vascular, Borg). Effects of Time and Session were calculated.
RESULTS: Preliminary results show that the number of blocks accomplished was 26% lower in the PM session, compared to the AM session. Borg CR10 scores to begin the PM session were significantly higher than those shown at the beginning of the AM session ($t = 0.039$), but significantly lower than those shown at end of the AM session ($t < 0.001$). Performance decrements (number of blocks worked) between morning and afternoon sessions were significantly associated with the difference in Borg CR10 scores at the onset of PM vs AM sessions ($r = -0.71$). Finally, upper trapezius (UT) sensory detection threshold was not significantly affected by the task in the morning nor by the between-session break, but significantly increased at the end of the PM task.
CONCLUSION: Performance was more affected by fatigue during the afternoon session than during the morning session. This could be related to the observation that Borg ratings did not return to baseline levels after the between-session break. Indeed, participants who showed the lowest between-session recovery in terms of perceived task difficulty are the ones who showed the biggest drop in performance. Despite Borg ratings being lower at the beginning of the PM session than at the end of the AM session, UT sensitivity did not change during this time, and they drastically increased at the end of the PM session. This suggests a mechanism of central fatigue that might lead to slow accumulation of metabolites, gradual development of motor impairment and ultimately, gradual performance decrease during a workday.



ENLARGING PERCEIVED LEVEL FOR AVOIDING MUSCLE FATIGUE RISK

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AIM: Subjective muscle fatigue expression has been used on many occasions as a tool to recognize the physical condition easily. However, it is ambiguous for muscle fatigue-related risk avoidance. Recently, there are researches to raise the certainty of expression with on-site feedback of biosignals. We are achieving this idea to enhance the accuracy of recognition of muscle fatigue then to secure the own safety assist system from muscle force failure.

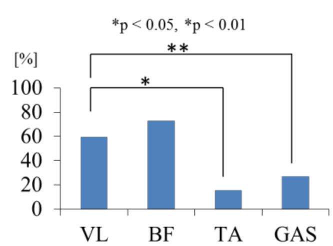
METHODS: The measurement system was composed of the 16 channels wireless unit with the two-bar active electrodes (Myomonitor IV and DE-2.1, Delsys) for the SEMG signals. Signals were sampled at 2000 Hz at a 16-bit resolution using the attachment software (EMGWorks 3.5, Delsys). The target muscle and the location of surface electrode were identified with both the muscle synergies at lower limbs and the 64 channels matrix electrode. A multiple regression model was used to model the relationship between perceived fatigue (PF) and measured data. Further the progression of muscle fatigue was predicted as the function of muscle fatigue related physiological variables and upward slope geography for cycling with electrically assisted bicycles (EABs). To identify the suitable muscle fatigue-related indices the principal component analysis was first applied. Then, the predicted PF was tuning by fuzzy inference for coping with individual differences. To complete this idea the feedback of both biosignals and self-reporting on-site with a tablet PC was developed.

RESULTS: Based on the time courses of both ARV and MPF and muscle synergies, the target muscle was identified as VL for ten participants. That is, for 60 trials, six trials per each participant, VL and BF showed significant large number of fatigue trials (Fig. 1). The averaged %RMS and the muscle synergy profiles showed a strong correlation coefficient (CC) and the number of trials was the largest at VL (Table 1 and Fig. 2). Enlarging the recognition of the level of PF with the history data could be effective for force failure.

CONCLUSION: We have studied a self power control system for EABs by the prediction of perceived fatigue after identifying the target muscle as VL by muscle synergies, combining the fatigue related variation in both ARV and MPF and the correlation coefficient between %RMS and synergy profiles. Moreover, the perceived fatigue with an on site feedback of biosignals could be a potential approach for developing a personally customized control system of EABs.

ACKNOWLEDGEMENT: This work was supported by JSPS KAKENHI Grant Number 23650341.

Right



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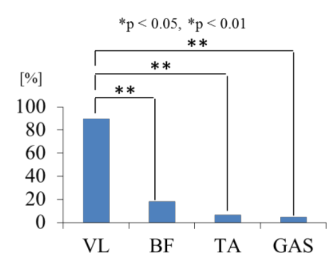

Putamen

IMPACT OF REST-BREAK INTERVENTIONS ON NECK AND HOULDER POSTURE OF SYMPTOMATIC VDU OPERATORS

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AIM: To examined the effect of rest-break interventions on neck and shoulder posture of symptomatic VDU operators over 1-hour computer typing task.
METHODS: Thirty symptomatic VDU operators were randommized assigned to active breaks with stretching, active breaks with dynamic movement, and passive breaks as a reference group. Subjects performed typing task for 60 minutes and received 3-minute breaks of each 20-minute work. The craniovertebral and forward shoulder angles were derived from the data at the 0th, 20th, 23rd, 43rd, 46th, and 66th minute of the typing task for a 60-s duration of each. The kinematics data were obtained from the 3D motion analysis system.
RESULTS: There were no significant differences of any types of rest breaks on the craniovertebral and forward shoulder angle of symptomatic VDU operators performing the typing task for 60 minutes.
CONCLUSION: Three types of rest-break interventions were positive effect on neck and shoulder posture during prolonged computer terminal work.

RESPIRATORY AND POSTURAL-RELATED ACTIVITIES OF ABDOMINAL MUSCLES DURING POST-EXERCISE HYPERVENTILATION

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AIM: The present study focused on the roles of the superficial abdominal muscles through electromyographic recordings during the maintenance of a bipedal stance perturbed by post-exercise hyperventilation.
METHODS: Twelve healthy subjects had to perform six 30-second postural tests: one pre-exercise test while breathing gently and then one test every minute for the five minutes immediately following a maximum-intensity, incremental cycling exercise test. Subjects were asked to maintain an upright stance on a force plate for 30 s, with their eyes open. Movement of the centre of pressure in the sagittal plane was monitored in the time domain. Myoelectric activities of the rectus abdominis (RA), external oblique (OE) and internal oblique (OI) muscles were recorded unilaterally using surface electromyography (EMG). Ventilatory parameters were measured with a portable, telemetric device.
RESULTS: The change in ventilatory drive induced by exercise was accompanied by a significant increase in both postural sway parameters and EMG activities. The quantification of EMG activities within the respiratory cycles revealed different EMG patterns (Figure 1). For OE and OI, the increased EMG activities were prominent during expiration. OI was silent during inspiration. OE and RA were activated during both expiration and inspiration.
CONCLUSION: The results suggest that abdominal muscles play a role in regulating the ventilatory response to incremental cycling exercise test, although some of the observed activity may support postural adjustments, presumably to reduce respiratory disturbances.

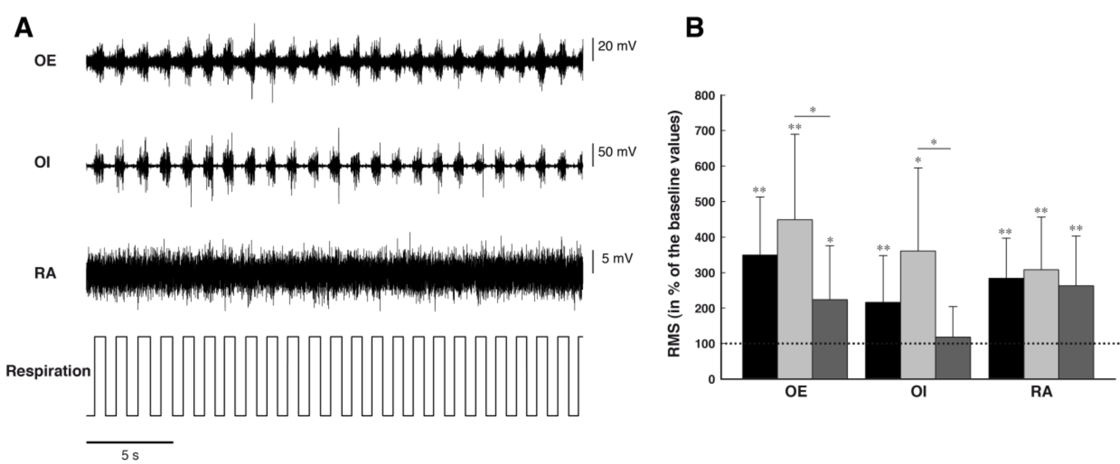

Figure 1: Recordings of respiration and electromyograms of the abdominal muscles in postural test just after an incremental cycling exercise for one subject (A). Myoelectric activities were quantified and expressed as percentages of the baseline values obtained in the pre-effort postural test (dotted line) over the entire respiratory cycle (black bars), over the expiratory phase (light grey bars) and over the inspiratory phase (dark grey bars) of respiration (B). Means plus one standard deviation are represented. * and ** denote significant differences at P<0.05 and P<0.01, respectively.

CHANGES IN BALANCE IN PATIENTS WITH CEREBRAL PALSY BASED ON THE USE OF NINTENDO WII-BALANCE BOARD VERSUS PHYSICAL THERAPY: RANDOMIZED CLINICAL TRIAL

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AIM: To investigate the effect of Nintendo Wii-balance board versus conventional exercise therapy on postural balance in patients with cerebral palsy (CP).

METHODS**:** Parallel, prospective, single-blind, randomised clinical trial. Thirty four patients with CP (Gross Motor Function Classification System level I and II) where every groups were randomised into a: experimental group (EG=17) and control group (CG=17). Eighteen training sessions -3 times per week for 6 weeks- for every groups. The EG performed balance exercises with Nintendo Wii-balance board games during 30 minutes and the CG with stretching, strengthening and axial mobility exercises during 40 minutes. The parameters measured were: area, velocity and sway in the mediolateral (ML) and anteroposterior (AP) direction of excursion of the center of pressure (COP) standing on a force platform AMTI OR67. Children stood quietly with eyes open (EO) and eyes closed (EC) during 30 seconds in every phase. The measures were made at the beginning (week 0), during (week 2 and week 4) and at the end of the training period (week 6). Statistical analysis was performed with repeated-measures analysis of variance (RM-ANOVA).

RESULTS: The EG showed reduction in area ($p = 0.005$) and AP sway ($p = 0.005$) of COP, with respect to CG during the EO condition. Pre-post differences in EO showed that both training area decreased ($p = 0.019$ for the EG and $p = 0.042$ for the CG) in patients with CP, the CG also decreased the AP sway ($p = 0.014$). In contrast, in the phase of EC obtained only significant decreases CG pre post intervention in the variables: area, ML sway, and ML / AP velocity ($p = 0.022$, $p = 0.027$, $p = 0.015$ and $p = 0.024$, respectively).

CONCLUSION: Six weeks of training with Nintendo Wii-balance board, improve postural balance in patients with CP during EO condition test and six weeks of conventional training improve postural balance in patients with CP during EC condition test. Therefore the proposed postural balance trainings are complementary.

CHANGING VISUAL INFORMATION THAT OCCURS DURING THE PROCESS OF ADAPTING FROM DARKNESS INTO ILLUMINATION AFFECTS POSTURAL CONTROL

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AIM: The visual system continuously sends information to the nervous system about the physical position and movement related to an individual's environment. Visual system function is important for the maintenance of the stable balance ability. If an individual cannot obtain clear information (such as within a dark room), their balance becomes unstable. In addition, when moving from a light to dark room (or vice versa), the visual system requires time to adjust before it can recognize objects. We researched postural control in the adaptation process that occurs when one moves between light and dark rooms.

METHODS: We compared body sway in 19 young people in an illuminated area and in darkness under three conditions. First, we measured body sway in the illuminated area; after that each subject wore an eye mask and stayed in the dark for 5 minutes. The subject then removed the eye mask and we measured body sway in the illuminated area. Body sway was then measured during an adaptation process 3 and 7 minutes later.

RESULTS: We found that body sway gradually improved just after, 3 minutes later, and 7 minutes later ($P<0.05$). At the last point, the data were equal to those collected in the beginning.

CONCLUSION: This finding suggests that a change in visual information that occurs during the process of adapting from darkness into illumination affects postural control. Accordingly, we believe that the visual adaptation process affects postural control. Therefore, a further study is necessary to continue investigating this issue.

DOES VISUAL FEEDBACK INFORMATION CHANGE THE CONTROL OF STANDING BALANCE?

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AIM**:** To evaluate whether the influence of visual feedback on postural sway during upright stance depends on the nature of the types of feedback.
METHODS**:** Twenty-six subjects (13 men; mean ± SD: 23.54 ± 3.61 years; 69.41 ± 13.77 kg; 1.69 ± 0.07 m) volunteered for this study. Three tasks were performed on a force platform: 1) standing with eyes open (EO; control condition); 2) minimizing postural sway using the visual feedback of subject' center of pressure (VF_{COP}); 3) reducing the displacement of a handhold laser pointer around a target (VF_{laser}). The center of pressure (COP) displacement and the ankle motion were measured through a force platform and a biaxial electrogoniometer, respectively, during 60 seconds in each experimental task. The following stabilometric parameters were computed: COP sway area and the standard deviation, the mean velocity and the mean frequency in the antero-posterior (AP) and medio-lateral (ML) directions using the whole trial data. Furthermore, the ankle motion variability (standard deviation) and its mean frequency in the sagittal plane (plantar flexion/dorsiflexion motion) were also calculated. A one-way analysis of variance (ANOVA) for repeated measures was used to compare the COP displacement and the ankle motion in the three tasks, and post hoc comparisons were made with the Tukey HSD test (significance level of 5%). RESULTS**:** The COP sway area and standard deviation (AP) were significantly smaller in the VF_{COP} than EO and VF_{laser}, and in the EO condition compared to VF_{laser} ($p<0.05$; Figure 1). The ML standard deviation showed also similar pattern, but no significant difference was observed between VF_{COP} and EO. The mean frequency was significantly higher in the VF_{COP} comparatively to EO and VF_{laser} in both directions, with EO being higher than VF_{laser} ($p<0.05$). The mean velocity shows the same pattern of the mean frequency, although in AP its value in EO did not depart significantly from that obtained in VF_{laser}. In addition, the ankle motion variability was significantly smaller in the VF_{COP} than EO and VF_{laser} ($p<0.05$), with no differences between EO and VF_{laser}. The ankle mean frequency was significantly higher in the VF_{COP} comparatively to EO and VF_{laser}, being higher in the EO compared with VF_{laser} ($p<0.05$).
CONCLUSION**:** The results showed that postural sway changes depending on the nature of the visual feedback, i.e., the utilization of visual feedback information seems to modify the postural control.

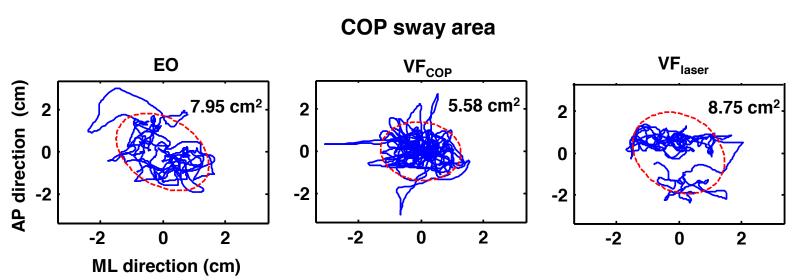

Figure 1. Elliptical area of COP displacement from a representative volunteer in each experimental task: eyes open (EO), visual feedback of COP displacement (VF_{COP}) and visual feedback of laser pointing (VF_{laser}).

EFFECT OF POSTURE ON HARDNESS OF THE ILIOTIBIAL BAND

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AIM: Iliotibial band (ITB) syndrome is an overuse injury associated with pain on the lateral aspect of the knee, and is caused by increased compression of fat and connective tissue that separates the ITB from the lateral femoral epicondyle. Excessive hip adduction, which could increase ITB hardness, have been associated with the ITB syndrome. However, no studies have measured ITB hardness, and the relationship between change in posture and ITB hardness is not well understood. This study aimed to clarify the effect of postural change accompanied by three-dimensional positional change of the pelvis on ITB hardness using quantitative shear wave elastography (SWE), which measures the shear elastic modulus as an indicator of tissue hardness.
METHODS: Fourteen healthy volunteers (7 men and 7 women; age, 22.0 ± 1.0 years) were instructed to stand on one leg under 7 conditions related to the pelvic position: normal (NO), 10° posterior tilt with anterior shift (i.e. hip extension; PT), 10° anterior tilt with posterior shift (i.e. hip flexion; AT), 10° drop of the contralateral side (i.e. hip adduction; CD), 10° rise of the contralateral side (i.e. hip abduction; CR), 10° posterior rotation of the contralateral side (i.e. hip external rotation; PR), and 10° anterior rotation of the contralateral side (i.e. hip internal rotation; AR). Hardness of the ITB was measured at the level of superior border of the patella using SWE (Aixplorer, SuperSonic Imagine) while maintaining each of the 7 positions. The diameter of the region of interest (ROI) was 1.5 mm and was determined based on ITB thickness. Three ROIs were set in the ITB and a mean value was recorded. All measurements were performed 2 times and mean values of the 2 trials were used for analysis. The ICC (1,2) for SWE measurement was 0.94. To detect any significant differences in ITB hardness between the NO and each of the other conditions, and between the conditions for which ITB hardness increased compared with that during NO, we used the Wilcoxon signed-rank test with Holm's correction.
RESULTS: Shear elastic modulus of the ITB for each condition is shown in Table 1. ITB hardness increased for PT, CD, and PR conditions compared with the NO condition. However, no significant difference was found among PT, CD, and PR conditions. ITB hardness was decreased for AT and CR conditions compared with the NO condition.
CONCLUSION: Besides hip adduction with pelvic drop of the contralateral side during one-leg standing, pelvic posterior tilt with anterior shift (i.e. hip extension) and pelvic posterior rotation of the contralateral side (i.e. hip external rotation) increase ITB hardness.

Table 1: Shear elastic modulus (kPa) of the ITB in each posture
Data are expressed as median (interquartile range).
NO: normal one-leg standing, PT: posterior tilt with anterior shift of the pelvis, AT: anterior tilt with posterior shift of the pelvis, CD: contralateral drop of the pelvis, CR: contralateral rise of the pelvis, PR: pelvic posterior rotation of the contralateral side, AR: pelvic anterior rotation of the contralateral side
*: significant difference compared with the NO condition

NO	PT	AT	CD	CR	PR	AR
10.7 (9.2–13.6)	12.4* (9.8–16.4)	8.8* (5.7–11.2)	13.2* (11.0–18.8)	8.1* (5.8–10.3)	14.6* (10.7–18.1)	12.0 (9.2–15.1)

RELATIONSHIP BETWEEN BALANCE ABILITY AND TASK-SPECIFIC MODULATION OF SOLEUS H-REFLEX

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AIM: Soleus(SOL) H-reflex has been extensively investigated during various tasks in humans. Previous studies have revealed that balance tasks induce a decrease in SOL H-reflex.
It was hypothesized that balance ability is related to the degree of task-specific SOL H-reflex modulation. The aim of this study was to examine relationship between balance ability and SOL H-reflex task-specific modulation in healthy normal subjects.
METHODS: Twelve neurologically normal subjects (mean 24±4year) participated. SOL H-reflexes, M waves and background electromyography (bEMG) (50ms window prior to stimulation) were obtained under three conditions: prone; neutral standing; and tandem standing with eyes closed (unstable standing). H-max/M-max ratios were calculated. Furthermore, an index of SOL H-reflex task-specific modulation between two different conditions was calculated as the one condition H-max/M-max ratio relative to the another one. There were three measures of modulation (prone-to-neutral standing, prone-to-unstable standing, neutral standing-to-unstable standing). Balance ability was assessed by standing on a wobble board that sways in the longitudinal direction. Subjects were instructed to keep the board equilibrium and not to hit edges of the board against a floor as possible when standing on the wobble board during 30 seconds. Two touch sensors were attached on both edges front and back of the wobble board. A period in which edges of the board were off the floor was calculated as balance ability.
RESULTS: SOL H-max/M-max ratios were not significantly different between all three conditions. bEMG of prone condition was significantly lower than other two conditions ($p<0.05$) (Table 1). Negative correlation was observed between balance ability and the degree of SOL H-reflex modulation when neutral standing to unstable standing (Figure 1).
CONCLUSION: Results of this study suggested that the degree of SOL H-reflex task-specific modulation is related to balance ability.

Table 1: SOL Hmax/Mmax ratio and bEMG of each condition

	Prone	*Neutral Standing*	*Unstable Standing*
Hmax/Mmax ratio	0.57±0.1	0.49±0.1	0.47±0.1
bEMG(mv)	8.8±0.6	17.2±7.0	16.1±3.5

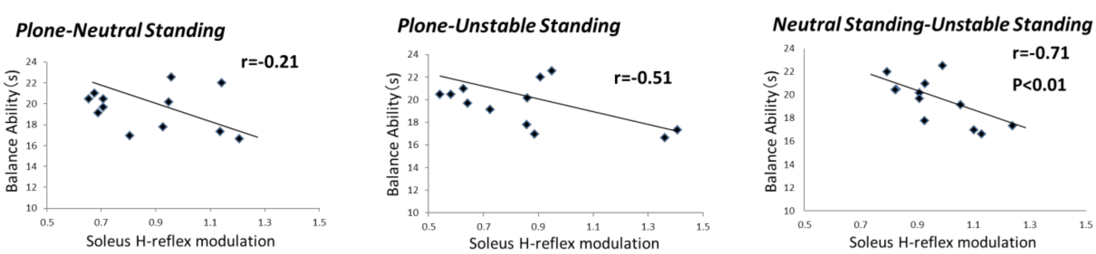

Figure 1: Relationship between task-specific modulation of SOL H-reflex and balance ability

ASYMMETRY AND CO-ACTIVATION INDICES OF TRUNK MUSCLES IN PATIENTS WITH SEVERE HAEMOPHILIA AND HEALTHY CONTROLS

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AIM: Recurrent bleeding episodes in patients with haemophilia lead to joint alterations and therewith disturbed muscle coordination patterns. Major weight-bearing joints are affected most. However, possible consequences on characteristics of trunk muscles have not been examined so far.
METHODS: Surface EMG (SEMG) of internal oblique (IO) and multifidus (MF) muscles were bilaterally recorded during a natural parallel stance in 20 patients with severe haemophilia A (PWH, age: 43 years (SD: 10)) and 18 non-haemophilic control (NHC, age: 45 years (SD: 11)) subjects twice within a session. Potential interferences of ECG were eliminated by applying a template-based algorithm [1]. Firstly, test-retest reliability (ICC) was determined for EMG amplitudes. In a second step, Symmetry (SI: between sides) as well as Co-activation (CAI: between IO and MF) indices were calculated from the first trial of the test session. Values of the lower active muscle were divided by those of the higher active muscle. Therefore, the maximum level is one. High values indicate low asymmetry or a high co-activation level, respectively.
RESULTS: SEMG amplitudes showed excellent reliability for both muscles and sides in either group (PWH: 0.857-0.941; NHC: 0.868-0.971). Neither SI nor CAI variables revealed significant differences between groups ($0.167<p<0.952$, Figure 1).
CONCLUSION: This study showed a comparable behavior of trunk muscles of PWH with NHC. Expected ascending alterations of muscle co-ordination could not be verified for this simple unperturbed postural task.

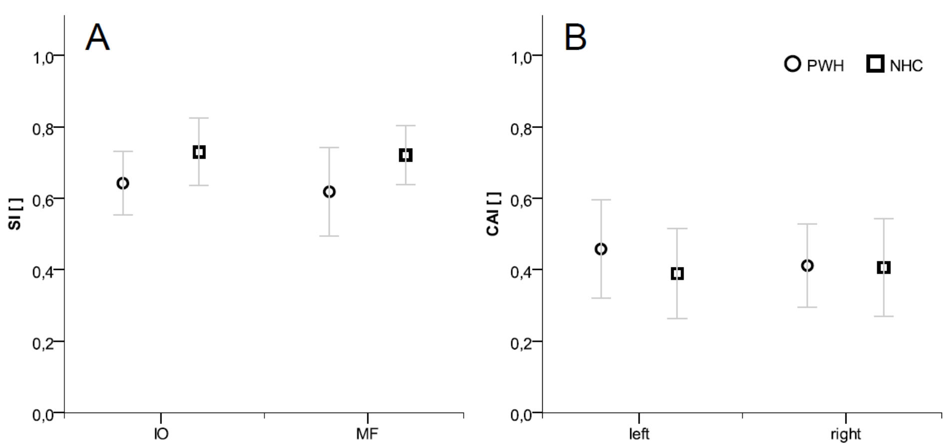

Figure 1: Symmetry (SI, A) and Co-activation (CAI, B) indices of internal oblique (IO) and multifidus (MF) muscles for patients with haemophilia (PWH) and non-haemophilic controls (NHC). Data represents means and 95% confidence intervals.

[1] Mörl F, Anders C, Graßme R (2010) An easy and robust method for ECG artifact elimination of SEMG signals. In: Farina D, Falla D, Popovic D, Sinkjaer, T (eds) Abstracts of the XVIII Congress of the ISEK, 16-19 June 2010, Aalborg, Denmark [CD-ROM].

DAMPING REGULATION OF THE WRIST JOINT AT DIFFERENT POSTURAL DEMANDS

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AIM: Although neuromuscular damping is regulated by antagonist pairs of a joint with respect to task demands, yet how neuromuscular damping is regulated to achieve different positional goals under sudden postural perturbations is not well understood. The aim of this preliminary study was to investigate how damping of the wrist joint was regulated at two postural demands.

METHODS: In terms of damping ratio (ξ) and the damped nature frequency (W*d*), we differentiated damping characteristics of the right wrist joint following an unexpected unloading response with "Resume position"(RP) and "Don't intervene"(DI) paradigms. The subjects were initially instructed to keep the wrist joint at the neutral position against a constant load of 1KG pulling in the extension direction. Sudden release of the inertial load caused unloading response of the wrist joint like a damped harmonic oscillation. In RP paradigm, the subjects restored their wrists to the neutral position after unloading. In the DI paradigm they didn't react to the unloading perturbation. Every subject executed 8 sets of 10 trials (RP 4 sets, DI 4 sets) with a pseudo-randomized order. Angular acceleration of the wrist joint was obtained by a second-order differential of wrist angular movement registered with an electro-goniometer. ξ of the wrist oscillation could be obtained from the logarithmic decay (δ) between two adjacent flexion acceleration peaks (P(i) and P(i+1))(Equations (1) and (2)). Pertaining to the degree of joint stiffness, W*d* was assessed with the time interval between two flexion acceleration peaks (T(i+1) and T(i)) (Equation (3)).

For each subject, ξ and W*d* of the first two oscillations, and the maximal flexion angle were averaged across

$$\delta = \ln \frac{P(i)}{P(i+1)} \quad (1)$$

$$\xi = \sqrt{\frac{\delta^2}{4\pi^2+\delta^2}} \quad (2)$$

$$Wd = \frac{1}{T(i+1)-T(i)} \quad (3)$$

trials for each paradigm. A paired t-test was used to examine the differences in the two damping parameters between the RP and DI conditions. The level of significance was 0.05.

RESULTS: The results showed that the maximal flexion angle (RP: 19.43±5.12 degree; DI: 22.55±5.75 degree; t=-5.308, $p<0.001$) and ξ (RP: 0.175±0.088; DI: 0.269±0.043; t=-4.648, $p<0.001$) of the second oscillation in the DI condition were larger than those in the RP condition. On the contrary, ξ of the first oscillation (RP: 0.132±0.070; DI: 0.109±0.056; t=2.409, p=0.029) and W*d* of the second oscillation (RP: 5.317±1.414; DI: 4.762±1.159; t=2.807, p=0.013) were larger in the RP condition.

CONCLUSION: During the early oscillation phase, the wrist joint in the RP condition is stiffer than that in the DI condition to timely restrict the joint movement. Over the late oscillation phase, the wrist joint in the DI condition is more compliant than that in the RP condition. This study suggests that the central nervous system could selectively scale joint damping according to different postural goals.

THE EFFECTS OF THE PRESENCE OR ABSENCE OF EQUINUS AND HEEL HEIGHT DIFFERENCES ON STANDING CENTROID OSCILLATION IN AMBULANT CEREBRAL PALSY PATIENTS

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AIM : For patients with cerebral palsy, the heel of an insole is raised to help stabilize a standing position or walking. However, appropriate heel height is decided by physicians and physical therapists based on their clinical experiences, as a clear standard has not been established. This study aimed to investigate the effects of either the presence or absence of equinus and heel height differences on standing centroid oscillation in ambulant cerebral palsy patients.

METHODS: Twenty－four patients whose gross motor functions were classified as level I or II were selected (equinus group, 13 patients; non-equinus group, 11 patients). We examined the impact of age, foot joint torque, the presence or absence of equinus, and heel height differences (0, 7, and 15 mm) on standing centroid oscillation. We analyzed the data by performing an unpaired *t* test, a repeated-measures two-way layout analysis of variance, and multiple comparisons using the Bonferroni method that assumed centroid oscillation as a dependent variable. A 5% level of significance was assumed for statistical processing using IBM SPSS Statistics Ver.19. The procedures performed in this study were approved by the ethical review board of Tokyo University of Technology (approval no. E13HS-008).

RESULTS: Age and foot joint torque showed no significant differences between the groups. In the non-equinus group, the total length of body sway and locus length significantly decreased in the 0-mm heel height compared with that in the 7- and 15-mm heel heights, and the rectangular area significantly decreased in the 0-mm heel height compared with that in the 15-mm heel height. The Y-direction unrest center displacement in the equinus group significantly decreased in the 0-mm heel height compared with that in the 7- and 15-mm heel heights.

CONCLUSION: Our results suggest that standing centroid oscillation did not change according to heel height differences in the equinus group but changed in the non-equinus group. In the equinus group, the position of the anteroposterior center of gravity moved forward according to heel height. This study provides useful data for setting a standard assistive heel height for equinus by investigating dynamic balance.

Table1: Change of standing centroid oscillation by heel height differences.

		0mm	7mm	15mm
total length of body sway	equinus group	56.2±11.2	55.4±12.5	56.4±13.3
	non-equinus group	102.0±12.2	106.8±13.6	121.4±14.5 **, ***
locus length	equinus group	1.08±0.21	1.15±0.25	1.13±0.29
	non-equinus group	1.83±0.23	1.93±0.28	2.25±0.31 **, ***
Y-direction unrest center displacement	equinus group	−0.73±0.54	0.14±0.59 *	0.30±0.56 **
	non-equinus group	−0.30±0.59	−0.34±0.64	0.18±0.64

*:0mm vs 7mm, **:0mm vs 15mm, ***:7mm vs 15mm, *, **, *** :p ＜.05

RELATIONSHIP BETWEEN ANKLE DORSIFLEXION AND TRUNK FLEXION DURING SIT-TO-STAND MOVEMENT IN HEALTHY YOUNG SUBJECTS

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AIM: To determine the ankle dorsiflexion timing and its relation with trunk flexion during forward displacement of Center of Mass (CoM) while performing the sit-to-stand (STS) task.
METHODS: Fifteen healthy young subjects (9 males and 6 females) aged 20-22 years participated in the present study, for which approval was obtained from the Osaka Prefecture University research ethics committee (2012-PT11). The subjects sat on a hard surface stool, set at a height at the subject's knee joint in the sitting position. To assess STS task, we used a motion analysis system (Kinema Tracer, Kissei Comtec) with 4 cameras (30Hz) synchronized by 1 force plate (100 Hz; TF-3040-A, Tec Gihan). The force plate was placed beneath the stool to measure the time at which the subjects lost contact with the seat. Ten reflective markers were placed bilaterally at the acromion process, greater trochanter, lateral tibial condyle, lateral malleolus, and the lateral aspect of fifth metatarsal. The STS task began with subject's trunk upright and in the vertical shank position. The task ended with the subject standing motionless. Five trials were recorded for each subject at a self-selected speed. The beginning of the STS movement was represented by the time at which the magnitude of the horizontal velocity at the midpoint between the acromion markers was more than 5% of its peak value. The time at which the magnitude of hip extension's angular velocity first reached 0 m/s was considered to be the endpoint of the STS task. Three trials with total movement time close to mean total time were selected for each subject for analysis. Thereafter we calculated the mean and standard deviation values of the total STS task duration and percentage of total task time at which the kinetic and kinematic events occurred, including maximum angular velocity of trunk flexion, ankle dorsiflexion initiation, lift-off (LO), maximum trunk flexion, maximum ankle dorsiflexion, and forward displacement of the CoM.
RESULTS: The total duration of the STS task was 3.30±0.30 s. Maximum trunk flexion and ankle dorsiflexion were achieved after LO (39.6%±7.0%) at 42.9%±6.9% and 54.3%±76.9% of the total time, respectively. Furthermore the forward displacement of the CoM reached its maximum forward point after maximum ankle dorsiflexion at 65.8%±7.3% of the total time. Ankle dorsiflexion initiation (at 29.5%±8.4% of the total time) and maximum angular velocity of trunk flexion (at 29.9%±7.2% of the total time) simultaneously occurred before LO.
CONCLUSION: These findings suggest that inter-segmental coordination between trunk flexion and ankle dorsiflexion may help young healthy subjects perform the STS task more efficiently.

THREE-DIMENSIONAL MOTION ANALYSIS OF THE HULA HOOP ACTION - COMPARISON OF UNSKILLED AND SKILLED PERSON

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AIM: Hula hoops can be used as a simple tool for exercise. However, there has not been much research on the physical effects of the hula hoop. This study compared the kinematic differences for unskilled and skilled hula hoop users.
METHODS: Ten healthy men (age: 19–23 years) without any history of orthopedic disease participated in this study. A three-dimensional motion analyzer (Vicon Nexus: 100 Hz) with six infrared camera units was used to measure the kinematic parameters during hula hooping.
Kinetic parameters such as the floor reaction force were measured using AMTI force plates (1000 Hz). EMG data were recorded using the Noraxon Myosystem (1000 Hz) while the participants performed hula hoop tasks.
RESULTS: Table 1 compares the center of gravity (COG) trajectories for the unskilled and skilled hula hoop users. Skilled users showed a significantly smaller amplitude in the COG trajectory compared to the unskilled persons ($p < 0.01$). Both skilled and unskilled users showed large amplitudes for the COG trajectory in the A-P direction relative to the M-L direction. Thus, the skilled users showed a stable bilateral ankle plantar flexion moment with the same timing (Figure 1: subject 1). The skilled users showed regular activity of the erector
spinae and rectus abdominis muscles; the same trend was also observed for the gastrocnemius and tibialisanterior muscles.
CONCLUSION: The skilled users could hula hoop while moving their COG very small distances. However, moving the center of gravity only small distances is difficult. The skilled users performed a difficult strategy where muscle groups regularly performed antagonistic activities in short periods of time.

Table 1: Center of gravity (COG) trajectories of skilled and unskilled users

	skilled(n=5)	unskilled(n=5)	
A-P direction	0.011(±0.001)	0.033(±0.005)	**
M-L direction	0.035(±0.005)	0.051(±0.006)	**

COG trajectory(m)/height(m)

Mann-Whitney's U test ** p<0.01

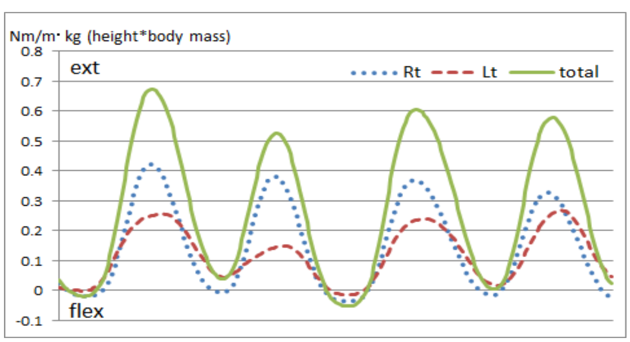

Figure 1: Bilateral ankle moment during hula hooping (subject 1)

ACTIVITY OF MASSETER AND TEMPORAL MUSCLES IN WOMEN WITH TEMPOROMANDIBULAR DISORDER

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[2]Morphology Department, Piracicaba School of Dentistry, State University of Campinas (UNICAMP), Brazil
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PURPOSE: Evaluate the activity of the masseter and temporal muscles in women with different degrees of myogenous temporomandibular disorder (TMD). METHODS: Forty-nine female volunteers aged 18 to 40 years were submitted to the following evaluations: Research Diagnostic Criteria for Temporomandibular Disorders for the diagnosis of TMD; the Fonseca Patient History Index for the determination of the severity of TMD; and electromyographic (EMG) analysis of the masseter and temporal muscles, bilaterally, during maximum isometric contraction and isotonic contraction. Three EMG readings were taken under each condition and the mean was calculated, with the root mean square (RMS) considered in the analysis. The EMG data were normalized by the peak signal, which had the smallest standard deviation. The muscle activity index was calculated [(RM+LM-RT-LT)/(RM+LM+RT+LT)*100], the result of which allows the identification of the which muscles are predominant during each action. Negative values correspond to greater activity of the temporal muscles and positive values correspond to greater activity of the masseter muscles. A zero value indicates equilibrium. The Kruskal-Wallis test was employed to determine whether the muscle activity index differed among the different degrees of TMD (mild, moderate and severe). P-values < 0.05 were considered statistically significant. RESULTS AND DISCUSSION: Temporal muscle activity was predominant during isotonic contraction in all groups. During isometric contraction, masseter muscle activity was predominant in the groups with mild and severe TMD and temporal muscle activity was slightly predominant in the group with moderate TMD. No statistically significant differences in the muscle activity index were found among the different groups under either condition (isotonic or isometric contraction) ($p > 0.05$). The temporal muscles reposition the mandibular condyle and are therefore not muscles of force. A predominance of activity overloads these muscles and leads to alterations in the biomechanics of the temporomandibular joints. A number of authors report that bruxism (clenching/grinding one's teeth) is one of the major factors triggering the occurrence of myogenous TMD. Over prolonged periods, these non-voluntary contractions are believed to reduce the capacity of the masseter muscles to generate tension. The temporal muscles take on an additional function when the masseter muscles are overloaded, performing both the positioning of the head of the mandible in the mandibular fossa (their main action) and generating force during the elevation of the jaw. Hypothetically, the inversion in the activity pattern of the temporal and masseter muscles during the chewing process is a compensatory mechanism to alleviate pain during a motor response in individuals with TMD and an adaptation among the elevator muscles of the jaw following the emergence of this disorder. CONCLUSION: Despite the lack of statistically significant differences among the different degrees of TMD, functional inversion was found in the relationship between the masseter and temporal muscles, demonstrating an imbalance in the musculature associated with this disorder.

ACKNOWLEDGMENT: Funding from the Brazilian fostering agency CAPES.

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Light and thin connections to electrodes minimize the movement artifacts and setup complexity. The optical fiber connection makes the system intrinsically safe and allows the subject to move up to 50m away from the PC.
MAIN FEATURES
•Battery powered*
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•Small and light
•Thin and lightweight connections
•The basic version acquires 64 channels (expandable up to 424 channels)
•Long distance (up to 50 m) fibre-optic connection to PC
*The battery supports acquisition of 64 ch for up to five hours without recharging
The W-EMG has been developed by LISiN (Laboratory of Engineering of Neuromuscular System) during a PhD program in partnership with Bitron.

	MTW DEVELOPMENT KIT LITE	MTW DEVELOPMENT KIT	MVN BIOMECH	MVN BIOMECH AWINDA
Motion trackers	1	1-32 (standard 6)	17+1	17+1
On-body wireless	Yes	Yes	No	Yes
On-body master	-	-	2x Xbus Master	-
PC-bound master	Awinda Dongle	Awinda Station Awinda Dongle	-	Awinda Station Awinda Dongle
Wireless range (open space)	50 m	50 m	150 m	50 m
Sample frequency (max)	-	-	120[1] Hz	-
Update rate (max)	150[1] Hz[1]	150[1] Hz	-	40/50/60[1] Hz
Video	-	-	MVN Reference Camera, synchronized video	MVN Reference Camera, synchronized video
Real-Time Preview	Graphical: 3D Orientation 3D Sensor component data: - Acceleration - Angular velocity - Earth mangnetic field - Pressure 3D Orientation cube	Graphical: 3D Orientation 3D Sensor component data: - Acceleration - Angular velocity - Earth mangnetic field - Pressure 3D Orientation cube	3D Scaled-character Orthogonal views Body CoM Network Streaming	3D Scaled-character Orthogonal views Body CoM Network Streaming
Post-Record View	Graphical: 3D Orientation 3D Sensor component data: - Acceleration - Angular velocity - Earth mangnetic field - Pressure 3D Orientation cube	Graphical: 3D Orientation 3D Sensor component data: - Acceleration - Angular velocity - Earth mangnetic field - Pressure 3D Orientation cube	3D Scaled-character Orthogonal views Body CoM Network Streaming Graphical: Time based plots Phase/Coordination plots - 3D Kinematics - 22 Joints - 23 Segments - Body CoM position - 3D Sensor component data	3D Scaled-character Orthogonal views Body CoM Network Streaming Graphical: Time based plots Phase/Coordination plots - 3D Kinematics - 22 Joints - 23 Segments - Body CoM position - 3D Sensor component data

[1] Depending on number of MTw's used and/or configuration

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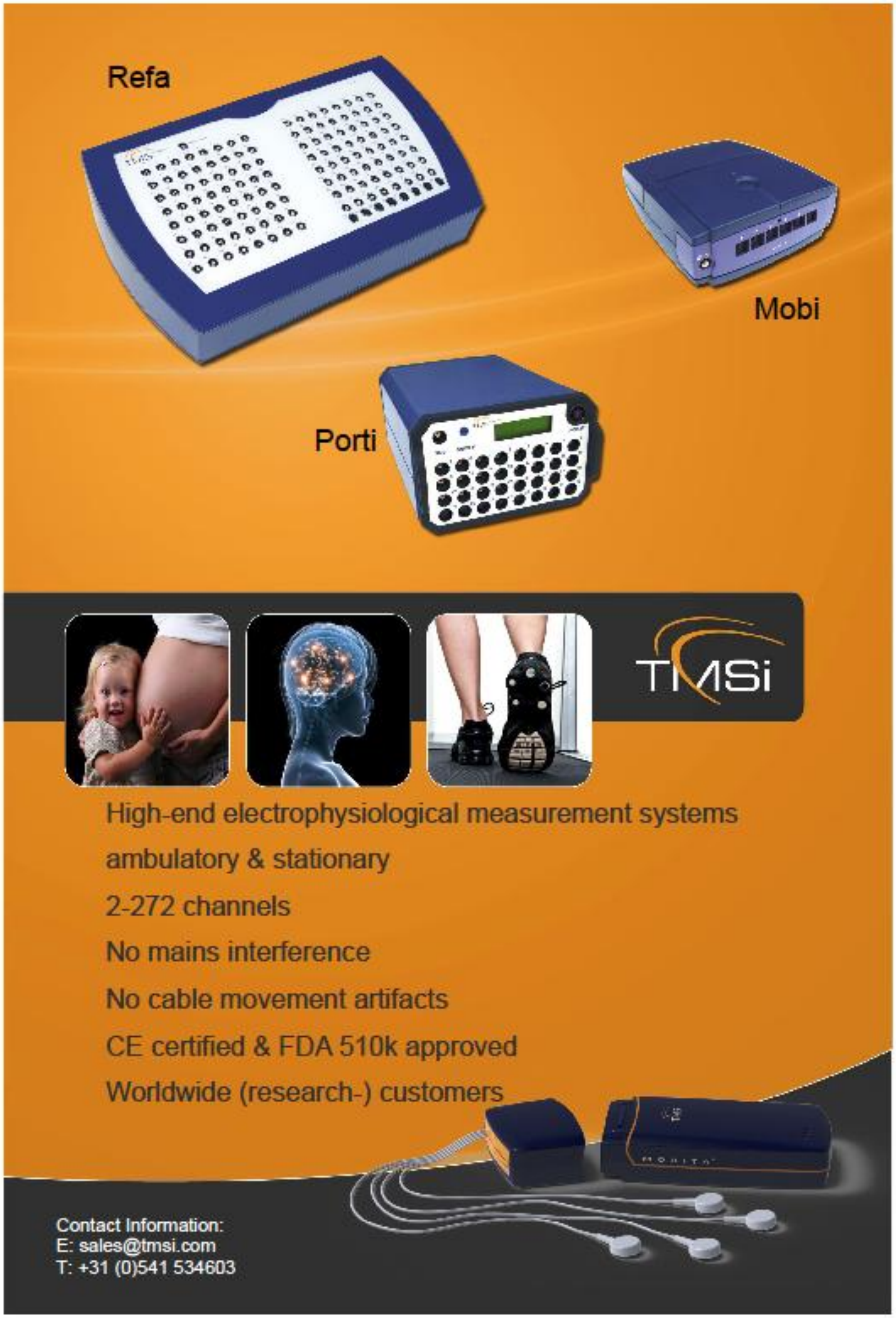
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