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Keywords:

A - Aging

B - AI & IoT

C - Biomechanics

D - Clinical Neurophysiology

E - Electrical Myostimulation

F – Fatigue

G - Modelling and Signal Processing

H - Motor Control

I - Motor Units

J - Muscle Synergy

K – Neuromechanics

L - Neuromuscular Imaging

M - Pain

N – Rehabilitation

O - Sensing & Sensors

P - Sports Sciences and Motor Performance

Q - Motor Disorders

P-A-1: Evaluation of upper and lower body muscle quality in older men and women

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BACKGROUND AND AIM: Aging presents a multitude of physical and physiological changes that may directly impact activities of daily living and quality of life. Maintenance of muscle strength and mass as aging occurs will greatly improve these functions and promote independent living and longevity. It is well known that men and women are not comparable in strength or absolute muscle mass after adolescence. In adulthood, when strength is expressed relative to mass, the disparity tends to be smaller, therefore, the primary aim of this study was to identify sex-related differences in muscle quality, defined as the upper and lower body strength relative to muscle mass of the upper and lower body, respectively, in older men and women. METHODS: Seventeen men [mean ą SD: age (years): 69.1 ą 6.6; height (cm): 177.4 ą 7.5; weight (kg): 84.0 ą 14.5] and 17 age-matched women [age (years): 68.9 ą 6.4; height (cm): 159.4 ą 7.9; weight (kg): 71.0 ą 12.8] completed maximal bench press and leg press to assess strength and underwent a full-body dual-energy x-ray absorptiometry (DXA) scan to quantify arm lean mass and leg lean mass. Strength was normalized to the amount of muscle mass for the upper and lower limbs, considered muscle quality. Independent samples t-tests were completed with an alpha of 0.05 determined as the acceptable type I error rate. RESULTS: As expected, there were significant differences in arm and leg lean mass (mean difference: 2.7kg, $p<0.01$ and 7.3kg, $p<0.01$, respectively) and upper and lower body strength (mean difference: 22.7kg, $p<0.01$ and 76.9kg, $p<0.01$, respectively). However, when maximal strength was normalized to muscle mass, there were no sex-specific differences in upper or lower body muscle quality (kg strength/kg muscle mass; mean difference: 0.7kg, $p\geq0.05$ and 1.1kg, $p\geq0.05$, respectively). CONCLUSIONS: These results indicate the quality rather than the quantity of contractile tissue may be the prominent factor contributing to strength. Men and women have comparable muscle fiber type distribution and the changes knowingly associated with age are not unique to men or women alone. The functional unit of muscle (motor unit) should be evaluated to sparse out sex-specific differences, if any, in muscle fiber recruitment to generate force. These data suggest there would be no difference despite the significant gap in strength between older men and women.

P-A-10: RELATIONSHIP BETWEEN KNEE FLEXOR AND EXTENSOR TORQUE AND FUNCTIONAL PERFORMANCE IN OLDER INDIVIDUALS

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BACKGROUND AND AIM: Functional capacity deteriorates with the aging process. Identifying muscular aspects that relate to functional performance is useful in the design of exercise interventions for the elderly. In this study, we investigated the association between functional performance and knee extensors and flexors torque. METHODS: Thirteen older men (73±5 years old) signed an informed consent form to participate in the study (ethics committee approval: IRB 2.034.508). Functional performance was assessed by the 30-s sit-to-stand test (30STS), the Timed Up and Go test (TUG), and the gait speed test. For the 30STS, participants were instructed to perform the maximal number of sit-to-stand repetitions in 30 s, with the arms crossed in front of the chest. TUG was assessed at preferred

speed and the participants should rise from a chair, walk 3 m, turn around a cone, return to the chair and sit down again. The gait speed was determined with the participants walking at preferred speed along a 10 m long walkway. For each test, two trials were performed, with a 1-min rest interval between them, and the best values were utilized for analysis. Bilateral knee flexors and extensors torque was assessed using an isokinetic dynamometer (Biodex System 3 Pro, Biodex Medical System, USA). Maximal isometric torque was assessed at 30º and 90º of knee flexion and at 60º and 90º for knee extension (three contractions, lasting 5 s each; 0º: full extension). Maximal isokinetic-concentric torque was assessed at 60º.s-1 and 180º.s-1, while eccentric torque at 60º.s-1 and 120º.s-1 (two series of three repetitions each; range of motion: 90-20º). Before the torque assessment, participants completed a warm-up consisting of two series of ten submaximal concentric repetitions, each at 90º.s-1. A 2-min interval was observed between contraction sets. As there were not differences between the lower limbs, the mean values from both legs (normalized by body mass) were utilized for analysis. Data normality was assessed through the Shapiro-Wilk test, and Pearson's and Spearman's correlation tests were performed, considering a significance level of 0.05. RESULTS: TUG performance and gait speed did not correlate with torque output. On the other hand, the number of repetitions performed in the 30STS was directly related to the torque. For knee extensors, direct correlations were observed for isometric torque at 90º ($r=0.73$; $p<0.05$) and concentric torque at 60º.s-1 ($r=0.61$; $p=0.02$) and 180º.s-1 ($r=0.68$; $p=0.01$). In addition, 30STS was correlated with knee flexors concentric torque at 60º.s-1 ($r=0.74$; $p<0.01$). Eccentric torque did not correlate with the functional performance. CONCLUSIONS: Functional tests involving locomotion (TUG and gait speed) performed at preferred speed did not correlate with knee flexors and knee extensors isometric and isokinetic torque. On the other hand, 30STS repetitions correlated with knee extensors isometric and concentric torque, and knee flexors concentric torque. These types of contraction should be considered when assessing and structuring exercise programs for older individuals.

P-A-11: Age-related change of mechanomyogram and electromyogram of digastric muscle during swallowing reflex

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BACKGRAOUND AND AIM: This study aimed to analyze the time-varying characteristics of the surface electromyogram (EMG) and mechanomyogram (MMG) of digastric muscle during swallowing reflex, and to examine the effect of aging on time courses of the EMG and MMG. METHODS: Food swallowing trials with the pudding of 5 ml were performed on eight older and eight younger volunteers (age 60.6 ą 6.7 and 22.1 ą 1.9 years; mean ą S.D., respectively) without the swallowing impairments. The time-frequency analysis using the short time Fourier transform were applied to the MMG and EMG recorded during swallowing trials. Then, the root mean square (RMS) amplitude and mean power frequency (MPF) of the MMG and EMG were calculated every 0.1 seconds. RESULTS: For younger subjects, the RMS amplitude of the EMG (EMGrms) reached its peak at the time corresponding to the onset time of the spike-like swallowing sound as was defined as the reference time (0 sec). The MPF of the EMG (EMGmpf) showed the maxmum on the range of -0.5 and 0.5 sec. The RMS amplitude and MPF of the

MMG (MMGrms and MMGmpf, respectively) also demonstrated similar time courses to that of the EMG. On the other hand, the time courses of the EMG and MMG of older subjects shifted by range of -0.5 and -0.1 sec from that of younger subjects. In addition, the ratio of the MMGrms of EMGrms at time when the EMGrms was at its peak had a significant difference between younger and older subjects (t-test, significance level = 0.05). CONCLUSIONS: These results suggest that the EMG and MMG of digastric muscle during swallowing reflex may be an index to evaluate the deterioration of swallowing function due to aging.

P-A-12: Relationship between neuromotor function of the triceps surae and clinical measures of performance in young and old men

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BACKGROUND AND AIM: The preservation of neuromotor function is critical to older adults being able to perform activities of daily living and maintain independence as they age. Declining muscle mass as well as decrements in muscle performance however, are associated with adverse health outcomes. In response, health professionals invest significant effort and time attempting to identify 'at risk' older individuals. A limitation of this approach is that many 'clinical measures' are descriptive or categorical, typically classifying individuals as healthy or unhealthy based on normative data. Although clinically useful, such measures reveal little about the mechanisms that underlie differences in neuromotor function in young and old. Examining neuromotor function in conjunction with common clinical measures of performance may help explain why differences exist between young and old, and assist in formulating more effective treatment strategies to combat age-related functional decline. Therefore, the aim of this project was to examine neuromotor function of the triceps surae in young and old, and the relationship to clinical measures of performance and measures of muscle size and quality. METHODS: Ten healthy young men (age: 26.1 ą3.1yrs) and eighteen older men (age: 73.4 ą4.9yrs) were recruited for testing. Whole body and leg composition measures were obtained using DXA and peripheral quantitative computed tomography (pQCT) scans. Clinical measures of functional performance were assessed via isometric knee extension strength, timed-up-and-go (TUG), 5-times sit-to-stand (5TSTS), and self-selected gait speed. Neuromotor function was assessed using electrical stimulation of the tibial nerve (Digitimer DS7AH, UK) and recording of EMG activity and torque during a graded plantar flexion contraction protocol. Measures included Level of Voluntary Activation (LoVA; 20%, 40%, 60% 80%, and 100% of MVC), resting and superimposed twitch (SIT), ankle torque, and EMG activity of the plantar and dorsi flexor muscles. RESULTS: Differences in SIT were observed between young and old men at 20% (Y=13.8 ą4.2%, O=10.5 ą3.8%, p<0.05), 40% (Y=7.8 ą2.4%, O=5.4 ą2.5%, p=0.02), and 80% (Y=0.98 ą0.42%, O=59.3 ą0.29%, p=0.01) contraction intensities. Maximal plantar and dorsi flexion torques were different between young and old men (PF: Y=161.3 ą51.4Nm, O=108.8 ą32.7Nm, p<0.003; DF: Y=41.8 ą11.1Nm, O=33.1 ą9.0Nm, p=0.032). Significant differences in knee extension strength (Y=862.8 ą123.3N, O=512.2 ą125.6N, p<0.001), TUG (Y=4.7 ą0.5s, O=7.2 ą1.5s, p<0.001), 5TSTS (Y=8.6 ą1.8s, O=14.1 ą3.5s, p<0.001), and gait speed (Y=1.60 ą0.15s, O=1.35 ą0.16s, p<0.001) were observed between young and old men. For old men, significant correlations were observed between gait speed and both plantar flexor MVC torque (R²=0.617, p=0.011) and plantar flexor LoVA (R²=0.566, p=0.022), as well as between TUG performance and both

plantar flexor MVC torque (R²=-0.545, p=0.029) and plantar flexor LoVA (R²=-0.630, p=0.009). No significant correlations were observed for young men. CONCLUSIONS: The observed differences in clinical measures of performance in older men, may be in part explained by changes in neuromotor performance. Specifically, sub-optimal neural drive from the level of the spinal cord and above appears to contribute to the differences in function in our cohort of older men. Differences in neuromotor performance in young and old men are not only apparent during maximal, but also sub-maximal contractions.

P-A-2: Impact of various resistance training modes on functional and muscular adaptations in older adults

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BACKGROUND AND AIMS: Resistance exercise is beneficial for people of all ages and training experience. The importance may be more important in older adults to assist in maintaining function (strength and ability) with senescence. In young men, there was no reported difference in muscle mass or strength after resistance training when comparing dumbbells and elastic bands. We hypothesize this will remain true in older men and women. Therefore, the purpose of this study is to determine if the mode of resistance training is equally beneficial in older adults. This may provide a portable, cost-effective means to adhere to a resistance training program in the target population. METHODS: Thirty-seven male and female (meanąSD: age: 63.9ą6.2 years; ht: 164.7ą10.4 cm; wt: 75.1ą15.0 kg) were asked to visit the lab fasted, hydrated, and rested for testing measurements. Each individual underwent a total body dual-energy x-ray absorptiometry (DXA) scan for fat free mass (FFM), total arm and leg lean mass (TALM and TLLM, respectively) and percent body fat (BF). Dominant handgrip strength (HG) was measured with an isometric handgrip dynamometer and upper and lower body strength was estimated from a 5-repetition maximum bench press (BP) and leg press (LP), respectively. All participants were randomized to one of three intervention groups: elastic band (EBRT), dumbbell (DBRT), and non-exercise control (NEC). EBRT and DBRT were asked to visit the laboratory twice weekly for 6-weeks to engage in a total-body resistance training program, whereas the NEC were asked to maintain their typical activity over the 6-week intervention period. Separate 2-way [time (pre vs. post) x group (EBRT vs. DBRT vs. NEC)] ANOVAs were completed to identify interaction or main effect on the dependent variables with an alpha of 0.05 as the predetermined level of significance. When necessary, post-hoc comparisons with Bonferroni adjustment were used. RESULTS: The results of the ANOVA indicate no two-way interaction for weight, FFM, BF, HG, and TLLM ($p>0.05$) for all. There were two-way interactions for BP, LP, and TALM ($p<0.05$). Specifically, the DBRT and EBRT groups improved from pre to post for BP and TALM ($p<0.01$ and $p<0.05$, respectively). Additionally, for LP, all groups improved after the 6-week intervention period ($p<0.01$). CONCLUSIONS: In a small sample of older adults undergoing 6-weeks of resistance exercise, DBRT and EBRT are equally effective at improving strength that may be related to improved muscle quantity. Conversely, the improved lower body strength was not reflected with a concurrent improvement in TLLM, indicating an alternative (potentially neural) mechanism for improved strength rather than hypertrophy.

P-A-3: Classification of elderly fallers and non-fallers using clinical assessment scores.

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The advent of advanced machine learning algorithms has found its application in different biomedical fields. Accidental falls are one of the leading causes of death among older adults [1]. Previous research classifying elderly fallers and non-fallers using machine learning algorithms reported high accuracy using inertial sensors [2] and force platforms [3]. However, it is not always feasible to use biomechanical sensors and devices in older populations. Fall prevention programs, which focus on reducing future incidences of falls in older adults, typically employ clinical assessment tools for identifying elderly fallers [4]. The Berg balance scale (BBS) and the brief version of balance evaluation systems test (Brief-BESTest) have been used to identify fall status in older adults [5]. However, it has been suggested that the previously recommended cut-off scores for BBS and the brief-BESTest scores were inconclusive in accurately identifying elderly fallers [6]. Therefore, is important to analyze the performance of machine learning algorithms to generate predictive models for identifying elderly fallers based on clinical assessment scores. The purpose of this study was to compare the accuracy of different classification models for identifying elderly fallers using commonly used clinical assessment scores. Balance performance of 59 non-fallers (NF) and 41 fallers (F) was assessed using the BBS and Brief-BESTest. Using these scores as input, five classification algorithms were used to build models: Naïve Bayesian (NB), Artificial Neural Network (ANN), Linear Discriminant Analysis (LDA), Support Vector Machine (SVM) and k nearest neighbours (kNN). The classification accuracy based on the previously recommended cut-offs were also analyzed for comparison. The kNN, SVM, NB, and ANN classifiers based on the clinical assessment scores resulted in a maximum accuracy of 92.93% for classifying faller/non-faller categories, which was higher than cut-off based classification (accuracy=75.61% for Brief-BESTest, accuracy=68.29% for BBS). Machine learning facilitates the higher dimensional analysis of the features (clinical scores) to form precise boundary functions resulting in accurate classification. The sensitivity (ability to correctly identify elderly fallers) was also higher for the machine learning classification than the cut-off-based classification. The results demonstrate that the classification of fallers/non-fallers using the cut-off on clinical scores (BBS and Brief-BESTest) did poorly compared to machine learning algorithms. These algorithms can be used to generate accurate predictive models for identifying elderly fallers using clinical assessment scores.

P-A-4: The search for optimal balance training for healthy older men and women: effects of neuromotor and strength training on static postural control and dynamic functional balance

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Background and Aims: Despite the large amount of research on the effects of exercise on balance in older individuals, the most favourable exercise regime is yet to be identified. Most studies so far have concentrated on strength training, due to associations between muscle weakness, balance disfunction and risk of falling in older individuals. The effects of neuromotor (coordination, agility and mobility) exercise for balance and postural control has been less investigated and no definite conclusions can be

made on its benefits. The aim of the present study was to compare the effectiveness of strength training (STT) and neuromotor exercise (NMT) on static postural control, dynamic functional balance and strength in healthy older individuals. Methods: Thirty-eight men and women aged 65 to 75 years participated to NMT or STT for 12 weeks, twice weekly for one hour per session. They were tested pre- and post-training for postural control (Romberg and Tandem positions on a force platform), dynamic functional balance (maximal walking speed in balance challenging conditions), maximal isometric handgrip strength, maximal knee flexors and extensors strength. Results: Significant improvements were observed in static postural balance in tandem position ($p < 0.05$, -1.07 mm/s), walking speed (hurdles $p<0.01$, 0.08 m/s; narrow path $p<0.05$, 0.07 m/s; picking up $p<0.01$, 0.07 m/s) knee extensors strength ($p<0.001$, 10.9 Nm); knee flexors strength improved significantly in the SST group only ($p<0.001$, 13.9 Nm). There was no correlation between changes in strength and in balance. Conclusions: The present study helps filling the gap in research on neuromotor exercise and proposes a suitable exercise alternative to strength training for managing static and dynamic balance decline in older individuals. Benefits for static postural balance and dynamic functional balance can be obtained through exercises of different nature targeting either muscular strength or coordination, agility and mobility. Future research should be addressed to optimizing the prescription of neuromotor exercise for balance enhancement.

P-A-5: Differences in foot structure between younger and older adults using a 3D foot scanner

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BACKGROUND AND AIM: Accurate and reliable anthropometric foot-measures are used to develop complex mechanical models of the foot to advance research in the field of biomechanics, medicine and footwear design. The use of portable technology, such as of three-dimensional (3D) body scanners, to collect foot anthropometrics, facilitates the exploration of potential differences between and within individuals. Previous research has suggested that changes in foot anthropometrics occur with age, however, these changes remain unclear. Therefore, the purpose of this study was to determine differences in foot anthropometrics between younger and older adults using a 3D foot scanner. METHODS: Sixteen young (8 males, 8 females, mean age 23.6±3.7 years) and sixteen older (8 males, 8 females, mean age 71.6±5.9 years) adults without foot deformities or lower-extremity injuries were recruited for the study. Data collection occurred in the Andrew and Marjorie McCain Human Performance Laboratory at the University of New Brunswick. Seven anthropometric measures of each foot were obtained during weight bearing (WB) and non-weight bearing (NWB) conditions using a portable, white light, 3D scanner (TechMed 3D Inc., QC). Measures included dorsal arch height (DAH), foot length (FL), truncated foot length (TFL), forefoot width (FFW), midfoot width (MFW), rearfoot width (RFW), and arch height ratio (AHR). Significant differences in foot measures between age groups were analyzed using an independent samples t-test. A secondary comparison between age groups was also evaluated using an analysis of covariance (ANCOVA) with TFL as a covariate. This latter test addresses reduced foot length that may result as a function of toe deformities. RESULTS: In the older group, only the measurement values of AHR during WB and NWB, as well as the RFW in a WB position were significantly greater than the younger group. However, after controlling for the TFL, the older group showed that the DAH, FL and RFW in WB, as well as DAH, FFW and RFW in NWB measurements were significantly greater than the younger group, whereas the FL in NWB were significantly smaller. A

significant effect of the covariate TFL on the MFW measurement under WB and NWB conditions was found, however, there was not a significant age effect, suggesting there is not a significant difference in MFW between the age groups. This result was also found on the FFW measurement under WB condition (Table 1). CONCLUSION: Preliminary results based on the sample size of the study provide evidence of anthropometric foot variations between younger and older adults. The overall results from the ANCOVA analysis suggest that these age-related differences could be explained by the TFL. Examining the differences of foot structures between younger and older adults is fundamental for comprehending their respective foot function during gait. This will also allow a better understanding of different disorders commonly seeing in aging. Future recommendations include increasing sample size and relating age differences in foot measurements to dynamic movement.

P-A-6: Electromyographic evaluation of the stomatognathic system of older adults after equine-assisted therapy

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BACKGROUND AND AIM: Equine-Assisted Therapy (EAT) is widely practiced worldwide by individuals of different age groups, including older adults. The three-dimensional movement of the horse is a valuable kinesiotherapeutic instrument, capable of influencing several systems simultaneously, such as the sensory, muscular, skeletal and limbic. In addition, the equine-human connection has helped to reduce post-traumatic stress disorder, anxiety and depressive symptoms. The aim of the present study was to investigate the effect of EAT on the stomatognathic system of older adults. METHODS: To this end, 16 individuals, aged 60 to 79 years, voluntarily participated in a hippotherapy program, twice a week, for three months. Pre and post-intervention of EAT the Delsys Trigno TM wireless electromyograph was used to evaluate the myoelectric activities of the masticatory muscles. Electromyographic recording of the bilateral masseter and temporal muscles, was performed during the postural resting condition (10 s) and activities that involved the active participation of these muscles in the following conditions: dental tightening with Parafilm M® (Pechinery Plastic Packaging, Batavia, IL, USA) (10 s); right and left laterality (10 s) and maxillary protrusion (10 s). During electromyographic recording, the environment was kept quiet, and subjects were positioned sitting with the trunk and head erect in a comfortable chair, such that they kept their eyes on the horizon, the soles of the feet resting on the ground, and arms resting on the thighs. The necessary instructions and explanations were given, asking the individual to remain as calm as possible, and to breathe slowly and calmly. RESULTS: The raw electromyographic data were tabulated and submitted to statistical analysis ($p \leq 0.05$) using the GraphPad Prism® software (version 5.0, San Diego, USA). There was a significant difference between the raw electromyographic data in the clinical condition of dental clenching for the right masseter muscle ($p = 0.0330$) and right laterality for the left temporal muscle ($p = 0.0479$). CONCLUSIONS: The EAT intervention promoted a reduction in the myoelectric activity of the masticatory muscles of older adults.

P-A-7: Age-related differences in muscle and tendon mechanical properties in vivo

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BACKGROUND AND AIM: Ageing is associated with changes in the structure and function of the contractile and elastic machinery that enables movement, posture, and balance. Alterations in structure and mechanical properties of the ankle plantarflexors and Achilles tendon are of particular interest due to their important "catapult-like" function during efficient and healthy human locomotion. Yet, to date, we have a limited understanding of the age-related differences in mechanical properties of both muscle and tendon, as studies have commonly considered either muscle or tendon, but not both. However, the integrated mechanical function of both muscle and tendinous tissues is critical for efficient locomotor performance. The primary aim of this study was to determine age-related differences in the in vivo mechanical properties of muscles and tendon. METHODS: In this study, we examined age-related differences in the in vivo mechanical properties of both muscle and tendon in the human ankle plantarflexors in healthy younger (21 ± 3.25y) and older (69 ± 2.86y) adults. Participants were physically active to isolate the effect of age from the effect of physical deconditioning. B-mode ultrasound was used to measure Achilles tendon cross-sectional area at rest and to measure the position of the muscle-tendon junction during ramped isometric plantarflexion contractions. The position of the muscle-tendon junction was used to estimate tendon length changes which were coupled with force measurements to determine in vivo Achilles tendon stiffness. Shear-wave elastography was used to measure shear modulus, an index of muscle stiffness, in the medial and lateral gastrocnemii. RESULTS: We found that older adults displayed 43% lower (p=0.004) Achilles tendon stiffness, 59% lower (p<0.001) Achilles tendon Young's modulus, and 34% greater Achilles tendon cross-sectional area (p=0.002) compared to younger participants. We found no difference in the shear modulus of the medial or lateral gastrocnemii between the younger and older individuals. The difference in tendon properties and lack thereof in muscle properties between the younger and older groups may be associated with the exercise profiles and high activity level of the older adults examined in this study. CONCLUSIONS: Natural strategies may be at play in physically active individuals to ensure that muscle shear modulus remains relatively unchanged with ageing, despite a significant reduction in tendon stiffness. A comprehensive understanding of age-related changes in plantarflexor muscle and tendon mechanical properties may improve our ability design targeted exercise programs to prevent mobility deficits in our rapidly ageing population.

P-A-8: Dynamic muscle shape changes in older versus younger adults

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BACKGROUND AND AIM: When muscles contract and shorten, they bulge in thickness and in width. These dynamic shape changes extend the functional range of skeletal muscle by allowing the whole muscle to shorten at higher velocities than the muscle fibres, a process defined as gearing¹. Previous animal studies have shown that age-related increases in muscle stiffness limit a muscles ability to vary gearing, such that older muscle is stuck in high gear, compared to younger muscle². These findings suggest that dynamic muscle shape changes are mediated by connective tissue properties and contractile forces. Yet to date, the effects of aging on in vivo dynamic shape

change in humans remains untested. The aim of this study was to determine the influence of aging on dynamic muscle shape changes in the gastrocnemii during a range of submaximal isometric plantarflexion contraction levels. METHODS: 15 older (70.1±2.5y) and 15 younger (20.7±2.2y) adults participated in this study. Participants were physically active to isolate the effect of age from the effect of physical deconditioning. Isometric plantarflexion contractions were performed at 20%, 40%, 60%, 80% and 100% of maximum voluntary contraction. B-mode ultrasound was used to measure fascicle length, pennation angle and muscle thickness in the medial (MG) and lateral (LG) gastrocnemius at rest and during each contraction. A linear mixed effects model was used to determine the effect of age, contraction level, and muscle on the change in fascicle length, pennation angle, and thickness. Differences were considered significant at p<0.05. RESULTS: There was no significant effect of age (p<0.05) on fascicle length, pennation angle, or thickness, therefore we had an opportunity to observe dynamic shape change in 30 participants and found intriguing variation between the MG and LG. There was a significant effect of contraction level (p<0.001) and muscle (p<0.001) on the change in fascicle length, pennation angle, and thickness. With increasing contraction level, fascicle shortening and changes in pennation angle both increased in the MG and LG. However muscle thickness increased only in the LG, while the MG stayed relatively constant. The relationship between pennation angle and thickness indicates that increased pennation angle may mediate increased thickness in the LG (r=0.76, p<0.001), but not in the MG (r=0.21, p<0.05). These results are consistent with other human studies³, however are contrary to previous animal work that drives much of our knowledge on dynamic shape change². CONCLUSION: Further research into how surrounding muscles and internal constraints mediate dynamic shape change in a synergistic muscle group will provide insight into the mechanisms governing in vivo muscle function. REFERENCES: 1. Azizi et al. (2008). PNAS, 105:1745-1750 2. Holt et al. (2016). J Exp Biol, 219: 998-1003 3. Randhawa et al. (2013) Eur J App Physiol, 113: 437-447

P-A-9: Changes in central control and peripheral characteristics of the motor units in elderly subjects after a half marathon.

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BACKGROUND AND AIM. Age-related adaptations lead to detrimental changes in the neuromuscular system. Physical activity and exercise can mitigate these alterations. This study aims to analyse acute central and peripheral changes of motor units after a half marathon in elderly subjects. METHODS. During the Run4Science event, we recorded high density surface electromyography (HD-sEMG, 128 channels) on the tibialis anterior muscle in ten elderly individuals. The participants performed static dorsiflexions of the foot lasting 40 seconds at 25% of the maximal voluntary contraction (MVC). The test was performed the day before the event and the day of the half-marathon, immediately after the race. A decomposition algorithm (Negro et al., 2016) was used to identify individual motor units and to extract information on their central control (discharge rate, recruitment and derecruitment relative effort threshold) and contractile (motor unit twitch) characteristics during the submaximal contraction before and after the half marathon. Average twitch profiles were estimated from the identified motor units using a recently published technique (Negro & Orizio, 2017). Motor units were matched PRE and

POST half-marathon by the cross-correlation of the spike-triggered averaged multichannel action potentials. RESULTS. The subjects showed no difference in the MVC before and after the half-marathon (P = 0.07). The area of the estimated average motor unit twitch profiles was significantly smaller after the marathon (PRE: 35.9 (33.1) AU; POST: 19.7 (12.2) AU; P = 0.039). The reduction in twitch area was compensated by a significant increase in the average discharge rate of the extracted motor units (PRE: 12.8 ± 1.7 pps; POST:14.4 ± 1.4 pps; P <0.001). No change in recruitment (P = 0.66) and de-recruitment (P = 0.11) torque thresholds was observed. CONCLUSIONS. In this study, we found that the half marathon induced an increase in the discharge rates of the active motor units to compensate for the reduced motor unit twitch profiles. Therefore, we demonstrated that intensive exercise can create acute neural changes that may counteract the deleterious effect of aging on the neuromuscular system. REFERENCES: Negro, F., Muceli, S., Castronovo, A.M., Holobar, A., Farina, D., 2016a. Multi-channel intramuscular and surface EMG decomposition by convolutive blind source separation. J. Neural Eng. 13, 26027. https://doi.org/10.1088/1741-2560/13/2/026027 Negro, F., Orizio, C., 2017. Robust estimation of average twitch contraction forces of populations of motor units in humans. J. Electromyogr. Kinesiol. 37, 132-140. https://doi.org/10.1016/j.jelekin.2017.10.005

P-B-13: Prediction of embryo implantation by multimodal uterine features and machine learning

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-Background and aim: In-vitro fertilization (IVF) is the most advanced treatment for infertility problems; however, its failure rate is still above 70% and the exact causes are often unknown. There is increasing evidence of the involvement of uterine contractions (UCs) in IVF failure, especially during and after embryo transfer (ET). Unfortunately, the role of UCs in affecting uterine receptivity for successful embryo implantation is not yet understood. Based on multimodal measurements of the uterine activity, both electrical and mechanical, the use of probabilistic classification tools can possibly lead to improved clinical decision-making and IVF success rate by better understanding the role of UCs in IVF. In this study, the use of probabilistic classification of the uterine activity, as either favorable or adverse to ET, is investigated using machine learning. Methods: In 16 women undergoing IVF treatment, electrical and mechanical uterine activity were measured simultaneously by electrohysterography (EHG) and B-mode transvaginal ultrasound (TVUS), respectively. Women were measured during follicular stimulation (FS) phase, one hour before ET (ET1), and five to seven days after ET (ET5-7). Two groups were defined: successful and unsuccessful pregnancy. Three sets of amplitude-, frequency-, and energy-related features were extracted for each phase from the derived signals after dedicated EHG analysis, TVUS speckle tracking, and singular-value-decomposition (SVD) techniques. After correlation filtering, multiple features were selected by forward feature selection and optimally combined by different machine-learning models, including support vector machine (SVM), K-nearest neighbors (KNN), and Gaussian mixture model (GMM). In order to avoid overfitting, hyper-parameter optimization and validation of each model were performed in a nested cross-validation loop. The classification performance was assessed by a leave-one-out cross-validation approach. Accuracy, sensitivity, and specificity were used as performance metrics. Results: The highest overall accuracy (93.8%) was achieved by SVM and KNN in

both FS and ET1 phase with sensitivity and specificity of 85.7% and 100%, respectively. Contraction frequency, standard deviation, and unnormalized first statistical moment, obtained from EHG, TVUS, and SVD analysis, were best features common to the SVM and KNN models. Discussion and conclusions: The combination of complementary features from multimodal recordings of the uterine activity produces improved prediction of embryo implantation. Our classification results support the feasibility and accuracy of a multimodal strategy based on machine learning, possibly contributing to improved clinical decision making and IVF success rate. Yet, a larger dataset is required for improved training of the considered prediction models.

P-B-14: A Hybrid Convolutional-Recurrent Deep Learning Approach for a Clinically Relevant Real-Time Classification of the Sit-to-Stand Movement.

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BACKGROUND AND AIM: The Sit-to-Stand movement (STS) has significant importance in clinical practice since it is an indicator of lower-limb functionality. As an optimal trade-off between costs and accuracy, accelerometers have recently been used to analyse the performance of STS in real-time. However, the recognition of clinically relevant phases within the motion pattern remains a challenge, that limits current analysis to the discrimination of static sitting/standing positions from the sit-to-stand/stand-to-sit transition movements. Recent evidence in time-series classification indicates that convolutional architectures can outperform canonical recurrent networks, such as Long-Short-Term-Memory (LSTM), over a broad range of tasks, suggesting the use of Temporal Convolutional Networks (TCN) as a starting point for sequential modelling. Hence, to implement a real-time classifier for finer discrimination of clinical specific STS phases, we explore the performances of three task-oriented deep-networks, using TCN, LSTM and a hybrid architecture (TCN+LSTM). METHODS: 36 healthy subjects (26 ± 2.9 years) performed 10 STS trials on a force plate, guided by auditory feedback to standardize the execution time of the movement. Participants wore 1 accelerometer placed on the trunk, from which values of Roll, Pitch, Yaw and 3-dimensional accelerations were acquired at 50 Hz. The means of these signals were calculated over 0,1 s along the registered time-series and used to build the final dataset, labelled in 4 STS phases according to the registered ground reaction force values: sitting, trunk leaning, raising, and standing. A nested 11*10-folds cross validation was implemented to evaluate the performance of the selected models. All the observations of a single subject were assigned to a single fold, assuring general independence across the dataset. Accuracies and prediction times (means [CI]) were calculated for each model, based on the performance over the different test folds. RESULTS: The performance estimates of the TCN model are reported as preliminary results. The optimal TCN implementation was identified by tuning the learning rate to 0.0891 and the filter size to 4 time-steps, leading to a temporal receptive field of 4,6 s. The estimated accuracy for such network architecture was 93,62% [90,63%; 96,62%] with a prediction time of 1,08e-03 s [0,93e-03; 1,22e-03]. Results for LSTM and hybrid architectures will be available soon. CONCLUSIONS: The temporal convolutional architecture achieved a relatively high accuracy considering the high inter-subject variability between the different test sets enhanced by the standardization in the execution time which introduces further oscillations in the natural movement kinetic. These results, together with the extremely fast predictions showed, promote the use of TCN

networks in hybrid models to extract significant temporal features to improve the real-time classification in precise Human Activity Recognition tasks.

P-B-15: Robust Decomposition of High-Density Surface EMG Signals with Deep Learning

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BACKGROUND AND AIM: Recent advances in blind source separation (BSS) algorithms have made it possible to identify large numbers of motor units (MU) within high density surface electromyography (HD-sEMG) signal. However, the output separation matrices exhibit poor generalisability to new signal, particularly in scenarios of high noise. Instead of directly applying the separation matrix to new signal, one unexplored alternative it to use the paired HD-sEMG signal and BSS output to train a deep learning model to predict MU activations. METHODOLOGY: A gated recurrent unit (GRU) network was trained to decompose both simulated and experimental HD-sEMG signal using the output of the popular gradient Convolution Kernel Compensation algorithm (gCKC). The trained neural network then decomposed unseen components of the HD-sEMG signal. Validation was conducted with both simulated data and with experimentally-collected HD-sEMG signal paired with concurrently recorded and decomposed intramuscular EMG signals. To further test robustness to noise, a final dataset was created by adding additional statistically-white noise to the experimental signal. In the simulated data the GRU network outperformed gCKC on the decomposition of unseen signal in noisy conditions. RESULTS: Using 12 seconds of experimental data per recording, the GRU performed similarly to gCKC, at median rates of agreement of 92.5% (IQR 84.5% - 97.5%) and 94.9% (IQR 88.8% - 100.0%) respectively for GRU and gCKC against matched intramuscular sources. When noise was added to the experimental signal to give lower signal-to-noise ratios (SNR) the GRU significantly outperformed gCKC on unseen data, with a median gap in rate of agreement of 9.9% (4.5% - 16.0%, $p<0.001$) at 10dB SNRs when compared to the intramuscular data and 12.8% (5.9% - 17.3%, $p<0.001$) at 0dB. CONCLUSION: By training a deep learning model to perform HD-sEMG decomposition on experimental and simulated data, it was demonstrated that neural networks generalise better to new signal than the output separation matrix of BSS algorithms. This is most pronounced when the incoming signal is very noisy, with the GRU proving highly robust to low SNRs.

P-B-16: Revealing the unique features in each individual's muscle activation signatures

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BACKGROUND AND AIM: Individuals can be identified by their distinct movement patterns (Schöllhorn et al. 2002; Pataky et al., 2012). This has led to the notion of individual movement signatures, much like a fingerprint or a handwritten signature (Slowinski et al., 2016; Horst et al., 2017). Recently, Hug and colleagues (2019) used a machine learning based classification that could identify individuals based on their EMG patterns. This suggests that individuals exhibit unique features in their muscle activations and

thus that the movement signatures originate, at least in part, from unique muscle activation signatures (Hug et al., 2019). However, this approach did not provide any information into the decision-making of the classification model. It therefore remains unknown what features of muscle activation make an individual unique, and therefore whether there is a physiological meaning behind the extracted signatures. METHODS: Here, we developed an approach to link back the relevant features for classification of an individual to the EMG data. We performed an extended analysis on data from Hug et al. (2019) from eight lower limb muscles of 78 participants pedalling at various power outputs (150 W, 10% and 15% of maximal power output; all at 80 rpm) and walking at 1.11 m/s. 53 participants were tested again on a second day. EMG data was collected using wireless surface electrodes, band-pass filtered (20-700 Hz), visually inspected for artefacts, full-wave rectified, low-pass filtered (12 Hz (pedalling), 9 Hz (walking)), and finally normalised to each muscle's respective maximal value per cycle and participant. A linear Support Vector Machine (SVM) was trained and validated using 30 consecutive cycles per task and participant. Then, we implemented the Layer-wise Relevance Propagation (LRP) method (Bach et al., 2015), which provided a relevance value for each data point, telling us how relevant it was for the identification of that individual. RESULTS: The SVM models from this study reached very high classification rates (> 98.9 ± 0.5%) and were highly robust across pedalling conditions and testing days. The LRP gives insight into which features of the muscle activation patterns make each individual unique (Fig. 1). Using this technique, even subtle differences are highlighted as being unique to each respective individual. High relevance mostly occurred during high relative EMG amplitude, but often relative EMG amplitude was high and relevance low (Fig. 1). CONCLUSIONS: We conclude that the proposed LRP technique, in combination with SVM can effectively identify which features make each individual unique in terms of muscle activation patterns. This study provides proof of concept for these techniques and opens promising opportunities to apply them in clinical populations or to further investigate the biomechanical or neurophysiological factors that make each individual activation signatures unique.

P-B-17: Effect of elbow joint angles on electromyographic amplitude versus force relationships of synergistic muscles of the triceps brachii

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BACKGROUND AND AIM: The electromyographic (EMG) amplitude and force relationship is a valuable index of the neuromuscular activation patterns of the synergists of a muscle group. The EMG-force relationship differs even within the synergistic muscles of a given muscle group, such as the triceps brachii (TB) (Harwood, et al. 2013) and quadriceps femoris (Saito and Akima 2013). However, there is minimal information available regarding the EMG-force relationship of individual triceps brachii (TB) muscles at different elbow joint angles. This study aimed to compare the EMG-force relationships of the medial (TB-Med), lateral (TB-Lat) and long heads (TB-Long) of the TB. METHODS: Seven men (age, 20.7 ą 1.0 year; height, 171.3 ą 7.1 cm: weight, 63.1 ą 10.1 kg) and 10 women (age, 19.6 ą 1.6 year; height, 160.0 ą 5.2 cm: weight, 52.2 ą 2.7 kg) performed elbow extension force matching tasks at 20%, 40%, 60%, and 80% isometric maximum voluntary contraction (MVC) at elbow joint angles of 60°, 90°, and 120° of extension (full extension = 180°). During the tasks, the surface EMG signals of the TB-Med, TB-Lat, and TB-Long were recorded using a single differential electrode sensor (4.1 cm long, 2.0 cm wide,

0.5 cm high) with a 1-cm inter-electrode distance, and input impedance of > 10¹⁵ Ω/0.2 pF, a 90 dB common rejection ratio, and frequency response of 20 ą 5 to 450 ą 50 Hz (DE-2.1, Delsys, Inc., Boston, MA, USA). The electrodes for the TB-Lat, TB-Long, and biceps brachii were placed in accordance with the locations recommended by the SENIAM, and the location of the electrode for TB-Med was also in accordance with previous studies (Ali, et al. 2014, Ali, et al. 2015, Doheny, et al. 2008). The EMG signals were normalized by the root mean square at 100%MVC. The sum of difference was also calculated to assess the linearity in the EMG amplitude and force relationship (Akima and Saito 2013, Alkner, et al. 2000, Saito and Akima 2013, Watanabe and Akima 2009). RESULTS: When comparing muscles at each joint angle, the normalized EMG amplitude did not significantly differ between the three muscles, except between the TB-Med and TB-Lat during 20%MVC at 60°. When comparing joint angle at each muscle, the normalized EMG amplitude during force levels of ≥ 60%MVC at 120° was significantly lower than that at 60° or 90° for each muscle. The sum of difference did not significantly differ in any muscle assessed. CONCLUSIONS: These results suggest that the EMG amplitude matches the relative force in the TB at relatively longer muscle lengths; however, less EMG amplitude is required to achieve relative percentage force levels at shorter muscle lengths in all three TB synergists.

P-C-18: The effect of the heel wedge on the weight-bearing response of navicular and talus bones

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BACKGROUND AND AIM; Heel wedge is often used to rebuild the foot arch and to stabilize the foot bones. However, the efficacy of the heel wedge is unclear due to the difficulty of the direct measurement of the weight-bearing response of foot bones. A new machine called positional MRI provides the direct measurement of both the vertical and medial weight-bearing response of navicular and talus bones. The purpose of this study was to clarify the effects of heel wedge on the weight-bearing response of navicular and talus bones using positional MRI. METHODS; Twenty-six male volunteers participated in this study. We took MRI scanning of the foot in the supine position (Non-loading condition) and the standing position (Full weight-bearing condition). We had participants wear three insole types, which include insole without heel wedge, insole with lateral heel wedge, and insole with medial heel wedge. We measured the navicular height (NH), the talus height (TH), the medial navicular position (MNP), and the medial talus position (MTP). For the measurement of NH and TH, we used the coronal images of the foot. The lowest point of the navicular and talus was defined as the measurement point of NH and TH. The NH and TH were measured as the distance from the floor to the measurement point. For the measurement of MNP and MTP, we used axial images of the foot. We determined baseline which connects the head of the fifth metatarsal and the most caudal point of the calcaneus. The MNP and MTP were measured as the distance from the baseline to the most medial point of the navicular and the talus bone. A two-way repeated ANOVA was used to evaluate the interaction (insole types by loading conditions) on NH, TH, MNP, and MTP. When a significant interaction was detected, a post-hoc test using the Bonferroni method was performed to identify the simple main effects of insole types or loading conditions. RESULTS; A significant interaction (insole types by loading condition) was found in NH ($F = 4.21$, $p = 0.02$, $\eta^2 = 0.14$). The post-hoc analysis showed that regarding full weight-bearing condition, NH on the insole with medial heel

wedge is higher than that on the insole with lateral heel wedge and that on the insole without heel wedge. There was no interaction in other measuring items. CONCLUSIONS; We found the main effect of the medial heel wedge on only NH. Our results suggested that insole with medial heel wedge stabilized the vertical weight-bearing response of navicular rather than talus. The heel wedge does not affect on the medial weight-bearing response of the navicular and talus bones. However, further study will be needed to examine the effects of the heel wedge.

P-C-19: Is plantar aponeurosis stiffness related to medial longitudinal arch stiffness?

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BACKGROUND AND AIM: The medial longitudinal arch (MLA) plays an important role as the primary absorber and load-bearing structure of the foot in locomotion. Thus, the mechanical properties of the MLA may be involved with injuries of foot and leg. Indeed, lower stiffness of the MLA is reportedly a risk factor for lower leg disorders. Among the constituents of the MLA, the plantar aponeurosis is considered essential to maintain the MLA. In other words, the MLA stiffness is considered to reflect the plantar aponeurosis stiffness. However, this has not been experimentally proven probably because of the difficulty of assessing the plantar aponeurosis stiffness in humans in vivo. In the present study, using ultrasound shear wave elastography, we aimed to examine the relationship between plantar aponeurosis stiffness and MLA stiffness. METHODS: Thirty university students (21 males and 9 females) participated in this study. The navicular height and shear wave velocity (an index of stiffness) of the plantar aponeurosis in supine and single-leg standing were measured using B-mode ultrasonography and shear wave elastography, respectively. The MLA stiffness was calculated based on the body weight, foot length, and the difference in navicular height between supine and single-leg standing conditions (i.e., navicular drop). The relationships between shear wave velocity of the plantar aponeurosis in supine or single-leg standing and MLA stiffness were calculated using Spearman's correlation coefficient. RESULTS: Shear wave velocity of the plantar aponeurosis in supine and single-leg standing was not significantly correlated to the MLA stiffness (spine: r = -0.14, P = 0.45 standing: r = -0.16, P = 0.41)). CONCLUSIONS: The lack of significant correlations in the present study would be due to the involvement of tissues other than the plantar aponeurosis (e.g., plantar intrinsic foot muscle). Additionally, deformation of subcutaneous tissues of the sole of the foot in standing, which leads to overestimation of the navicular drop and accordingly underestimation of the MLA stiffness, would be involved. In conclusion, the MLA stiffness does not represent the plantar aponeurosis stiffness.

P-C-20: Development of ultrasound imaging to analyze muscle dynamics

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Introduction The use of ultrasound imaging to reveal the characteristics of muscle shape changes during physical movement is important to understand the mechanism of motion generation. In the past decade, studies were performed conventionally using a camera motion capture system and surface

electromyography, which could clarify the amount of muscle activity but not the muscle shape changes or the relationship between muscle shape and joint motion. To overcome these limitations, recently, ultrasound imaging was introduced for the analysis of muscle function. It demonstrates muscle shape changes during muscle contraction and joint motion. Many studies focused on the gastrocnemius muscle but few on the hamstrings. Furthermore, few studies analyzed the relationship between muscle shape changes and kinematics as a time series analysis with sufficient objectivity and validity. The aims of this study were to analyze the elongation and contraction of the hamstrings when standing up and to establish a method to clarify muscle shape changes as time series data. Methods The subjects were 10 healthy adults, and the equipment included the camera motion capture system VICON, an ultrasound diagnostic device, four force platforms, and a surface electromyogram. Subjects performed sit-to-stand motion on the force plate. Data were sampled at a rate of 100 Hz, and the shape change was elucidated by tracking feature points of the muscle and tendon fibers using ultrasound imaging. To analyze the muscle shape changes, we created an original program using Python. Results It was difficult to keep the target muscle fibers and tendons clear. Issues regarding optimizing the fixing method for the ultrasonic probe and the limitations of feature point tracking were encountered. However, the muscle fibers could be objectively extracted as time series data with the analysis method using a Gabor filter-based human visual system. Discussion Recently, ultrasound imaging data were represented as time series data by complementing a small amount of imaging data or performing a short analysis of less than 1 s. Most studies subjectively determined the analysis target, and a small error could significantly affect the method. Therefore, we created and used an auto-tracking program for the quantitative analysis and challenged the dynamic analysis. However, we could not perform tracking without errors because the muscle shape changed in three dimensions. Our results suggest that the current methods using a short period data for analyzing the muscle shape have critical errors. In the future, the measurement method that captures the tendon fibers should be improved to compare and examine muscle shape changes and kinematics.

P-C-21: Temporal stability of the effect of cooling on lowering knee extension muscle strength

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BACKGROUND AND AIM: The compensation ability of humans in situations where certain muscles are deactivated or weakened has been examined through simulation studies [1]. However, it is not well known what occurs when actual humans encounter a similar situation. It is known that cooling the skin surface with ice temporarily reduces the strength of the subcutaneous muscles [2]. By using this, it can be expected to observe the actual human behavior in the above situation. In order to use for such a purpose, it is necessary to grasp the temporal stability of the muscular strength lowering effect by the treatment. The aim of this study is to estimate how temporally stable this treatment is. METHODS: Ten physically active male graduate students participated in the experiment. Using a dynamometer (Con-Trex MJ), Participants executed isokinetic (120deg/s) knee extension with maximum effort. In one trial, knee extension was performed three times in succession, and the highest peak torque value was recorded. The experimental protocol is summarized as follows. Session 1: Practice - 30 minutes rest - Trial 1 - 30 minutes rest - Trial 2 - 10 minutes rest - Trial 3. Session 2 and 3: Practice - 30 minutes rest - Trial 1 - 30 minutes rest + cooling - Trial 2 - 10 minutes rest + cooling - Trial 3. Session 4: Practice - 30

minutes rest - Trial 1 - 30 minutes rest + cooling - Trial 2 -10 minutes cooling + 10 additional knee extensions - Trial 3. RESULTS: About peak knee extension torque, the ratio of trial 2 to trial 1 was 98.7 ą 7.6 % in session 1 and 78.1 ą 8.4 % in session 2, indicating that strength of quadriceps could be reduced by cooling. The ratio of trial 3 to trial 2 in sessions 2 and 3 was 95.8 ą 6.2 %, indicating that the additional muscle weakening effect was small between 30 and 40 minutes after the start of cooling. The ratio of trial 3 to trial 2 in session 4 is 108.6 ą 7.6 %, indicating that with additional knee extension, muscle strength recovered to some extent. CONCLUSIONS: The muscle recovery effect of the additional exercise should not be ignored. Therefore, in conclusion, when using this method to analyze changes in human behavior during muscle weakness, it is necessary to consider muscle recovery by performing a motor task itself. [1] Komura et al., (2004). J Biomech. 37(4): 425-436. [2] Bergh and Ekblom, (1979). Acta Physiol Scand. 107(1): 33-37.

P-C-22: Gravitational force-induced change in three-dimensional muscle geometry causes an alteration of muscle force generation capacity

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AIM: The purpose of this study was to determine whether skeletal muscle geometry and force generation are influenced by the orientation of muscle with respect to the force exerted by gravity. METHODS: Muscle geometry and contractile performance were examined for the calf muscle in 16 healthy young adult males (22.1ą 1.1 yrs). Participants laid on a padded bed in prone (PN) and supine (SP) positions with the knee and hip joints fixed at ~180° and were instructed to avoid voluntary muscle activation throughout the experiment. The right ankle joint was set to positions of -15° (DF15), 0° (N), and +15° (PF15) to adjust the length of the calf muscle and allow the effect of length-dependent muscle stiffness to be explored. A three-dimensional motion capture system ensured the angles of the three joints were similar between PN and SP. The geometry of the right calf muscle at rest was measured by means of a three-dimensional scanner with 0.5 mm resolution. Maximum values of transverse (TV) and anteroposterior (AP) width were calculated from a transverse segment at ~30% of the lower leg length. A constant-current electrical stimulator was used to evoke maximal twitches from the plantar flexors by means of a 50-µs square pulse delivered transcutaneously to the tibial nerve. A single twitch was elicited at each ankle position. Peak force was subsequently determined. RESULTS: Maximum values of TV and AP width differed for SP and PN. SP was associated with higher AP widths, but lower TV widths. The effect of joint position on muscle geometry was also distinct for SP and PN. Rotating the ankle into plantar flexion caused AP width to increase in SP and remain constant in PN. Rotating the ankle into plantar flexion caused TV width to decrease in SP and increase in PN. As such, the ratio of AP-to-TV width was significantly higher in SP than in PN (P < 0.05), especially at PF15. Peak force was greater in SP compared with PN. The effect of limb orientation was also most pronounced for PF15 (24.7%). No difference in peak force was evident in DF15 (P > 0.05). CONCLUSION: Limb orientation with respect to gravity influenced resting muscle geometry and twitch force. Differences in both resting muscle geometry and twitch force tended to increase as muscle length was reduced, suggesting that positional differences in twitch force were related to positional differences in muscle

geometry. Gravitational forces acting on muscle at rest and during contraction may affect force transmission pathways and dynamic muscle shape change. The effect of gravity on muscle geometry may be more pronounced at short lengths owing to lower muscle stiffness. ACKNOWLEDGEMENT: Supported in part by Grant-in-Aid for Scientific Research (B) in Japan to YY, NM, and HK.

P-C-23: Biomechanical Strategies in Patients with Unlilateral Anterior Cruciate Ligament Deficiency Classified as Copers during Obstacle-Crossing

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Introduction Anterior cruciate ligament deficiency (ACLD) affects the performance of walking but some patients classified as copers are able to minimize the effects via proper musculoskeletal compensations. Since many daily activities are more challenging than level walking, e.g., obstacle-crossing, it is not clear whether copers are able to cope with such increased challenge. A successful and safe obstacle-crossing requires not only sufficient foot clearance of the swing limb but also the stability of the body provided mainly by the stance limb. Failure to meet these demands may lead to falls owing to loss of balance or tripping over obstacles. The purpose of the current study was to identify biomechanical strategies in ACLD patients who are classified as copers when crossing obstacles of different heights for a better function assessment. Materials and Methods Ten coper ACLD patients and ten healthy subjects participated in the current study. The coper subjects were those who had been able to return to their pre-injury level activities, had less than one episode of giving-way during the last six months and a Lysholm knee score of greater than 70. Each subject walked and crossed obstacles of heights of 10%, 20% and 30% of their leg lengths at a self-selected pace. Kinematic and kinetic data were measured with a 7-camera motion analysis system (Vicon, Oxford Metrics, U.K.) and two force plates (AMTI, U.S.A.). The leading and trailing toe clearances were calculated as the vertical distances between the toe markers and the obstacle when the toe was directly above the obstacle. Joint angles of both limbs, and joint moments of the stance limb, were calculated. Peak extensor moments at the knee during the stance phase were extracted for statistical analysis. A 3 by 2, 2-way mixed-model analysis of variance with one between-subject factor (group) and one within-subject factor (obstacle height) was performed (α=0.05). SAS version 9.4 was used for all statistical analyses. Results Compared with the healthy subjects, the coper ACLD patients maintained more or less the same leading and trailing toe clearances during obstacle crossing (P=0.36 and 0.17). Moreover, there were no significant differences in peak extensor moments of the trailing limb (Affected limb leading: P=0.81; non-affected limb leading: P=0.23) during the stance phase between the ACLD and Control groups. Discussion The coper patients with unilateral anterior cruciate ligament deficiency showed similar gait patterns with the healthy controls during obstacle crossing. The coper ACLD patients did not significantly reduce flexion and peak extensor moments at the affected knee (i.e., quadriceps avoidance) during the stance phase before the un-affected/affected leading limb crossing. These results suggest that some patients with unilateral isolated ACLD (copers) adopted a strategy to reduce the risk of tripping over the obstacle during obstacle-crossing. It is suggested that monitoring of the biomechanical strategies adopted by patients with ACLD during obstacle-crossing may be needed in future rehabilitation programs with the aim of reducing tripping risks during obstacle-crossing.

P-C-24: The relationship between tendon stiffness in lower limb and acceleration ability in 100-m sprinters

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【BACKGROUND AND AIM】Tendon stiffness in lower limb plays an important role in sprint running. Previous researches had been reported the significant correlation of tendon stiffness with a 100-m sprint running record, although 100-m race is classified in three phases, acceleration, maximal-speed, and speed maintenance. Among them, the ability of the acceleration phase is primarily a key factor in attaining the higher velocity. However, it is still unknown whether stiffness influences acceleration ability (i.e., velocity, force, and power). Therefore, the purpose of this study was to clarify the relationship between tendon stiffness in lower limb and acceleration ability during a 100-m sprint running. 【METHODS】Nine male sprinters participated in this study (100-m personal best record: 10.25s to 10.98s, 10.63 ą 0.23s). Participants attended the official track meeting, and they run a 100-m race in all their efforts. The theoretical parameters in the acceleration phase (i.e., velocity, force, and power) were determined, and defined as the acceleration ability. Participants performed maximum isometric plantar flexion and knee extension contractions on a dynamometer. B-mode ultrasound images of the myotendinous junction of medial gastrocnemius and vastus lateralis were video captured. Elongations of Achilles tendon and patellar tendon were calculated from the ultrasound images. The relationship between estimated tendon force and tendon elongation was fit at linear regression, and the slope was defined as stiffness. Measurements were conducted in series two days, first and second. Correlation coefficients were computed to assess the relationships among the stiffness of tendon and acceleration ability. The level of significance was set at $P < 0.05$. 【RESULTS】The stiffness of the patellar tendon was significantly correlated to the 100-m sprint running performance（100mPersonal best record, $r = 0.68$, $P < 0.05$; 100m Race record, $r = 0.69$, $P < 0.05$）. Furthermore, the stiffness of the patellar tendon was significantly correlated to Vpeak ($r = -0.70$, $P < 0.05$) and some variables of acceleration ability (Vmean, $r = -0.76$, $P < 0.05$; Ppeak, $r = -0.70$, $P < 0.05$; P/BWpeak, $r = -0.72$, $P < 0.05$). Whereas, the stiffness of Achilles tendon was not significantly corelated to all variables. 【CONCLUSIONS】It was clarified that for the sprinter, the more compliant patellar tendon, the more superior to accelerate. Furthermore, it was clarified that the patellar tendon properties of superior sprinters were more compliant. Therefore, it was speculated that the patellar tendon stiffness may be one of the determinants of 100-m running performance, though stiffness of Achilles tendon has no significant correlation with acceleration ability and 100-m running performance.

P-C-25: Running movement features that could cause hamstrings strain injury detected by support vector machine

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BACKGROUND AND AIM: Hamstrings Strain Injury (HSI) is one of the most common injury in sports, which causes significant loss of training and competition time. Particularly, high re-injury rates remain a major problem following HSI (Opar & Williams, 2012). To investigate running movement features of participants followed by HSI, we tried to classify the running kinematics labeled by HSI experience using a Support Vector Machine (SVM), which is one of the machine learning techniques to solve two-class classification problems efficiently. METHODS: Participants ran on a treadmill for 30 seconds. The trials were repeated three times at 4.5 m/s constant belt speed of the treadmill. Six of 10 participants experienced HSI within five years (HSI participants), and the others had no experience of HSI. The kinematic data were recorded using a motion capture system. We focused on the data in the most hazardous phase that causes HSI; the minimum of hip joint angles, and the maximum of knee joint angles, angular velocities and hip angular velocities in the late swing phase; and the maximum of vertical ground reaction force at the beginning of the stance phase (Liu et al., 2017). The features for SVM were defined as 13 kinds of descriptive statistics, such as mean and standard deviation and so on, based on the histograms that represented the distribution of the parameters extracted from 32 to 46 gait cycles in each trial. Then, 60 (3 trials Ũ 2 legs Ũ 10 participants) Ũ 65 (5 histograms Ũ 13 parameters) datasets were created. The datasets were divided into two splits: one for training having parameters of 9 participants and one for testing including data of the other participant. Thus, the classification performance was tested in each participant. RESULTS: Almost 90% of data were classified accurately. The selection of the parameters using recursive feature elimination showed that the crucial features for classifications were the median and the coefficient of variation (CV) of the maximal knee joint angle. The post-hoc comparison demonstrated that the average of maximal knee joint angles in the late swing phase was smaller in HSI participants, as reported previously (Liu et al., 2012). Furthermore, the variance of the maximal knee joint angles across gait cycles was larger in HSI participants. High variability of maximum knee joint angles would increase the probability of exceeding the threshold that leads to re-injury of hamstrings. CONCLUSIONS: The new feature that characterizes high injury rates after HSI was detected using the SVM classification. The results provide the possibility that this feature will be a powerful factor in predicting the risk of injury in sports.

P-C-26: Helical axis analysis for the evaluation of knee joint kinematics during gait

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BACKGROUND AND AIM: Knee joint is characterized by poor congruence among its articular surfaces leading to continuous displacement of joint rotation center during movements. The instantaneous center of rotation of the joint can be estimated in vivo through the analysis of the distribution of helical axes (HAs), which can be considered an index of joint stability. HAs dispersion depends on the morphology of articular surfaces as well as on the muscular activity. The neuromuscular functions are often compromised in older asymptomatic adults. In addition, HAs can be analyzed not only during simple movements, but also during functional tasks such as walking. Therefore, the aim of this study was to describe knee HAs dispersion during walking in young and elderly healthy subjects. METHODS: Forty healthy volunteers were enrolled in the study (20 young: age 23.3ą2.4 years and 20 elderly: age

69.3ą4.9 years). Participants were asked to walk on a treadmill at spontaneous speed with reflective markers placed on thighs and shanks in order to detect kinematics with an optoelectronic system (SMART DX, BTS, Italy). Knee kinematics was described during the following gait phases: 1) flexion from 95% and 10% of gait cycle, 2) extension from 10% to 40% of gait cycle, 3) flexion from 40% to 70% of gait cycle, 4) extension from 70% to 95% of gait cycle. Mean Distance (MD) and Mean Angle (MA) were computed in reference to sagittal, frontal and transversal plane during each phase. RESULTS: Table 1 shows the results. Young subjects revealed lower MD on sagittal plane during phase 1 ($p<0.001$) with respect to elderly. Moreover, young subjects showed lower MA on sagittal plane during phases 1 ($p<0.001$) and 2 ($p<0.001$) compared to elderly subjects. Finally, all participants showed greater MD and MA on sagittal and frontal planes during phases 1 and 2 compared to phases 3 and 4. CONCLUSIONS: Young subjects showed lower HAs dispersion during walking. Moreover, all subjects revealed greater HAs dispersion during the stance phase of gait cycle. These findings could be explained through lower neuromuscular control during walking in elderly, especially when the transversal component of the articular forces is greater, and by mean of joint degeneration described in elderly.

P-C-27: Fatigue induced modifications of shoulder helical axes during repetitive movements

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BACKGROUND AND AIM: Shoulder complex is characterized by joint rotation center displacement during upper limb movements and capsular, ligament and muscular structures are essential to provide stability. Shoulder complex stability can be investigated through the analysis of helical axes (HAs) dispersion, which has been reported to be influenced by neuromuscular control. Fatigue is a complex phenomenon that influences neuromuscular control and alters muscular activation timing, kinematics and proprioception during upper limb movements. The aim of the study was to describe HAs dispersion during upper limb movements before and after a fatiguing task in young healthy subjects. METHODS: Thirty healthy right-handed volunteers (age 23.2□2.6 years) were asked to perform two cycles of 15 shoulder flexion and rotation movements with both upper limbs during two different recording sessions spaced by 6 hours of rest. Subsequently to each task, participants were fatigued at right side using the same task performed in isometric condition (50% MVC) for three times. After a rest of 10 seconds, they repeated the task with right and with left upper limbs. Retro-reflective markers were placed on participants' arms and trunk and kinematics was recorded by an optoelectronic system (SMART DX, BTS, Italy) before and after fatigue. HAs dispersion was computed using Mean Distance (MD) and Mean Angle (MA). RESULTS: Higher MD ($p=0.001$) and MA ($p=0.019$) were found in right side after fatigue during flexion. Moreover, greater MD and MA were found in right ($p=0.002$ for MD; $p=0.047$ for MA) and left ($p=0.038$ for MD; $p=0.019$ for MA) upper limbs after fatigue during rotation (Table 1). CONCLUSIONS: Fatigue seems to alter neuromuscular control leading to increased HAs dispersion during upper limb movements. This phenomenon occurred in right side during flexion, whereas in both sides during rotation due to the contralateral synergic activity of external rotator muscles during fatigue session. The analysis of HAs dispersion might be useful in monitoring shoulder stability or risk of injury in subjects undergoing fatigue.

P-C-28: The acute effects of ankle plantar flexor force steadiness exercises on postural control during single leg standing on stable and unstable platforms in healthy adults

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BACKGROUND AND AIM: Force steadiness is the ability to maintain steady contractions at a given target torque. Our previous study showed that center of pressure (COP) fluctuation during single leg standing on stable platform was related to the force steadiness at 5 % of maximum voluntary contraction (MVC), while the COP fluctuation on unstable platform was related to the force steadiness at 20 % of MVC. Considering these findings, there is a possibility that exercises to maintain steady contractions at low-intensity torque such as 5 % and 20 % of MVC, contribute to improve the postural control abilities on the stable and unstable platforms, respectively. The aim of the present study was to reveal the effects of the force steadiness exercises on COP fluctuation on stable and unstable platforms. METHODS: Sixteen healthy adults (24.2 ą 2.0 yrs, male; n = 8) participated and completed a crossover protocol that consisted of the force steadiness exercises at 5 %, 20 % and 50 % of MVC. Force steadiness exercises were performed 3 sets of 5 repetitions which consisted of 15-s steady isometric contractions of ankle plantar flexor at each target torque using a dynamometer. During the force steadiness exercises, the target and exerted torques were shown on the monitor for visual feedback. Before and immediately after the force steadiness exercises, postural control abilities were assessed using Biodex Balance System SD. As the postural control tests, single leg standings on stable and unstable platforms were performed for 20 s. The COP velocities were calculated with the anteroposterior COP during the meddle 15 s. To investigate the acute effects of force steadiness exercises on the COP velocities, paired t tests were performed to compare the COP velocities before and after force steadiness exercises. RESULTS: The COP velocity on stable platform decreased significantly after force steadiness exercise at 5 % of MVC (95 % CI: 0.22 - 3.99 mm/s, $p < 0.05$), whereas there were no significant changes after force steadiness exercises at 20 % and 50 % of MVC. The COP velocities on unstable platform were not changed after any force steadiness exercises. CONCLUSION: The COP velocity on stable platform decreased after ankle plantar flexor force steadiness exercise at the target torque of 5 % of MVC. The result suggests that repeating steady contraction task at low-intensity torque could improve a postural control ability on stable platform.

P-C-29: Muscle activities of bowing arm during playing the violin.

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While playing the violin, the fine motor control of both arms and their coordination is required. In a previous study, the acceleration peaks of bow, wrist, and elbow joint movements appeared in different timing between slow and fast musical passages (Winold et al. 1994). The purpose of the present research is to investigate the muscle activities of upper arm and forearm in the bowing arm among three different rhythms. Participants were five professional violinists (20 ą 2 year of experience).

Participants were told to play the violin with three different rhythms (slow: 1.25 Hz, middle: 2.5 Hz and fast: 5 Hz) with the metronome. The tasks were simple repetitions of down and up bowings with only one tone. The electromyograms (EMG) were recorded from biceps brachii (BB), triceps brachii (TB), flexor carpi radialis (FCR), and extensor carpi radialis (ECR) with 2k Hz. The EMG data of the forty strokes were averaged. The total length of one down and up bowing cycle was normalized as 100 %. The Figure 1 shows the averaged EMG data of all subjects. The stroke switching from down bowing (DOWN) to up bowing (UP) occurred at 50 % normalized time. FCR activity at the slow tempo, starting in the middle of the DOWN was maintained during the UP. ECR activity in the 0-10 % time range at the middle tempo was greater than that at the slow tempo ($p = 0.020$), and that in 10-30% at the fast tempo was greater than that at middle ($p = 0.049$), and that in 50-60 % at the fast tempo was lower than that at the middle. At all tempi, the TB activities were shown before the stroke switching (UP to DOWN). In 80-90 % time, the TB activity at the fast tempo was greater than middle one ($p = 0.004$). At the fast tempo, the switching of muscle activities between agonist and antagonist clearly appeared both in the upper arm and forearm. The high muscle activity of ECR was observed at the slow tempo from 30 to 90 % normalized time (mainly the UP phase). This ECR was activated to extend the wrist joint to keep the bow angle during the elbow extension (DOWN). However, the ECR activity changed with the change in tempo. Because the bow stroke range becomes smaller as the tempo becomes faster, the wrist joint movement would become more important in the fast tempo. Thus, the ECR function changed from fixation of the wrist joint to the active movement of wrist flexion/extension. At all tempi the activities of TB were shown before the switching stroke (UP to DOWN) that correspond to the elbow movement from flexion to extension. Because at the fast tempo violinists did not control the bow with elbow movement, the BB had been expected to co-contract with the TB to maintain the elbow angle. Interestingly, however, switchings were observed not only between the FCR and ECR but also between the BB and TB. In conclusion, the joint of stroke movement would be changed by the tempo during playing the violin.

P-C-30: Thoracic-pelvic angle at seat-off in the sit-to-stand motion contributes to balance and subsequent muscle activities

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BACKGROUND AND AIM: Performing the sit-to-stand motion requires the ability to accurately place the body's center of mass (CoM). Humans must carry the CoM away from the seat to a small foot in front of the upper-body. At seat-off, their waist slightly flexes, and the thorax precedes the pelvis. We hypothesized that the reason of this control was to carry the heavier thorax forward. This study aimed to clarify the reason for controlling the movement within the trunk, which has been considered rigid in motion analysis. METHODS: Five healthy adults participated in this study. The subject performed a sit-to-stand motion with a belt wrapped around the thorax and pelvis (normal condition). The subject then performed the motion while the trunk was fixed by connecting the belt (fixed condition). The experimenter instructed the subject to stand up with the trunk vertically as far as possible. Each condition was performed five times. Measurements were taken using a three-

dimensional motion capture system (Vicon Inc.) and a surface electromyogram (Delsys Inc.). For the parameters shown in the results, the differences between the conditions were compared using a paired t-test. The significance level was set as p = 0.05. RESULTS: Under the fixed condition, the pelvis at seat-off was tilted forward (p < 0.001). However, the distance between CoM and the center of pressure (CoM-CoP distance) at seat-off was not significantly different between the conditions (p = 0.36). Under the fixed condition, the support moment product after seat-off was higher (p < 0.001). Particularly, the knee extension moment was high (p = 0.02), and the muscle activities of the knee extensor was also high (p < 0.001). CONCLUSIONS: Under the fixed condition, the pelvis was tilted further forward to maintain the CoM-CoP distance at seat-off. This data supports our hypothesis that the reason the thorax precedes pelvis in normal conditions is to carry the CoM further forward. Furthermore, we have shown that the thoracic-pelvic angle affects not only the balance at seat-off, but also the support moment and muscle activities after seat-off. Because of the importance of thoracic-pelvic movements, researchers who considered the trunk as a rigid segment will ignore the critical features of the sit-to-stand motion.

P-C-31: Smartphone use requires more significant thumb joint movement compared to daily activities use

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BACKGROUND AND AIM: A smartphone is often operated by single-handed use, such as inputting text messages. Some reports indicate that repeated text message inputs lead to musculoskeletal disorders of the thumb; thus, the single-handed use of the smartphone might require more significant thumb joint movements than that of the daily activity use. If so, it may be necessary to propose the operating area where the thumb joint movement becomes small during smartphone use for preventing the thumb musculoskeletal disorders. We aimed to examine whether the thumb joint movements were more significant during single-handed smartphone use compared to daily activity use and to determine the area where the thumb joint movements became small. METHODS: Twenty healthy right-handed adults (seven males and 13 females) without a history of musculoskeletal disorders in the wrist and fingers participated in this study. As tasks, they performed flicking (four directions) and tapping (nine locations) at the bottom half of the display with their thumb on an Apple iPhone 8 as a smartphone use. Also, they conducted handwriting, manipulating chopsticks, flipping a cloth, and picking up a coin as a daily activity use. To measure the thumb joint movements during tasks, a three-dimensional motion capture system with 12 infrared cameras recorded ten reflective marker displacements of the thumb. Next, we calculated the flexion/extension angle of the interphalangeal (IP), metacarpophalangeal (MP), and carpometacarpal (CMC) joint and the abduction/adduction and pronation/supination of the MP and CMC joint in the thumb. Then, we computed all maximum join angle and joint angle ranges relative to maximum joint angle ranges (joint range ratio) of the thumb. Furthermore, we separated tapping locations into five areas and calculated joint range ratios. Finally, we compared the difference in the joint angles and joint range ratios between all tasks and the joint range ratios between all areas. RESULTS: The flexion, extension, abduction, and pronation angle of the CMC joint were significantly larger in smartphone use than in daily activity use. Also, the flexion angle of the IP and MP joint in smartphone use was significantly larger than that in daily activity use. All joint range ratios of flicking

and tapping were significantly larger than those of daily activity use; interestingly, all joint range ratios of the tapping were largest between tasks. The area near the thumb was the smallest joint range ratio (48%). CONCLUSIONS: We found that the thumb joint movements in smartphone use were more significant than those in daily activity use; additionally, thumb joint ranges were smallest in the area near the thumb. If the smartphone is operated by the unilateral thumb, decreasing the operating area by the unilateral thumb may assist in preventing the thumb musculoskeletal disorders.

P-C-32: The Effect of Neck Fatigue on Shoulder Proprioception

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Background and Aim: Cervical extensor muscle (CEM) fatigue has been linked to decrements in upper limb proprioception. However, limited research exists quantifying this interaction at the shoulder due to the kinematic and muscular complexity inherent in shoulder movement. The primary purpose of this study was to utilize a novel humeral rotation device to assess changes in shoulder proprioception following CEM fatigue. We additionally aimed to investigate how well our humeral rotation device constrained humeral movement to solely internal and external rotation. Methods: Fatigue group participants (n=20) were tasked with performing 4 sets of 3 shoulder joint angle matching trials while interacting with a custom-built shoulder humeral rotation device. Between sets 2 and 3, participants were tasked with completing a CEM fatiguing protocol. Control group participants (n=30) were tasked to obtain right upper limb kinematics when conducting the joint angle matching task with no CEM fatigue. Absolute, constant, and variable humeral joint position recreation error was analyzed with a mixed model 3(time) x 2 (sex) x 2 (group) repeated measures ANOVA. Raw scores were transformed with a square root function. Standard and stepwise multivariate regression models were utilized to compare upper limb degrees of freedom (DOF) to shoulder device rotation. Results: CEM MPF decrease, RMS increase, and decrement in post-fatigue MVC confirmed the induction of significant neck fatigue. However, no significant decrement in humeral rotation proprioception. The control group achieved a moderate Pearson correlation with the shoulder humeral rotation device (r=0.45). Only humeral rotation and wrist deviation significantly contributed to device rotation (r=0.433). Conclusions: No decrements in humeral rotation proprioception accuracy were observed. This does not align with trends in the literature. Kinematic analysis confirmed that DOF's at the wrist contributed significantly to task variability. Correlation coefficients suggest that variables extraneous to the upper limb may also be contributing to statistical variability.

P-C-33: In-situ comparison of spinal postures during smartphone use versus non-use among university students

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Background and Aim: Nowadays it is common for young people to use the smartphone as the primary instrument for communication instead of desktop or laptop computer. Adopting the "head-down" posture for prolonged periods may lead to increased risk of neck-shoulder pain. Research in recent years

have mainly examined the use of smartphones and tablet computers in the laboratory setting, involving short duration and standardized tasks. This study compared the real-time spinal movements and postural variations during smartphone-use versus non-use in university students in their natural environment - the university campus. Ten males and eight females (mean age of 21.5+2.6 years) participated, with similar daily phone use time between the two sexes. Three-dimensional kinematics was recorded for 3 hours on a typical weekday while the participants went about their usual academic activities such as attending classes, meeting with other students or studying on their own. Five inertial motion sensors were attached to the cervical, thoracic and lumbar spinal regions, and the signals were captured on the data-logger worn on the waist. Methods: The active phone use time was captured on the smartphone of the participants during the data collection period. Kinematics data were recorded with a sampling frequency of 100 Hz and filtered using a low-pass Butterworth filter of 3rd order (Fcutoff: 3Hz). The data were examined in terms of: 1. Median 50th%APDF of the postural angles in the cervical, upper thoracic, lower thoracic and lumbar regions; 2. Zero crossing (ZC) per min, with a threshold set to the mean angle +10 before change of movement direction (Szeto et al., 2012) to assess changes in the amplitude and variations of the adopted spinal postures. Results: Results showed that significantly greater degrees of cervical and upper thoracic flexion angles were adopted during phone use versus non-use time ($p<0.01$). The mean cervical flexion angle was recorded as 8.0° Flexion (SD7.5) during phone use compared to 4.2° Extension (SD8.2) during non-use ($p<0.01$). These postural angles were referenced to their standing postures recorded at the start. There was also significantly greater frequency of postural variations (zero crossing per min) in all spinal regions in the sagittal plane (all $p<0.05$), and in some of the movements in the transverse and frontal planes. For example, the ZC per min in the cervical flexion plane was 10.5 (SD6.3) per min during non-use compared to 5.5 (SD3.1) during phone use. These results showed that the participants maintained a more static posture with less postural variations during phone use. The postural variables also showed some significant correlations with the self-reported pain score in the neck and upper back regions. The mean neck pain score among the participants was 2.1(SD1.6) for female participants and 2.4(SD2.2) for male participants at baseline. Conclusions: The present results revealed that the university students maintained their neck and upper thoracic spine in more static postures and with increased flexion angles during phone use compared to non-use. This factor may contribute to increased risk of developing neck-shoulder pain in the student population. Reference: Szeto, G.P.Y., Cheng, S.W.K., Ting, A.C.W., Poon, J.T.C., Tsang, R.C.C., Ho, P. 2012. A study of surgeons' static posture and movement repetitions during open and laparoscopic surgery. J. Surg. Res. 172 (Jan), e19-e32.

P-C-34: Fatigue alters turns kinematics in female soccer players

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BACKGROUND AND AIM: Anterior Cruciate Ligament (ACL) rupture is among the most severe injuries in women soccer, accounting for 43% of absence from match play [1]. ACL injury mechanism involves multiplanar movement patterns that can occur during landing, turning, cutting or pivoting actions [2]. Despite fatigue may have an effect in enhancing ACL injury risk [3], its impact on movement mechanics is still unclear [4]. Our aim is to deeper understand these mechanisms, which would expand the basis of

evidence for the development of prevention programs. METHODS: Nine élite female soccer players (age: 20-31 years, BMI: 18.4-22.7 kg·m⁻²) belonging to the first or second Italian division ("Serie A" and "B") completed a 5-m shuttle run test until exhaustion, paced at 70% of their own Maximal Aerobic Speed (2.6 ± 0.2 m·s⁻¹). The three-dimensional position of 37 reflective markers was acquired during the test with an optoelectronic motion analysis system (BTS, Italy). Peak blood lactate concentration was measured at the end of the test. Hip, knee and ankle 3D kinematics were obtained from a biomechanical model developed in Visual 3D (CMotion, USA). Statistical Parametrical Mapping (SPM) paired t-tests were used to compare joint kinematics during the stance phase between the turns 6-10 and the last 5 turns performed with the preferred leg. RESULTS: Post-exercise blood lactate concentration was 10.7 ± 3.0 mmol·L⁻¹. The hip was more extended at mid-stance ($p = 0.038$, $t = 2.398$), as well as the knee ($p = 0.005$, $t = 2.635$). The tibia was more internally rotated from 20% to 80% of the stance phase ($p < 0.001$, $t = 2.677$). No significant differences were observed at the ankle level. CONCLUSIONS: These findings depict a sequence of concatenated alterations to the mechanics of changes of direction that are commonly described as biomechanical risk factors for ACL injury [2]: reduced knee and hip flexion ("stiff" landing), tibial internal rotation and knee dynamic valgus. Surprisingly, we did not observe alterations in knee kinematics on the frontal plane: it could be either that the high training level of the assessed cohort did not let such difference emerge, or that while the drop between the fresh and the fatigued condition was not significant, the baseline value (10-15 degrees of knee abduction) is potentially hazardous per se, even before the onset of fatigue. As outlined in a recent work on men [3], it is confirmed and reinforced (given the higher incidence in women [4]) the need of planning specific neuromuscular exercises at the end of trainings, as when players are fatigued they can get the highest benefit from tackling modifiable biomechanical risk factors. 1. Larruskain et al., Scand J Med Sci Sport, 28:237-245, 2018. 2. Fox et al., Sports Med, 44:815-832, 2014. 3. Zago et al., Eur J Sport Sci, 19:1072-1081, 2019. 4. Bourne et al., Sports Med, 49:1629-1635, 2019.

P-C-35: Inter-and intra-rater reliability and validity of a 3D body segment scanner to obtain foot anthropometrics

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BACKGROUND AND AIM: Many biomechanical analyses rely on the availability of subject-specific foot segment measurements. Most studies use manual measurements of foot parameters, such as arch height and truncated foot length, to examine foot mechanics and evaluate foot posture. Unlike hand-measurements that are time consuming and prone to human error, the development of three-dimensional (3D) body scanners has the potential to revolutionize the orthotics field. These devices allow users to quickly render subject-specific models that can be used to develop custom foot hardware. However, the reliability and validity of these scanners to measure foot dimensions has not been determined. Therefore, the aim of the study is to determine the reliability and validity of a portable 3D white light body segment scanner to obtain foot anthropometrics across two different sessions. Validity of the scanner was measured against manual measurements, which included a combination of a custom 3D printed foot measurement device and a caliper. METHODS: Fourteen control participants (9 males, 5 females, mean age 23.9 ± 1.7 years) were recruited to participate. Seven anthropometric measures of their dominant foot under weight bearing and non-weight bearing conditions were obtained using a 3D

scanner (TechMed 3D Inc., QC). The same seven anthropometric measures were manually obtained using a custom 3D printed foot measurement device (printing tolerance of +/- 0.5 mm, 0.2 mm nozzle) and a caliper (Model #54-100-112-2, Fowler High Precision Inc., USA, accurate to 0.02mm). Both sets of measurements were combined and compared to those obtained from the 3D scanner. Manual measurements were considered the gold standard for the validity test, as these techniques are commonly used for obtaining foot anthropometrics in research and clinical setting. To test reliability, a two-way mixed model intraclass correlation coefficient (ICC) analysis and standard error measurement (SEM) were used. To assess validity, Pearson correlation coefficient (PCC) and variability (SD) were examined. To determine accuracy, the error between both techniques was also calculated. All statistical analyses were completed using R Studio (RStudio 2018, RStudio, Inc., USA). RESULTS: The 3D scanner results showed good to excellent ICC; ICCs for intra-rater reliability ranged from 0.99-0.46; inter-rater reliability ranged from 0.99-0.40. The SEM ranged from 0.05-0.27. Results from the PCC showed that both measurement techniques were strongly correlated in 6 out of 7 measurements (range from 0.40 - 0.98). For the WB and NWB, the measurement error ranged from -3.2 to 4.7 mm and -4.2 to 4.2 mm, respectively. CONCLUSION: Findings suggest that 3D scanners are a reliable and accurate instrument to collect foot anthropometrics. This work is a step in demonstrating the usability of 3D scanning technology in research and clinical settings to develop biomechanical models, custom orthoses or sensor-based insoles. Future studies should focus in testing the full capabilities of 3D body segment scanners including more and complex measures of the foot, as well as larger sample sizes. Nonetheless, this work was able to demonstrate the intra- and inter-rater reliability and validity of 3D segment scanners to obtain foot anthropometrics.

P-C-36: Fatigue effects on two return-to-sport jump tests

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BACKGROUND AND AIM: Return to activity remains the most notable concern following a sport injury. Many functional test batteries, consisting of different stability and jump tasks, have been proposed for return to sport after an ACL injury [1]. Among them, Counter Movement Jump (CMJ) and Single Leg Hop (SLH) are two of the most common functional tests evaluated following ACL reconstruction [2,3]. However, despite evidence demonstrating that neuromuscular fatigue reduces functional performance and knee stability, functional tests are often not performed in a fatigued condition [3]. We aim to investigate the effect of a sport-specific fatigue protocol on performance and knee kinematics during two different functional jump tests. METHODS: Eleven female soccer players (age: 20-31 years, BMI: 18.4-22.7 kg·m⁻²), playing in the first or second Italian division ("Serie A" and "B") were evaluated. After a warm-up, two jump tests were performed in rest condition (2 repetitions for CMJ and 2 repetitions per limb for SLH). Then, participants performed a fatigue protocol consisting of a 5-m shuttle-run (SR) until exhaustion. Peak blood lactate concentration was measured at the end of SR. Afterwards, the jump tests were repeated in a fatigue condition. The three-dimensional position of 37 reflective markers was acquired during the tests with an optoelectronic motion analysis system (BTS, Italy). Knee 3D kinematics was obtained from a biomechanical model within Visual 3D (C-Motion, USA).

Repeated measures one-way (pre vs. post SR) and two-way (pre vs. post SR and right vs. left limb) ANOVAs were conducted to evaluate differences in height for CMJ and length for SLH, respectively. Statistical Parametric Mapping (SPM) unpaired t-tests were used to compare knee kinematics during CMJ and SLH tests, before and after SR. RESULTS: Post-exercise blood lactate concentration was 10.7±3.0 mmol·L⁻¹. No significant differences were found for CMJ height and SLH length before and after SR. SMP revealed no significant side differences for knee kinematics, except for SLH abduction moment in fatigued conditions, from 2% to 13% of the weight acceptance phase (t=3.051, p=0.016). CONCLUSIONS: We did not observe differences for jump tests performed before and after the SR fatigue protocol. This result is probably due both to the limited duration of the protocol (less than 5 minutes) and to the time between the end of SR and the repetition of jump tests (at least 1 minute for lactate sampling). These factors probably allowed participants to recovery from neuromuscular fatigue induced by the SR protocol before the second jump tests. However, the asymmetry for SLH abduction moment suggests a potential effect of fatigue on knee kinematics during the initial part of the landing. The findings of this pilot study can be useful for future research aiming to enhance ecologically valid return-to-sport test batteries, in which the role of fatigue should be evaluated. 1. Hildebrandt et al, Knee Surg Sports Traumatol Arthrosc, 23:1273-1281,2015 2. van Melick et al, Knee Surg Sports Traumatol Arthrosc, 27:549-555, 2019 3. O'Malley et al, J Athl Train; 53:687-695, 2018

P-C-37: Impact of autologous haematopoietic stem cell therapy on the stomatognathic system of subjects with systemic sclerosis

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BACKGROUND AND AIM: Systemic sclerosis is a progressive autoimmune connective tissue disease that can affect the stomatognathic system, especially the masticatory muscles and / or associated structures. The aim of this study was to evaluate, through the electromyographic activity of the masticatory muscles, bite force and tongue and lip pressure, individuals with systemic sclerosis who underwent autologous haematopoietic stem cell therapy. METHODS: Seven subjects (mean ± SD 40.1 ± 9.6 years) who were initially submitted to electromyographic analysis of the masseter and temporalis muscles in the mandibular tasks at rest, right and left laterality, protrusion and maximum voluntary contraction; molar bite force and tongue and lip pressure. EMG activity was recorded using a wireless system (Trigno, Delsys Inc., Boston, MA, USA). After two months of treatment subjects were again evaluated by the same methods. Data were tabulated and submitted to statistical analysis using the repeated-measure test (p <.05). This study was approved by the Research Ethics Committee (process # 94010718.4.00000.5419). RESULTS. After two months of autogenous stem cell transplantation and analyzing the absolute values, there was lower normalized electromyographic activity in the masseter and temporalis muscles in all mandibular tasks, with significant difference in the maximum voluntary contraction for the left temporal muscle (p=.04). There were no significant differences for molar bite force and tongue pressure. CONCLUSIONS: Autologous haematopoietic stem cell therapy in subjects with systemic sclerosis improved stomatognathic system function, especially related to

electromyographic activity. ACKNOWLEDGEMENT: CAPES, FAPESP and National Institute and Technology - Translational Medicine (INCT.TM).

P-C-38: Analysis of masticatory efficiency in different severity of sleep buxism

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BACKGROUND AND AIM: The functions of the human body must be in harmony so that the systems and organs remain balanced. However, pathological and/or behavioral changes of various intensities can interfere in this equilibrium, leading to functional changes. This study analyzed electromyographic signal of the masseter and temporalis muscles, of individuals with different severity degrees of sleep bruxism, determined by the BiteStrip®. METHODS: Thirty-four subjects with sleep bruxism were divided into two distinct groups: mild sleep bruxism (average ± DP 31.3 ± 6.2 years; n=15) and severe sleep bruxism (average ± DP 29.8 ± 7.1 years; n=19). Eligible subjects underwent a polysomnography was performed at night. The ensemble average was the mathematical calculation used to determine the masticatory cycle efficiency of the electromyographic signal for the masseter and temporalis muscles in habitual chewing with peanuts, habitual chewing with raisins and non-habitual chewing with Parafilm M. EMG activity was recorded using a wireless system (Trigno, Delsys Inc., Boston, MA, USA). This study was approved by the Research Ethics Committee (process No. 02735812.9.0000.5419). RESULTS: There was significant increase in electromyographic activity in the severe sleep bruxism group compared to the mild sleep bruxism group in the chewing with peanut for the right (p=.03) and left (p=.03) temporal muscles; chewing with raisin to the right (p=.01) and left (p=.05) temporal muscles and chewing with Parafilm M for the right (p =.008) and left (p=.02) temporal muscles. CONCLUSIONS: Sleep bruxism interferes negatively in masticatory efficiency, as there was increased electromyographic activity in the masseter and temporalis muscles of subjects with severe sleep bruxism ACKNOWLEDGEMENT: FAPESP and National Institute and Technology - Translational Medicine (INCT.TM).

P-C-39: The effect of front and rear heel position on the ankle during high heel walking.

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Purpose: High heels are often worn, especially by women, for professional and personal reasons i.e. in business situations or as fashion. However, there are concerns about the negative health effects of high heels. Due to their design, high heels have raise the heel, forcing the ankle into plantar flexion, which can lead to decreased stability and pain in the ankle due to muscle fatigue. Much research has been done on heel height and heel position in relation to the ankle. However, in most studies, the effect of heel height or lateral positional changes in heel position were observed. Therefore, the purpose of this study was to examine the effect of a front and rear heel position on the ankle during walking. Method: Ten women wore specially designed high heels, commonly known as 'pumps' in Japan, which had the heels removed and replaced with a wooden board and heel, held together with superglue, and then

walked normally on a flat surface for about 10 m. Three pairs of high heels with the heel in three different positions, a) Original, b) Front, and c) Rear (Front and Rear heel positions were 2.5 cm forward or back from the Original heel position, respectively), were examined (Fig. 1). Walking motion was recorded with a three-dimensional motion analyzer (VICON) and joint angle and joint moment of the ankles, knees and hip, and ground reaction forces, were analyzed. Results: Ankle plantar flexion moment decreased significantly in the Front heel position compared to the Original heel and Rear heel positions. Discussion: By moving the heel, which is the load point, forward, the Center of Pressure moved further forward shortening the lever arm at the ankle accordingly. We believe that this shortening mechanism resulted in a decrease in the ankle plantar flexion moment. These results suggest that the position of the heel can affect the ankle strategy for dealing with the heel rocker mechanism that occurs during the early to middle stages of the stance phase.

P-C-40: The effect of 12-week training with minimalist shoes on Achilles tendon loading during running

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Achilles tendon (AT) has particularly high overuse injury rates. The transition to run in minimalist shoes with forefoot strike pattern has been considered as a method to decrease the risk of the running injury. Nevertheless, evidence is still limited regarding chronic adaptation in AT by a minimalist running pattern. The purpose of this study was to explore the effects of 12-week running training with minimalist shoes on AT loading during running. Methods: Seventeen recreational male athletes without minimalist shoe running experience were randomly assigned to two groups (SBR group, n=9, age: 33.4±6.4 yr; MIN group, n=8, age: 27.4±5.9 yr). The SBR group run in minimalist shoes (INOV-8 BARE-XF 210 v2; heel-toe drop 0mm; 227 g) with a forefoot strike, while MIN group run in minimalist shoes with existing foot strike during 12-week running training. Before and after the intervention, all participants were asked to run along a runway at 3 m/s (±5%) in minimalist shoes. The cross-sectional area of the AT was obtained by ultrasound imaging. Sagittal plane ankle kinematics and ground reaction forces were recorded by a motion capture system and a force platform simultaneously. Ankle joint mechanics and the mechanical properties of the AT were calculated. A two-way ANOVA (group × time) was used as a statistical analysis. Results: A significant interaction was observed for the foot inclination angle ($p = 0.013$). Post-hoc analyses revealed the foot inclination angle was changed from the rearfoot strike pattern to the forefoot strike pattern in SBR group ($p = 0.012$), while no significant change in MIN group. A significant lower in the foot inclination angle of SBR group than MIN group was also observed post-training ($p = 0.014$). For kinetics at the ankle, a significant interaction was observed for ankle moment ($p = 0.030$). Post-hoc analyses revealed ankle moment was significantly increased 15.4% in SBR group ($p < 0.001$) and 7.7 % in MIN group ($p = 0.034$), respectively. For the AT mechanical properties, a significant interaction was observed for time to peak AT force. Post-hoc analyses revealed a significant decrease in time to peak AT force in SBR group ($p = 0.019$), while no significant change in MIN group. Also, significant main effects were also observed across time for peak AT force ($p < 0.001$), AT impulse ($p < 0.001$), peak AT loading rate ($p < 0.001$), average loading rate ($p = 0.001$), peak AT stress ($p = 0.020$), AT strain ($p = 0.020$), and corresponding peak rate ($p = 0.023$; $p = 0.043$). Specifically, the above parameters were observed increased after 12-week training no matter groups. Conclusion: The results of this study

indicate that it is possible to change AT mechanics properties with minimalist shoes in runners who habitually wear conventional shoes within 12 weeks. A gradual transition to minimalist shoes was recommended for runners who wish to improve the ability of AT to load and reduce the risk of Achilles tendon injury.

P-C-41: Impact of the bichectomy surgical technique on the electromyographic activity of the masseter and temporalis muscles: a preliminary study.

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BACKGROUND AND AIM: Aesthetic procedures have become very popular around the world, such as removal of part of the buccal adipose tissue. This study aimed to evaluate the electromyographic activity of the masseter and temporalis muscles of women after bichectomy surgical technique. METHODS: Five healthy women (mean age of 26.6 years) with indications removal of part of the buccal adipose tissue were included in this study. EMG activity of the masseter and temporalis muscles was recorded using a wireless system (Trigno, Delsys Inc., Boston, MA, USA). Protocol for mandibular tasks: rest, right and left laterality, protrusion and dental clenching in maximal voluntary contraction. All datas collects were made before the procedure and 120 days after the bichectomy surgical technique. Data were tabulated and submitted to statistical analysis using the repeated-measure test ($p < .05$). This study was approved by the Research Ethics Committee (process # 10589419.0.0000.5419). RESULTS: There was a significant difference after 120 days at rest for the right masseter muscle ($p = 0.05$) and right laterality for the right masseter muscle ($p = .04$). CONCLUSION: The authors suggest that the removal of part of the buccal adipose tissue in women, through the bichectomy surgical technique, changes the function of the stomatognathic system, related by electromyographic activity. ACKNOWLEDGEMENT: CAPES, FAPESP and National Institute and Technology - Translational Medicine (INCT.TM).

P-C-42: A comparison of inter-joint coordination during gait between patients with knee osteoarthritis and healthy adults

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BACKGROUND & AIM: Inter-joint coordination examines relationships between segments by analyzing two adjacent segments during movement and relating them in terms of relative timing and positioning. The latter can provide valuable information regarding the timing and sequencing of neuromuscular control and the adaptability of the motor control system in patients with knee osteoarthritis (OA). However, there is limited research examining inter-joint coordination during gait in this population. Therefore, the objective of this study was to compare inter-joint coordination amplitude and variability during gait between participants with knee OA and healthy adults. METHODS: This cross-sectional study

used a database containing participants with mild-to-moderate knee OA (n=35), severe knee OA (n=12) and healthy adults (n=35). Gait was measured with a motion capture system and force plates. Participants ambulated at self-selected speeds for 5 trials. Continuous relative phase (CRP) was calculated for the foot-shank and shank-thigh in the sagittal plane and represented inter-joint coordination. Mean absolute relative phase (MARP, represents CRP amplitude) and deviation phase (DP, represents CRP variability) were determined. A one-way analysis of variance (ANOVA) with Bonferroni correction compared MARP and DP during gait between groups. MARP and DP were also compared between groups and across gait phases (stance, swing) using a 2-way mixed ANOVA. RESULTS: There was a significant difference between groups in shank-thigh MARP during gait ($F(2,79)=5.672$, $p=0.005$), whereby the shank-thigh MARP was significantly reduced for the severe knee OA group compared to the healthy ($p=0.004$) and mild-to-moderate KOA ($p=0.016$) groups. A significant interaction was found between the effects of gait phase and group on shank-thigh MARP values ($F(2,79)=4.596$, $p=0.013$). CONCLUSIONS: Individuals with severe knee OA exhibit a more in-phase or symmetrical shank-thigh movement pattern during stance compared to individuals with mild-to-moderate knee OA and healthy adults. This may be explained by higher levels of knee muscle co-contraction commonly seen in individuals with severe knee OA to account for loss of passive knee stability secondary to advanced degenerative changes.

P-C-43: Limitations of a Manual Digitization Technique? No Impact of Abdominal Bracing on the Non-Invasive Assessment of Sacroiliac Joint Position During Standing Spine Motion

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BACKGROUND: The sacroiliac joints (SIJ) connect the spine and pelvis. They have been implicated as one of many potential low back pain generating structures. Conscious bracing of the abdominal wall muscles has been previously shown to reduce spinal motion under some conditions. These muscles have direct attachments to the pelvis, yet the influence of their contraction on SIJ motion and stabilization has not been explored. The aim of this project was to quantify SIJ position during standing spine flexion and axial rotation with and without abdominal bracing. It was expected that sacroiliac joint angles would demonstrate a greater range (suggesting greater motion) across the non-braced spine postures as compared with the braced spine postures. METHODS: To date, 9 healthy young participants have been recruited. Participants were immobilized across the greater trochanters to minimize standing sway while preserving the ability to move the spine and pelvis. Participants were instructed to touch targets through the adoption of postures including spine flexion and flexion with both left and right axial twisting, all performed with and without coached abdominal bracing. Lumbar spine kinematics were recorded with rigid bodies while the anterior and superior iliac spines were manually digitized in all postures. The pelvic landmarks were used to generate vectors to calculate SIJ angles (Fig 1). All angles were normalized to initial neutral standing trials. Surface electromyography was collected from the following muscles: internal and external obliques, lumbar erector spinae, gluteus medius and biceps femoris, and normalized to isometric maximum voluntary contraction. RESULTS: Preliminary results show no clear trends for any measured sacroiliac joint angles; all postures showed no significant differences between the non-braced and braced conditions. Individuals flexed their spines further in the braced trials compared with equivalent non-braced trials. Bracing lead to increases in the activity of the

internal and external obliques as well as the erector spinae and left biceps femoris. CONCLUSIONS: Surprisingly, abdominal bracing caused individuals to flex more through their spines when touching the targets. However, abdominal bracing did not appear to influence the calculated SIJ angles. It is possible that the demand on the SIJ was inherently greater in the braced conditions due to the greater flexion of the spine, ultimately resulting in no reduction in SIJ motion. Alternatively, the lack of trends in SIJ motion may be due to inherent limitations of the manual digitization. This technique is dependent upon consistent placement of a probe tip measuring less than 1 cm in diameter over landmarks which have much larger surface areas. Error from probe placement may be further compounded with shifting of the participant in between individual digitizations. It is recommended that future work focus on the evaluation and reduction of this potential error.

P-C-44: Fear of re-injury following anterior cruciate ligament injury is manifested in the biomechanics of side-hop landings

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Background and aim: Rupture of the anterior cruciate ligament (ACL) often results in both physical and psychological consequences. Despite extensive rehabilitation programmes, less than 50% patients return to the same level of sport within 12-24 months after ACL reconstruction. This is largely attributed to fear of movement (kinesiophobia), particularly fear of re-injury. Evidence of associations between kinesiophobia and movement patterns among ACL-reconstructed (ACLR) individuals are scarce and not specific to injury-mimicking manoeuvres. We aimed to determine whether fear of re-injury is manifested in joint kinematics and muscle activation patterns during landings within a standardised side hop paradigm, as well as in patient-reported outcome measures (PROMs), among anterior cruciate ligament-reconstructed (ACLR) individuals. Methods: Forty ACL-reconstructed (ACLR) individuals, grouped into HIGH-FEAR (n=18, 7.0-76.7 months post-surgery) or LOW-FEAR (n=22, 7.0-60.0 months post-surgery) based on a fear of injury discriminating question (Q9; Tampa Scale of Kinesiophobia-17), and 44 asymptomatic controls performed standardised rebound side hops. Three-dimensional motion recordings were used to calculate trunk, hip and knee joint angles at initial contact, and range of respective joint motion during landing. Surface electromyography registered mean amplitudes and co-contraction indices (CCI) for biceps femoris, semitendinosus, vastus medialis and vastus lateralis muscles, during preactivation (50ms) and landing phases. PROMs of knee function, knee health, and physical activity were also analysed. Results: HIGH-FEAR demonstrated lower hip frontal plane range of motion ($P \leq 0.048$), higher biceps femoris amplitude ($P \leq 0.001$), and higher anterior-posterior CCI ($P \leq 0.020$) compared to LOW-FEAR and controls. HIGH-FEAR had more trunk flexion at initial contact than controls ($P=0.018$), and both HIGH-FEAR and LOW-FEAR displayed more hip and knee flexion at initial contact than controls ($P \leq 0.017$). HIGH-FEAR and LOW-FEAR had similar ratings for most PROMs. Conclusions: Fear of re-injury among ACLR individuals was expressed in altered movement and muscle activation patterns compared to controls, yet poorly expressed in their PROMs. This psychological aspect, based on an answer to a single question, should therefore be viewed as an independent outcome to evaluate throughout rehabilitation after ACL reconstruction. Clinicians should adapt a holistic view on rehabilitation by considering biopsychosocial models and how movement patterns may be influenced by various intrinsic factors. Finally, the standardised rebound side-hop test represents

knee-demanding movements common to those found in sport, and should therefore be considered when screening and evaluating ACLR for landing biomechanics in the context of both fear of re-injury and functional performance.

P-C-45: Drop jump performance is related to resting calf muscle stiffness

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BACKGROUND AND AIM: There is a relationship between parallel elastic element, such as resting muscle stiffness, and rapid force production during explosive isometric contraction in the plantar flexor muscle (Ando and Suzuki 2019). It has not yet been examined if stiffness of resting muscle stiffness affects dynamic movement performance, such as drop jump. We hypothesized that drop jump performance is positively related to resting calf muscle stiffness. METHODS: Twenty-four healthy men (age: 22 ą 1 yr, height: 173 ą 7 cm, body mass: 66 ą 10 kg) participated in this study. Shear moduli of the medial gastrocnemius (MG) and the soleus (SOL) were measured at rest at 0š of ankle joint angle as an index of muscle stiffness using ultrasound shear wave elastography. Participants then performed the maximal explosive isometric contraction in the plantar flexion. Electromyography was recorded from the MG during isometric task. Electromechanical delay (EMD), defined as the timing lag between onsets of muscle activation and muscle force production, was calculated as an index of tendon stiffness based on the negative correlation between EMD and tendon stiffness reported previously (Waugh et al. 2013, 2014). Participants performed drop jump from the 15 cm box height. A drop jump index was calculated by jump height (m) divided by contact time (s). The Pearson's correlation coefficient was used to examine relationships between each parameter. RESULTS: The drop jump index (0.919 ą 0.415 m/s) was correlated significantly with MG shear modulus (14.2 ą 3.2 kPa) ($r = 0.415$, $P = 0.04$) but not with SOL shear modulus (6.0 ą 1.9 kPa) ($r = -0.013$, $P = 0.95$). There was no significant correlation between EMD (73.6 ą 13.2 ms) and the drop jump index ($r = 0.213$, $P = 0.32$). CONCLUSIONS: Drop jump performance was positively related to MG stiffness but not SOL stiffness. Given that MG could be tensioned at 0š of ankle joint angle while SOL could be slack (Hirata et al. 2015), the difference in nature of parallel elastic element at a given ankle joint angle may influence discrepancy of relation of drop jump performance with MG and SOL.

P-C-46: Development and Design Of A Wearable Capacitive Wrist Sensor System And Presentation Of A Novel Aruco Markers Calibration Method For Motion Tracking

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BACKGROUND AND AIM: Many biomechanical research applications and medical and industrial settings can benefit from the availability of small, low cost, flexible, wireless joint angle sensors to gain a greater understanding of joint movement, treatment effectiveness, and injury prevention. The purpose of this work was to: 1) design and develop a wireless, wearable capacitive wrist angle sensor (flex sensor), and 2) develop a novel calibration and validation technique for this sensor using synthetic square ArUco

markers [2]. The developed sensor system consisted of two capacitive sensors [1], as well as an electronic evaluation system for the acquisition and wireless transmission of the sensor data. The sensors are casted in a 90x40x3mm silicon housing, the miniature format evaluation System plus LiPo battery (40x20x16mm) can be casted in the silicon housing as well. Capacitive sensors change their electrical properties on each use as the placement position and therefore, the output behaviour is variable. The information from the calibration procedure will be used to match the local recorded raw sensor data to the real joint angles after the data assessment.[3] The flex sensor calibration using ArUco markers provided an easy, accurate and touchless method to calibrate the sensor for the objective measurement of accurate and reliable joint angles. The advantage of ArUco calibration is that it can be completed using a simple webcam or a mobile phone and does not require a expensive or complex camera setup. METHODS: The ArUco marker pose estimation was validated in a static and a dynamic test procedure with a 12 camera T160 Vicon motion capture system (Oxford Metrics Group, Oxford, UK), sampling at 100 Hz, by tracking the three-dimensional trajectories of a specific designed ArUco-Vicon-Marker pattern placed on the participant's palm and forearm. In the static test, data from both sensor systems were recorded and compared in five wrist poses to calculate the mean maximum absolute position error. In the dynamic maximum range of motion test, the sensor data recorded from the flex capacitive sensor during dynamic movement from radial deviation into ulnar deviation and palm extension to palm flexion were correlated with the ArUco data via linear regression. RESULTS: The results of the static test show a mean absolute maximum position error of 2.50 degrees, determined as the deviation ArUco marker positions vs Vicon coordinates (Table 1). In the dynamic test, the root-mean-square error of the wrist angles recorded via the ArUco system and the linear regressed capacitive flex sensor data were calculated. RMSE-values of 5.2 degrees (Figure 2) for extension/ flexion and 5.9 degrees (Figure 1) for radial ulnar deviation were observed and serve as a reference for the quality of the calibration. CONCLUSIONS: Both tests show that an accurate wrist position determination with ArUco markers is possible and that this data can be used as a training input for the sensor calibration. With this work a non-bulky, skin attachable complete wrist sensor system and a novel calibration method is developed which can be applied for a great variety of motion sensor approaches. References: [1] Atalay, A. et al. (2017). Advanced Materials Technologies, 2(9). ISSN 2365709X. [2] Garrido-Jurado, S. et al. (2014). Pattern Recognition, 47(6). ISSN 00313203. [3] Huang B. et al. (2017). Sensors, 17(12). doi: 10.3390/s17122708.

P-C-47: A biomechanical and neuromuscular investigation of incline and decline walking in patients with femoroacetabular impingement

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BACKGROUND AND AIM: Femoroacetabular impingement (FAI) is a proliferative musculoskeletal diagnosis in young adults and a proposed risk factor for the development of hip osteoarthritis. Inconsistent biomechanical findings during level ground walking between individuals with FAI and asymptomatic individuals suggest that more challenging walking conditions may be necessary to better detect FAI-related mechanics potentially associated with disease progression. The purpose of the current study was to compare the effect of challenged walking on gait biomechanics and neuromuscular activity in individuals with FAI and asymptomatic individuals. METHODS: Fourteen individuals were

recruited to participate including seven individuals with a clinical diagnosis of FAI who were recruited from an orthopaedic surgeon and seven age matched asymptomatic individuals who were recruited from the community. All participants underwent 3D gait analysis using an 8-camera motion capture system with a full body passive reflective marker set, synchronized with a dual-belt instrumented treadmill. Surface electromyography (EMG) was used to collect neuromuscular activation of gluteus maximus (Gmax) and medius (Gmed) following SENIAM guidelines. Gait speed was determined using a GaitRite system and adjusted to participant comfort on the treadmill. All participants were assessed during level ground walking followed by four randomized walking conditions including incline and decline walking at both 5- and 10-degree inclinations. After the walking protocol, maximum voluntary isometric contractions were collected for normalizing the EMG data collected during walking. A 2-way mixed methods ANOVA assessed for within and between group differences for sagittal plane hip range or motion (SROM), peak hip flexion and extension angles, and peak and mean activation of the Gmax and Gmed. Effect sizes (ES) were calculated using the mean change between level ground and each incline and decline walking condition between groups, and interpreted using Cohen's d. RESULTS: There were no significant differences between groups for demographics or clinical characteristics, and no significant interactions for group and walking condition. However, significant main effects for walking condition were found for all biomechanical and neuromuscular variables ($p \leq 0.05$). Moderate to large ES for SROM at 5 degree decline (ES=0.78), 5 (ES=0.84) and 10 (ES=0.98) degree inclines, peak hip extension at 5 degree decline (ES=0.61), 5 (ES=1.03) and 10 degree incline (ES=1.21), peak (ES=0.77) and mean (ES=0.81) Gmax activation at 10 degree incline, and peak Gmed at 5 (ES=0.57) and 10 (ES=0.58) degree inclines between FAI and healthy controls. CONCLUSIONS: Moderate to large ES suggest that more challenging walking tasks may be required to observed biomechanical and neuromuscular differences between individuals with FAI and healthy, asymptomatic controls, which may further our understanding of the mechanisms of disease.

P-C-48: History-dependence of muscle slack length in humans: effects of contraction intensity, stretch amplitude and time

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BACKGROUND AND AIM: The slack length of a relaxed skeletal muscle can be reduced by contracting the muscle isometrically at short lengths ("contract-short conditioning"). This study explored how the effect of contract-short conditioning on muscle slack length can be modified by (a) the intensity of the conditioning contraction, (b) the delay between the conditioning contraction and measurement of muscle slack length, and (c) the amplitude of a stretch delivered to the relaxed muscle after the conditioning contraction. METHODS: Muscle fascicles in the human vastus lateralis muscle were observed with ultrasound imaging in 10 healthy participants (26.4 years +/- 5.9 (SD)). The knee angle at which muscle fascicle slack was taken up was used as a proxy for muscle slack length. RESULTS: Conditioning the muscle with voluntary isometric contractions at short muscle lengths reduced vastus lateralis muscle slack length, measured 60 seconds later, by a mean of 10°. This effect was independent of contraction intensity over the range of contraction intensities from 5% to 100% maximal voluntary contraction. The effect was largest when first observed (5 seconds after the contraction), decayed about

one-third by 60 seconds, and then remained nearly constant at least until the last observation 5 minutes after the contraction. A slow stretch given to the relaxed muscle after contract-short conditioning increased muscle slack length (i.e., reduced the effect of contract-short conditioning). Muscle slack length increased non-linearly with stretch amplitude. Very large stretches (> 30 degrees, and possibly as large as 90 degrees) were required to completely abolish the effect of contract-short conditioning. CONCLUSIONS: These findings show that isometric contractions at short muscle lengths create bonds which form part of the shortest continuous longitudinal structures in the muscle. It is likely these bonds form in intracellular structures, suggesting that the slack length of the human vastus lateralis muscle is determined by intracellular structures, at least after contract-short conditioning. The bonds are remarkably persistent, lasting for many minutes and completely broken only by very large amplitude stretches. The phenomena described here share some characteristics with, and may be caused by similar mechanisms to, passive force enhancement and muscle thixotropy.

P-C-49: Effect of rocker sole design features on dynamic stability during gait in healthy people

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BACKGROUND AND AIM: Rocker sole (RS) shoes are prescribed for treating diabetic foot and preventing recurrence and have been showed to be effective in reducing forefoot planter pressure (Brown et al. 2004), and a previous study has examined RS designs that were effective in reducing plantar pressure in terms of apex angle, apex position, and rocker angle (Chapman et al. 2013). In contrast, RS had negative effect on control of balance (Albright et al. 2009, Kimel-scott et al. 2014). Diabetics have reduced balance and gait ability. Accordingly, it is necessary to investigate the effect of different designs of RS on walking stability, however there are few studies in this area. Therefore, the purpose of this study was to investigate the features of RS design that affect dynamic stability during gait. METHODS: Twenty healthy young people, 10 male and 10 female participated in this study. The exclusion criteria were a history of any musculoskeletal/neuromuscular disease. Prior to participation, the subjects provided written informed consent. A 6-camera Vicon motion analysis system at a sampling frequency of 100 Hz (Vicon nexuses, Vicon Motion Systems Ltd., Oxford, UK) was used to capture motion trajectories of each subject during level walking (10m). Participants were asked to walk at a comfortable speed. The influence of RS design was investigated using five different types of shoes and a control shoe. Five types of rocker shoes were manufactured: R60-95 (apex position was 60% of the shoe length with an apex angle of 95°), R60-110 (60% apex position, 110° apex angle), R60-70 (60% apex position, 70° apex angle), R50-95 (50% apex position, 95° apex angle) and R70-95 (70% apex position, 95° apex angle). Walking trials with the control shoe were recorded initially followed by walking with five experimental shoes in a random order. Dynamic stability during gait was quantified by the margin of stability (MOS) method, and the lateral MOS (LMOS) was calculated. Statistical analyses were conducted using two-way split-plot ANOVA (RS design as the within subject factor and gender as the between subject factor) and the Bonferroni post-hoc test (α=.05). RESULTS: The main effect of gender was significant, $F(1, 18) = 7.29$, $p < 0.05$, as was the main effect of RS design, $F(5, 90) = 5.50$, $p < 0.05$. The interaction of these two factors was not significant, $F(5, 90) = 18.08$, $p = 0.33$. The post-hoc test showed that LMOS was significantly increased from R60-70 compered to the control shoe. CONCLUSIONS: The results of this study indicated that RS affects dynamic stability during gait. Particularly, there was an effect on dynamic balance as apex

angle increased. Previous studies have reported that the LMOS during gait in destabilizing environments increased in healthy adults. Therefore, RS with a small rocker angle has a risk of impairing lateral dynamic stability during gait which means that it is necessary to carefully adjust rocker angle when using RS for patients with impaired control of balance.

P-C-50: Machine-Learning Insights for Postural Pattern Analysis

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Background and Aim: Based on our ISEK 2018 presentation, we provide deeper insights into the additional focus that machine-learning techniques bring to the study of musculoskeletal disorders (MSDs) in office workers. These machine-learning techniques, when combined with three symptom classification systems, let us uncover patterns describing movements associated with risk and reduction of fatigue and pain in office workers. While the risks of static and extreme posture are known, the association between specific movement types and repetition of identified movements and the expression of MSDs is uncertain. This work uses computational pattern discovery to identify patterns shown to be associated with the expression, or avoidance, of fatigue and pain within a group of volunteer participants performing desk-based work in a simulated office setting. Methods: Ten working-aged adults volunteered for one-hour data entry tasks wearing wireless 2D inclinometers on the head and upper back to capture accurate deviations recorded during tasks using three workstations: a seated desk and two desks that automatically alternated between standing and seated heights. Standing lasted 6 or 9 minutes of a 20-minute cycle. Following each recording, participants reported perceived back pain, neck pain and fatigue on a 10 cm Visual Analogue Scale indicating the degree of agreement of each value for each participant and workstation. Since these perceptions are known MSD precursors, postural deviation patterns could be key. Postural patterns (sequences) were created by combining the raw postural states in a given window length where each pattern had an associated perceived symptomology. These patterns were evaluated under two machine learning systems and with three quantization strategies: RULA, the Rapid Upper-Limb Assessment; the standard provided by the INRS (Institut national de recherche et de sécurité in France) and unquantized raw angular position. Identified patterns that provide a high degree of accuracy in identification of fatigue or pain status of the head or neck were extracted through a 10-fold cross-validation technique in which each subset of the data was studied for accuracy of identification when the remainder of the data was used for machine-language training. The underlying physical motion associated with these patterns was then identified and related to the movement of the relevant body segments. The salience of these patterns and the efficacy of their extraction were then compared against the purely statistical analysis provided in our 2018 report. Results: The machine learning analysis has produced a variety of patterns providing a context of which patterns are associated with fatigue and/or pain across the set of participants. Analytic results allow a discussion of the efficacy of pattern-finding using purely statistical methods versus machine learning techniques, with a focus on the ability of the discovered patterns to be interpreted in light of the underlying physiological model. Discovered patterns were compared to reveal trends in the types of patterns that the learning systems evaluated as pain and fatigue risk vs. avoidance. Patterns were also evaluated between workstations, providing insights about the key differences in movement between sitting and sit-stand workstations. Machine-learning revealed varying

patterns which force further reflexion and proved much more efficient in identifying salient patterns. Conclusions: Machine-learning based analysis provides a deeper objective measurement which supports the exploration of links between postural gesture patterns and perceived MSD risk indicators.

P-C-51: Effect of heel gel insole on joint movement during gait

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BACKGROUND AND AIM: Footwear is a tool to improve gait performance of patients with functional disorders. A soft heel in footwear is assumed to reduce the shock of force from the ground after heel contact, and thus protect the joints while walking. In the medical field, a high viscosity gel insole is widely used to treat skin at the heel due to its large load distribution. Gel insoles that are comfortable to wear but unstable in their functionality may provide a relaxed feeling, but limit heel rocker functions. The aim of this study is to determine the effect of heel gel insole on gait performance, kinetically. METHODS: Sixteen young healthy participants, who provided written consent, were recruited, and the institutional review board approved the study. A rigid and a soft heel gel insole were provided. To nullify the effect of sole thickness, the thickness of the rigid insole was adjusted to match that of the compressed soft gel insole by a body weight. Same footwear but different the insoles were used in the measurement. Three-dimensional (3D) coordinates for reflective markers and ground reaction force was obtained on a treadmill at speeds of 0.8 and 1.0 m/s respectively, in random order. Sampling rate was 100 Hz for the marker trajectories and 1000 Hz for the ground reaction force. A plug-in-gait, full body AI model with 39 markers on anatomical landmarks was used. Ground reaction force data and marker positions were low-pass-filtered using a Butterworth filter with a cutoff frequency of 6 Hz and 200 Hz respectively. Joint angle and movement during stance phase were calculated and represented as 100% Stance Phase (SP). The joint movement was normalized by body weight. The difference of joint angle and movement at every 10% SP between rigid insole and gel insole were tested by paired t-test. RESULTS: Strides in gait did not show any differences between the two conditions. Additionally, no difference was found in any joint angle either, and similar patterns were visible during the stance phase. At a speed of 0.8 m/s, the gel condition exhibited significant higher ankle plantar flexion during 30% and 40% SP (30% SP: rigid 0.45ą0.40 Nm/kg gel 0.58ą0.39 Nm/kg, 40% SP: rigid 0.68ą0.42 Nm/kg gel 0.84ą0.42 Nm/kg,). Ankle abduction moment also showed an increase in the gel condition during 20, 30, 40, and 50% SP. Neither the hip nor knee movements showed any significant difference. CONCLUSIONS: This study did not show any evidence that soft gel insole has shock absorption function, as the statistical differences in hip and knee extension movement. Our findings showed an increase in the plantar flexion and abduction moment at the early stance phase. These results indicate that compression of the gel insole might affect heel rocker function and increase ankle moment at the mid-stance phase.

P-C-52: Elastic bounce of the body in unilateral transfemoral amputees with running-specific prosthesis

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BACKGROUND AND AIM: Running-specific prostheses (RSPs) have allowed unilateral transfemoral amputees (uTFAs) to run using the alternate elastic bounce achieved with affected and unaffected limbs (AL and UL, respectively). The elastic bounce is achieved through negative external work to absorb the total mechanical energy of the body center of mass (Etot) after landing, and positive external work to restore the Etot before take-off. As the durations of negative and positive Etot flows correspond to braking time (Tb) and push-off time (Tp), respectively, the ratio (Tp/Tb) indicates the elastic behavior of the musculoskeletal system. In non-amputees, the Tp/Tb ratio would approach unity (Tp/Tb = 1) at higher running speeds (15 km/h ~), indicating an ideal elastic bounce of the system without hysteresis. However, information regarding the elastic bounce of the body in uTFAs wearing RSPs is scarce. This study aimed to evaluate the Tp/Tb ratio in the UL and AL of uTFAs across a range of running speeds. <P>METHODS: Eight uTFAs wearing RSPs ran on an instrumented treadmill at incremental speeds (30%, 40%, 50%, 60%, 70% and 80% of the average speed of their 100-m personal records). We measured the ground reaction forces at 1000 Hz, where Etot in the sagittal plane was calculated as the sum of potential and kinetic energies. In the present study, we determined Tb and Tp from the increment and decrement phases of Etot, respectively (Figure 1-A). Then, we analyzed 10 consecutive steps and averaged 5 steps of each limb (AL and UL) to determine the Tp/Tb ratio at all speeds. We performed two-way ANOVA (two limbs Ũ six speeds) to compare the Tp/Tb ratio between the UL and AL at different speeds. If a significant main effect was observed, we performed a Bonferroni post-hoc multiple comparison. Statistical significance was set at $P < 0.05$. <P>RESULTS: As shown in Figure 1-B, significant main effects of the speed ($P < 0.01$) and interaction effects between the limb and the speed ($P < 0.01$) on Tp/Tb were observed. However, no significant main effect of the limb was observed. The Tp/Tb ratio in the UL tended to decrease as the speed increased up to 80% speed. Consequently, the Tp/Tb ratio in the UL at 80% speed approached unity (Tp/Tb = 1). However, no change was observed in the AL across the range of speeds in which Tp/Tb was not unity (Tp/Tb ≈ 1.2). Although the Tp/Tb ratio in the UL was significantly greater than that in the AL at 30% speed, the Tp/Tb ratio in the UL was significantly smaller than that in the AL at 70% and 80% speeds. <P>CONCLUSIONS: As the Tp/Tb ratio indicates the elastic behavior of the musculoskeletal system, the Tp/Tb ratio in the UL tended to be unity at higher running speeds, indicating an ideal elastic bounce of the system. However, the Tp/Tb ratio in the AL remained nearly constant (Tp/Tb ≈ 1.2) at all speeds, indicating that the elastic bounce of the body using AL was accompanied with hysteresis due to its mechanical constraints.

P-C-53: The pattern of pressing the floor with the Phalanges and Metatarsals of the Foot during Gait

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[Background and aim] We has been measured for the floor pressing force (FPF) vector with the toes (1st toe, 3rd toe, 5th toe) and metatarsal head (1st metatarsal head, 5th metatarsal head) during gait. (Arisue et al. 2018) No research on the patterns how pressing with toes during gait. The purpose of this study was to classify the pattern of pressing the floor with each part of the toes (1st toe, 3rd toe, 5th

toe) and metatarsal head (1st metatarsal head, 5th metatarsal head) during gait. [Participants and Methods] Nine college students without history of orthopedic disease participated. The participants walked 3 times on a flat straight road of about 8m. We measured the FPF vector for right toes (1st toe, 3rd toe, 5th toe) and right metatarsal head (1st metatarsal head, 5th metatarsal head), right heel. We used the sensors, attached the acrylic plates (10 mm Ũ 10 mm Ũ 2 mm) to 3-axis force sensor (Tec Gihan Co., Ltd.), for measuring the FPF vector (anteroposterior component, lateral component, vertical component) of each toe. We set the sampling frequency of the sensors to 100 Hz. We specified a walking cycle from the right heel contact to next right heel contact. We normalized with the time taken for a walking cycle as 100%. When the positive and negative peak values were converted to absolute values, the larger peak value was extracted. Hereafter, we expressed the time of the extracted value as the anteroposterior peak time, the lateral peak time, the vertical peak time. We normalized the peak value of the extracted value with the body weight of each participation. The peak values and the peak times obtained through 27 trials (9 participants x 3 trials) were examined using cluster analysis, adopting the Ward method. [Results] As a result of the cluster analysis, each component can be classified. Focusing on classified vertical component, they differed peak time. A tendency for pressing the floor with the toes was obtained. [Conclusion] The peak values and the peak times of the FPF vector during gait were classified. We showed that we could evaluate how toes press the floor during gait.

P-C-54: Inter-joint coordination variability and kinematics in basketball free-throw shooting

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A decrease of error and variability in goal-directed movements is recognized to improve the performance of sports such as basketball shooting or darts throwing. Understanding the strategy of sports experts that minimizes the variability of movements while dealing with intrinsic noise is beneficial. Basketball shooting, especially free throw, is a typical sports movement in which reducing motor variability improves the performance. Our previous study focused on the ball trajectory and clarified skilled strategy of ball release [1]. However, how skilled players control their joints to produce the required release variables in free-throw shooting is still an open question. The aim of this study is to clarify inter-joint coordination variability and kinematics in basketball free-throw shooting. Eight male collegiate basketball players participated in the experiment. The participants provided written informed consent prior to the experiment and the experimental procedure was approved by the Ethics Committee of the Graduate School of Arts and Sciences of the University of Tokyo. Participants made 50 shots in the experiment from the free-throw line after warm-up. The coordinates of the reflective markers attached onto the body landmarks and the ball were recorded using a 16-camera motion capture system at a sampling rate of 200 Hz. Inter-joint coordination variability between trials was quantified from 0 (random variability) to 1 (identical maximum consistency) using vector-coding method [2]. The coordination variability varied greatly between participants in most of phases. However, the coordination variability between wrist and the other joint (i.e. wrist-elbow, wrist-shoulder, and wrist-MP) decreased to minimum toward the ball release time for all participants. In addition, the decrease in the coordination variability was common for both success trials and miss trials. Regardless of whether the shot result was successful or unsuccessful, the inter-joint coordination of wrist-elbow, wrist-shoulder, and wrist-MP joints was most consistent between trials when the ball was released. This is

consistent with the fact that the inter-joint coordination of wrist-elbow increased consistency toward a ball release time in free-throw shooting [3]. A compensatory interaction of joints along the kinematic chain has been suggested to minimize the variability of release parameters [4]. Therefore, it is suggested that the coordination of the wrist joints at the appropriate timing according to the movements of the other joints is important for improving the reproducibility of the ball release in basketball shooting. Reference [1] Nakano et al., Hum Mov Sci, in press. [2] Tepavac and Field-Fote, (2001). J Applied Biomech. 17(3): 259-270. [3] Mullineaux and Uhl, (2010). J Sport Sci. 28(9): 1017-1024. [4] Bartlett et al., (2007). Sports Biomech, 6(2): 224-243.

P-C-55: Effect of hip flexion angle on the stiffness of the adductor longus muscle during isometric hip flexion and extension

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[Background] The adductor longus (AL) muscle has an important function in hip flexion and extension, as well as hip adduction. As the hip flexion angle increases, the changes in the moment arm length of the AL muscle influences the change in its function between hip flexion and extension. The AL muscle injuries may be correlated with activities involving hip flexion and extension, such as kicking. However, the mechanical properties of the AL muscle during hip flexion and extension are not yet clarified. [Purpose] This study examines the effect of the angle of hip flexion on the stiffness of the AL muscle during isometric hip flexion and extension. [Method] Seventeen healthy, male participants were recruited for this study. All subjects performed the submaximal voluntary contraction (MVC) task at 0%, 25%, 50%, and 75% during isometric hip flexion following the MVC task at 0°, 40° and 80° hip flexion angles. In addition to hip flexion task, 7 subjects performed the submaximal voluntary task during isometric hip extension. The shear modulus of the AL muscle was considered as an index of muscle stiffness. It was measured using ultrasound shear-wave elastography (SWE), during two tasks at each contraction intensity and for each hip flexion angle. In addition, to exclude the effect of hip flexion torque difference between each hip flexion angle, the normalized shear modulus of the AL muscle was divided by the value of the hip flexion torque at 75% of MVC. The shear modulus of the AL muscle was analyzed using a two-way (hip flexion angle Ũ contraction intensity) ANOVA with repeated measures. For the normalized shear modulus, one-way (hip flexion angle) ANOVA with repeated measures was used. The level of statistical significance for all comparisons was set at $P = 0.05$. [Result] During hip flexion, a significant interaction of the hip flexion angle and contraction intensity of the shear modulus of the AL muscle was observed ($P < 0.05$). It was observed that for each contraction intensity, the shear modulus of the AL muscle at 0° was significantly higher than that at 40° and 80° of hip flexion angles. ($P < 0.05$). The normalized shear modulus of the AL muscle at 0° angle was significantly higher than at 80° angle of hip flexion. Conversely, during hip extension, a significant interaction was not observed ($P > 0.05$). Additionally, the normalized shear modulus of the AL muscle was not significant between each angle of hip flexion. [Conclusion] These results suggest that during hip flexion, the angle of hip flexion affects the stiffness of the AL muscle. Therefore, during isometric hip flexion, the mechanical stress on the AL muscle may be higher at the 0° angle of hip flexion.

P-C-56: Association between lower-limb joint loading pattern and center of pressure during squat exercise in subjects with anterior cruciate ligament reconstruction

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BACKGROUND AND AIM: Loading pattern of lower limb joints during squat exercise was altered after anterior cruciate ligament (ACL) reconstruction. Knee extension moment during squat was lower in subjects with ACL reconstruction compared to healthy control subjects, while hip and ankle extension moment was greater in those with ACL reconstruction. However, it is not clear how the lower-limb joint loading pattern alters after ACL reconstruction. The position of center-of-pressure (COP) would be related to lower-limb joint moment because the COP position affects the lever arm of joint moment. The purpose of this study was to clarify the association between lower-limb joint loading pattern and COP position during squat exercise in subjects with ACL reconstruction. METHODS: Nine subjects (8 female, 1 male) who had undergone unilateral ACL reconstruction participated in this study (age 24.0 ą 2.9 years, height 164.8 ą 7.4 cm, weight 56.9 ą 9.1 kg, time since surgery 7.6 ą 3.1 years). Participants stood with their feet shoulder-width apart on two force plates, one for each foot. Then, 3 sets of 5 continuous double-leg squats were performed at a constant pace (2 s for descent and ascent phase). Participants were instructed to squat dawn to a level where their thighs were parallel to the floor. Hip, knee and ankle extension moments were analyzed using a motion analysis system with seven high-speed digital cameras and synchronized force plate data. To assess the loading patterns, hip/knee extension moment ratio and ankle/knee extension moment ratio were calculated. In addition, anterior-posterior (AP) COP position was calculated. AP COP position was expressed relative to foot length and set zero at heel marker. Moment ratios and AP COP position were averaged through descent phase and the average values were used for statistical analysis. Paired t-test was used to assess inter-limb differences. Pearson's product correlation coefficient was used to assess the associations between moment ratios and AP COP position. The statistical significance level was set at $P < 0.05$. RESULTS: There were no significant inter-limb differences in hip/knee extension moment ratio, ankle/knee extension moment ratio and AP COP position ($P = 0.171$, $P = 0.165$ and $P = 0.086$). Hip/knee extension moment ratio was significantly correlated with AP COP position ($R = 0.679$, $P = 0.002$, Fig. 1a). Ankle/knee extension moment was also significantly correlated with AP COP position ($R = 0.893$, $P < 0.001$, Fig. 1b). CONCLUSIONS: The findings of the present study suggest a possibility that subjects with ACL reconstruction alter lower-limb joint loading pattern by changing AP COP position. More anterior position of COP was associated with greater hip/knee extension moment ratio and greater ankle/knee extension moment ratio. Future study should examine the effect of changing COP position on the lower limb joint loading pattern in subjects with ACL reconstruction.

P-C-57: Kinematic and kinetic features of walking deviating from inverted pendulum prediction

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BACKGROUND AND AIM: Vertical ground reaction force (vGRF) at mid-stance during walking is predicted by the combination of gravitational and centripetal acceleration requirements over walking speed when walking using an inverted pendulum (IP) mechanism (Usherwood, 2012). This study aimed to clarify the characteristics of the kinematics and kinetic profiles while walking in the subject whose measured vGRF values at mid-stance deviate from the theoretical value for the walking using IP mechanism. We also examined the difference in the number of participants with large and small measured values compared to the theoretical value in the elderly and young people. METHODS: One hundred twenty-nine older people and 108 younger people participated in this study. Fifteen infrared cameras and nine force plates were used to record kinematic and kinetic data during five comfortable walking, respectively. The joint angles were calculated using the inverse kinematics methods. The joint angular excursions were derived from the joint angles of each joint. We defined that the mid-stance was timing when the location of the CoM reached just above that of the center of pressure in the progression direction. The theoretical vGRF value for IP walking was calculated from the amplitudes of the gravitational and centripetal acceleration for walking speed. If the measured vGRF value exceeds the boundary of theoretical value, the trial was classified as a high force (HF) group. The others were classified as low force (LF) group. As a representative of each group, the top 30 subjects that have a large deviation from the theoretical vGRF value were extracted. An unpaired t-test was performed to analyze the difference in the kinematics and kinetic profiles between the extracted subjects in HF and LF groups. A chi-squared test was used to compare the number of elderly and young people between HF and LF groups. Statistical significance was accepted for values of $p < 0.05$. RESULTS: HF groups had a significantly smaller amplitude of GRF and CoM movement in the sagittal plane, joint angular excursion of the hip joint, and that of the knee joint in initial contact to late stance compared to those of LF group. Also, HF groups had significantly larger ankle dorsiflexion excursion in mid-swing to terminal swing. The number of the HF group in the older adults had considerably more than that of the young people. CONCLUSION: The degree of deviation of the measured vGRF value at mid-stance from the theoretical value for IP walking affected the amplitude of the CoM movement, joint angular excursion, and GRF generation during walking. Notably, these in the HF group were consistent with the characteristics of older people reported in the previous study. Therefore, older adults might have a high probability of becoming the HF group. This study suggested that the kinematic and kinetic profiles during walking were evaluated only using the values of the vGRF and walking speed at mid-stance.

P-C-58: Kinetics of the foot and lower extremity joints during drop-jump tests

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BACKGROUND AND AIM: Previous studies have found that foot-arch mobility may affect adjacent proximal joints and athletic performance. However, many studies have focused on static foot structure, and few studies have focused on foot-arch mobility during dynamic movement. Drop-jump movements are dynamic movements with a high risk of acute trauma. This study aims to clarify the kinetics of the foot and adjacent lower extremity joints during drop-jump movements. METHODS: Twenty healthy adults (10 men, 10 women) performed a drop-jump from a 40-cm

high box onto force plates. We analyzed the foot motion on the contact section of the right foot using the Rizzoli foot model. We analyzed the drop-jump movement in two phases; landing and jump preparation. We analyzed the participants' center of mass (COM), the joint angle of the hip, knee, hallux reflect to forefoot, and the planner angle of medial longitudinal arch (MLA). The gender differences of the joint angle and the differences between the peak timing of the MLA angle and the other parameters were compared using the Wilcoxon signed-rank test. The relationship between the peak angle of the MLA and the lower extremity joints was analyzed using Spearman's rank correlation coefficient. RESULTS: There was no gender difference between the joint angles in the static standing posture. The peak timing of the MLA angle was significantly delayed compared to the peak timings of COM, the angles of hip, knee, and hallux, respectively ($p < 0.01$, $p < 0.01$, $p = 0.03$, and $p = 0.02$). The peak angle of the MLA in the landing phase was significantly higher in women than in men ($p = 0.02$). In men, the peak angle of the MLA in the landing phase was significantly negatively correlated with the varus angle of the knee joint ($r = -0.6$). CONCLUSIONS: The results of this study suggest that the foot-arch mobility may be affected by the displacement of the COM and the external force in dynamic whole-body movement under gravity. It also suggests that even if the static structure of the foot was normal, the mechanical stress on the sole and the knee joint might increase depending on the control function of the foot arch during movement. This study provides fundamental data that may contribute to physical therapy in preventing foot and proximal joint disorders.

P-C-59: Intramuscular difference in mechanical properties of rectus femoris muscle and muscle stiffness-passive knee extension torque relationship during passive knee flexion: An ultrasound shear wave elastography study

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BACKGROUND AND AIM: As per research in various fields, regional differences are known to exist within the rectus femoris (RF) muscle. However, intramuscular differences in muscle stiffness concerning muscle injury or disability are relatively unknown. Additionally, the relationship between muscle stiffness and passive joint torque, a conventional index for evaluating muscle stiffness, does not appear to have been demonstrated in extant studies. Ultrasound shear wave elastography (SWE) can quantify the stiffness of specific muscular regions. This study aims to determine (1) whether intramuscular regional differences exist based on the changes in stiffness in the rectus femoris muscle during passive knee flexion, and (2) whether stiffness and passive knee-extension torque are related. METHODS: Sixteen healthy males (aged 21.8 ą 1.1 years) participated in the experiment wherein the shear modulus of the rectus femoris muscles was measured at seven locations during passive knee flexion at 2°/s within a knee-joint motion range of 0-130°. The shear modulus-passive knee torque relationship of each subject was analyzed via fitting of a least-squares regression line, where an alpha value of < 0.05 was considered significant. To examine the degree of coincidence of the change patterns in different unit indices of elastic modulus and torque, the Sum of Difference (SOD) was calculated by summing the difference between the relative elastic modulus change and relative passive torque change. RESULTS: A significant interaction was observed (location Ũ knee angle) ($P < 0.01$). The stiffness of the rectus femoris muscle increased with the knee flexion angle, and the stiffness of each longitudinal segment was higher in the order of proximal, central, and distal. The stiffness of each transversal segment was

lower for the medial segment as opposed to the central and lateral segments in the flexed knee position (all P < 0.05). The relationship between the shear modulus and passive knee-extension torque was highly linear for all sixteen subjects (P < 0.05). The mean (ą standard deviation) coefficient of determination (R²) was 0.769 (ą 0.106; range: 0.31-0.95). The changing patterns of stiffness and torque of each region (SOD) up to a knee flexion angle of 130° coincided more with the proximal region when compared to the distal region (proximal; 285.94 ą 107.39, distal; 369.20 ą 56.74) (P < 0.01). CONCLUSIONS: The results indicated that the stiffness for the proximal region exceeded that for the central and distal regions during passive knee flexion. The stiffness-torque relationship was highly linear for all the measurement segments, and the changing pattern of the stiffness in the proximal region was similar to that of torque observed during passive knee flexion. Therefore, intra-muscular regional differences exist in the mechanical properties of the RF muscle during passive knee flexion, and the difference is particularly characteristic of the proximal region.

P-C-60: Postural control during quiet standing before and after total knee arthroplasty

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BACKGROUND AND AIM:Improvement in postural control is important for decreasing likelihood of falling in patients with knee osteoarthritis (OA) after total knee arthroplasty (TKA). Previous studies investigated serial changes of the center of pressure (COP) variables during quiet standing after TKA. The COP movement always exceeds and controls the center of gravity (COG) movement during quiet standing. The COP is therefore the controlling variable, the COG is the controlled variable, and the distance between COP and COG (COP-COG) is considered as the error of the postural control system. COG and COP-COG as well as COP should be evaluated to represent the characteristics of postural control. The aim of this study was to examine serial changes of COG and COP-COG variables as well as COP variables following TKA. METHODS:Twenty-one subjects (15 females) diagnosed with knee OA participated in this study (age 72.1 ą 7.6 years, height 155.5 ą 6.6 cm, weight 67.6 ą 14.1 kg, Kellgren-Lawrence grade 3 or 4). Each subject underwent primary TKA and a standard rehabilitation protocol. The tests of postural control were performed before and 3 months after TKA. During the testing, all subjects were instructed to stand on a force plate as stably as possible for a period of 20 s, with their eyes open (EO) and closed (EC). The COP positions in the anterior-posterior (AP) and the medial-lateral (ML) directions were calculated. The COG position in each direction was calculated from COP and ground reaction force data using a zero-point-to-zero-point double integration technique. Then, COP-COG (the distance between COP and COG) in each direction was also calculated. The following postural control variables in each direction were evaluated: (1) the mean velocity (MV) of COP and COG; (2) the root-mean square (RMS) of COP-COG. The paired t-test was used to assess serial changes of postural control during quiet standing following total knee arthroplasty. The statistical significance level was set at P < 0.05. RESULTS:In the AP direction, MV of COG and RMS of COP-COG in the EC condition significantly decreased 3 months after TKA compared to preoperative values as well as MV of COP (COP, P = 0.040; COG, P = 0.029; COP-COG, P = 0.031). There were no significant serial changes in the EO condition (COP, P = 0.693; COG, P = 0.452; COP-COG, P = 0.780). In the ML direction, there was not significant serial change in postural control variables in both the EO

and EC conditions. CONCLUSIONS:Our findings suggest that patients with knee OA after TKA demonstrate improvements in COG and COP-COG variables as well as COP variables in the AP direction when the eyes are closed. On the other hands, postural control variables in the ML direction did not change significantly. Further research is needed to investigate how rehabilitation improves postural control in the ML direction.

P-C-61: Classifying neck pain status using scalar and functional biomechanical variables using functional data boosting

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BACKGROUND AND AIM Predicting the course of neck pain typically requires the use of predictive models. Biomechanical variables have not been used in the development of predictive models in neck pain, unlike in other areas of musculoskeletal and sports research, such as in anterior cruciate ligament injury. Individuals with neck pain have different movement and muscular activation (collectively termed as biomechanical variables) patterns compared to healthy individuals. Incorporating biomechanical variables as covariates into prognostic models is challenging due to the high dimensionality of the data. The primary aim of the present study was to use a state-of-the-art machine learning technique "FDboost" to develop a predictive model of neck pain status using both scalar and functional biomechanical covariates. METHODS Motion capture with electromyography assessment on the sternocleidomastoid, splenius cervicis, erector spinae, was performed on 21 healthy and 26 individuals with neck pain during walking over three gait conditions (rectilinear, curvilinear clockwise (CW) and counterclockwise (CCW)). After removing highly collinear variables, 94 covariates across the three conditions were used to classify neck pain status using functional data boosting (FDboost). The area under the Receiver Operating Characteristic curve (AUC) was used to quantify the model's ability to discriminate the two groups. RESULTS Two functional covariates trunk lateral flexion angle during CCW gait, and trunk flexion angle during CW gait; and a scalar covariate, hip jerk index during CCW gait were selected. The model achieved an estimated AUC of 80.8%. For hip jerk index, an increase in hip jerk index by one unit increased the log odds of being in the neck pain group by 0.37. To simplify the interpretation of the β coefficients of the functional covariates (Figure 1a), the predicted log odds was calculated for each participant when only an instantaneous unit change occurs in a gait cycle (Figure 1b), and the cumulative increase in class probabilities was calculated when a change occurs across all time points (0% to 100%) of gait (Figure 1c). As examples, a 1° increase in trunk lateral flexion in CCW walking alone or a 1° increase in trunk flexion angle in CW walking alone only altered the log odds of being in the neck pain group by <0.02 in magnitude (Figure 1b). At the cumulative level, a 1° increase in trunk lateral flexion angle throughout gait alone reduced the P (group = neck pain) from 0.5 at 0% gait to 0.15 at 100% gait (Figure 1c); and a 1° increase in trunk flexion angle throughout gait alone increased P (group = neck pain) from 0.5 at 0% gait to 0.9 at 100% gait. CONCLUSION Interpreting the physiological significance of the extracted covariates, with other biomechanical variables, suggests that individuals with neck pain performed curvilinear walking using a stiffer strategy, compared to controls; and this increased the risk of being in the neck pain group. FDboost can produce clinically interpretable models

with complex high dimensional data and could be used in future prognostic modelling studies in neck pain research.

P-C-62: Associations between ankle joint stiffness, plantar flexor stiffness, and sprint performance in sprinters

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BACKGROUND AND AIM: Many sprinters and their coaches believe that stiffer ankle joint is beneficial to superior sprint performance. Nevertheless, this has not been experimentally proven. Additionally, we have recently demonstrated that higher passive and lower active muscle stiffness of the thigh muscle (specifically the vastus lateralis) is associated with higher sprint performance. However, it remains unclear whether this is true for other muscles of the leg (such as the plantar flexor). In the present study, therefore, we examined the associations between ankle joint stiffness, plantar flexor muscle stiffness, and sprint performance in sprinters. METHODS: In 18 male sprinters (season-best time of official 100-m race: 10.25-11.61 s), both of the ankle joint stiffness and the shear wave velocity (an index of stiffness) of the medial gastrocnemius (MG) were assessed under passive (resting) and active (contracting the plantar flexors at 20, 50, and 80% of maximal voluntary contraction (MVC) at 15° of the ankle plantar flexion) conditions with the knee fully extended, by using an isokinetic dynamometer and an ultrasound shear wave elastography system. The ankle joint stiffness was calculated from the slope of the torque-angle relationship during short-range stretch of dorsiflexion from 15° of the ankle plantar flexion. RESULTS: The 100-m race time was negatively correlated to the ankle joint stiffness under 50% and 80% MVC but not passive and 20% MVC conditions. The 100-m race time was negatively correlated to the MG shear wave velocity under all conditions. The MG shear wave velocity was positively correlated to the ankle joint stiffness under 50% and 80% MVC conditions, but not under passive and 20% MVC conditions. CONCLUSIONS: The present findings indicate that although high stiffness of the plantar flexors under either passive or active conditions is beneficial to superior sprint performance, the mechanisms for the association of the plantar flexor stiffness with sprint performance would be different between passive or weakly active and moderately-to-high active conditions. Specifically, high stiffness of the active plantar flexor at moderate-to-high contraction intensities contributes to superior sprint performance via increased ankle joint stiffness, whereas the contribution of the plantar flexor stiffness under passive and weakly active conditions would be due to mechanisms other than the ankle joint stiffness.

P-C-63: Muscle stiffness exceeds tendon stiffness at low levels of muscle activation

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BACKGROUND AND AIM: Purposeful physical interactions require appropriate regulation of limb impedance, a quantitative measure of mechanics. Impedance depends strongly on the mechanical properties of musculotendon units within a limb and how they are activated by the nervous system. While studies have quantified limb and joint impedance, it has not been possible to directly measure

contributions from individual muscles and tendons, structures that are altered by aging, injury, or disease. Previous attempts to estimate muscle and tendon stiffness, the static component of impedance, were performed under a restricted set of muscle activations. Different conclusions about the relative stiffness of these structures have been reached, partly because of the different activation ranges over which they have been measured. Quantifying the impedance of muscles and tendons over a range of activation levels will clarify their respective roles in healthy and impaired states. We recently developed a technique for this purpose, allowing us to simultaneously estimate the impedance of the muscle, tendon, and joint. The aim of this study was to quantify the relative contributions of muscle and tendon to the impedance of the ankle over a physiologically relevant range of plantarflexion torques. METHODS: Four healthy young adults were seated with their right foot rigidly secured to a rotary motor, and the ankle positioned at 90°. Small, quick, stochastic perturbations of ankle angle were applied while ankle angle and torque were measured. The muscle-tendon junction (MTJ) between the medial gastrocnemius muscle and the Achilles tendon was imaged using B-mode ultrasound. Subjects generated voluntary plantarflexion torques of either 0, 10, 20, or 30% maximum voluntary contraction during each trial. System identification was used to estimate ankle impedance from the measured ankle rotations and torques, and the frequency response function between ankle rotations and MTJ displacement. The latter, when scaled by the Achilles tendon moment arm, represents the ratio of the net musculotendon impedance to muscle impedance - a relationship we refer to as the impedance ratio. Muscle and tendon impedance can be calculated from these experimental estimates. Stiffness, the static component of impedance, is presented below due to its relevance to postural stability. RESULTS: Ankle stiffness increased with voluntary torque, as previously reported. As torque increased, the stiffness of the muscle increased proportionally faster than that of the muscle-tendon unit as indicated by the decreasing stiffness ratio (Fig. 1A). Muscle and tendon stiffness both increased with torque, but the stiffness of the muscle increased proportionally faster than that of the tendon ($p<0.001$), being larger than tendon stiffness for torques greater than ~5 Nm (Fig. 1B). CONCLUSIONS: This is the first simultaneous measurement of muscle, tendon, and joint impedance across a range of activation levels. We found that the Achilles tendon is less stiff than the muscle over most of the tested range. This implies that the stiffness of the ankle is dominated by the mechanical properties of the tendon rather than the muscle over nearly the entire range of physiological activations.

P-D-64: Quantitative assessment of abnormal muscle tome in Parkinson's disease patients using multi-channel surface electromyography

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Background and aim: The Unified Parkinson's Disease Rating Scale (UPDRS) is a widely used scale to assess the motor dysfunction in Parkinson's disease (PD). Although UPDRS is a semi-quantitative scale, the assessment varies among examiners. The motor symptoms are observed as abnormalities of muscle activity caused by dysfunction of the central nervous system. This study aimed to establish a method for quantitative assessment of abnormal muscle tone in PD patients using multi-channel surface electromyography (SEMG). Methods: Eight female PD patients (Age, 75.3ą8.3 years old, Disease duration, 1.6ą2.2 year, UPDRS part III, 18.0ą7.7) and ten healthy female subjects (Age, 73.2ą9.2 years old) were enrolled in the present study. All subjects performed a sustained isometric knee extension in a

10% maximal voluntary contraction (MVC) task for 20 s. Signals recorded by a multi-channel SEMG were analyzed to estimate single motor unit (MU) firing behavior in the vastus lateralis muscle during isometric knee extensor contractions. Results: A total of 247 MUs for the PD patients (affected side = 127, non-affected side = 120), and 88 MUs for the control subjects (dominant side) were acquired for data processing. The affected side in the PD patients exhibited a higher coefficient of variation (CV) of MU firing rates and mean MU firing rates compared with control subjects (26.8ą2.8 vs. 19.8ą2.6 p=0.006, and 13.8ą2.5 vs. 9.6ą2.2, p=0.036, respectively) and strong correlation observed between UPDRS part III and mean and CV of MU firing rates (r=0.8361, p=0.0191, r=0.899, p=0.002, respectively). The non-affected side in the PD patients exhibited a higher CV of MU firing rates compared with control subjects (22.5ą4.1 vs. 19.8ą2.6, p=0.036). Control subjects showed a negative correlation between mean firing rates of MU and MU threshold (r=-0.352, p=0.001), while the affected and non-affected side in the PD patients did not show a negative correlation (r=-0.0818, p=0.361, r=0.0241, p=0.793). Conclusions: PD patients exhibited abnormal motor unit recruitment pattern not only affected side but also non-affected side. Our findings suggested that using multi-channel SEMG examiner can quantitatively assess the abnormal muscle tone in PD patients.

P-D-65: Leg joint limitation hinders the consistency of corticospinal activity between different walking speed

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BACKGROUND AND AIM: Intermuscular coherence analysis of paired surface electromyography (EMG-EMG coherence) is believed to be effective in probing the corticospinal control of walking. A clear effect of walking speed on EMG-EMG coherence remains unknown. Healthy corticospinal control could correspond to different walking speeds by using a common motor unit. However, we assume that the restriction or immobility of joints may hinder the usage of the common motor unit. In the present study, we investigated the effect of knee joint limitation on the consistency of corticospinal activity, between slow and fast walking, using EMG-EMG coherence analysis. METHODS: Eighteen healthy participants were assigned to the control (eight) and orthosis (ten) group. EMG activities (Delsys, 1000 Hz) of the medial gastrocnemius (MG) and soleus (SOL) were recorded during a treadmill (Bertec) walk with a stance phase of 20 steps. Walking speed conditions were 0.9 and 1.8 m/s. A single side knee restraint, using a soft knee orthosis with fittings (REAQER), limited the range of motion within 20-145°. This restraint did not limit flexion, and only the extension was restrained to angular displacements within 0-20°. All subjects provided written informed consent in accordance with the Declaration of Helsinki prior to the start of the proposed investigation. The study was approved by the ethics review committee in the Saitama Prefectural University (No. 29501). The general signal analytical methods were based on the previous study. Paired t-tests were used to evaluate the frequency difference between the walking speeds within groups (control and orthosis) and between legs (restraint side and non-restraint side in the orthosis group). RESULTS: In the control group, the frequency difference was not significant (0.9 m/s = 26.7 Hz, 1.8 m/s = 26.0 Hz, p = 0.83). In the orthosis group, the frequency difference was significant for the restraint side (0.9 m/s = 27.6 Hz, 1.8 m/s = 19.8

Hz, p < 0.05) but not significant for the non-restraint side (0.9 m/s = 19.7 Hz, 1.8 m/s = 22.6 Hz, p = 0.19). CONCLUSIONS: In the present study, the limitation with knee joint extension reduced the beta band of the EMG-EMG intermuscular coherence of synergistic muscle (MG-SOL) from slow to fast walking. Previous study mentioned that corticomuscular activation is modified in healthy subjects after immobilization. The present study suggests that a single side joint limitation would hinder the usage of the common motor unit on each leg side. Bipedal walking is not tightly coupled and the networks responsible for the motor drive on each leg side are selective and independent.

P-D-66: Effect of obesity on the stomatognathic system: electromyographic analysis and maximal molar bite force.

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BACKGROUND AND AIM: The prevalence of obesity grows around the world and worries health professionals. This is an observational study with obese individuals (Group I; n = 20) and eutrophic individuals (Group II; n = 20) matched by age, sex and height. The classification in eutrophic and obese individuals was made through physical examination. The aim of this study was to evaluate how much obesity interferes with the electromyographic activity of the masticatory muscles and the maximal molar bite force. METHODS: The Delsys Trigno TM wireless electromyograph was used for both the static and functional evaluation (rest and maximal clenching) of the masseter, temporal, orbicularis and suprahyoid muscles. The maximum molar bite force was analyzed by the Kratos dynamometer. The data was analyzed statistically by independent t test (SPSS 22.0) after application of normality test (Shapiro-Wilk) and observation of the QQ-plot graphs considering an alpha of 5%. RESULTS: In the analysis of normalized electromyographic data, it was found that the obese group had lower myoelectric activity at rest and in maximum voluntary contraction, with statistical difference only for the activity of the suprahyoid muscles ($p < 0.01$). The results showed that obese individuals had a maximal molar bite force much higher than eutrophic individuals ($p < 0.001$). CONCLUSION: The consolidation of this research will contribute to clarify the influence of obesity on the functions of the stomatognathic, as well as, generating knowledge for the scientific community favoring treatments and prognoses of individuals affected by this disease. ACKNOWLEDGEMENT: FAPESP (2019/10352-8) and National Institute and Technology - Translational Medicine (INCT.TM).

P-D-67: Correlation between Maximal Expiratory Pressure and Electromyographic Activity of the Abdominal Muscles during Forced Expiration in COPD individuals

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BACKGROUND AND AIM: Chronic obstructive pulmonary disease (COPD) causes alterations in the thoracic cavity and in the respiratory mechanics, limiting the diaphragmatic strength during expiration.

Therefore, the abdominal muscles can help mobilize the diaphragm, improving the output of air from the lungs. The objective of the present study was to analyze the correlation between the maximal expiratory pressure (MEP) and the activity of the abdominal muscles in COPD individuals. METHODS: Twenty subjects (10 men, 10 women), with mean age = 65.65 ± 8.11 years and BMI = 24.92 ± 2.97 were selected. The diagnostic criteria for COPD were based on spirometry, which classified the disease in stages II to IV. The respiratory muscle strength was assessed by measuring the MEP. The surface electromyographic (EMG) activity of the rectus abdominis and external oblique muscles were evaluated. The correlation between the quantitative variables was analyzed using the Spearman correlation coefficient, with a significance level of $p<0.05$. RESULTS: The results showed a positive correlation between MEP and the EMG variables of the rectus abdominis and the external oblique muscles in COPD individuals during forced expiration ($p<0.01$). CONCLUSION: The present study suggests a positive correlation between MEP and EMG activity of the abdominal muscles during forced expiration. Consequently, greater EMG activity of the rectus abdominis and oblique external muscles during forced expiration will be required to increase expiratory muscle strength. ACKNOWLEDGEMENT: FAPESP (2016/09921-0).

P-D-68: The interference of malocclusion in the electromyographic activity of children before and after orthodontic correction

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BACKGROUND AND AIM: Characterized as growth and development ale, dental malocclusions may modify the functionality of the stomatognathic system. METHODS: The purpose of this research was to evaluate the electromyographic activity (EMG) of the right (MD) and left (ME) temporal (TD) and left (TE) and right (OD) and left (OE) and suprahyoid (SH) muscles in children aged 6 to 10 years, of both genders, with crossbite, before and after 7 days of removal of the orthodontic apparatus. EMG was analyzed in resting conditions, right and left lateralities, protrusion and maximum voluntary contraction (MVC), as well as in the chewing of consistent (MAC) and soft (MAM) foods using the Delsys electromyograph. RESULTS: The data were normalized and analyzed for $p\leq0.05$ (SPSS software). There was an increase in EMG at rest for DM ($p=0.02$) and ME ($p=0.02$); on the right sidefor MD ($p=0.00$), ME ($p=0.01$) and TD ($p=0.03$); on the left sidefor MD ($p=0.01$), ME ($p=0.00$) and TD ($p=0.04$); in the CVM for MD ($p=0.00$), ME ($p=0.02$) and OE ($p=0.05$); in protrusion for ME ($p=0.02$) and ET ($p=0.02$); in MAC for ME ($p=0.01$) and MAM for ME ($p=0.02$), TD ($p=0.04$) and TE ($p=0.05$). CONCLUSIONS: Thus, it is concluded that, even after the correction of the crossbite with orthodontic apparatus, the electromyographic activity of the analyzed muscles was high, proposing that new evaluations be performed after 6 months, in order to verify possible changes in the performance of the stomatognathic system.

P-D-69: Effect of dry needling technique on masseter muscle relaxation in individuals with muscle temporomandibular disorder

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BACKGROUND AND AIM: The temporomandibular disorder (TMD) is characterized by involving all the muscles of the face, as joints and structures, harming all the stomatognathic system. The aim of this study was to evaluate the performance of the masseter and temporal muscles before and after seven days of using the dry needling technique, in individuals with TMD of muscular origin. 21 individuals aged between 21 and 60 years, of both genders participated in this research. METHODS: The dry needling technique was performed at the trigger points of the masseters using an acupuncture needle. The effectiveness of dry needling therapy for pain was analyzed using a Visual Analogue Scale (VAS). The MyoSystem Br1_P84 electromyograph was used for the postural conditions of the mandible of the masseter and temporal muscles. The maximum molar bite force was analyzed by Kratos dynamometer. The data were submitted to statistical analysis using the GraphPad Prism 6.0 software ($p \leq 0.05$). RESULTS: The results showed decreased pain ($p < 0.0001$); increase in the right ($p = 0.015$) and left ($p = 0.008$) molar bite force. The analysis of normalized electromyographic data showed statistical difference only for the left masseter in the right laterality ($p < 0.0001$). CONCLUSION: The dry needling technique was effective in muscle relaxation with significant improvement in painful symptoms and better performance of the stomatognathic system, favoring treatments of individuals affected by this disease.
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P-D-70: Evaluation of the stomatognathic system by means of electromyography in individuals after stroke

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BACKGROUND AND IAM: Stroke is a cerebrovascular disease that occurs due to a hemorrhagic or ischemic event. The objective of the research was to analyze the electromyographic signals of the masseter and of the right and left temporal muscles of individuals after stroke. METHODS: This is a cross-sectional study that evaluated the stomatognathic system of post-stroke patients. Twelve individuals aged between 40 and 80 years participated in the study and were divided into two groups (G1: <60 years) and (G2:> 60 years). To assess the electromyographic activity, the electromyograph Trigno TM Wireless System was used and the analysis was performed recording the masseter (right and left) and temporal (right and left) muscles during the condition of rest, protrusion, right and left laterality. , parafilm tightening, parafilm chewing, peanuts and raisins and muscle fatigue. The data were tabulated and analyzed statistically by the program SPSS 22.0 for Windows. RESULTS: The results obtained from the masseter (right and left) and temporal (right and left) muscles at rest, protrusion, right and left laterality, tightening of the film, chewing of the film, peanuts and raisins and muscle fatigue show that the activation data muscle strength were not statistically significant. CONCLUSION: It is concluded that the clinical conditions analyzed in this study by means of EMG did not present a

significant difference in post-stroke patients aged less than or over 60 years. ACKNOWLEDGEMENT: FAPESP and CAPES.

P-D-71: Analysis of electromyographic activity of respiratory and accessory muscles after stroke and comparison between ages

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BACKGROUND AND AIM: This study evaluated and compared whether age among individuals after stroke has an influence on the electromyographic activity of respiratory and accessory muscles. METHODS: For this, twelve groups were divided into two groups: Group (G1) under the age of 60 (n = 6) and group 2 (G2) over the age of 60 (n = 6). The Miosystem BR-1® electromyograph was used to analyze the electromyographic activity (EMG) of the following muscles: right sternocleidomastoid, main major pectoralis, right external intercostal, right diaphragm, right diaphragm, right anterior serratus, right anterior serratus, right oblique and straight abdominal. Under the following conditions: 1) respiratory rest, for 10 seconds; 2) maximum inspiration of the residual volume, for 4 seconds; 3) maximum breathing of the total lung capacity for 4 seconds and 4) breathing cycle for 10 seconds. RESULTS: The data were tabulated and submitted to statistical analysis ($p < 0.05$). A statistical difference was observed only for the external intercostal muscle, in the condition of respiratory rest ($p = 0.03$ and $p = 0.04$) for both groups, demonstrating that such muscle has hyperactivity, even if in the resting condition. CONCLUSION: We can conclude that only the external intercostal muscle, in the condition of respiratory rest between the groups, presents hyperactivity. ACKNOWLEDGEMENT: FAPESP and CAPES.

P-D-72: A novel approach to evaluate the excitability of corticomotor pathways to the pelvic floor muscles in females

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Hypothesis/ aims of study: The aim of this study was to determine whether a novel approach to transcranial magnetic stimulation (TMS) generates MEPs in the female pubovisceral (PV), bulbocavernosus (BC) and external anal sphincter (EAS) muscles that are distinct from each other and from larger nearby muscles. Study design, materials and methods: Cis-females over 18 years of age were recruited and were instrumented with adhesive EMG electrodes (Delsys-D.E.2.1) on the skin overlying the tibialis anterior (TA), the adductor longus (ADD) and the lateral abdominal wall (LAW) on the right side. A pair of custom suction electrodes was placed intravaginally, with the active pole on the lateral sidewall over the bulk of the PV muscle and the reference pole located anteriorly over the pubis, just within the introitus to avoid crosstalk from the urethral sphincters. Adhesive electrode pairs, trimmed to be 10mmX20mm, were placed unilaterally on the perineal skin over the BC and the EAS,muscles on the right side. A common reference electrode was placed on the skin overlying the right anterior superior

iliac spine. TMS pulses (Magstin® 200) were applied over the vertex using a double cone coil; resting motor threshold (rMT) was determined using TA as the target muscle. Twelve TMS pulses were then delivered at 1.3*rMT and MEPs were recorded from all instrumented muscles while participants remained relaxed. Next, five TMS pulses were delivered to the same location at 1.3*rMT while participants gently contracted their PFMs. Outcome variables were MEP peak-to-peak amplitude and latency measured from ensemble-averaged MEPs recorded while the PFMs were relaxed, and mean cortically mediated silent period (cSP) measured across the five MEPs recorded while the participants contracted their PFMs. EMG data from individual trials were low pass filtered at 30Hz, and cross-correlation functions were computed between pairs of channels to determine the peak of the cross-correlation function (rmax) and the time lag (tl) associated with that peak. The 95% confidence intervals (95%CIs) for the mean tl between pairs of channels were used to evaluate whether or not distinct signals were being recorded. Results: Thirty-one women participated, with a mean age of 30.1 (±6.6) years. Seven participants reported symptoms of vulvar pain including provoked vestibulodynia (n=3) and deep dyspareunia (n=4). The mean (95%CI) of the three outcomes of interest, as well as the rmax, and tl computed between pairs of channels are presented in Table 1. The confidence intervals for tl did not include zero for any cross-correlation functions computed between pairs of EMG channels. Concluding message: This novel approach for generating MEPs from the PFMs appears to be effective for generating distinct MEPs from the PV, BC, and EAS muscles that are also unlikely to be contaminated by crosstalk from the nearby adductor or abdominal muscles. The capacity to assess excitability of corticomotor projections to the different muscular components of the female pelvic floor may be important to our understanding of several conditions, including dyspareunia, urinary urgency, urgency incontinence, dyssynergic voiding and more, where altered corticomotor excitability is suspected to play an important role.

P-D-73: Differences in common neural drives to ankle muscles between abrupt and gradual gait adaptations in healthy young adults

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BACKGROUND AND AIM: Human walking must be flexible and gait adaptation is a practice-dependent alteration in response to a novel perturbation during gait. The corticospinal tract contributes to the initial processes and storages of gait adaptation. However, no studies have investigated whether the corticospinal contribution differs between gait adaptation conditions. This study aimed to investigate the differences in common neural drives to ankle muscles between abrupt and gradual gait adaptations using coherence analyses of paired surface electromyographic (EMG) recordings. METHODS: Sixteen healthy young adults were subjected to consecutive gait measurements: baseline treadmill gait for 5 minutes, treadmill gait with the perturbation resisting forward movement of the right leg during the swing phase for 10 minutes (adaptation period), and post-adaptation treadmill gait for 5 minutes. Subjects randomly experienced 2 gait adaptation conditions on 2 different days: abrupt (a single, large, abrupt perturbation) and gradual (a series of small perturbations that gradually increased) conditions. To evaluate the common neural drives to ankle muscles, EMG-EMG coherence was calculated from the proximal and distal ends of the tibialis anterior muscle (TA-TA) and the medial and lateral gastrocnemius muscles. The areas under the coherence curve were calculated in the beta (15-35 Hz) and low-gamma

(35-60 Hz) frequency bands during the early and late adaptation periods because these frequency bands are strongly related to the corticospinal drive. Symmetries of swing phase durations and step lengths were compared using repeated measures two-way ANOVA and post hoc comparisons with Bonferroni corrections. To compare the coherence areas, multiple comparisons were performed using Wilcoxon signed-rank tests with Bonferroni corrections. RESULTS: Swing phase and step length symmetries showed significantly greater asymmetry in the abrupt condition than those in the gradual condition in the early adaptation period. In the early post-adaptation period, after-effects of gait adaptations on swing phase and step length symmetries were similarly observed in the 2 conditions, which indicated no significant differences in after-effects between the 2 conditions. TA-TA coherence during the swing phase in the low-gamma band on the perturbed side was significantly higher in the abrupt condition than that in the gradual condition in the early adaptation period, and was significantly higher in the early adaptation period than that in the late adaptation period in the abrupt condition. CONCLUSIONS: The initial abrupt perturbation in the early adaptation period seems to require the corticospinal contribution to resist a larger perturbation, in spite of no differences in after-effects between the abrupt and gradual gait adaptation conditions. These results may support the application of gait adaptation paradigms in clinical rehabilitation in patients with asymmetric gait patterns after central nervous system disorders.

P-D-74: High-definition versus conventional transcranial direct current stimulation: comparison of corticospinal and cortico-cortical excitability and response variability

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BACKGROUND AND AIM: High response variability in transcranial direct current stimulation (tDCS) literature highlights a need to explore different tDCS techniques. Conventional tDCS involves the use of an active electrode over the cortical area of interest and a return electrode over the contralateral supraorbital area. On the other hand, high-definition (HD) tDCS involves the use of a central active electrode placed directly over the cortical area of interest with four surrounding return electrodes arranged in a ring formation spaced equidistant apart surrounding the central active electrode. The main objective in the current study was to compare corticospinal excitability (CSE), cortico-cortical excitability and response variability following conventional and HD anodal (a-tDCS) and cathodal (c-tDCS) tDCS. METHODS: A repeated measure randomised cross-over design was utilised. Fifteen healthy young male volunteers attended randomly in four intervention sessions at least one week apart: 1. conventional a-tDCS, 2. conventional c-tDCS, 3. HD a-tDCS, 4. HD c-tDCS. The tDCS cortical area of interest was the primary motor cortex and were administered at 1mA for 10-minutes with conventional tDCS via 6x4cm active and 7x5cm return electrodes and HD-tDCS via 4x1 ring electrodes positioned 3.5cm apart around the active electrode in a ring formation. Twenty-five single-pulse transcranial magnetic stimulation (TMS) peak-to-peak motor evoked potentials (MEP) were recorded for CSE. Twenty-five paired-pulse MEPs were recorded with inter-pulse interval (IPI) of 3 milliseconds (ms) and twenty-five at 10ms to assess short-interval intracortical inhibition (SICI) and intracortical facilitation (ICF) respectively. Single-pulse MEPs standardised z-values standard deviations represented intra-individual variability. Outcome measures were recorded at baseline and 0-minutes and 30-minutes post-tDCS. RESULTS: Statistical analyses were conducted using SPSS (Version 25.0, IL, USA). One-way

analysis of variance (ANOVA) did not reveal significant differences in baseline values between interventions. Repeated measure ANOVA (RM-ANOVA) reported no significant differences in CSE between conventional a-tDCS and HD a-tDCS but significant differences between conventional c-tDCS and HD c-tDCS 0-minutes post-tDCS. Intra-individual variability was significantly less at 0-minutes following conventional a-tDCS compared to HD a-tDCS and significantly less at 30-minutes following conventional c-tDCS compared to HD c-tDCS. No significant changes were reported in SICI and ICF. CONCLUSIONS: The significance of this current study lies in the novel finding that CSE following conventional tDCS appears less variable compared to HD-tDCS. This is despite reports of increased focality of HD-tDCS compared to conventional tDCS. Reduced intra-individual variability suggests future large-scale tDCS studies addressing response variability should use conventional tDCS to reduce the influence of intra-individual variability ensuring tDCS after-effects are true changes in CSE and cortico-cortical excitability. In addition, the novel results of this current study highlight current technical issues with HD-tDCS particularly under cathodal conditions. With the possibility that a current intensity of 0.25mA in surrounding return electrodes over cortical areas with functional connections to M1 is sufficient to induce an excitatory response, investigation into methodologies for reducing the return electrode current intensity are necessary.

P-E-75: Evaluation of electrical properties of muscle during electrical stimulation

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BACKGROUND AND AIM:At present, electrical stimulation to the living body is used in various fields such as treatment and training.The history of electrical stimulation is very old, and many related studies have been conducted.When electrical stimulation is given from the electrodes on the skin surface, the degree of muscle contraction changes depending on the position where the electrodes are attached.This is due to the relative positional relationship between the electrode and the muscle.The position where muscle contraction is most likely to occur is called the motor point.The motor point is said to be where the nerve enters the fascia or just above the neuromuscular junction.In recent years, stimulators that can stimulate deep muscles have been commercialized.However, it is still unclear how electrical stimulation approaches deep muscles.Furthermore, there is no report comparing the electrical properties of the living body at the motor point and other places.Therefore, the purpose of this study is to quantitatively evaluate the electrical characteristics of the living body during electrical stimulation. METHODS: In order to quantitatively evaluate the electrical characteristics, a two-dimensional map of the electrical characteristics centering on the motor point is created. In this study, "FREUDE" NF-2De manufactured by Technolead was used as a stimulator. FREUDE is a stimulator that can output complex high frequency. FREUDE electrodes were applied to the subjects so that the rectus femoris muscle was stimulated. A 1 ohm resistor was connected in series between the living body and the stimulator. The stimulation voltage to the living body and the voltage applied to the resistance were measured. The stimulation voltage was based on the minimum voltage at which the muscle contracted. Measurements were made for a total of five stimulus voltages: the reference voltage, -20%, -10%, + 10%, and + 20%. RESULTS: The current flowing in the circuit was calculated from the voltage applied to the resistance. The biological impedance during electrical stimulation was calculated from the stimulation voltage and the circuit

current. CONCLUSIONS: The impedance was calculated at nine points around the motor point. From the calculation results, a two-dimensional map of impedance during electrical stimulation was created.

P-E-76: Combined effects of electrical muscle stimulation and voluntary exercise on cognitive performance

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BACKGROUND AND AIM: Electrical muscle stimulation (EMS) enhances muscle glucose metabolism, and EMS can be used as an alternative to voluntary exercise for those who have difficulty to exercise. Acute voluntary exercise improves cognitive performance, particularly at moderate intensity. However, in contrast to voluntary exercise, EMS appears not to improve cognitive performance. The purpose of this study was to examine whether combination of EMS and voluntary exercise improve cognitive performance. METHODS: Seventeen healthy male subjects (Age: 23.2ą 1.4 yr., height: 171.5 ą 6.5 cm, weight: 66.1 ą 10.6 kg) participated in this study. The participants performed Go/No-Go tasks before and after 20 min EMS combined with voluntary exercise. Reaction time (RT) and accuracy of the task was used to assess cognitive performance. The participants performed arm cranking exercise combined with EMS in two conditions. In the EMS with Load (EMS+L) condition, exercise intensity of arm cranking was adjusted to keep heart rate (HR) at 120 bpm. As a Control, the participants performed arm cranking exercise combined with EMS with no load (EMS+NL) condition. Polar HR monitor was used to measure R-R interval data, and natural log-transformed root mean square of successive differences (LnRMSSD) was calculated to evaluate sympathetic nervous system (SNS) activity. RESULTS: Two-way ANOVA revealed a significant interaction of RT ($P < 0.05$). Post hoc analysis indicated that RT decrease in the EMS L condition (Pre: 308 ą 15 ms, Post: 297 ą 16 ms, $P < 0.01$). However, no changes were observed in the EMS NL condition (Pre: 306 ą 22 ms, Post: 311 ą 14 ms, $P = 0.35$). Accuracy of the cognitive task was not affected in both conditions. Decrease in LnRMSSD was greater in the EMS L condition as compared with EMS NL condition ($P < 0.01$), which indicates that SNS activity was grater in the EMS L condition. CONCLUSIONS: The present results suggest that combination of EMS and voluntary exercise improves cognitive performance. Our results also suggest that enhanced SNS activity is associated with cognitive improvement after exercise.

P-E-77: Neuromuscular electrical stimulation superimposed to voluntary movement increases Hoffmann reflex but does not affect maximal voluntary contraction

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BACKGROUND AND AIM: Neuromuscular electrical stimulation (NMES) has long been used to preserve, restore, or enhance skeletal muscle mass and function in both healthy and injured individuals. In the last decades, NMES superimposed to voluntary muscle contraction has emerged as an innovative training mode within sport and rehabilitation (Labanca et al. 2018, Med Sci Sports Exerc), however its

neuromuscular effects on voluntary and reflex contribution to force production are still unclear. The aim of this study was to investigate acute responses in spinal excitability, as measured by the Hoffmann (H) reflex, and in maximal voluntary isometric contraction (MVIC) following NMES superimposed to voluntary isometric contractions (NMES+ISO) compared to passive NMES only and to voluntary isometric contractions only (ISO). METHODS: Healthy young adults (n=8) were required to maintain an ankle plantar-flexor torque of 20% MVIC for 20 contractions (6s/6s rest) during each experimental condition (NMES+ISO, NMES and ISO). A muscle stimulator was used to deliver intermittent electrical stimuli (50Hz, 400µs) over the triceps surae muscle, while the intensity of stimulation was adjusted to match the 20% MVIC for each contraction. During NMES+ISO, current intensity was set to generate half of the torque target and participants were asked to voluntarily contract their muscles to achieve the full torque target of 20% MVIC. Surface electromyography was used to record peak-to-peak H-reflex and motor waves following percutaneous stimulation of the posterior tibial nerve. A test H-reflex intensity was identified on the ascending limb of the H-reflex recruitment curve, while maintaining a constant associated small motor wave throughout the experiment. An isokinetic dynamometer was used to assess MVIC of the ankle plantar-flexors on a semi-reclined position before and after each experimental condition. RESULTS: H-reflex test amplitudes significantly increased by 4.2% and decreased by 6% following NMES+ISO and passive NMES conditions, respectively, compared to baseline values; there was no change in reflex responses following ISO. Neither amplitude of the maximal motor wave or the MVIC torque showed significant changes following each of the three experimental conditions. CONCLUSIONS: These findings indicate that NMES superimposed to voluntary isometric contractions of the ankle plantar-flexor muscles produces acute potentiation of the stretch reflex pathway at spinal level, which could be related to a combination of greater motor neuronal and corticospinal excitability. The findings of the current study provide novel information on the neuromuscular mechanisms underlying electrical stimulation superimposed to voluntary contraction, suggesting that NMES+ISO could represent a more effective training modality compared to passive NMES only and/or voluntary exercise only.

P-E-78: The Effects of Peripheral Neuropathy on the H-reflex of the Triceps Surae Muscles

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Hoffman's reflex (H-reflex, both H/M ratio and H-index) is affected by peripheral neuropathy (PN). The soleus muscle was the most commonly used muscle for H-reflex study in humans. However, there also reports on the H-reflex of the gastrocnemius muscle in people with PN. The Primary Purpose of the project was to test the relationship of H-reflex parameters among the triceps surae muscles and to compare these relationships between people with PN and healthy controls. The Secondary Purpose of the project was to examine the relationship between H-reflex parameters and functional gait. Methods: Thirteen controls and ten individuals with physician-diagnosed PN were recruited for the experiment. In addition to anthropometrics, the outcome variables were 6-minute walk distance (6MWD), duration of the timed up-and-go test (TUG), and H-reflex of the soleus (SO), medial (MG) and lateral (LG) gastrocnemius muscles of right leg during standing. Significance of ANOVA analysis presented with p-value and effect size (Cohen's d). The strength of the Pearson's correlation is presented with correlation coefficient (r) and its associated p-value. Results: H/M of SO was significantly greater than that of both MG ($p<.001$, $d=0.232$) and LG ($p<.001$, $d=0.098$), while no difference in the H-index among the three

muscles was detected. The SO H/M ratio was only significantly (r=.872, p=.001) related to that of the LG in the PN group. However, the SO H/M ratio was significantly associated with that of both MG (r=.886, p<.001) and LG (r=.569, p=.042) in the control group. The only significant relationship observed for the H-index was between MG and LG in the control group (r=.779, p=.002). For 6MWD and TUG tests, the PN group walk shorter distances in the 6MWD test (p=.001, d=1.67) and slower in the TUG test (p=.006, d=1.41). 6MWD significantly reduced with the increase of LG H/M ratio (r=-.721, p=.019) for the PN group. And, TUG increased significantly with the H/M ratios of LG (r=.671, p=.034) and SO (r=.639, p=.047) also for the PN group. There was only one significant linear correlation observed for the control group (TUG reduced with the H-index of MG, r=-.579, p=.038). Discussion and Conclusion: SO H/M ratio was greater than that of the MG and LG in both groups consistent with literature for a healthy population[1]. The magnitudes of the SO H/M ratio were proportional to that of the LG. Better functional gait performance associated with reduced H/M ration in people with PN but with increased H-index in controls[2]. PN affected the H-reflex of the triceps surae muscles and their relationship with gait differently. References Makihara, Y., Segal, R. L., Wolpaw, J. R., & Thompson, A. K. (2012). H-reflex modulation in the human medial and lateral gastrocnemii during standing and walking. Muscle & Nerve, 45(1), 116-125. Zhang, S. Q., Manor, B., & Li, L. (2015). H-Index Is Important for Postural Control for People with Impaired Foot Sole Sensation. Plos One, 10(3).

P-E-79: H-reflex Parameters are Sensitive to the Severity of Peripheral Neuropathy

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Hoffmann-reflex (H-reflex) has been an effective test method to test neuromodulatory processes for healthy and Peripheral Neuropathy (PN) populations [1]. H-reflex shows differences in different postures in healthy and PN populations. The H-reflex parameters (H-index and H/M ratio) could be different based on the severity of PN. The purpose of the project was to examine the influence of PN severity on the relationship between H-reflex parameters and different postures. Methods: Thirty people with PN were recruited in this project. Foot sole pressure sensitivity was assessed with 5.07-gauge monofilaments at the heel, midsole, bases of first/fifth metatarsals, and hallux [2]. H-reflex parameters were collected among prone, standing, heel-contact, midstance, and toe-off (Stimulator: Digitimer Ltd., England; EMG collection: Delsys Inc., USA). In the prone and standing conditions, the H-reflex was elicited by a 500ìs square-pulse constant voltage stimulus. Stimulation started from 5mA with 2mA increments (10s inter-stimulus interval) until the full recruitment curve obtained. In the walking tests, heel-contact to heel-contact step cycle was detected using a footswitch taped under the right heel. 15-20 H-reflexes were evoked at heel-contact, midstance, and toe-off, at 5, 20, and 55% of the step cycle when walking at a self-selected speed. Stimulus intensity was set based on a small proportion (15- 35%) of standing Mmax. The stimuli were given at least 2s apart from one another dispersed randomly over the stride cycle. Results: Participants were separated into the Less (LA), Moderately (MA), and Severely affected (SA) groups based on our observed foot sole sensation and H-index results. Standing H-index was greater than that of the heel-contact (p=.013, d=1.1) and midstance (p=.042, d=1.2) phases in LA. The H-index of LA was greater than that of MA in both the heel-contact (p=.015, d=1.4) and toe-off (p=.044, d=1.7) phases. The H-index of LA was greater than MA (p<.001, d=2.9) and SA (p<.001, d=3.2)

during standing. No group differences for Hmax observed. The Hmax of standing was greater than the heel-contact (p=.031, d=0.5) and toe-off phases (p=.003, d=0.9). The Hmax of prone was also greater than that of the heel-contact (p=.014, d=0.5), and toe-off phases (p=.014, d=0.7). Discussion and Conclusion: The H-index was more sensitive to the severity of PN than the H/M ratio. As the severity of the PN increases, the neural adaptability reduces, and lack of flexibility in the neural system could be detrimental for posture and functional gait among people with PN. References Guiheneuc & Bathien. (1976). Two patterns of results in polyneuropathies investigated with the H reflex. Correlation between proximal and distal conduction velocities. Journal of the Neurological Sciences, 30(1), 83-94. Li, & Manor. (2010). Long term Tai Chi exercise improves physical performance among people with peripheral neuropathy. Am J Chin Med, 38(3), 449-459.

P-E-80: Systematic identification of torque outputs during electrical stimulation of motor points of quadriceps femoris

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BACKGROUND AND AIM: Transcutaneous electrical stimulation can be used to activate quadriceps femoris muscles to produce knee extension torque via seven distinct motor points, which are the most sensitive locations to electrical stimulation over muscle bellies. It remains unclear how the transcutaneous electrical stimulation on different motor points of the quadriceps femoris muscles contribute to the knee joint torque, and how stimulating different combinations of motor points synergistically affects the knee joint torque. Here we systematically investigated the contribution of each motor point of quadriceps femoris muscles to the knee joint torque produced by transcutaneous electrical stimulation. METHODS: Ten able-bodied individuals participated in this study. Transcutaneous electrical stimulation was applied by simultaneously delivering electrical impulses on motor points at any combinations among seven motor points (i.e., totaling to 127 combinations) at two different stimulation intensities while recording isometric knee joint torque. RESULTS: We found that a linear addition of twitch torques induced by single motor point stimulation over-estimated the twitch torques induced by multiple motor point stimulations, suggesting that there were overlaps in muscle fibres activated by each motor point stimulation. Using multiple linear regressions, we identified the contribution of each motor point stimulation to knee extension torque. We found significant differences in contributions to knee extension torque among the motor points. CONCLUSION: The result provides useful information to design rehabilitation using transcutaneous electrical stimulation on quadriceps femoris muscles.

P-E-81: Stimulus phase duration, not waveform, influences the relative recruitment of sensory and motor axons in a human peripheral nerve

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BACKGROUND AND AIM: Neuromuscular electrical stimulation (NMES) is used for rehabilitation following neuromuscular injury or disease to restore function and prevent secondary complications.

NMES is typically delivered to depolarise motor axons and produce contractions. However, NMES also depolarises sensory axons, which can contribute to the contractions and also act as a form of "neuromodulation" that alters the excitability of circuits in the central nervous system (CNS) that control movement. Such neuromodulation can augment residual function and eventually lead to improvements in function that persist even when the stimulation is off. Maximising the recruitment of sensory axons, relative to motor axons, during NMES favors the production of large, fatigue-resistant contractions and may increase CNS circuit excitability and improve function. METHODS: In the present study we applied single pulses of stimulation over the tibial nerve to assess the effect of phase duration (2 ms, 1 ms, 0.5 ms, 0.1 ms) and waveform (monophasic, biphasic, kHz frequency) on the relative recruitment of motor and sensory axons in 20 participants with no history of neurological injury or disease. Outcome measures included: 1) the ratio of the maximal Hoffmann-reflex (H-reflex) to maximal motor-wave (M-wave), 2) H-reflex size when the M-wave was ~5% of the maximal M-wave, and 3) the size of the M-wave when the H-reflex was maximal. RESULTS: When all four phase durations were tested using monophasic pulses, outcome measures 1 and 2 were significantly lower and outcome 3 significantly higher, when using the 0.1 ms phase duration pulses compared to all other phase durations. This result demonstrates more effective recruitment of sensory axons when using longer phase durations compared to 0.1 ms pulses. When two phase durations (0.1, 0.5 ms) were tested using all three waveforms, there was a significant main effect of phase duration for all outcome measures and no effect of waveform for any outcome. Similar to above, when using 0.1 ms phase duration pulses, compared to 0.5 ms pulses, outcome measures 1 and 2 were significantly lower and measure 3 was significantly higher, consistent with an increase in the relative recruitment of sensory axons when using the longer phase duration pulses. These results show that altering stimulus phase duration, not waveform, impacts the relative recruitment of motor and sensory axons in human peripheral nerves. CONCLUSIONS: For NMES, one could select a phase duration depending on the goal, such as preferentially recruiting motor axons to produce consistent contractions with little impact on the CNS, or favoring the recruitment of sensory axons, to produce more fatigue-resistant contractions and facilitate recovery of function. For other applications in which surface stimulation is used to neuromodulate CNS circuits, these data suggest that to maximise sensory input and the impact on CNS circuits, phase duration, not waveform, matters.

P-E-82: Stimulus phase duration, not waveform, influences the variability of responses evoked by stimulation of axons in a human peripheral nerve

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BACKGROUND AND AIM: Electrical stimulation can be applied over a peripheral nerve to evoke reflexes or produce contractions to restore function and prevent secondary complications following neuromuscular injury or disease. For reflex testing 1 ms phase (or pulse) durations are recommended, to preferentially recruit sensory axons over motor axons, and square and biphasic pulses are typical. What is not known, however, is whether changing the stimulus phase duration or waveform influences response variability. Differences in variability may influence conclusions drawn from reflex tests or alter the way electrical stimulation generates contractions. The present study was designed to characterise the effect of two phase durations (0.5ms, 0.1ms) and three waveforms (biphasic, monophasic, KHz

frequency) on the variability of responses evoked by peripheral nerve stimulation. METHODS: Twenty individuals with no history of neurological injury or disease participated. Single pulses of stimulation were applied over the right tibial nerve to evoke M-waves (by stimulating motor axons) and H-reflexes (by stimulating sensory axons). Twenty stimuli were delivered in separate blocks of trials for each combination of phase duration and waveform. Stimulus intensity was adjusted to evoke M-waves that were ~5% of maximal (i.e. 5% M_{max}) with each stimulus type. Outcome measures included response amplitude and variability. RESULTS: By design, M-waves were not significantly different between the six combinations of phase duration and waveform, indicating that approximately the same number of motor axons were stimulated with each waveform. In contrast, there was a main effect of phase duration, but not waveform, for H-reflex amplitude. Reflexes were significantly larger when using 0.5 ms phase durations than 0.1 phases, consistent with the idea that wider phases preferentially recruit sensory axons. Regarding response variability, there was a main effect of phase duration, but not waveform, for M-waves and H-reflexes. The coefficient of variation was significantly lower for both M-waves and H-reflexes when using 0.5 phase durations compared to 0.1 ms phase durations. Thus, altering stimulus phase duration, but not waveform, influenced the variability of responses to stimulation of both motor and sensory axons. Wider pulses may result in less variability because the longer depolarisation time depolarises the membrane more securely. CONCLUSIONS: Wider phase durations not only preferentially activate sensory axons over motor axons to produce larger reflexes, but responses are also less variable. This decreased variability may help identify significant differences with fewer samples for reflex tests and produce more consistent torque during NMES. These data also demonstrate that changing stimulus waveform, at least those we investigated, has little impact on response variability or the relative recruitment of motor and sensory axons.

P-E-83: Changes in metabolic response by adding electrical myostimulation using various frequencies during bicycle exercise

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[Background] It is known that the combination of aerobic exercise with electrical myostimulation increases oxygen consumption and reinforces the effect of aerobic exercise. According to the report from the previous study, the application of electrical myostimulation at 4 Hz to the lower body during 20 minutes of bicycle exercise at 80% of the ventilation threshold significantly increases the oxygen intake amount, heart rate, and respiratory exchange ratio (Watanabe et al. 2014 Euro JAP). However, changes in metabolic response based on various frequencies of electrical myostimulation have yet to be examined. [Purpose] The purpose of this study is to examine the effects on metabolic response when electrical myostimulation is applied at various frequencies during bicycle exercise. [Method] The test subjects were 5 males (age: 25.2 ą 1.1, height: 175.4 ą 3.2 cm, weight: 66.6 ą 3.4 kg, BMI: 21.6 ą 0.7). The devices used were wearable electrical myostimulation devices (manufactured by MTG) whose electrodes are placed on a region close to the biceps brachii, triceps brachii, rectus abdominis, oblique, quadriceps femoris, hamstring, and gluteus maximus muscles. The strength of the electrical myostimulation applied was set to a level that the test subjects were able to withstand to the utmost. For the bicycle exercise, fitness bicycles (manufactured by MTG) were used. A cadence of 60 rpm and a moderate intensity load were applied for 10 minutes as the standardized conditions in all bicycle

exercises. An expired gas analysis device, Aero Monitor [AE-310S] (manufactured by Minato Medical Science Co., Ltd.) was used to measure expired gas during the exercise. The frequencies of electrical myostimulation were set to 4 Hz, 6 Hz, 8 Hz, 10 Hz, and 12 Hz to enable accomplishing the bicycle exercise without experiencing tetanus. Exercise without electrical myostimulation was also performed. Note that each test was conducted randomly on a different day. [Results] The average value for oxygen intake amount (VO2) throughout the tests was 26.7 ą 1.4 ml/kg/min. without electrical myostimulation, 30.4 ą 1.9 ml/kg/min. at 4 Hz, 32.0 ą 2.4 ml/kg/min. at 6 Hz, 31.8 ą 2.4 ml/kg/min. at 8 Hz, 33.4 ą 2.5 ml/kg/min. at 10 Hz, and 34.5 ą 2.8 ml/kg/min. at 12 Hz. Significant differences were observed between those with and without the electrical myostimulation. Note that, regarding the tests with electrical myostimulation, it is inferred that the higher the frequency, the higher the oxygen intake amount.

P-E-84: Possible neural mechanisms of the bilateral force deficit

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BACKGROUND AND AIM: The bilateral force deficit occurs when the bilateral force of two limbs exerting force simultaneously is less than the combined unilateral strength of two limbs (Jakobi & Chilibeck, 2001; Magnus & Farthing, 2008; Aune et al., 2013). Presently, no specific neural mechanisms have been associated with this observed deficit (Aune et al., 2013; Howard & Enoka, 1991). The purpose of this study was to identify potential neural mechanisms that contribute to the bilateral force deficit in thumb flexion muscles. The V-wave was assessed as a measure of central drive (Upton et al., 1971) as a means to understand the bilateral force deficit. METHODS: Participants (n=12) performed 3 thumb flexion maximal voluntary contractions (MVCs) bilaterally, and on their right and left sides. The thumb flexors were chosen due to the minimal amount of countering antagonist activity (Kaufmann et al., 1999). The task was performed in a custom device that isolated thumb flexion. During each MVC, the participant's median nerve was stimulated with a supramaximal intensity to evoke an M- and V-wave. The V-wave was quantified using the V/M ratio. The bilateral force deficit was observed if the bilateral MVC force was less than the combined unilateral force from the right and left MVCs, as measured from a 500 ms window directly before the stimulation. We used the Bilateral Index (BI) to assess whether the bilateral deficit was present, as indicated by a negative value (Howard & Enoka, 1991). RESULTS: Differences were observed between the simultaneous bilateral and the combined unilateral MVC forces (t=-2.52, df=11, p=0.028). Interestingly, the bilateral force deficit (BI = -7.62 ą 5.12%) was observed in 9 participants, while bilateral facilitation (BI = 3.24 ą 1.8%) was observed in 3 participants. There were 8 participants with identifiable V-waves on both thumbs, 6 exhibiting a force deficit and 2 exhibiting bilateral facilitation. We compared the relationship in the bilateral index between the force and V/M ratio using a Pearson's correlation. The relationship was found to be insignificant (r=0.0931, p=0.8264). CONCLUSIONS: Currently, these findings suggest that the relationship between descending drive and the force output do not fully explain the bilateral force deficit. In the future, investigators should aim to understand the possible central contributions to this deficit (Aune et al., 2013).

P-F-85: Effects of Screw Driving on The Forearm Muscular Strength and Fatigue

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ABSTRACT BACKGROUND AND AIM: Screwdriver is one of the most commonly used hand tools employed in several occupations. It requires repetitive movements of the hands-arms, providing the power grip force to exert torque from the hands and fingers. During screwing, the driving task can be described by supination/pronation, wrist extension/flexion and radial/ulnar deviation. However, this repetitive motion can induce forearm muscle fatigue and increase the risk of upper limb injury and disease, particularly in the biceps brachii (BB), brachioradialis (BR), pronator and supinator arm muscles. It has been reported in many studies that such diseases are mainly caused by either over-exertion or repetitive/prolonged poor working postures while performing tasks. Quantifying muscle fatigue is helpful to manage labor because muscle fatigue can be reduced by scheduling a fixed daily rest period. This study aimed to investigate the effects of screw driving on the forearm muscular performance fatigability to understand whether screw driving-related tasks increase the risk for forearm musculoskeletal disorders. METHODS: Twelve adults participated in this study. Eight stainless screws were inserted into a prismatic wood bar specimen using a 35-mm handle diameter screwdriver. A six-axis load cell was used to measure the driving torque and push force. The pre- and post-fatigue maximum isometric forces, insertion rate of the screws and corresponding electromyography responses were measured to assess the muscle strength loss and fatigue of the forearm when inserting screws. RESULTS: After screwing, the maximal grip force, maximal driving torque, and maximal push force losses were approximately 32%, 24%, and 27%, respectively. The percentage force loss of grip force and driving torque in the brachioradialis and extensor carpi ulnaris was greater than those of the biceps brachii. The percentage of maximum driving torque and push force decreased significantly on the 8th screw compared with the first screw. The insertion rate decreased linearly with the number of inserted screws; however, a significant decrease in the insertion rate of the fourth screw was observed. CONCLUSIONS: Muscle fatigue may occur in subjects who are inserting more than four screws. More muscle force loss and a higher risk of fatigue occurred in the brachioradialis and extensor carpi ulnaris than the biceps brachii. The results of this study can be used to assess the muscular performance fatigability and potential risk of forearm injury due to exposure to repetitive screw driving tasks. Keywords: muscle fatigue, maximum isometric forces, driving torque

P-F-86: Detection of local muscle fatigue in surgeons during its laparoscopic interventions

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Introduction: Applied Ergonomics is very important in Minimally Invasive Surgery (MIS), especially with the introduction of robotized techniques that have changed the surgeons' work conditions. However, the main aim remains the engineering to enable compatibility of surgeons' tasks' fulfilment in a physical, logical and organizative environment with security, comfort and efficiency. Ergonomics contribution is oriented both to design and re-design utilized material and work organization. A further relevant consequence of the effort applied during MIS is local muscle fatigue (LMF), an important factor to

consider in musculoskeletal pathologies. The aim of this work is using EMG analysis to be able to define the most appropriate posture that surgeons should adopt during MIS to decrease LMF apparition risk level and at the same time to increase capacity to variate the posture without reducing task performance precision. The level of effort involved in the development of work tasks in a particular job is a risk factor for musculoskeletal pathologies. In the studies carried out by the BioĒrgon Group EMG (Surface EMG) has been used as an instrumental technique to analyse the relationship of the position adopted by the surgeons. Methods: Electromyographic data was recorded with surface electrodes to establish upper trapezius and middle deltoid intervention as neck- shoulder area stabilizers. 13 surgeons (4 woman and 9 men), with different experience level, performed a surgery simulation of 60 minutes duration at the Jesús Usón Minimally Invasive Surgery Centre, as mentioned in section 4. The analysis of the electromyographic data in the frequency domain made it possible to detect median frequency (fmedian) of the appearance of local muscular fatigue (LMF), which is one of the risk factors that cause discomfort and musculoskeletal disorders. Surgery time was divided in 60 intervals with a duration of one minute each. In each interval an EMG record was made, meaning that a period of one minute passed between one record and the next. Results: Results show that LFM appears in 62% of analysed surgeons in part of the analysed muscles (table 1) Conclusion: Factors and levels of risk of suffering musculoskeletal injuries in the neck and shoulder associated with posture and muscular activity have been determined, which can be used for the prevention of musculoskeletal pathologies. In addition, the knowledge what was gathered from the real environment of the operating theatre can be useful for training of surgeons in laparoscopic surgery on adaptation of the posture during the intervention. ACKNOWLEDGMENTS: This manuscript has been partially supported by the Government of the Community of Extremadura, Grant Ref. GR15161, project Grant. Ref. IB16198 and GR18191; and the project "Centro de Tecnificación del Deporte Paralímpico - DEPATECH 2014-2015".

P-F-87: Fatigue induces a shift of electrical activity during multiple fatiguing repetitive contraction of the upper trapezius: a single subject design.

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Background: High density surface electromyography (HD-sEMG) is a non-invasive technique to measure muscle activity from large portions of muscles. Muscle fatigue can be observed during sustained isometric contractions as a shift of the barycenter of activity using topographical mapping. The main hypothesis is that the longer a contraction is sustained, the larger are the changes in the spatial distribution of muscle activity. To date there is still little information regarding the actual changes in the distribution of EMG signals and their possible correlation with the subject's perception of exertion. Objectives: The aim of the study was to identify changes in the spatial distribution of upper trapezius activity after repetitive fatiguing exercise. Materials and Methods: HD-sEMG signals were recorded with a 8x8 array of electrodes from the upper trapezius muscle of three healthy male subjects (S1, S2, S3) during isometric contractions with shoulders 90° abducted in a sitting position. Subjects had to elevate their right shoulder for 10 times holding a weight 50% of their maximal voluntary contraction (MVC) for as many sets as possible in a sitting position. The signals were recorded during isometric lateral arm abduction, performed after each set of 10 weight lifting movements. In addition, after each set, subjects

were asked to indicate their perceived level of fatigue using Borg-RPE scale. Each subject underwent three fatiguing sessions between those interposed at least two days. Data were assessed visually, statistically, and by comparing mean differences before and after the fatiguing exercises. Results: A cranial shift ($p < 0.05$) of the HD-sEMG barycenter between the isometric contractions at rest and those after fatiguing tasks (figure 1). The barycenter shifted towards the upper region of the muscle in each of the three subjects (S1 0.21 cm, S2 0.14 cm, S3 0.16 cm). Conclusions: This changes can play a role in the different muscle activities exercised during a fatiguing task, not only within-sessions but also longitudinally. Cranial shift could be correlated with different type of muscle fiber recruitment and probably with changing in EMG-parameter during an incremental-fatiguing muscle activation.

P-F-88: Can multi-material polymer fiber electrodes measure lower back muscle fatigue? Pilot testing during the Biering-Sorensen test.

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BACKGROUND: Low back pain (LBP) constitutes an important socioeconomical burden and generates the highest number of claims due to work-related injuries. This condition has been associated with changes in spine biomechanics and impaired motor control, and these changes might be secondary to muscle fatigue in stabilizing muscles such as the erector spinae. Many studies on this topic have been carried out in laboratory and controlled environments. However, the emergence of novel fabrics, miniaturization and wireless technologies will soon allow research to be carried out in real-life environments. GOAL: The goal of the present study was to test if a new type of electrodes made of multi-material polymer fiber and embeddable into a smart shirt design, was sensitive enough to measure lower back muscle fatigue. METHODS: pairs of multi-material polymer fiber were placed bilaterally over the erector spinae muscles at T12-L1 level, side-by-side with small commercial Delsys Trigno mini electrodes. The Biering-Sorensen test, a test validated to asses muscle endurance of the lumbar extensor muscles and consisting of maintained contractions of these muscles against gravity until exhaustion, was used to fatigue the lower back muscles. Twelve healthy young adults participated in the study. EMG power spectrum median frequency (MF) was measured every second by both the commercial and multi-material polymer fiber electrodes. RESULTS: Participants were able to maintain a horizontal back position against gravity for periods varying from 60 to 360 sec. Drop in Median frequencies in the erector spinae muscles were observed in 7/12 participants with the commercial system. The multi-material polymer fiber system showed a drop in MF comparable to that of the commercial system. CONCLUSION: Low-cost, low power multi-material polymer fiber electrodes are a potential source of new generation electrodes for the design of smart shirts capable of measuring the appearance of lower back muscle fatigue. This opens new possibilities for real-world measurement and is potentially important for preventing musculoskeletal injuries and chronic pain.

P-F-89: Characterization of performance fatigability in patients with facioscapulohumeral muscular dystrophy using surface EMG

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BACKGROUND AND AIM: In facioscapulohumeral muscular dystrophy (FSHD), the third most common hereditary myopathy, fatigue has been recognized as 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, its occurrence has been poorly investigated and little is known about the pathophysiology of this disabling condition. Therefore, we aimed to determine if the levels of fatigability experienced during a performance task in a sample of FSHD patients differed in comparison to healthy controls. METHODS: 18 patients diagnosed with FSHD (10 men and 8 women) were included in the study and compared to 18 matched controls. Participants performed a 20% maximal voluntary isometric contraction of 2 min, and afterwards a 60% MVC held until exhaustion. sEMG signals were detected using bi-dimensional arrays of 64 electrodes from the dominant biceps brachii. Initial values and rates of change (slope) of mean frequency of the power spectrum (MNF), conduction velocity (CV) and fractal dimension (FD) of the EMG signal were calculated. Trait levels of fatigue experienced by FSHD patients were quantified using the Checklist Individual Strength (CIS) fatigue-subscale. RESULTS: Statistically significant differences between people with FSHD and healthy controls were observed in the MVC intensity, endurance time, initial values of MNF and FD at 20% MVC ($p<0.01$) and in the slopes of MNF, CV and FD at 60% MVC ($p<0.05$) (Table 1). A correlation between perceived and performance fatigability was not determined. CONCLUSIONS: The results suggest that people with FSHD experience (1) lower levels of performance fatigability, probably related to a fast-to-slow muscle fibers transition, which is pointed out by the longer endurance time with respect to the healthy controls; and (2) a loss of muscle strength, which may justify the lower CV slope at higher degree of force production.

P-F-90: Effect on muscle function of a lumbar region backrest with soft tissue release function

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Introduction: Low back pain (LBP) is associated with lumbar muscles fatigue caused by maintaining a seated posture for a long time1,2. Such lumbar pain is a common occupational injury in industrial health. LBP from damaged muscle and fascia cannot be judged in medical images. Many patients with LBP have stiffness of low back muscles and restricted forward flexion of the trunk. Treatment for LBP includes equipment with some massage function. However, massage by pressing force causes pain and fails to relieve symptoms in some patients. Another method involving soft tissue release to extend the soft tissue including muscular fasciae and stimulation with less force than pressing has lower risk of pain and disorder. Purpose/Aim: We compared physical function for different function of backrest changed

lumbar muscle. Materials and Methods: The study protocol was approved by the Tokyo Metropolitan University of Health Sciences Ethical Review Board (Authorization Number 18054). All authors declare they have no conflicts of interest. Twenty-four healthy subjects were randomized into three groups of eight who sat for 10 minutes on a chair under one of three backrest conditions: backrest soft tissue massage (BSTM, Labonetz I), backrest finger pressure (BFP Doctor AIR Dream factory Inc.). or backrest control. Measures taken before and after including elasticity of musculus erector spinae using a soft tissue stiffness meter, tenderness, upper trunk flexibility, FFD (Floor Finger Distance)?C and SLR (straight Leg Rising),were compared using two-way ANOVA in the SPSS statistical package for Windows, version 24.0, with $p < 0.05$ considered statistically significant. Results: Pain threshold increased in only the BSTM group and differed significantly with BFP group. Trunk forward flexion indicating trunk flexibility, improved in both BSTM and BFP groups. Flexibility of hip joint and lower limbs by SLR measure was improved in only the BSTM group as was stiffness of the lumbar muscle. Conclusion: The results suggest increased pain threshold reduced the perception of pain derived from muscle function degradation. Flexibility of the lower limbs is strongly related to LBP, and it is thought that improvement in flexibility of the lumber muscles improved flexibility of the hamstrings in the present subjects. Soft tissue stiffness is regarded as an index of muscle fatigue, and stiffness was increased by fatigue. A decrease in soft tissue stiffness suggests improved muscle condition. Hence, BSTM was more effective in myofunctional improvement of the lumbar region than BFP as measured by soft tissue release.

P-F-91: Impact of Parkinson's disease on electromyographic fatigue of masseter and temporalis muscles

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BACKGROUND AND AIM: Parkinson's disease is a chronic, progressive, and degenerative neurological disorder that affects millions of individuals worldwide. This study analyzed the electromyographic fatigue of the masseter and temporalis muscles in individuals with Parkinson's disease. METHODS: The median frequency of the electromyographic signal was analyzed in 16 individuals, aged between 50 and 70 years, with Parkinson's disease in stages I and III of the Hoehn and Yahr disability scale (n = 8) and without the disease (n = 8). The data were tabulated and analyzed statistically (t-test, $p < .05$). This study was approved by the Research Ethics Committee (process # 61113916.6.0000.5381). RESULTS: Compared with the group without Parkinson's disease, the group with the disease showed increase in the median frequency, with significant differences for the right masseter (p=.05) and the right temporal (p =.03) muscles. CONCLUSION: The results suggest that there is a link between Parkinson's disease and functional alterations of the masticatory system, especially when electromyographic fatigue is assessed.
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P-F-92: Fatigue-induced firing of group III/IV afferents modulates intracortical facilitation and corticospinal excitability of knee extensors

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BACKGROUND AND AIM: Group III/IV muscle afferents evoke sensations of work and pain during exercise and contribute to central fatigue development. Recently, effects on cortical excitability have also been demonstrated. That is, sustained fatigue-induced firing of group III/IV muscle afferents after exercise maintains intracortical facilitation (ICF) of human hand muscle. However, hand muscles have a small number of afferent fibres. Therefore, the current study assessed if afferent firing from a large muscle group in the lower limbs impacts intracortical networks and corticospinal excitability. METHODS: Eighteen healthy adults (15M, 3F; 26.2±3.8 y) performed a fatiguing 2-minute sustained maximal voluntary isometric contraction of the knee extensors on two separate days (OCCLUSION or CONTROL). Surface electrodes over vastus lateralis recorded the electromyogram. Responses to femoral nerve, and single- and paired-pulse transcranial magnetic stimulation were recorded from the resting muscle pre- and post-exercise and used to assess maximal compound action potentials (MMAX), motor evoked potentials (MEPs), ICF (12 ms interstimulus interval), and short-interval intracortical inhibition (SICI; 2 ms interstimulus interval). Test pulse intensities were set and adjusted post-exercise to maintain a MEP amplitude of ~0.5-1.0 mV. Conditioning stimulus intensities were set to evoke ~50% of maximal ICF for each participant and kept constant between and throughout conditions. To maintain fatigue-related afferent firing during OCCLUSION, the muscle was held ischemic during post-exercise testing via a blood pressure cuff inflated (~250mmHg) around the upper thigh. The cuff was not inflated at any time during CONTROL. Participants were asked to rate muscle pain (0-10 scale) every 30 seconds during pre- and post-exercise testing. RESULTS: Pain was higher at the end of the protocol for OCCLUSION (mean±SD; 9.2±1.4 vs. 2.3±2.6, $P<0.001$). Post-exercise, MEP amplitude /MMAX amplitude was depressed for CONTROL (44.8±25.7%, $P<0.001$) despite an increase in test-pulse intensity (+10.3±7.0%, $P<0.001$). MEP/MMAX ($P=0.301$) and test pulse intensity (+4.0±5.1%, $P=0.073$) did not change for OCCLUSION. Additionally, ICF decreased pre-to-post exercise for OCCLUSION (-20.2±26.6%) compared to CONTROL (-1.3±45.3%, $P=0.038$). SICI did not differ from pre-to-post exercise for either condition ($P=0.082$). CONCLUSIONS: Decreased ICF during post-exercise occlusion of the knee extensors is in contrast to preserved ICF with sustained group III/IV afferent feedback in hand muscle. Maintenance of corticospinal excitability during occlusion also differs from post-exercise MEP depression observed with fatigue. Taken together, these results suggest distinct corticospinal and intracortical modulation to group III/IV feedback dependent on the muscle group and/or magnitude of afferent feedback.

P-F-93: The effect of inter-individual contractile properties on degree of fatigue induced by neuromuscular electrical stimulation

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BACKGROUND: Neuromuscular electrical stimulation (NMES) is effective tool for training and rehabilitation. Using the most suitable (optimal) stimulation condition and the searching it are important clinically. "Optimal NMES" is associated with various parameters including stimulus frequency. The purpose of this study was to investigate the degree of neuromuscular fatigue elicited by NMES at fixed stimulus frequency is varied with inter-individual differences in contractile properties. METHODS: Thirty-

eight healthy men and women (age: 30.2ą9.5 years, height: 166.8ą9.1 cm, weight: 59.5ą10.7 kg) participated in the study. They performed isometric knee extension and were stimulated for quadriceps femoris muscle. NMES fatiguing tasks stimulus frequency was 20Hz, duration was 20 minutes and targeted force was 10%MVC. This fatiguing tasks consisted of 6-sec on/contraction and 4-sec off/rest. Area under the curve of evoked for integral was calculated as total workload in fatiguing task. For estimating contractile properties of quadriceps femoris muscles for each participant, NMES for force-frequency curve was performed before and after the fatiguing task. Stimulus frequencies were 10-50Hz (5Hz each) and target force for stimulus intensity was set 30% of the maximal voluntary contraction (MVC). We differentiated evoked torque as torque fluctuation and normalized it at each frequency by the highest fluctuation. The torque fluctuation-frequency curve should be decreased remarkably and become plateau with changing to tetanic contraction. Therefore, we extracted the frequency which the change in the inclination of the curve as the point of achieving tetanic contraction. In this study, this point was assumed as "optimal" frequency. Based on extracted frequency as reaching tetanic contraction, subjects were divided into 3 groups (Low: 15-25 Hz, Mid: 30-35 Hz, High: over 40Hz). MVCs were compared between before and after fatiguing task using paired t-test. For the decline rate of MVC and time*torque integral (total workload) in fatiguing task, one-way analysis of variance was used to compare between 3 groups by optimal frequency. RESULTS: The post-fatigue MVC was significantly decreased 20.8 % than pre-fatigue MVC ($p<0.05$). The decline rate of MVC was no significant difference between the groups with different optimal frequencies ($p>0.05$). There was no significant difference in the total workload in fatiguing task between the groups with different optimal frequencies ($p>0.05$). CONCLUSION: These results suggested that the difference of fixed frequency by the point of tetanic contraction was not affected to muscle fatigue by NMES. We suggested that degree of neuromuscular fatigue induced by NMES at a fixed stimulation frequency (20Hz) were not influenced by inter-individual differences in contractile properties that are provided from the optimal stimulation frequency for tetanic contraction.

P-F-94: Effect of muscular fatigue on shoulder control during a virtual reaching task in a healthy population

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BACKGROUND The role of the upper limb is to position the hand in space to perform daily life activities. To enable these activities, a high level of mobility is required, especially at the shoulder joint. While shoulder anatomical configuration provides a high level of mobility, preserving stability remains a challenge. Shoulder movements and stability are based on the ability of the central nervous system to integrate the sensory information and to create an appropriate motor command. Given its complexity, various daily encountered factors can potentially compromise shoulder control, such as muscular fatigue. The aim of this study was to explore how muscle fatigue influence shoulder control, characterized by upper limb kinematic and temporospatial variables. The hypotheses were that shoulder muscles fatigue would lead to an increase of the trunk and sternoclavicular joint movement and a reduction of the shoulder movement, as well as a reduction in movement speed and movement accuracy. METHODS The study population consisted of young adults aged between 18 and 35 years with no self-reported upper limb pain and no movement restriction. Participants completed two reaching

tasks with their dominant arm: 1) Baseline: control condition without fatigue; 2) Post-fatigue: following completion of a validated upper limb fatigue protocol. The reaching task consists of a series of 5 targets on a virtual reality environment that participants had to reach with their hand as accurately and rapidly as possible in a seated position. The targets positions were set at pre-established shoulder elevation positions (above 90° of elevation). During the task, temporospatial data were collected using the VivePro Controllers, while upper limb kinematics data were collected using inertial measurement units. Temporospatial variables of interest were the time taken to reach the targets, initial angle of endpoint deviation reflecting planification, final error reflecting accuracy and area under the curve; while upper limb kinematics variables were movement and limb position at the shoulder, sternoclavicular and trunk. Baseline data were compared to post-fatigue data using a paired t-test. RESULTS There was a significant difference ($p < 0.001$) in the initial joint position at the shoulder and sternoclavicular joint following the fatigue protocol: initial sternoclavicular elevation and shoulder external rotation were significantly higher after fatigue, and initial glenohumeral flexion significantly lower. However, there was no significant difference between the time taken to reach the targets, the initial angle of endpoint deviation, the final error and the area under the curve. CONCLUSION Results showed an impact of muscle fatigue on inter-joint coordination of the shoulder complex without affecting the performance in the reaching task. These findings suggest different movement patterns can be successfully used to execute reaching tasks in acute fatigue conditions. The impact of chronic fatigue or ongoing movement adaptations are unknown.

P-F-95: Evaluating the changes in lower limb motor strategy during the 6MWT in Canadian soldiers learning to wear a passive, load-bearing exoskeleton: A case series.

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BACKGROUND AND AIM: Military soldiers are often physically overburdened by the weight they have to carry during missions. Resulting consequences may include generalized muscle fatigue and reduced movement and maneuvering, which in turn can increase the likelihood of acute and chronic injuries, and negative impact on mission readiness and effectiveness. Passive or active exoskeletons may enhance load-bearing capacity in experienced soldiers, but the effect of wearing these human augmentation devices on soldiers motor control is not yet understood. It is hypothesized that passive exoskeletons can redistribute some of the weight away from the soldier, thereby reducing the muscle force required to move. However, while wearing the exoskeleton, soldiers must also be able to generate enough force to transport the additional weight of the exoskeleton and cope with the resulting moment of inertia. This requires an adaptive modification of lower limb motor strategy during walking. The goal of this study was to quantify the impact of wearing a passive exoskeleton on lower limb muscle activity and to assess changes occurring during a familiarisation period to the device. It was hypothesized that muscle fatigue would initialy increase when wearing the exoskeleton, and then return towards baseline by the end of familiarization. METHODS: Three Canadian soldiers were instrumented with wireless EMG sensors (Delsys Trigno) and completed a 6-minute walk test (6MWT) under marching order conditions (ie, load of 84lb) at maximum walking speed. Users were tested under three conditions: 1) No Exoskeleton/No load, 2) No Exoskeleton/Load and 3) Exoskeleton/Load. The exoskeleton condition was tested multiple

times to evaluate the capacity of the user to adapt to this new assistive device and to evaluate the efficacy of the familiarization process. Five main muscle groups were recorded bilateraly with surface EMG (Rectus Femoris, Semitendinosus, Medial gastrocnemius, Soleus and Extensor digitorum longus). Relative level of activation (RMS of signal amplitude) and fatigue development (fall in EMG median frequency) were analysed. RESULTS: When comparing across conditions, all participants reduced their walking speed to adjust to the added weight. Soldiers seems to compensate their walking to mitigate muscle fatigue as little change in the median frequency among all muscles instrumented and a reduction in activation amplitude was observed. After familiarization, soldiers increased their overall walking speed towards baseline, with no effect on the median frequency and a normalization of amplitude. CONCLUSIONS: These results suggest that the three soldiers adapted to the load-bearing exoskeleton by modulating their walking speed in the early phases of familiarization. This in turn seemed to reduce/prevent muscle fatigue. Further evaluation at controlled walking speed (e.g. on a treadmill) is now needed to assess the effectiveness of the passive load-bearing exoskeleton at actually reducing muscled fatigue.

P-F-96: Acute hypoxic exposure increases perception of fatigue prior to affecting quantitative measures of fatigue during maximal contractions

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BACKGROUND AND AIM: Although reducing blood oxygen saturation (SpO2) can cause rapid changes in exercise performance, few studies have examined the direct consequences hypoxia has on the development of fatigue in the motor system. Therefore, the purpose of this study was to examine how severe acute hypoxia affects an individual's ability to voluntarily activate muscle, as well as the individual's perception of fatigue during maximal elbow flexions. METHODS: Fourteen individuals (23 ą 2.2 yr) were exposed to a hypoxia and a sham intervention. SpO2 was titrated over 15 min and remained at 80% SpO2 during testing. Motor performance was assessed before titration (Pre), 0 hr, 1 hr, and 2 hr after the titration period. At each time point brief unfatigued elbow flexor MVCs were performed, followed by sustained 20 s MVCs to induced fatigue. Motor point superimposed and resting twitches were obtained from the biceps brachii to calculate level of voluntary activation (VA), and ratings of perceived fatigue were obtained with a modified CR-10 Borg scale. RESULTS: In fresh muscle there was no difference in VA between sham and hypoxia. During fatiguing contractions, the perception of fatigue was significantly greater for the hypoxia condition at 0 hr ($p = 0.04$), 1 hr ($p = 0.007$), and 2 hr ($p < 0.001$) compared to sham. VA remained unaffected by hypoxia until the 2 hr timepoint, where VA in the fatigued muscle decreased by 7% compared to sham ($p = 0.002$). CONCLUSIONS: Perception of fatigue is exacerbated while performing fatiguing maximal contractions during hypoxic exposure. Furthermore, the ability to voluntarily activate the fatiguing muscle during maximal contractions is compromised with hypoxia - which may be due to declines in cortical excitability. Our results suggest that acute hypoxia alters an individual's perception of fatigue prior to measurable declines in motor activity.

P-G-100: Musculoskeletal torque models based on deep learning and surface electromyographic signals recorded using Myo armband

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Musculoskeletal torque models based on deep learning and surface electromyographic signals recorded using Myo armband BACKGROUND AND AIM: Active forces are produced by skeletal muscles to move or stabilise the skeleton. The force exerted by a skeletal muscle cannot be directly measured noninvasively, but it can be related to an electrical activity which can be measured by surface electromyography (sEMG). Nonlinear models make it possible to capture additional subtle behaviour in the relationship between inputs and output. Deep Learning or Deep Neural Networks (DNN) is a specific way to formulate a function that is very useful in a variety of research areas. This study aimed to use deep learning time-series prediction methods for EMG-force modelling. Moreover, the upper frequency of sEMG bandwidth is up to 500 Hz, and the usual sampling rates recommended in the literature are between 1 kHz and 2 kHz. However, with the successful application of sEMG signals sampled at a lower sampling rate in other problems (e.g., https://doi.org/10.1371/journal.pone.0186132), we explored whether deep learning is suitable in such cases. METHODS: Five healthy subjects without a history of any neuromuscular disorders participated in the experiments. A Myo-armband from the Thalmic Labs was used to record the signals from the main elbow flexors and extensors (namely as Biceps Brachii, and Triceps Brachii) using eight bipolar channels during one-minute sub-maximal isometric force-varying elbow extension and flexion. The torque signal was recorded using a KUKA LBR iiwa robot. The sampling rate of both systems was 200 Hz. The normalised envelopes of the sEMG signals were estimated. The following methods were used to determine the force: DNN with Long Short-Term Memory (LSTM) Layers with/without a moving average filter (MA), time-delayed NN with 20 hidden layers (two-sample delays), Linear-in-the-parameters models namely as linear least-squares (LS) and the second-order LS. In all cases, the musculoskeletal delay was estimated during the learning procedure and the hold-out validation framework was used (50% estimation and 50% validation). The following performance indices were reported: Mean-Square Error (MSE) between the estimated and recorded torque signals, R-square as the goodness-of-fit, Intraclass Correlation Coefficient (ICC) with 95% Confidence Interval (CI). RESULTS: The results of the methods were listed in Table 1. DNN with LSTM Layers with MA filter outperformed the other methods. While the Mean values of R-square and ICC values of the best approach was about 0.90, the standard deviation between subjects was very low (less than 0.06), showing that the method generally performed well for all subjects. CONCLUSIONS: DNN is a promising modelling method, even when sampling the EMG at a much lower sampling rate than recommended e.g. 200 Hz. This could be because such envelopes contain only the lower frequencies of the signal spectra.

P-G-101: An application of the ARIMA model to the center of foot pressure while standing posture

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BACKGROUND AND AIM: An association exists between body standing balance and the center of foot pressure (COP). Quantitative evaluation using COP includes LNG, RMSarea and so on. If the COP, which

is time-series data, can be modeled, qualitative evaluation of human standing balance will be possible. The purpose of this study is to investigate whether COP can be applied to the ARIMA model. METHODS: Two women (54, 53 years) participated in this study. We got the written informed consents from them. While they were standing, the coordinate of COP was measured. For measuring COP, we used stabilometer (Unimec Co., Ltd., UM-BARII). The sampling frequency was set at 100 Hz. Data downsampled to 20 Hz was analyzed. Three types of measurement positions were used: a wide stance, a narrow stance, and one-leg stance. All measurements were performed barefoot with their eyes open. Each measurement was performed 20 times for each limb position. In the wide stance and the narrow stance, the hands were down. Each measurement was performed for 30 seconds, and all sections were analyzed in these cases. In the one-leg stance, the hands were on their waist. Each measurement was performed for 40 seconds, and data from 10 seconds to 40 seconds after the start of the measurement was analyzed. The medial-lateral direction of COP coordinate is expressed in COP(x), and the anterior-posterior direction of that is expressed in COP(y). New time-series data (COP (px), COP (py)) were obtained by rotating COP (x), COP (y) so that the principal axis of the COP became the coordinate axis. Another new data (COP (mx), COP (my)) were obtained by rotating COP (x), COP (y) so that the sample mean direction of the COP became the coordinate axis. We applied to the ARIMA model COP (x), COP (y), COP (px), COP (py), COP (mx), and COP (my). The ARIMA model was applied to these six time series data. RESULTS: The following numbers are the cases out of 20 trials, that we may apply to the ARIMA model: In the order of COP (x), COP (y), COP (px), COP (py), COP (mx), COP (my), in the wide stance, subject A: 13,12,13,9,12,15, subject B: 17,13,14,13,13,12, in the narrow stance, subject A: 13,13,14,14,10,14, subject B: 9,16,7,12,10,14, in the one-leg stance: 1,12,6,3,11,4, subject B: 13,13,9,12,13,9. CONCLUSIONS: The ARIMA model can be applied to more than half of the subjects A and B, either COP (x), COP (y), COP (px), COP (py), COP (mx), or COP (my). However, the ARIMA model is not a model that can be applied to the majority of multiple trials for the same person and the same position. For the data that did not applied well with COP (x) and COP (y), some data could be applied by rotation. It was suggested that the rotating data using the principal axis and the sample mean direction could be applied to the ARIMA model.

P-G-102: Study on visualization method during swallowing using Matlab

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Pneumonia is the third leading cause of death in Japan, most of which is aspiration pneumonia, which is caused by the inability to swallow food and entering the respiratory tract. In the medical and nursing care setting, the current situation is to check for "swallowing" by palpation, etc., and establishing a non-invasive, quantitative and reproducible evaluation method has become an urgent issue. There is an attempt to measure the movement of the "Adam's apple" that goes up and down during "swallowing". However, the esophagus cannot be opened and the "Adam's apple", which is important for sending food to the esophagus, cannot be moved forward. The purpose of this research is to realize real-time visualization. For this purpose, we are developing a system that visualizes the skin shape of the entire throat by using a Digital Signal Processor capable of high-speed signal processing and Matlab, which has many advanced processing commands. In this study, the surface of the throat during swallowing was imaged using a non-contact, non-invasive device for evaluating swallowing equipped with an image

sensor combining a grid-shaped laser spectroscopy and a CCD camera. From the image to be processed, continuous grayscale images were binarized, and the barycentric coordinates of the four connected elements were obtained. After labeling each barycentric coordinate, grid assignment was performed and finally 3D. Detailed results will be announced on the day.

P-G-103: Development of the reconstruction technique of the measurement error signal in the high-density electromyogram

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BACKGROUND AND AIM: By using the high-density electromyogram, we can measure the conduction velocity and the electric potential distribution of the action potential of the motor unit. The maximal characteristic is to be able to evaluate the activity information of the motor unit noninvasively.
 However, as the high-density electromyogram has many channels, the channel where normal electromyogram is not available by the influence of motion artifact or contact failure may occur. In this case, we cannot use the measurement data.
 Therefore an aim of this research is to develop technique to reconstruct inappropriate signal in appropriate signal using appropriate signal of the high-density electromyogram.
 METHODS: For this technique, there are two steps.
 The first step is the detection of the inappropriate signal.
 The second step is the reconstruction of the appropriate signal.
 In the first step, we judged by the correlation coefficient of the signal of the channel next to each other parallel to a muscle fiber direction.
 In the second step, we used the cubic spline interpolation using the signals from channel group in parallel with the muscle fiber direction, or the method using the average of the signal of two channels by the inappropriate channel.
 RESULTS: This technique detected the signal of the inappropriate signal as shown in 1) of figure.
 This technique reconstructed the inappropriate signal in detected the signal of the developed technique as shown in 2) and 3) of figure.
 CONCLUSIONS: We developed the technique to detection of the inappropriate signals using the correlation coefficient of two channels and, to the reconstruct inappropriate signal used the cubic spline or average of the signal of two channels.
 However, by this technique, we consider that the application of this technique is difficult when a channel next to each other is inappropriate, the reconstitution of the electromyogram of the channel of the end or the wide electrode interval.
 In future, we will verify the coverage of this technique and the validity of the motor unit of identification by the template matching using the reconstituted high-density electromyogram.

P-G-104: Upper Limb Torque Estimation in Quasi Dynamic Contractions Using a Convolutional Neural Network

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In this study, linear high-density (HD)-surface electrode arrays were used to record EMG signals from the long head and short head of the biceps brachii, brachioradialis, and triceps brachii muscles, during

isotonic and isokinetic elbow flexion and extension. The objective of this study is to estimate the torque generated at the elbow under quasi-dynamic conditions. Data were recorded from five subjects who provided informed consent. The experiments were conducted using a Biodex model 840-000 device, operated under isotonic-non-isokinetic and non-isotonic-isokinetic conditions. The isotonic protocol was conducted for 3 torque levels, 5, 8, and 12 Nm. For the isokinetic protocol, there were 3 velocity levels: 60, 90, and 180 deg/sec. For each subject, the data were collected in one session with 12 trials per condition (3 sets of 4 repetitions with 20 seconds rest between sets). Torque and position data were recorded by the Biodex. The EMG signals were recorded using 4 linear HD-electrode arrays with 8 monopolar channels (5 mm spacing). The EMG data were sampled at 2048 Hz and collected using the Bioelettronica EMG-USB2 HD system. Torque modelling was performed using a deep learning method, the convolutional neural network (CNN), where the model's inputs are the EMG recordings and the ground truth is the recorded torque. CNN was used because it can deal with high-dimensional raw data since it is able to learn from the data and extract relevant features. The CNN developed for this study consisted of an input layer, two convolutional layers, where each layer has normalization and rectified linear unit as an activation function, two maximum pooling layers after each convolutional layer, a fully connected layer, and a regression layer. We developed two models, for individual subjects. One model used only the differential HD-EMG signals acquired from the 4 muscles (28 channels), and the second used positional information (the elbow angle in degrees) in addition to the EMG signals, as inputs to the CNN model to estimate the elbow torque. The evaluation criterion used is r-squared. When using just the EMG signals as inputs to the CNN, r-squared values, averaged across subjects, of 0.85 ± 0.07 and 0.48 ± 0.1 were obtained for the isotonic and isokinetic protocols, respectively. Averaged r-squared values increased to 0.87 ± 0.06 and 0.66 ± 0.08 for isotonic and isokinetic protocols, when positional information was incorporated in the models. Thus, modelling performed better for the isotonic than for the isokinetic case and the incorporation of positional data was more beneficial for the isokinetic protocol. Therefore, for fully dynamic contractions, where the torque level, position and movement speed are not consistent, the EMG signal will not be enough for reliable torque estimation; incorporating mechanical information, such as position, is essential. We also compared the CNN model with a multilayer perceptron neural network and support vector machine for regression with linear, polynomial, and radial basis function kernels. The comparison results showed that the CNN model's performance is better than others for all experimental conditions.

P-G-105: emgGO: An Open-source Toolbox for Optimal Identification of Muscle Activation Intervals in Surface Electromyography

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Surface electromyography (sEMG) is the process of recording muscle electrical signals using electrodes placed on the skin. This technique has a wide range of applications. An example which immediately come to mind is the study of the sequence in which different muscles are activated in a particular task such as walking. Identification of the precise start and end of muscle activation from sEMG is a challenging task. Traditionally, muscle activation intervals in sEMG data are identified in one of the two ways. Either by manual labelling or by automated detection with an algorithm. Manual labelling is reliable and repeatable but time consuming. Automated detection is fast but replete with errors and has

to be followed by manual tweaking of the algorithm results[1]. Automated detection also requires in-depth understanding of the chosen detection algorithm and continuous update of its parameters with varying signal conditions across muscles within the same participant and across different participants. In a recently published work, we have proposed a novel approach for identification of muscle activation intervals called nOptim[2]. This approach simplifies the sEMG data processing by shifting the focus from understanding the algorithms to understanding the data. It allows the researcher to identify precise muscle activation intervals using any detection algorithm by simply specifying an estimate for the number of muscle activation intervals expected in the signal under consideration. Thus, the researcher is saved from spending time on understanding the algorithm in-depth and continuously changing its parameters. We have implemented this approach as a user-friendly open-source software toolbox with a graphical user interface, as shown in Fig. 1, and have made it available online free of charge. We propose that using this software, sEMG practitioners can improve the time-efficiency of their data processing. This may as well increase the uptake of novel and sophisticated detection algorithms by sEMG practitioners who would rather spend more time processing their data than learning new techniques. The toolbox is available on GitHub at https://github.com/GallVp/emgGO 1. Hodges, P. W., & Bui, B. H. (1996). A comparison of computer-based methods for the determination of onset of muscle contraction using electromyography. Electroencephalography and Clinical Neurophysiology/Electromyography and Motor Control, 101(6), 511-519 2. Rashid, U., Niazi, I. K., Signal, N., Farina, D., & Taylor, D. (2019). Optimal Automatic Detection of Muscle Activation Intervals. Journal of Electromyography and Kinesiology.

P-G-106: Non-Parametric Rank Statistics for Spectral Power and Coherence Analysis of Neural Signals

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BACKGROUND AND AIM: Despite advances in multivariate spectral analysis of neural signals such as electroencephalography (EEG) or electromyography (EMG), statistical inferences involving measures such as spectral power and coherence remain a challenge in practical and real-life scenarios. The non-normal distribution of the signals and presence of artefactual components make it difficult to use parametric methods for robust estimation of measures or to infer the presence of specific spectral components above the chance level. Furthermore, the bias of the coherence measures and their complex statistical distributions are impediments in robust statistical comparisons when examining coherence under different conditions or between different groups. Non-parametric methods based on the median of auto-/cross-spectra have shown promise for robust estimation of spectral power and coherence estimates. However, the statistical inference based on these non-parametric estimates remain to be formulated and tested. METHODS: We have used a set of methods based on non-parametric rank statistics to formulate 1-sample and 2-sample statistical analyses of frequency domain measures such as spectral power and coherence. The proposed methods were demonstrated and tested using simulated neural signals in different conditions, including in presence of artefactual components, to assess the robustness of the proposed non-parametric methods against traditional parametric tests.

RESULTS: The results show that non-parametric methods provide robustness against artefactual components. Moreover, they provide new possibilities for robust 1-sample and 2-sample testing of the complex coherency function, including both the magnitude and phase, where existing methods fall short. The utility of these methods are further demonstrated by examples on experimental EEG and EMG data. CONCLUSIONS: The proposed approach provides a new framework for non-parametric spectral analysis of digital signals. These methods are especially suited to the analysis of neurophysiological signals in neuroscience and neural engineering applications. Given the attractive properties such as minimal assumption on distributions, statistical robustness, and the diverse testing scenarios afforded, they have the potential to guide new best practices for robust analysis of neurophysiological signals in future.

P-G-107: Body posture effects EGG frequency content? Case report

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BACKGROUND AND AIM: Electrogastrography (EGG) is a method for recording of electrical activity of smooth stomach muscles, and as a non-invasive technique is attractive for wider application in both clinical and research settings. Currently, the biggest obstacles are lack of standardized recording protocol and artifact vulnerability. The aim of this case report is to provide preliminary insights in effects of body posture on EGG signal as a step closer to the EGG standardization. METHODS: Recordings were obtained in healthy 24 years old female subject (56 kg, 168 cm) in postprandial phase of gastric cycle. Volunteer signed Informed Consent in compliance with the Code of Ethics of the University of Belgrade and according to the Declaration of Helsinki. For test meal, commercially available oatmeal (274 kcal - 14.1% protein, 61.6% carbohydrates, 8.4% lipids, 5.9% fibers) was used. After the test meal intake, following protocol was applied: (1) subject relaxation and explanation of the protocol (10 min), (2) recording in supine position (5 min), (3) break (1 min), (4) recording in sitting position (5 min), (5) break (1 min), and (6) recording in standing position (5 min). Subject was asked to relax, not to talk, and to minimize body movements. EGG signals were filtered with Butterworth 3rd order band-pass filter with cut-off frequencies 0.03 Hz and 0.25 Hz. In order to evaluate characteristics of frequency content, normogastric (2-4 cpm) power share in percentages and dominant frequency, as the most commonly used EGG parameters, were calculated. RESULTS: Normogastric power shares were 74.4%, 30.0%, and 45.2%, while dominant frequencies were 2.93 cpm, 3.10 cpm, and 2.75 cpm, for the supine, sitting, and standing positions, respectively. CONCLUSIONS: Having in mind that subject reported no history of gastrointestinal problems, it was expected that dominant EGG power share will be in normogastric range. Our preliminary results suggest that posture affects frequency content of EGG signal substantially. Higher percentage of power share in normogastric range speaks in favor of recording in supine position. Results were much different for sitting and standing postures regarding both dominant frequency and normogastric power share. For the sitting that could be a consequence of disturbances induced by dislocation of surface electrodes due to the skin crumpling. Altered position of the gastrointestinal organs in standing position can provide explanation for decrease of power share in normogastric range. Main outcome from this case report is that body posture could be very important element in EGG recording protocol, and that it should be further investigated in larger sample with randomized multi-session protocol. To the best of authors knowledge, there are no published

randomized studies on this matter, so that could be the next step in order to obtain stronger conclusions.

P-G-108: Fuzzy Topographical Structure differences due to the size and sliding windowing to create EMG topographical maps

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BACKGROUND AND AIM: Strategies to visual presentation of neuromuscular electrical activity are searched as a way to promote better visualization and understanding of surface electromyography data (EMG). However, to provide 2D image representation of EMG signal processing parameters may be determinant on its pattern changing the own structure (1,2). Here we determine the effect of size and sliding windowing on Fuzzy Topographical Structure of maps obtained through high-density electromyography technique. METHODS: We analyzed 73008 topographic maps obtained from seven healthy participants (age 21.4 ± 1.5 year-old, body mass 74.5 ± 8.5 kg) performing isometric plantar flexion with ankle at neutral position. We used a rigid array of 64 surface electrodes placed over the medial gastrocnemius muscle to collect the data. Size windows of 50, 100, 150, 250, 500 and 1000 ms were used in a factorial design with sliding of 0, 25, 50, 75, and 90%. A non-linear cross-entropy dimensional reduction of maps was applied to the data. RESULTS: The volume of fuzzy topographical structure increased with the increase of windows size, while entropy decreases when windows size increased. CONCLUSION: The change of window size and sliding to generate the intensity of topographic EMG maps cause a loss of fuzzy topographical structure, which reflects the change in maps patterns. References [1] Ghaderi et al. 2016.IEEE Trans Biomed Eng., 64, 1513-23. [2] Merletti et al. 2019. J Electromyogr Kinesiol, 49, 102363.

P-G-109: A novel encoder-decoder framework for interpreting neural drive information from individual motor units towards precise estimation of muscle force

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BACKGROUND AND AIM: The surface electromyography (sEMG) decomposition into individual motor unit (MU) activities has been known as a promising technique for decoding neural drive information towards advanced applications. However, its practical applications are restricted by limited performance of this cutting-edge technique, i.e., incomplete decomposition and difficulty in cross-trial tracking of individual MUs. Aimed at well interpreting neural drive information, a novel framework was proposed and applied to muscle force estimation. METHODS: The high-density sEMG (HD-sEMG) data were recorded from the abductor pollicis brevis muscles of 5 healthy subjects using a flexible 8 Ũ 8 (=64) electrode array when the subjects were performing isometric contractions of thumb abduction. Meanwhile, the thumb abduction force was recorded. Each data recording trial consisted of a 2-sec force increasing phase and a 3-sec maintaining phase at a target level. The subjects completed 8 trials

for each of three target levels at 10%, 20% and 30% of their maximum voluntary contraction, respectively. The original HD-sEMG data from each trial were separately decomposed using the progressive FastICA peel-off algorithm. For each MU in each trial, the 64-channel MUAP waveforms were converted into a 64-channel twitch force using a twitch-force model, where the twitch force amplitude was linearly correlated with the MUAP amplitude in each channel. The force was estimated on every 50-ms (100 data points at 2000 Hz) segment of the summation of twitch force trains from all MUs in each trial. Every segment (in a 100 Ũ 8 Ũ 8 matrix) was fed into hybrid deep networks including an encoder network with 4-layer 2-d convolutional blocks to characterize MU spatial information, followed by a decoder network with 2-layer long short-term memory blocks to decode the force. In the proposed framework, there was a special module that first clustered all the obtained MUs into 10 patterns using MUAP features and the k-means algorithm, and then established a linear discriminant classifier for recognizing the pattern of any given MU. This module enables the cross-trial MU tracking in a general sense. Another module was further designed to predict a gain factor so as to decode the target force level for each trial, using the linear support vector machine fed by features describing MU pattern distribution in the trial. This module was used to overcome the incomplete decomposition issue. Finally, the estimated force was obtained by multiplying the gain factor with the output of the decoder network. The above supervised machine learning methods were performed in a user-specific manner. For each subject, an eight-fold cross-validation was conducted. RESULTS: The proposed framework yielded averaged root-mean-square-error of 6.62 ą 0.89% between the estimated force and the true force, and it outperformed three other common methods including the method based on sEMG envelop (14.03 ą 3.54%), the method based on sEMG root-mean-square amplitude (17.26 ą 5.27%), and the method using MU firing sequences (16.12 ą 6.09%), with statistical significance ($p < 0.001$). CONCLUSIONS: This study offers practical solution to appropriate interpretation of microscopic neural drive information toward precise force estimation and other advanced applications.

P-G-110: In-vivo continuous estimation of human elbow joint dynamics using robust direction-based Hill models

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BACKGROUND AND AIM: Elbow joint angle estimation from surface electromyography (sEMG) is of major importance for modeling muscular systems, with wide applications in biomechanics and biomedical engineering fields. Previous studies mainly employed a very simple protocol to estimate reciprocating movements of the elbow joint, even using EMG from a single muscle (either biceps muscle or triceps muscle). The real situation of the elbow joint movements in daily life is much more complex, and it often involves the elbow joint suspension and turns in opposite direction at any position within the movement range. The aim of this study is to present a robust framework of direction-based Hill models driven by sEMG for continuous estimation of elbow joint dynamics in real situation. METHODS: Five neurologically intact volunteers (age: 21-26 years old, male, right-handed) participated in the experiments. All subjects were asked to perform 5 designated movement tasks in a movement range of elbow joint flexion angle between 15 to 90 degrees (0 degree at full extension of the elbow joint), with 3 repetitions for each task. These tasks involved a variety of motion situations, such as elbow joint suspension and turns in opposite direction at the movement range boundaries and during the flexion or

extension movements. The sEMG signals from two muscles (biceps and triceps) were recorded, and meanwhile the elbow joint angle was recorded using a goniometer. From the collected sEMG data, we first extracted features describing activation strength of both biceps and triceps muscles and their synergistic coordination, and then designed a multi-threshold and multi-stage decision strategy to detect the transition timings (including the turns in direction) among 3 defined movement patterns: flexion, extension and suspension. Given the sEMG data segmented and labeled with the movement pattern, two Hill models depending on each movement direction (i.e., extension and flexion) were established respectively. Finally, by feeding every 1-sec sEMG data segment into the well-trained Hill model according to detected movement direction, the elbow joint angle was continuously estimated. The above supervised machine learning approaches were conducted in a user-specific manner. For each subject, the percentage of data used for training and testing was 20% and 80%, respectively. Two common methods for elbow joint estimation were also implemented for comparison: a single Hill model driven by the sEMG data from biceps (HMB) or triceps (HMT). The root-mean-square error (RMSE) and correlation coefficient (CC) between the measured angle and estimated angle were calculated for performance evaluation. RESULTS: The proposed framework achieved the mean RMSE and CC of the proposed method were showed as 11.28 ą 1.057 and 0.87 ą 0.029 , and it outperformed both the routine HMB method (RMSE: 31.79 ą 3.416 CC: 0.55 ą 0.083) and the HMT method (RMSE: 31.62 ą 1.216 CC: 0.58 ą 0.057), with statistical significance ($p < 0.001$). CONCLUSIONS: Our study helps to improve the performance and robustness of estimating elbow joint dynamics using sEMG data from both biceps and triceps muscles.

P-G-111: Removal of ECG interference from trunk EMG with Singular Value Decomposition

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BACKGROUND AND AIM: Trunk electromyography (tEMG) is a non-invasive technique that can potentially be used to directly monitor respiratory effort in patients with sleep disorders, as an alternative to current invasive techniques such as esophageal pressure monitoring. tEMG aims at recording the electrical activity of respiratory muscles such as diaphragmatic muscles. Due to contamination by cardiac electrical activity (ECG), trunk EMG has not been widely exploited to monitor respiration. Different algorithms have been proposed for ECG cancelling, including gating, high-pass filtering, templating subtraction and Independent Component Analysis (ICA)[1,2]. The aim of the present work is to propose an algorithm based on singular value decomposition (SVD) for ECG cancelling in tEMG and to compare its performance with alternative algorithms from the literature. METHODS: The protocol was approved by the ethical committee of the Māxima Medical Center (Veldhoven, Netherlands). A synthetic dataset was built to enable the assessment of the performance of the algorithm. Muscular activity of the biceps was acquired on nine healthy volunteers. For each, six EMG signals were extracted as the mean of four channels from a high-density grid (64 channels, 4-mm diameter, 8-mm inter-electrode distance, Refa amplifier at 2048 Hz) during isometric contraction. Nine physiologic ECG (6 derivation each) were obtained from the Physionet database. ECG and EMG signals were summed to obtain a mixed EMG with a SNR from 0 to 20 dB, in line with real trunk EMG applications. The first step of the ECG cancelling algorithm was to detect the QRS complexes[3]. For each QRS complex, SVD was

applied to a matrix with dimension NxM, with N = number of QRS complexes considered (N=50) and M = number of samples in the RR interval of the current QRS complex. Each row of the matrix was composed by a single QRS centered 0.3 s before the R peak, with length equal to the RR interval. Finally, the ECG component was extracted through inverse SVD considering an optimized number of singular values (SVs), and it was subtracted from the mixed EMG. The optimized number of SVs was extracted through an experimental calibration curve. The error in the EMG reconstruction was assessed as the relative mean squared error (MSEr) of amplitude and mean-frequency difference (MFD) in time and frequency domains. Non parametrical statistical analysis was conducted to evaluate the performance of the proposed algorithm compared to gating, high-pass filtering, templating and ICA. RESULTS: The median(interquartile) MSEr was lower than 16(8)%, while the MFD was lower than 1.0(1.0)Hz with any SNR tested (see figure). Results showed superiority of the SVD algorithm in terms of amplitude and frequency with respect to the other algorithms (p-value<0.01) but ICA. ICA obtained similar results both in time and frequency domain (RE=18(5)%, MFD= 2.0(1.5)Hz, p-value<0.01) at 0 dB, but inferior performance in the other conditions. CONCLUSIONS: The proposed approach outperform other methods in reconstructing tEMG. REFERENCES: [1] Willigenburg NW, et al. J. Electromyogr. Kinesiol. 2012. [2] Drake JDM and Callaghan JP, J. Electromyogr. Kinesiol. 2006. [3] Varanini M et al., Comput. Biol. Med. 2017.

P-G-97: A Weighed K-Nearest Neighbors classifier as a tool for identification of upper limb spasticity in children with Cerebral Palsy

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BACKGROUND AND AIM: Here we introduce a Weighed K-Nearest Neighbors (WKNN) classifier to identify upper limb spasticity. METHODS: In order to build the classifier and to test its ability to detect spasticity, it was necessary to register and compare normal and pathological muscular activity during eccentric contraction of elbow flexion and extension. Voluntary sinusoidal patterns of movement of 8 healthy children (11.8ą1.55 years old) and 5 children with spastic cerebral palsy (9.2ą2.28 years old, Modified Tardieu Score=1-2 and Modified Ashworth Score=1) were performed and recorded at 4 controlled angular velocities (30°/s, 50°/s, 80°/s, 100°/s) in random order and 4 external load resistance configurations (0.5kg flexion resistance, 1kg flexion resistance, 0.5kg extension resistance, 1kg extension resistance). Surface electromyography (sEMG) of brachioradialis (BRD), biceps brachii (Bic), triceps lateralis (Tlat) and triceps medialis (Tmed) was measured using 4 SX230FW preamplifiers and a datalogger (Biometrics ltd, UK) at a sampling frequency of 1000Hz. Control of motion kinematics and motion resistance were attained using a pulley machine (Mobile Speed Pulley, Lojer, Finland) and the biofeedback Koakin-motion software (RWTH University, Germany). Each trial contains two flexion-extension cycles for each velocity with approximately one second between them. Two trials per external load were registered with one-minute rest period between trials in order to avoid subjects' fatigue. An electrogoniometer SG110 (Biometrics ltd, UK) was attached to subject's arm to register elbow's position.

Elbow's position was filtered using a lowpass 4th order Butterworth filter with a cutoff frequency of 6.6 Hz. Gradient of elbow's position was calculated to obtain elbow's angular velocity. Envelopes of sEMG were obtained by filtering sEMG raw data using a zero lag 18th order Butterworth filtered with a passband from 10 to 450 Hz. sEMG signals were rectified. sEMG signals were smoothed using a moving average filter with a window size of 80 ms. sEMG envelope was normalized to maximum value per patient among all trials. Institutional research and ethics committees approved the measuring protocol. All subjects and parents gave their informed assent and consent respectively prior to any acquisition of data. WKNN classifier was calculated using 10 predictors based on time domain features of motion kinematics and muscle activity (position, velocity, sEMG envelope of Bic, BRD, Tmed & Tlat). WKNN classifier training and evaluation was done in MATLAB R2019a (Natick, MA, USA). RESULTS: More than 8 million observations with a 59% prevalence of spasticity were used. WKNN classifier was validated using 5-fold validation method. WKNN classifier reached an accuracy of 100%, a precision, sensitivity and specificity >99%, a false negative rate and a false discovery rate <1%, and an area under the curve=1.0. CONCLUSIONS: the proposed method promises to be a valuable tool for identification of spasticity. Thanks to CONACYT-FONCICYT 26773.

P-G-98: Taking advantage of EMG?s strengths: additive use of EMG-based information in a conventional control strategy for active exoskeletons

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BACKGROUND AND AIM: Exoskeletons support several different use cases. The most common of those are the therapy of paraplegia and stroke related movement disorders, as well as the support of workers in industrial settings. In the latter case, the aim is to prevent workers from work-related musculoskeletal diseases. Conservatively, control strategies of active exoskeletons that respond to the user's movements make use of mechanical sensors, i.e. inertial and force sensors. Using mechanically based information for control provides the advantage of dealing with variables directly connected to the effective forces and external influences. Still, those measurement systems are only able to register actions already performed. A control strategy based on this information has inevitable time latencies, making instantaneous control impossible. Control schemes based on surface electromyography (sEMG) mostly underlay studies on prosthesis applications, but as well found application in exoskeleton control. However, surface measurements are only able to extract representative and averaged muscle activation signals. Thereby the real state of the muscular system is not observable in detail (but nearly in real time). Additionally, the relation between muscular activity and exerted force is highly dependent on the individual and environmental circumstances, and thus does not allow for modeling in sophisticating detail. Nevertheless, the information on the muscles' states that the sEMG contains is valuable in special cases. These especially include the ability to register activation before muscle force arises, and to assess the fatigue state of the muscles. In this study, we present an approach of a sensor fusion based control strategy focusing on the sEMG's key values. It consists of a basic control relying on mechanical sensory information, and a sEMG based pre-estimation of the movement start to reduce system response delay. Additionally, estimated peripheral muscular fatigue influences regulation of support force. METHODS: To check the viability of this approach, 20 voluntary test persons performed load-handling tasks at a seated workplace, monitored by 18-channel bipolar sEMG and a motion tracking camera system. Test

persons performed lowly standardized movements to gain results comparable to real application situations. RESULTS: Averaged sEMG hull curves for each movement show recognizable sEMG signals related to the upcoming movement with significant time difference to its start. sEMG parameters change associated with peripheral muscular fatigue could be observed under static and dynamic conditions. CONCLUSIONS: These results confirm that sEMG provides valuable information on the start of the movement and the fatigue state of the muscles. sEMG thus allows supplementing mechanical sensory information in key functions. It gives valuable contribution to the further design of the novel sensor fusion control strategy addressed above.

P-G-99: Diaphragm Electromyography to estimate respiratory effort: a preliminary study

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BACKGROUND AND AIM: Obstructive sleep apnea (OSA) is a pathological condition that affects over 9% of adults in western countries, with an estimated cost of $150 bln per year in the United States. The standard approach to monitor respiratory effort is based on esophageal pressure (Pes), which is unsuitable for long-term monitoring since it is obtrusive and often affected by artifacts due to sensor misplacement. Diaphragmatic electromyography (dEMG) is a non-invasive alternative but its use is often hampered by ECG contamination. Recently, our group has proposed a Blind-Source-Separation algorithm to remove the ECG artifacts. This might enable the use of dEMG for monitoring the respiratory effort. The aim of the present work is to investigate the feasibility of using dEMG to estimate respiratory effort. METHODS: The protocol was approved by the responsible ethical committee. Twelve healthy subjects took part to the protocol. To simulate OSA, participants were breathing through an obstacle that increased the resistance to the flow (hole with diameter of 2 mm, 3 mm, 4 mm, 5 mm, 5+2 mm, no obstacle). Twelve 1-minute trials (two for each condition) were recorded. During each trial, the esophageal pressure was measured using a catheter located transnasally in the distal part of the esophagus, (Gaeltec S7d, sampling frequency=128Hz). dEMG was measured with 8 monopolar Al/AgCl electrodes located on the 6th intercostal space (4 on the right side and 4 on the left side) and one reference electrode on the sternum, (Compumedics Grael, sampling frequency=512Hz). Due to the poor quality of the signal (presence of artifacts on Pes or low SNR), data from 3 subjects were discarded from further analysis. The 6 bipolar dEMG signals was filtered between 20 and 250 Hz. To remove ECG contamination, the algorithm based on singular value decomposition recently developed by our group was applied. The envelope (rectification and moving average filtering) of the clean dEMG signal has been computed and compared with Pes in terms of Spearman correlation coefficient R. The respiratory effort has been estimated as area under the curve (AUC) and peak-to-peak (PP) during the inhale phase. For each respiratory cycle, onset and offset of inspiration were detected as maximum and minimum values of Pes, respectively. RESULTS: dEMG and Pes of the left channels are moderately correlated (from R=0.5ą0.2 to R=0.6ą0.1). The estimation of the respiratory effort performed with AUC show a high correlation (R>0.7ą0.2) between the two methods. On the contrary, a poor correlation (R<0.3ą0.2) was found in terms of PP. DISCUSSION AND CONCLUSIONS: The correlation between dEMG and Pes during simulated obstructive apnea shows the ability of dEMG to track respiratory cycles. AUC seems a more

promising approach to estimate the respiratory effort. Further investigations on OSA patients are needed to elucidate the feasibility dEMG to measure respiratory effort.

P-H-112: Electromyographic activity of the quadratus lumborum muscle during walking and running

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BACKGROUND AND AIM: Quadratus lumborum (QL) is expected to contribute to the motor control of lumbo-pelvic region because it attaches to the iliac crest and transverse processes of lumbar spine in the deep layer of the trunk muscles. There are the anterior (QL-a) and posterior (QL-p) layers of the QL and recent studies have reported differences in regional functions of the QL-a and QL-p. The aim of this study was to clarify the electromyographic (EMG) activity of the QL-a and QL-p during walking and running. METHODS: Twelve healthy men (meanąSD; age: 23 ą 1 years; height: 174.0 ą 4.5 cm; mass: 71.9 ą 8.1 kg) participated in this study. The fine-wire intramuscular electrodes were inserted into the unilateral QL-a and QL-p at the L3-4 level guided by using ultrasonography. A wireless EMG telemeter system with a sampling rate of 2000 Hz was used to measure fine-wire EMGs. Participants with barefoot performed the walking at 4 km/h and running at 8 km/h three times each. The walking and running trials were recorded using 3D motion capture cameras (200 Hz) and a force plate (1000 Hz). Participants were asked to step on the force plate with the foot on the ipsilateral measurement side during walking and running. One cycle of walking and running was defined as from the moment of the heel on the ipsilateral measurement side grounded to the moment where it grounded again. The EMG data during one cycle of walking and running were normalized as a percentage maximal voluntary isometric contraction (%MVIC) during ipsilateral trunk lateral flexion in the side lying position, and converted into 11 points (0, 10, ... , 90, 100 %cycle). The mean value of three times was used for statistical analysis as the representative value of each muscle. The pelvic kinematics were calculated from the markers on the anterior/posterior superior iliac spine. Two-way ANOVA (muscles by phases) with post-hoc Bonferroni test was used to compare the activity of the QL-a and QL-p. The significance level was set at $p<0.05$. RESULTS: During walking, the pelvic kinematics in the coronal plane showed the peak lateral tilt toward ipsilateral measurement side (3.5 ą 3.0 °) at 66%cycle (the initial of contralateral leg support phase). Both QL-a (19.6 ą 7.6 %MVIC) and QL-p (9.7 ą 11.1 %MVIC) showed the highest activity at 60 %cycle (immediate before the start of contralateral leg support phase). There were significant main effects in the muscles and phases. The QL-a activity was significantly higher than the QL-p activity throughout the walking ($p < 0.05$). During running, the pelvic kinematics in the coronal plane showed the peak lateral tilt toward ipsilateral measurement side (3.7 ą 2.7 °) at 66% cycle (middle of contralateral leg support phase). Both QL-a (30.4 ą 15.6 %MVIC) and QL-p (15.7 ą 10.5 %MVIC) showed the highest activity at 70 %cycle (middle of contralateral leg support phase). There were significant interactions between the muscles and phases. The QL-a activity was significantly higher than the QL-p activity at 60 and 70 %cycle ($p < 0.05$). CONCLUSIONS: The QL-a was active at ipsilateral pelvic tilt during walking and running. The QL-a may have a large contribution to the motor control of pelvis in the coronal plane because it attaches laterally compared to the QL-p.

P-H-113: Fractal analysis of the center of pressure during multiple standing tasks

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BACKGROUND AND AIM: The characteristics of complex systems, such as the posture control system, can be evaluated by fractal analysis of the variable that reflects the posture control of the whole body. The fractal characteristics of the center of pressure (COP) during one-leg standing and tandem standing, which require more advanced postural control, have not been clearly compared to COP during quiet standing. We sought to clarify the difference in COP control characteristics between one-leg standing and tandem standing, and quiet standing using detrended fluctuation analysis (DFA). METHODS: This study included 8 healthy male participants. The standing tasks were quiet standing (QS), one-leg standing (OS), and tandem standing (TS). Two faceplates (AMTI, sampling rate: 1 kHz) were used to obtain all faceplate data for stable 30-second standing during quiet standing, one-leg standing, and tandem standing tasks. For the anterior-posterior(AP) and mediolateral (ML) COP positions (COPAP, COPML), velocity (VELAP, VELML) were calculated, and DFA was performed on the obtained time-series data. A scaling index (α) was calculated for the short-range (α1) and the long-range (α2) data. When the transition point (crossover point: CP) from the persistent correlation to the anti-persistent correlation was confirmed, the time domain where the crossover occurred was calculated. The Friedman test was performed to compare each index, and Bonferroni's correction was performed as a post hoc test ($p < 0.05$). RESULTS: We found that α1 significantly increased on COPAP in QS. On the other hand, α1 significantly decreased on COPML in OS. No significant difference was observed α1 of VELAP between all standing tasks. α1 of VELML showed significantly higher values in the order of TS>OS>QS. There was no significant difference in α2 of COPAP, COPML, and VELML. In QS, α2 of VELAP was significantly increased relative to other tasks. The crossover was observed only at the COP position data, and the crossover of VELML was significantly lower in the OS. CONCLUSIONS: Until now, it has been thought that controlling the COP in the ML direction is important during one-leg standing or tandem standing because the base of support in the ML direction is narrow. However, the results of the recent study indicate that the control of the COP position in the AP direction may change due to a decrease in the lateral base of support. Further, the results show that there is no simple correspondence between the decreasing base of support and the change in COP control. This is presumably an effect of increasing effort, which supports the total weight with one-leg, in addition to decreasing the base of support for one-leg standing.

P-H-114: Co-contraction of ankle muscle activity during quiet standing in individuals with incomplete spinal cord injury associates with postural instability

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BACKGROUND AND AIM: Individuals with incomplete spinal cord injury (iSCI) often experience balance impairments. It is hypothesized that the muscle activation pattern is affected after SCI, resulting in reduced balance ability. Specifically, larger co-contraction of the dorsiflexor and plantarflexor muscles is

expected in individuals with iSCI compared to able-bodied individuals. Here we investigated the differences in co-contraction of these lower leg muscles between individuals with iSCI (SCI group) and able-bodied individuals (AB group). METHODS: Thirteen able-bodied individuals (57.1 ą 10.5 yrs) and 13 individuals with iSCI (52.6 ą 13.9 yrs) were asked to stand quietly on a force plate with eyes open (EO) and eyes closed (EC). Electromyograms (EMG) were collected from TA, soleus (SOL) and medial gastrocnemius (MG) bilaterally. Periods of muscle activity were determined based on the muscle's resting EMG level. Muscle activation during trials of maximum voluntary contractions were recorded prior to the standing trials to quantify the level of muscle activity during standing (%MVC). The root mean square of the centre of pressure velocity (COPv) was used to quantify postural sway for each participant. RESULTS: In both conditions, the COPv of the SCI group was significantly larger than the AB group (EO: 0.656 ą 0.175 cm/s and 1.54 ą 1.01 cm/s; p = 0.036, EC: 0.931 ą 0.197 cm/s and 2.62 ą 1.71 cm/s; p = 0.016, for AB and SCI groups respectively). The muscle activation levels for the TA during EO and EC were significantly larger in individuals with iSCI (EO: 1.93 ą 0.528%MVC and 7.09 ą 6.02%MVC; p = 0.004, EC: 2.08 ą 0.780%MVC and 6.97 ą 6.51%MVC; p = 0.010, for the AB and SCI groups respectively). There was a significant increase in the co-contraction period of the TA to the MG and SOL (TA/MG: 15% AB group vs. 75% SCI group; p < 0.001, TA/SOL: 15% AB group vs. 72% SCI group; p < 0.001) in the SCI group. Interestingly, the postural sway during co-contraction of the TA and plantarflexors corresponded with an increase in the postural sway in the SCI group when compared to the postural sway during no co-contraction, for both conditions (EO: 2.09 ą 1.23 cm/s vs. 1.21 ą 0.35 cm/s; p = 0.036, EC: 3.14 ą 2.06 cm/s vs. 1.88 ą 0.77 cm/s; p = 0.016, for co-contraction and no co-contraction respectively). Conversely, in the AB group, there was no difference between the postural sway during periods of co-contraction and no co-contraction, for both conditions (EO: 1.10 ą 0.31 cm/s vs. 1.09 ą 0.26 cm/s; p = 1.00, EC: 1.44 ą 0.28 cm/s vs. 1.34 ą 0.21 cm/s; p = 1.00, for co-contraction and no co-contraction respectively). CONCLUSIONS: We conclude that individuals with iSCI show more co-contraction period between plantarflexsor and dorsiflexor muscles. The results suggest that the individuals with iSCI applied co-contraction to reduce postural sway when it increased dramatically or that the co-contraction induces larger postural sway via increasing the degree of freedom in controlling posture or ankle stiffness.

P-H-115: Blockade of muscarinic receptors increases cortical excitability in resting muscle and following voluntary contractions

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BACKGROUND AND AIM: The cholinergic system plays a critical role in human movement, where the blockade of muscarinic receptors in the CNS affects the excitability of intracortical motor networks [1]. However, it is unknown if muscle activation influences these TMS responses, and if spinal motoneurone excitability contributes to altered responses. METHODS: Ten healthy individuals (22 ą 2 yr) were randomly administered a placebo, or 20 mg promethazine (Phenergan), in 2 testing sessions. Single pulse transcranial magnetic stimulation (TMS) was applied to the motor representation of abductor digiti minimi (ADM) to obtain motor evoked potentials (MEP). F-waves were obtained from the ADM via electrical stimulation of the ulnar nerve (30 stimulations at 0.5 Hz). Normalised MEPs and F-waves were obtained from resting muscle, after a 10 s 50% MVC, and after a 10 s MVC. RESULTS: A main effect of drug was identified for MEP area (p < 0.001) where the MEP was significantly greater for the

antimuscarinic condition compared to the placebo condition. A main effect of contraction intensity was also identified for MEP area (p = 0.008) where the MEP was greater for the 50% MVC intensity compared to the 0% MVC and MVC intensity. No drug by contraction interaction was identified for MEP area, and no differences were found for F-wave persistence or area for any condition. CONCLUSIONS: Antimuscarinic effects were only observed for the cortical TMS measures, and not measures that directly reflect spinal motoneurone excitability. Given that cholinergic pathways modulate cortical inhibition, it is likely that the antimuscarinic drug used in this study potentially suppressed inhibitory mechanisms in the motor cortex. 1. Di Lazzaro, V., et al. (2000). Muscarinic receptor blockade has differential effects on the excitability of intracortical circuits in the human motor cortex. Experimental Brain Research. 135(4):455-61.

P-H-116: Modulations of muscle activity in the elderly during transient lateral floor transition with temporal instructions and use of a handgrip

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BACKGROUND AND AIM: Currently, autonomous buses are being tested, which will be a valuable transportation option to help elderly people stay active. There is a need for autonomous buses that can carry passengers safely. This study aimed to investigate the postural dynamic response of lower limb muscles to temporal directions and lateral floor movement while holding a handgrip in the elderly. METHODS: This study included 11 men with a mean (SD) age of 75.9 (7.0) years. Informed consent was obtained from all subjects after explaining the experimental protocols, which were approved by our institutional ethics committee (N.19-08). The test floor was made from a steel board (105 cm Ũ 105 cm) equipped with a handgrip. An actuator facilitated the translation movements of the steel board only right direction, which was detected by a fixed motion-activated camera. Surface electrodes (Blue Sensor type SP-00-S; Ambu, Denmark) were used with a wireless telemetry system (Telemyo G2 system; Noraxon Inc., USA) to record an electromyogram (EMG) of the following muscles on both sides: tibialis anterior, peroneus longus, gluteus medium, and adductor longus. Four distinct conditions, combined with temporal instructions about floor transitions and holding the handgrip, were used in this experiment as follows: no cue about the perturbation onset timing and holding handgrip (NoCue-HG), a cue and holding handgrip (Cue-HG), no cue and no handgrip (NoCue-NoHG), and a cue and no handgrip (Cue-NoHG). Each condition was repeated 3 times and their order was randomized. The average rectified EMG value of 50 ms was calculated from 400 ms before to 800 ms after the floor transition. The average EMG response to the 4 conditions and the time it took to complete each course were compared with analysis of variance for split-plot factorial design and post hoc test (SPSS ver. 25; IBM Japan, Japan). RESULTS: The average EMG of most muscles in NoCue-HG and Cue-HG conditions was lesser than that of NoCue-NoHG and Cue-NoHG conditions. The average EMG of the left tibialis anterior, left peroneus longus, and right gluteus medium before floor transition in the NoCue-NoHG condition significantly increased compared to the Cue-HG condition. CONCLUSIONS: EMG before floor transition was increased by temporal instructions and the postural muscle response was decreased by holding a handgrip. These results reveal that with the aid of temporal instructions and handgrips, the elderly could prepare for perturbation and maintain a standing position with less muscle activity. Autonomous buses that clearly

announce departure and are equipped with handgrip-monitoring systems may better serve elderly passengers.

P-H-117: Trial-to-trial peak-force variation in planter flexor MVC is associated with time-lag of electrical activities of agonist muscles

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BACKGROUND AND AIM: We often experience variation of peak force among several MVC trials; while its detailed mechanism from the viewpoint of agonist muscles activities remains to be unclear. The aim of this study was therefore to assess the influence of time-lag among electrical activities of agonist muscles on the peak-force fluctuation in repeated MVC trials. METHODS: Eight healthy young subjects volunteered for this study. Surface EMG (bipolar Ag/AgCl electrodes; pick-up diameter 4 mm; inter-electrode distance 20 mm) was obtained from medial gastrocnemius (MG), lateral gastrocnemius (LG), and soleus muscles (SOL). The reference electrode was located on the lateral malleolus. Also, the mechanomyogram (MMG) was simultaneously recorded from MG and SOL. The subjects performed isometric planter flexion with maximal effort in the right leg, where the knee and ankle joint angles were fixed at 180° and 90°, respectively. In the MVC trial, the force output was guided by a target force line (Δ40 %MVC/s) on the screen. This MVC trial was repeated ten times with sufficient rests between trials. The root mean square (RMS) of each EMG and MMG signals were obtained for each of successive 0.1-s time windows. The timings of peak RMS values for each EMG and MMG and of peak torque were detected for each MVC trial. Then, the time-lags were calculated among these peaks for each MVC trial. The ten MVC trials were categorized for each subject, depending on the peak torque value: successful and failed trials for best and worst three trials, respectively. RESULTS: In the successful trials, the time-lag between EMG peak and torque peak was significantly shorter than that of failed trials in MG and SOL ($P<0.05$). The time-lag between MG EMG and LG EMG tended to be shorter in the successful trials ($P=0.09$). However, this was not the case for MMG. CONCLUSIONS: It was suggested that the time-lags of the agonist muscles' electrical activities relate to the unexpected variation of MVC peak torque in the isometric planter flexion.

P-H-118: Do the first and second toes serve different functions during standing?

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BACKGROUND AND AIM: An association exists between toes and the balance ability during standing. Although there are five toes in a foot, during standing, the function of each toe has not been entirely revealed. The purpose of this study was to clarify each toe's function during one-leg standing. METHODS: A total of 17 women (age range, 27-59 years) participated in this study. We got the written informed consents from all subjects. While the subjects were standing on one-leg, the coordinate of the foot center of pressure (COP) and the load of each toe were measured. For measuring COP, we used stabilometer (Unimec Co., Ltd., UM-BARII. The medial-lateral direction of COP coordinate is expressed in

COP (x), and the anterior-posterior direction of that is expressed in COP (y). For measuring the load for each toe, we used compression load cell (Tokyo Measuring Instruments Lab; for the first toe: CLS-500NB, 500 N load, 20 mm diameter, and 9 mm height; for the second to fifth toes: CLS-100NA, 100 N load, 12 mm diameter, and 4 mm height). The sampling frequency was set at 100 Hz. The subject weared with the trunk orthosis for restricting the flexion, contacted both palms on the lumbar region, stood with right leg of the bare foot and opened eyes and stood with right-leg for about 30 s. The analysis section was from 1.01 to 6.00 s after the one-leg standing onset. Acceleration of COP(x) and acceleration of COP(y) were calculated. The cross-correlation functions between each Acceleration of COP and each toe load were also calculated. The variables of a cluster analysis were the peak value of the cross-correlation function and the time lag at which it occurred. RESULTS: The results showed that the different functions were revealed in the first toe and other toes. The function of the first toe was to press the floor just before the COP turned from the medial to the lateral of the foot. The function of the second to fifth toes was to press the floor just before the COP turned from the lateral to the medial of the foot. CONCLUSIONS: The first and second toes serve different functions during standing. These results can help to estimate the effect of toe impairment on standing balance.

P-H-119: TRUNK MOTOR CONTROL DURING REPETITIVE SAGITTAL MOVEMENTS FOLLOWING A REAL-TIME TRACKING TASK IN PEOPLE WITH CHRONIC LOW BACK PAIN

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Introduction: Cumulative spinal loads, especially from fast paced repetitive trunk movements, can be associated with the development and perpetuation of low back pain (LBP) which is known to be a major health problem worldwide. Research has demonstrated that people with LBP often display impaired trunk motor control, which may affect precision of their movement. Traditionally, precision of trunk movement has been examined by testing relocation accuracy rather than evaluating the accuracy of tracking dynamic movement. Thus, in this study we used a 3-D motion capture system to provide a real-time tracking task that requires precise trunk movement. The effect of varying speed of motion on the temporal accuracy of movement, the kinematic variability of segmental motion of the spine as well as the recruitment of trunk muscles when preforming repetitive movements in people with or without LBP was assessed. Methods: Seventeen asymptomatic volunteers and 15 participants with chronic non-specific LBP were enrolled in this study. Trunk motion was captured using eight optoelectronic infrared cameras (BTS Bioengineering, Italy). Seventeen reflective markers were used to construct 3D kinematic data of the trunk, synchronised with four wireless bipolar surface electromyography (EMG) probes placed bilaterally over the lumbar erector spinae, latissimus dorsi, and external oblique muscles. From a seated position, participants were instructed to perform 12 continuous cycles of trunk flexion-extension following real time visual feedback at two different speed levels: 30°/s (slow), 50°/s (fast). A cross-correlation analysis was used as a measure of similarity to detect any temporal differences between the actual trunk motion and the feedback signal. The variability of trunk kinematics was evaluated with the mean of standard deviation of the angular displacements of trunk flexion/extension movements throughout the 12 continuous cycles. Results: Significant temporal differences were observed between the two groups when following the feedback at the fast ($p<0.05$) and slow ($p<0.001$) speeds. A moderate to high linear correlation was found between the kinematic variability of the lumbar spine segment and

scores from the Fear-Avoidance Belief Questionnaire for physical activity (FABQ-PA) during fast (r=0.35) and slow (r=0.50) movements. The co-contraction index was significantly higher (p<0.001) for the LBP group compared to the asymptomatic group at both fast (74%) and slow (90%) speeds. Discussion: Both asymptomatic and people with LBP showed an anticipatory motor adaptive behaviour, however, the response of those with LBP was consistently delayed in tracking the visual feedback compared to the control group. Moderate to high correlation was observed between the variability of lumbar spine motion and the FABQ-PA score during both tracking tasks, suggesting higher kinematic variability especially in the area of pain in those with fear of movement. Additionally, LBP participants displayed increased trunk-muscle co-contraction compared to healthy controls.

P-H-120: Sensorimotor Changes After Prolonged Experimental Neck Pain in Healthy Participants

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BACKGROUND: Neck pain is a leading cause of disability on a global scale and it is often associated with changes in sensorimotor control and function. The neural mechanisms underlying such changes are not yet fully understood. However, evidence of changes in corticospinal excitability has been identified in several persistent painful musculoskeletal conditions, indicating such changes may play a role in the persistence of pain. Whether changes in the corticospinal excitability are a pre-existent condition or a consequence of pain is unclear. Prolonged experimental pain models applied in asymptomatic subjects provide the possibility to investigate CSE changes during the initial phases of persistent pain model. This study investigated the effect of a prolonged experimental neck muscle pain following intramuscular injections of Nerve Growth Factor (NGF) into the splenius capitis muscle (SC), on corticospinal excitability of neck extensor muscles in healthy participants. METHODS: Thirty-nine pain-free participants were recruited in a controlled double-blinded study. Participants were randomized to receive two separate injections (day 0 & 2) of either NGF (0.5ml, 5 µg) or isotonic saline (0.9%, 0.5ml) into the right splenius capitis (neck) muscle. Pain intensity (NRS; 0=no pain, 10=worst imaginable pain) and bilateral pressure pain thresholds (PPTs) over the neck and extensor carpis radialis (forearm). Additionally, corticospinal excitability was studied by stimulating the left motor cortex using transcranial magnetic stimulation (TMS) recording the electromyographic response from the SC muscle. Rest (rMT) and active motor threshold (aMT), along with amplitude of motor evoked potentials (MEP) at 115% of aMT and short intracortical inhibition (SICI) were assessed. Measurements were conducted at day 0, 4 and 15. RESULTS: The NGF group displayed higher neck pain NRS scores than the control group (P<0.01) at day 4. Reduced PPT at the injection site was seen for the NGF group at day 4 (P<0.05) compared to control. For the NGF group this decreased PPTs at the injection site remained reduced at 15 (P<0.005) compared to day 0. In the NGF group. PPTs were also reduced at the contralateral neck site (P<0.05) and at right forearm (P<0.01) muscles in comparison with the control group. Compared with controls, aMT was increased in the NGF group at day 4 (P<0.05) and returned to baseline at day 15. No significant changes were seen for rMT, MEP and SICI. CONCLUSION: This study provides evidence that intramuscular injection of NGF into a neck extensor muscle causes prolonged neck pain and changes in the sensorimotor pathways lasting for days. The increased pain sensitivity and decreased corticospinal

excitability parallels the reports in chronic neck pain. The results support the use of NGF as an experimental pain model allowing for investigating potential underlying mechanisms involved in the transition to persistent pain during following the initial onset.

P-H-121: The effects of temporary blood flow restriction on human motor control

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Background and aim: Recent studies suggest that transitory blood flow restriction (BFR) may improve the outcomes of training both from anatomical (hypertrophy) and neural control perspectives. Whilst the chronic consequences of BFR on local metabolism and tissue adaptation have been extensively investigated, its acute effects on motor control are not yet fully understood. Methods: In this study, we investigate the neuromechanical effects of 7 minutes of continuous BFR, either partial or complete, in comparison with non-restricted circulation (atmospheric pressure - AM) during isometric elbow flexions. Partial BFR was achieved applying an external pressure either between systolic and diastolic values (lower pressure - LP) of 1.3 times the systolic pressure (higher pressure - HP). Three levels of torque (15, 30 and 50% of the maximal voluntary contraction - MVC-torque) were combined with the three levels of pressure (9 randomized conditions). Each condition was repeated 3 times for a total of 27 trials. The protocol was administered to 12 healthy young adults. Neuromechanical measurements (i.e., torque and high-density electromyography - HDEMG) and a numerical rating scale of discomfort (NRS) were used to investigate the adjustments of the central nervous system in response to continuous blood flow restriction. The investigated variables were: root mean square (RMS), and area under the curve (AUC) in the frequency domain, for the torque, and average RMS and median frequency (MDF) across the electrode matrix, for the EMG. Results: The NRS values show a dramatic increase in discomfort, correlated with both pressure level and time of restriction. The torque RMS value did not change across conditions and repetitions. Spectral content, however, revealed a decrease in power at the tremor band (5-15Hz), which was enhanced by the level of pressure and the number of repetition. The average EMG amplitude showed no differences whilst the MDF decreased over time and across trials, but only for the highest levels of torque and pressure. The values at trial 1 for each condition did not differ from all the other trials at AM, suggesting a complete recovery after 10 minutes of unrestricted blood flow. Conclusion: The neuromechanical adjustments reported are compatible with a motor neuron pool inhibition caused by the increased activity of type III and IV and a decreased activity of spindle afferents (testified by the increased NRS rating and the decrease of the AUC).

P-H-122: Timing of muscle activity during the stance phase preceding a forward vs a backward step in fore and hindlimbs of horses

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? BACKGROUND AND AIM: Moving backward is a complex task that is effected by a backward direction of the horizontal movement of the limb during the swing phase. Before any step is taken, the preceding stance phase is a preparatory necessity for this movement, which has not yet been characterized for quadrupedal locomotion. ? METHODS: In 6 horses (mean 11 years of age, mean 556 kg body mass) the pattern of stepping forwards and stepping backwards were compared regarding the surface electromyography (sEMG) measurements of two forelimb muscles (trapecius and triceps) and of two hindlimb muscles (gluteus and biceps femoris) in relation to the swing phase of the same hoof. A maximum of three trials per horse was considered in each direction, and from the kinematic of the hoof marker the second stance phase, the second swing phase and the third stance phase were selected for analysis. Only left limbs and left sided muscles were used. Of the sEMG traces, root mean square values were calculated and local minima and maxima during the stance phase preceding and following the second swing phase of the respective hoof were localized. ? RESULTS: The minimum muscle activity of trapezius was lower by 26% during the stance phase preceding the swing phase of backward walking compared to forward walking, and the minimum activity of the gluteus was lower by 14 % during the stance phase following the swing phase of backward walking compared to forward walking. No significant differences were found for the maxima of muscle activity in the stance phase preceding and following the swing phase. No significant differences in the localization of the minima and maxima of muscle activities were found in the stance phase preceding and following the swing phase. The test whether any of the muscles was used similarly before the swing phase in the one movement direction as after the swing phase in the other movement direction showed significant differences (P=0,00) between these two scenarios in all four muscles regarding the RMS values and/or the location of their minima and maxima. The localization of minimum activity during the swing phase of the biceps femoris muscle differed significantly (P=0,03) between forward and backward walking. ? CONCLUSIONS: This shows that walking backward and forward do not differ markedly in the maximum muscle activities of the four muscles measured, nor do they differ markedly in the location of these maxima during the stance phases. Comparing the stance phases of the two movement directions with the limbs in similar positions in relation to the body (i.e. backward preceding the swing phase and forward following the swing phase), reveals significant differences in muscle activity patterns between the two scenarios. This shows that the horizontal components of movement differ markedly between backward walking and forward walking in horses, whereas the vertical components are relatively similar.

P-H-123: Ultrasound imaging provides a better estimate of force fluctuation than traditional surface EMG approach

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AIM: Force fluctuation during a steady contraction has been primarily assessed by quantifying the temporal correlation between fluctuations in force and the rectified surface EMG or the oscillations of motor unit discharge frequency. The correlation between force and muscle activation is typically moderate, suggesting that this approach may be limited by interreference from different signal sources and distortion of the surface EMG signal by amplitude cancellation. As series-elastic compliance in skeletal muscle permits fascicle shortening during isometric force development, measuring the degree

of fascicle shortening/lengthening against the stretch and recoil of the series elastic element during force maintenance may yield a stronger association. However, force does not always increase in proportion to fascicle shortening because tendon/aponeurosis exhibit non-linear force-length relationships. Accordingly, the purpose of this study was to determine whether 2D ultrasound imaging can detect changes in muscle fascicle length (FL) associated with low-amplitude fluctuations in joint torque during isometric torque maintenance. This study also examined whether the relationship between changes in instantaneous FL and isometric torque was sensitive to contraction intensity. METHODS: Eleven healthy adults performed isometric steady plantarflexion at target torques of 10 and 50% of the maximal voluntary contraction (MVC) torque with the knee extended and ankle in 15° dorsiflexion. As we have shown that the medial gastrocnemius muscle (MG) plays an important role in the control of isometric plantarflexion force, surface EMG and B-mode ultrasound images (120 fps) were recorded simultaneously from MG during each contraction. Instantaneous FL was determined for each frame of ultrasound through implementation of an automatic tracking algorithm in MATLAB. After low-pass filtering (3Hz), the cross-correlation function (CCF) was employed to determine the temporal correlation between changes in FL and torque output and changes in rectified EMG (rEMG) and torque. RESULTS: There was a main effect of both method and contraction intensity on peak CCF. Fluctuations in FL and torque yielded higher correlations than fluctuations in rEMG and torque (0.70 vs. 0.37, P < 0.05). Higher correlations were also evident for the 50% MVC contraction (0.63 vs. 0.45, P < 0.05), which exhibited a higher torque fluctuation (SD, 0.96 Nm vs. 0.21 Nm). Though the peak CCF value for the correlation between FL and torque was considerably lower for the 10% MVC contraction (0.59 vs. 0.82), it remained higher than the peak CCF between rEMG and torque for the 50% MVC contraction (0.44). CONCLUSION: This study suggests that ultrasound imaging may be provide a better estimate of the fluctuation in force than the traditional surface EMG approach. The predictive capacity of ultrasound imaging was lower at a lower contraction intensity but remained higher than EMG.

P-H-124: Regional distribution of motor evoked potentials in the low back extensor muscles: a combined HDsEMG and TMS study.

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Changes in corticospinal excitability (CSE) are frequently described in musculoskeletal pain conditions. CSE can be assessed by stimulating the M1 with transcranial magnetic stimulation (TMS) to elicit a response in the muscle of interest. These motor evoked potentials (MEP) are traditionally studied using bipolar surface EMG; however, this technique has the disadvantage of possibly recording signals originating from multiple muscles. This is especially important for muscles with a complex anatomical architecture, such as the spinal muscles, where findings are often complicated by large intra- and inter-subject variability. By collecting surface EMG signals from several locations over the muscle group, high-density surface EMG allows to quantify the spatial distribution of muscle activity, possibly reducing the variability of responses to TMS. This study aimed to investigate the within and between-subject variability of the spatial localization of MEPs within the low back extensor muscles. Preliminary analyses were performed on 4 healthy participants. CSE was studied by stimulating the left M1 using TMS. EMG responses were recorded from the spinal muscles with two grids of 64 electrodes (8x8,

OTBioelettronica, Torino, Italy) placed on the skin over the lumbar region. 50 TMS stimuli were delivered at the hotspot with a 9 cm double-cone coil at 120% of the active motor threshold during active contraction with EMG biofeedback. The amplitude of the response was measured as the peak-to-peak value for each channel, resulting in an amplitude distribution of 16x8 values for each MEP. The location of the response was calculated as the centroid of the channels with amplitude higher than 70% of the peak value of each amplitude distribution. Regional variations of activation were clearly observed between participants. While in the variability of the MEP location within-participants, one participant showed consistent responses in a single region of the low back extensors, whereas larger variability was observed in the other 3 participants. In the cranio-caudal direction, 2 participants showed a consistent caudal localization of the response, with MEPs located between L5 and L3; the other two participants showed more cranial responses, between L4 and L1, and between L2-L1 respectively. The location of the centroid was highly variable in the medial-lateral direction within-subject, although the median values were similar between participants (7-10 cm lateral to the spinous processes). This study provides novel information regarding the CSE of the lumbar extensor muscles. The variability in spatial localization of the MEPs may relate to the heterogeneous distribution of activation observed in lumbar spinal muscles during dynamic and isometric contractions. These findings suggest that HDsEMG may improve the estimation of CSE of the lumbar extensor muscles, possibly improving our understanding of regional neuromuscular changes in chronic pain conditions such LBP

P-H-125: Effects of Dual Muscle Tendon Vibration on the Performance of a Goal-directed Aiming Task

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BACKGROUND AND AIM: Proprioception allows humans to control their moving limbs efficiently and effectively, especially when visual feedback is absent. Proprioception loss has a significant effect on the quality of voluntary movement, especially in the upper limb. The application of muscle-tendon vibration(MTV) has been studied over the last decade and is suggested as a tool to stimulate the somatosensory afferents. Therapeutic MTV protocols are applied using a mechanical device that produces vibration with specific amplitude and frequency that stimulate the muscle spindles (low amplitude vibration within the frequency range of 70-120Hz). Clinical evidence has shown the effectiveness of MTV for improving muscle strength and function, reducing spasticity, and consequently improving functional performance. Also, MTV may be beneficial for older adults experiencing healthy aging. However, there has not been much attention given to wearable rehabilitation devices, such as a muscle-tendon vibration band, for enhancing upper extremity sensorimotor function through proprioceptive stimulation. The purpose of this preliminary study was to investigate the effect of applying MTV over the wrist flexors and extensors on the performance of a goal-directed aiming task. METHODS: 20 Participants were randomly assigned to the vibration group or the control group. They performed a computer aiming task that included acquiring targets successfully by moving a cursor illustrated on a computer screen toward one of six possible targets without the vision of the cursor and their upper limb. Participants performed four blocks of the aiming task that each included 24 trials. The knowledge of results was presented with the location of the cursor becoming visible at the end of each trial. Also, participants performed an immediate transfer block of aiming task which includes 18 aiming

trials while vibration was off for the vibration group and on for the control group. The performance of the aiming task was assessed using absolute, constant, and variable errors. Moreover, temporal characteristics of task performance were assessed using movement time and reaction time. RESULTS AND CONCLUSIONS: The preliminary analysis of the results of this study showed that the two groups did not perform significantly different in terms of end-point error and variability. However, the control group showed significantly longer reaction time comparing to the vibration group. Moreover, there were trends toward longer movement time for the vibration group. Further data analysis will be performed to explore possible adaptation to vibration as the four blocks of trials unfold. Since this preliminary study did not show a significant adverse effect on the performance of the participants who received vibration comparing to the control group, future work will examine the effects of a novel vibration device on the performance of individuals with chronic stroke and older adults.

P-H-126: Effects of visual feedback frequency on postural control during quiet standing

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BACKGROUND AND AIM: It has been suggested that not continuous but intermittent proportional-derivative (PD) control model is more appropriate for explaining postural control system [1]. On the other hand, a previous study represented intermittencies of visual processing and motor control through force adjustment task with intermittent visual feedback (VFB) [2]. The aim of this study was therefore to investigate the relationship between intermittencies of visual processing and postural control during quiet standing. METHODS: Eight subjects completed quiet standing tasks on a force platform while looking at a monitor for 30 s. During the trial, the location of center of mass (CoM) was displayed on the monitor as VFB in addition to a stationary target line. The output frequency of VFB was 4, 5, 6.7, or 10 Hz, based on the previous study for index finger force control [2]. Each VFB trial and control trial without VFB (CON) was repeated five times in random order. During each trial, we recorded anteroposterior positions of CoM and foot center of pressure (CoP) and electromyogram (EMG) of triceps surae muscles. RESULTS: Root mean square (RMS) of CoM and CoP significantly decreased at all VFB conditions ($p<0.05$), while the EMG RMS did not change ($p>0.05$). In addition, power spectral density (PSD) of CoP in low frequency (0 - 1 Hz) range significantly decreased at only 4-Hz VFB condition compared with CON ($p<0.05$). While we estimated less than 0.3 Hz of intermittency for postural control based on the results of peak frequency of CoP (i.e., 0.22 - 0.28 Hz in the VFB conditions), VFB frequency did not influence the intermittency. DISCUSSION: VFB itself contributed to making the body sway smaller and influenced frequency domain of postural control, but the difference of VFB frequency did not affect them. There are two explanations on the result for the VFB frequency. First, an inherent visual feedback influences low frequency component of postural sway [3]. Second, systemically, an intermittency longer than time delay of feedback loop (100 - 200 ms in quiet standing) stabilizes intermittent control systems depending on time periods [4]. CONCLUSIONS: Our experimental VFB frequency seemed to be too high to estimate intermittency of visual processing in postural control system and should be customized for the system. REFERENCES: [1] Asai et al., PLoS One. 4(7), e6169, 2009 [2] Slifkin et al., J Neurophysiol. 84(4), 1708-1718, 2000. [3] Kouzaki and Masani, Gait posture. 35(1), 11-7, 2012. [4] Insperger, IEEE Trans Control Syst Technol. 14(5), 974-977, 2006.

P-H-127: INFLUENCE OF THE DIRECTION OF THE CURRENT OF THE TRANSCRANIAL MAGNETIC STIMULATION ON THE INTRACORTICAL AND CORTICOSPINAL EXCITABILITY OF THE REPRESENTATION OF MULTIFID MUSCLES

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Background: Trunk muscles such as superficial multifidus (SM) are involved in postural control, but they are also prime movers during voluntary spine movements. Different neuronal networks and areas are involved in the control of postural and voluntary motor tasks. Roughly, premotor regions including the supplementary motor area (SMA) seem to be involved in postural control (e.g anticipatory postural adjustment) whereas the primary motor cortex (M1) is known to be involved, inter alia, in voluntary movement execution. Previous studies suggested that transcranial magnetic stimulation (TMS) could activate different neuronal networks by changing the direction of the electrical current induced in the brain. While posteroanterior current (PA) depolarizes mainly interneurons in M1, an anteroposterior current (AP) is suggested to target neurons or related neurons from premotor regions/SMA. Objective: The aim of the study was to determine if the current direction (PA vs. AP) activates differently motor networks and the corticospinal projection involved in the control of SM. We hypothesised that the use of AP direction activates different networks or the same networks but at a different extent compared than PA direction. Methods: In ten healthy participants, we examined SM motor-evoked potentials (MEPs) using multiple TMS paradigms. MEPs were recorded using surface electromyography electrodes at L3-L4 level. Participants maintained 15±5 % of maximal voluntary contraction (MVC) of SM during TMS. Active motor threshold (AMT), recruitment curve (90, 100, 110, 120, 130, 140, 150 and 160% AMT), and excitatory and inhibitory mechanisms using paired pulses TMS (80% [conditioning] followed by 120% [test] AMT stimuli at 2-3-10 and 15ms inter-stimulus intervals [ISI]) were tested using both current directions (PA vs. AP). Results: AMT was significantly higher for AP compared to PA current direction (53.6% and 40.7% respectively [p = 0.006]). AP produced more inhibition compared to PA at ISI 2ms (p = 0.003) and 3ms (p = 0.02). No difference was observed at ISI 10 and 15ms and for the recruitment curve. Conclusions: Our results suggest that the AP direction influences or recruits differently neuronal networks of the SM cortical representation. Neuronal motor networks recruited by PA current direction were more easily recruited than those recruited by AP current direction suggesting that the neurons recruited by PA were more excitable or better positioned relatively to the current flowing into the brain. However, PA activated intracortical inhibitory networks conversely to AP. The absence of facilitation for both current directions could be explained by the contraction of SM during TMS that may have saturated these circuits. Further studies are needed to determine if neuronal networks activated by PA and AP comes from different cortical areas (e.g. M1 and premotor/SMA) and fulfills different functions in the control of trunk muscles.

P-H-128: The effects of another pedestrian's limb movements on locomotor control within virtual environment

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BACKGROUND AND AIM: Circumventing another pedestrian is a frequent daily activity that is essential for safe community ambulation. Virtual reality allows controlling characteristics of obstacles such as their appearance and movement properties while recreating environments that are representative of the community setting. It is known that healthy young adults circumvent an inanimate cylinder differently than another pedestrian, but whether limb motion is responsible for this difference and how global (whole body) versus local limb movements of the other pedestrian affect circumvention is still well not understood. The purpose of this study was to understand how local limb movement of another pedestrian affects the planning and execution of circumvention trajectory and clearance. METHODS:Ten healthy young adults (24.5 ± 3.0 years) were immersed within a head mounted display in a virtual environment representing a shopping mall. Participants walked to a shop located directly in front of them while circumventing a virtual agent which, when present, approached from straight ahead with one of four different locomotor patterns: 1-Normal locomotor movements; 2- No arm movements; 3- No leg movements; 4- No arm and leg movements. Trajectory deviation points, minimum clearance, fluidity and coordination of horizontal head and trunk orientations along with center of mass lateral displacement were examined. NparLD statistical analysis was used to compare variables across the different conditions. RESULTS: Minimum clearance was smaller for normal locomotor movements compared to all other conditions (p=0.004 - p=0.027), but segmental coordination, fluidity and onset of circumvention trajectory deviations remained unchanged (p=0.227 - p=0.917). CONCLUSIONS: These results suggest that global body movement is sufficient to plan circumvention trajectories in a predictable avoidance task, but greater clearance safety margins are required when less local motion cues, such as limb movements of another pedestrian, are available.

P-H-129: Source analysis of evoked potentials involved in audiovisual multisensory processing in young adults with and without Attention-Deficit/Hyperactivity Disorder.

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BACKGROUND: Multisensory integration (MSI) is a complex form of neural processing that significantly influences how individuals interact with their environment. MSI is defined as the processing and integration of numerous occurring stimuli with a predominance of audiovisual integration an imperative in an individuals adapted response. Attention-Deficit/Hyperactivity Disorder (ADHD) is considered to be a neurodevelopmental disorder that exhibits unique neurological and behavioural characteristics 1, 2. These characteristics may influence how adults with ADHD integrate and respond to multisensory stimuli, particularly in sensory-rich environments. Our previous work using event-related potentials demonstrated that adults with ADHD process audiovisual multisensory stimuli somewhat differently than neurotypical controls 3, 4. ADHD participants responded faster to all stimulus types (e.g. auditory, visual, and audiovisual) in violation of the race model, indicative of multisensory integration. The goal of this present research was to identify specific neural substrates involved in multisensory processing and to determine whether there were underlying neurophysiological differences in those with ADHD compared to neurotypical controls. METHODS: This work utilized a two-alternative forced-choice discrimination task, which emphasized both response time and accuracy. Stimuli included a unisensory visual (red, blue, or green circle), auditory unisensory (female verbalization), and a semantically congruent audiovisual stimulus. Continuous whole-head electroencephalography (EEG) was recorded

while completing this task. Source localization (sLORETA) software was utilized to determine neuroanatomical differences in the contribution made by neural generators pertinent to audiovisual MSI, in those with ADHD versus neurotypical controls. RESULTS: Source localization techniques elucidated that controls had greater neural activity when compared to the ADHD group, this was at 164 ms post-stimulus onset when presented with an audiovisual condition. The source of this activity was found to be Brodmann Area 2, postcentral gryus, right-hemispheric parietal lobe referenced to Montreal Neurological Institute (MNI) coordinates of X = 35, Y = -40, and Z = 70 ($p < 0.05$). CONCLUSIONS: This work is the first to assess audiovisual multisensory processing through utilization of source analysis in young adults with a diagnosis of ADHD. Results suggest differences in multisensory integration areas in those with ADHD, particularly those present in parietal brain regions. Structural alterations to parietal regions in ADHD may have important implications for the processing of complex sensory information, while in audiovisual sensory-rich environments.

P-H-130: Crosstalk in motor evoked potentials recorded from resting and active vastus medialis in response to transcranial magnetic stimulation

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BACKGROUND AND AIM: Transcranial magnetic stimulation can be used to stimulate the corticospinal pathway to lower limb muscles. Motor evoked potentials (MEPs) are commonly used to evaluate the responsiveness of the pathway. MEPs recorded from forearm muscles may contain crosstalk from non-target muscles. The extent to which crosstalk is present in MEPs recorded from lower-limb muscles has not been investigated. The purpose of this study was to quantify the occurrence of cross-talk in MEPs recorded from the vastus medialis (VM) muscle. METHODS: Transcranial magnetic stimulation was delivered over the motor cortex of 10 young healthy participants (nine female, one male; age range 18-27 years) using a double-cone coil. Responses were recorded from the VM using conventional bipolar surface electrodes and a high-density (HD) electrode array (4 x 8 electrodes; 10-mm interelectrode distance) placed along expected fibre orientation. Suprathreshold stimuli were delivered while VM was resting and while active at 10% maximum performing isometric knee extension. An MEP was identified if the EMG signal in the MEP window (15-70 ms post stimulus) exceeded a threshold defined using pre-stimulus EMG amplitude. MEP amplitude was quantified as peak-to-peak EMG amplitude in this window. Conduction velocity (CV) was estimated for the maximal voluntary contraction (MVC) and each MEP from the HD EMG data using maximum likelihood estimation. MEP propagation was defined as physiological if $r > 0.7$, CV >3 m/s, and CV < upper bound (the highest value between 6 m/s or 105% of the value measured during MVC). MEPs without physiological propagation were considered to be influenced by crosstalk. The proportion of MEPs with crosstalk was compared between resting and active conditions using a paired t-test. For each condition, MEP amplitude was compared between trials with and without crosstalk using a paired t-test. RESULTS: At rest, a large proportion of MEPs recorded from VM contained crosstalk (range 18-100%, mean (SD) 77 (28)%). The prevalence of crosstalk reduced when VM was active (33 (36)%, range 0-86%; $p = 0.017$). In the resting condition, MEP amplitude was smaller for trials with crosstalk than for trials without crosstalk ($n = 8$; $p = 0.036$ and 0.030 for HD and conventional EMG, respectively). In the active condition, MEP amplitude was smaller for trials with crosstalk than for trials without crosstalk for HD EMG ($n = 7$; $p = 0.008$) but not conventional EMG ($p =$

0.34). CONCLUSIONS: MEPs recorded over the VM muscle are not always specific to VM, especially when elicited at rest. Smaller MEP amplitude in trials with non-physiological propagation, identified as containing crosstalk, was observed for HD EMG, but not always for conventional bipolar EMG. This suggests that MEPs recorded with HD EMG are less affected by crosstalk than MEPs recorded with conventional bipolar EMG, and better reflect the response in the underlying VM muscle.

P-H-131: Goal-dependent tuning of muscle spindle receptors during movement preparation

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Voluntary movements are believed to be advantageously prepared before they are executed, but the neural mechanisms at work have been unclear. For example, there are no overt changes in skeletal muscle activity during movement preparation. Using a delayed-reach manual task, we demonstrate a decrease in the firing rate of human muscle afferents (primary spindles) when preparing stretch rather than shortening of the spindle-bearing muscle. This goal-dependent modulation of proprioceptors begun early after target onset but was markedly stronger at the latter parts of the preparatory period. In two additional experiments, whole-arm perturbations during reach preparation revealed a congruent modulation of stretch reflex gains of shoulder and upper arm muscles. Our study shows that movement preparation can involve sensory elements of the peripheral nervous system. We suggest that central preparatory activity can also reflect sensory control, and preparatory tuning of muscle spindle mechanoreceptors is a component of planned reaching movements.

P-H-132: A robot-based evaluation of the volitional component of pelvis and trunk control

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Trunk and pelvis control are fundamental both while standing and walking. Neurological diseases, such as multiple sclerosis or Parkinson, and brain or spinal cord injuries affect these control abilities, forcing people to functionally reorganize their movements and to adopt new strategies. To assess trunk control in the clinical practice there are several methods, but most of these are based on questionnaires or on qualitative evaluation of motor performance. The instruments and protocols for quantitative assessments of pelvis and trunk control are limited. Here, we propose and characterize a robot-based assessment to quantify the volitional pelvis and trunk control in unimpaired healthy subjects. Subjects sat on a motorized chair (hunova®, a medical robotic device). The device has two independently controlled platforms, one under the chair and another under the feet. The latter was kept fixed, while the former was maintained in unstable equilibrium, tilting in response to the subjects' weight shift. The device (impedance controlled) provided an elastic force field tending to restore the platform parallel to the floor. Subjects were requested to move a cursor from a central starting point toward one of eight equidistant radially arranged targets that appeared on the screen (placed 1-meter far from the subject). To move the cursor, subjects should tilt the sitting platform in the direction of the targets. We asked them to minimize trunk motion. The evaluation included 12 repetitions of this exercise, thee for each

combination of the following conditions: (1) two body configurations: arm free to move and arm crossed on the chest; (2) two different target distances corresponding respectively to 5 and 7 degrees of angular tilt (in degrees)of the platform. The mapping between the forward-backward and left-right angular tilt of the sitting platform and the up-down and left-right cursor movements on the screen was 1 deg:1cm. During the assessment, we recorded the seat angular position, the center of pressure on the seat and foot platforms and the trunk movements with an inertial measurement unit placed on the sternum. Electromyography was recorded bilaterally from the following eight muscles: obliquus, erector spinae, latissimus dorsi, vastus medialis, semitendinosus, medius gluteus, tibialis anterior, soleus. We characterized the response of eight healthy subjects both in terms of kinetic and kinematic parameters as well as in terms of single muscle and synergistic activations. We identified changes due to different target directions, arm-configurations and target distance. The application of this approach to clinical contexts will be considered under the hypothesis that benefits to automatic postural control may be obtained by targeted practice of volitional control.

P-H-133: The long-latency stretch reflex separately scales shoulder and elbow input to the arm's position-dependent dynamics

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BACKGROUND AND AIM: The long-latency stretch reflex (LLSR, 50-100ms) helps stabilize the arm against external perturbations in a flexible manner. For example, a shoulder muscle's LLSR to elbow displacement is greater when the elbow position is extended than flexed which accounts for the position-dependent interaction torque. Previous studies only examined a single perturbation direction and could not test whether the positon-dependent modification reflected uniform or selective scaling of elbow and shoulder inputs. Uniform scaling would entail the same change in response magnitude for all perturbation directions. Selective scaling would entail a direction-dependent change in response magnitude better mirroring the limb's position-dependent and direction-dependent dynamics. We tested between these two hypotheses in a postural hold task and in a reaching task. METHODS: 30 healthy individuals (mean = 25yro, 15M/15F) participated. They interacted with a programmable robot (KINARM "exo") allowing flexion/extension of their shoulder and elbow. Surface EMG was obtained from the shoulder extensor muscle (posterior deltoid). In the posture task (n =15), participants had their elbow in a flexed (120 deg) or extended (45 deg) position, shoulder angle = 45 deg. Torque pulses (~100 ms) displaced the arm by an equal amount in eight directions. Reflex tuning was characterized by a plane-fit: Response = a*(shoulder displacement) + b*(elbow displacement). Slope magnitude indicates the LLSR's gain whereas slope orientation indicates the LLSR's preferred motion direction, PMD. T-tests contrasted the LLSR's gain and PMD at the two positions. The reaching task (n = 15) involved moving from the extended to flexed position within a movement time of 700-900 ms. Occasionally, the arm would be displaced into pure elbow flexion or shoulder flexion-elbow extension from its nominal trajectory. Perturbations occurred near the extended start or flexed end position. The LLSR's start-end slope was determined for each perturbation direction and contrasted with t-tests. RESULTS: During the postural task, the shoulder extensor's LLSR was modified by elbow position. Greater reflex gain occurred in the extended posture ($p < 0.005$) and the PMDs also differed ($p < 0.001$) with greater upscaling to

elbow than shoulder inputs. During the reaching task, the LLSR increased from the extended start to flexed end consistent with movement termination increases we have reported, but the change was selective: 220% for shoulder flexion-elbow extension displacements vs 15% for pure elbow flexion displacement. The start-end slopes were significantly different ($p < 0.001$) indicating greater position-dependent downscaling for elbow than shoulder inputs. CONCLUSIONS: These results demonstrate that shoulder and elbow inputs for the LLSR are selectively scaled with elbow position during posture and movement tasks. Accordingly, the long-latency stretch reflex expresses detailed information about the mechanical properties of arm.

P-H-134: Stretch reflex modulation during ballistic movements is explained by the activity in agonist and antagonist muscles

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BACKGROUND AND AIM: Sensitivity of short latency stretch reflexes changes dramatically with task, contributing to task-dependent changes in muscle activation. This modulation cannot be explained by activity within the stretched muscle, but rather follows a more complex pattern especially in tasks that require the coordinated activity of multiple muscles. It has been suggested that this modulation has a central origin, but it remains unclear if the neural signals controlling reflex modulation are distinct from those activating the muscles required for movement. Microneurography studies show that muscle spindle sensitivity reflects the balance of activity between antagonistic muscles controlling motion of a joint. The objective of this work was to determine if a similar balance could explain modulation of the stretch reflex. Specifically, we tested the hypothesis that stretch reflex amplitude in the elbow flexors and extensors can be predicted by activity of antagonistic muscles better than individual muscles. Ballistic movements were used as they create sizable activity in agonists and antagonists. METHODS: Data were collected from 14 adults (7M, 7F) as they made 150-350 elbow flexion and extension movements. Each participant's forearm was fixed to a rotary motor centered about the elbow, used to apply pseudorandom perturbations during movement to elicit stretch reflexes. Surface electromyograms (EMGs) were recorded from the biceps brachii, brachioradialis, and triceps brachii long and lateral heads to measure volitional and reflex activity. Background volitional activity was quantified as average rectified EMG from 0-40 ms before each perturbation; short latency stretch reflexes were quantified in the window 20-50 ms after each perturbation. Regression was used to determine the influence of agonist and antagonist background activity on the stretch reflex. RESULTS: Triphasic EMG patterns were observed in agonist and antagonist muscles during all movements. Stretch reflexes, monitored continuously during movement, were modulated in a pattern distinct from any single muscle EMG. Flexor muscle background activity accounted for 50 +/- 8% (Mean +/- SE) of the flexor reflex activity during flexion, and extensor background activity accounted for 45 +/- 7% of extensor reflex activity during extension. The ability to predict the reflex amplitude during flexion and extension movements increased to 72 +/- 5% and 70 +/- 5% when background of the antagonist was also considered. Our regression analysis suggested that antagonists inhibited agonist reflex activity in all movements. CONCLUSIONS: Our results show that dynamic changes in stretch reflex sensitivity can be predicted by the balance of activity in agonist and antagonist muscles. This suggests that, for ballistic

movements, central control of reflex sensitivity closely follows the control needed to complete a desired movement, providing a unified approach for regulating feedforward and feedback control of movement.

P-H-135: Characteristics of Stride Time Interval Fluctuations Before and After Knee Arthroplasty

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BACKGROUND AND AIM: Gait dynamics can represent a marker of gait instability. The stride time interval of normal gait has non-linear characteristic and long-range correlation (LRC) between the stride time intervals. However, accurate evaluation of LRC requires large number of strides. It is difficult to adapt to patients with knee arthroplasty (KA). The purpose of this study was to determine the number of strides required to evaluate the LRC of stride time interval in the patients with KA, and to evaluate the change in the LRC before and after KA. METHODS: Subjects were 10 patients (3 males / 7 females) with knee arthroplasty (KA), aged 53-84 (mean 72.6, SD 10.4 years) participated in the study. The subjects walked around 20m path shaped like figure 8 at comfortable walking speed for 7 minutes. Measurements were taken one day before and one month after KA. Tri-axial accelerometers were attached to the heels, and stride time interval were determined from the vertical component of acceleration. The time series data of 350 stride time intervals obtained from walking for 7 minutes was divided into seven different data lengths (1-50, 1-100, 1-150, 1-200, 1-300, and 1-350 stride). Scaling exponent (SE) was calculated by detrended fluctuation analysis (DFA) to evaluate the LRC of the stride time interval for each different data length. The surrogate method using random shuffling was used to confirm whether the nonlinearity of time series data of stride time interval changes with the data length. Conventional linearity gait parameters (gait speed, step length, cadence, CV stride duration) were also measured before and after KA for comparison with non-linear parameter (SE). The measured parameters for 10 subjects were averaged and then tested for significance difference before and after KA. Data normality was confirmed by the Shapiro-Wilk test. Paired t-test was performed for the data with normality, and a Mann-Whitney test was performed for the non-normal data. All analyses used R-version 2.8.1 with a significant level of 5%. RESULTS: Statistically significant differences were found in the SE between surrogate data and original data for all seven different data lengths. SE was significantly larger after KA for data lengths greater than 150. No statistically significant differences were found after KA in the measurement parameters excluding SE. CONCLUSIONS: The time series data of stride time interval had nonlinearity from the data length of 50 strides, and DFA could be applied to the data length longer than 50 strides. SE was significantly increased after KA from the data length of 150 strides, and other measurement parameters could not detect statistically significant differences after KA. It was suggested that SE is a useful index to judge the gait ability, especially gait instability after KA.

P-H-136: Suppression of the swallowing reflex by stimulation of the pedunculopontine tegmental nucleus in the rat

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It has been reported that the swallowing central pattern generator (CPG) is divided into two parts in the medulla; a dorsal area including the nucleus of the solitary tract and a ventral area corresponding to the reticular formation around the nucleus ambiguus. Morphological study has reported that pedunculopontine tegmental nucleus (PTg) projects to the latter area. It is therefore likely that the PTg is involvement in control of swallowing. This study examines whether the swallowing reflex is modulated by stimulation of the PTg. These experiments were performed on rats anesthetized by urethane (1.3 g/kg, i.p.). Electromyograms were recorded from the mylohyoid muscle to identify swallowing event. The swallowing reflex was evoked by electrical stimulation (0.2 ms duration, 30 Hz) of the superior laryngeal nerve (SLN). Repetitive electrical stimulation applied to the pedunculopontine tegmental nucleus (PTg) (0.2 ms duration, 30 Hz, 150-200 µA). During recording sessions, the SLN and the PTg were simultaneously stimulated for 10 s. As a control, the SLN was solely stimulated for 10 s twice before and after the simultaneous stimulation. After each experiment, the stimulus sites were checked histologically. The PTg stimulation had suppressive effect on the number of swallowing reflexes. The number of swallows was 8.8 ą 0.9 (mean ą SE) in the pre-control, 4.3 ą 1.0 during Ce stimulation, and 9.6 ą 1.0 in the post-control (n = 6). The onset latency of the first swallow was significantly longer (0.70 ą 0.31 s; mean ą SE, n = 6) than in the pre-control (0.31 ą 0.12 s) or the post-control (0.27 ą 0.18 s). The outside of the PTg stimulation had no effect on the number of swallowing reflexes and the onset latency of the first swallow. The present study suggests that the RN is involved in the control of swallowing, and that stimulation of the PTg affects the swallowing CPG.

P-H-137: Pelvic fluctuation does not reflect COM acceleration during quiet standing

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BACKGROUND AND AIM: Center of mass (COM) acceleration fluctuation in static standing is thought large derivative gain and reflect postural control instability. We can measure body sway using a triaxial accelerometer easily, some researchers attached an accelerometer to pelvis because COM exists around S2 height in human body. However, postural control in static standing is not single inverted pendulum but multi-segmental model. COM is the weighed average of each body's segment mass, so it is likely that COM fluctuation does not correspond pelvic fluctuation. METHODS: Eight healthy adults(22.8ą3.7 years), fourteen chronic stroke patients (5.7 years being the mean time since stroke), and nine healthy elderly (70.5ą3.5 years) participate in this study. We used VICON Nexus (VICON Corp.), force plate (Kistler Corp.), reflective marker attached to subject's back head and pelvic, they stood quietly 30sec eye open and closed. We obtained (1)head and ②pelvis acceleration by second order differential of marker displacements, (3)COM acceleration(COMacc) calculated from horizontal ground reaction force divided by subject's weight on the basis Newton's second law. All parameters were quantified root men square.The two-way ANOVA were performed(groupÕeye conditions) in each acceleration parameter, and the correlation between each parameter was investigated using Pearson's correlation. RESULTS: The

stroke group were larger COM fluctuation than young and aged group (both p<0.001), also the same in head oscillation (p<0.003, p<0.001, respectively). There was no difference of pelvis fluctuation in three group. The relationship between COM and head was moderate (r=0.78), but between COM and pelvis was worse (r=0.53). CONCLUSION: Measuring body fluctuation by using the triaxial accelerometer to evaluate static postural control is simple and easy, fluctuation of COM acceleration is useful for evaluation of postural control stability. The problem is where should we attached sensor in subject's body. In the present study, COM accelerations are higher in stroke patients, it indicates neural control deficits, and the same in head acceleration. However, pelvis which COM exists in anatomical position dose not reflect COM acceleration. It reveals that accelerometer attached in pelvis could not measure COM acceleration, meanwhile, we confirm that human static standing control is multi-segmental model.

P-H-138: Body's center of mass clearance while reactive turning in healthy adults

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BACKGROUND AND AIM: Situations in daily life often require quick and unpredictable turnsļ so-called "reactive turning"ļ to avoid obstacles with limited time for planning. When turning is unpredictable, the risk of falling increases in older people, patients with stroke, or Parkinson's disease. We expect that the control of the body's center of mass (COM) in reactive turning changes depending on when people are informed the turning direction; however, previous research regarding this is unknown even in the case of healthy adults. The aim of this study is to investigate how COM trajectory changes when healthy adults are instructed to turn depending on the timing of the instruction. METHODS: Seven healthy adult males (mean age 26.1ą3.3 years) participated in this study. They walked at their self-selected, comfortable speed and turned at the intersection point, which was marked by four pylons. In the pre-planned condition turning (PT), the turning direction was provided before participants started to walk. In the reactive condition turning (RT-A, RT-B, RT-C), the visual cue was activated when participants walked through the infrared sensor of either of the three pairs. The sensors were located approximately one to three steps length before the turning point (RT-A was the closest to the point, see Figure 1). The cue was the illumination of an arrow located at the end of the straight walkway. A motion camera (Vicon Motion System) was used to determine the spatial location of body segments and to calculate COM while the participant was engaged in the turning task. The data were recorded at 100Hz. COM clearance was calculated as the distance in the horizontal plane from COM to the corner pylon. One-way repeated measures ANOVA and post hoc comparisons were performed on COM clearance in the turning conditions. The probability level of statistical significance was $p < .05$. RESULTS: COM clearance for RT-A (480.8mm) was significantly longer than for the other conditions (RT-B: 390.4mm, RT-C: 349.2mm, PT: 371.4mm, $p < .01$). In contrast, no significant differences were found between PT and RT-B, or RT-C, and between RT-B and RT-C ($p > .05$). CONCLUSIONS: These results suggest that healthy adults performed a specific COM clearance only when they were instructed to turn before one step prior to the turning point (RT-A). On the other hand, when people received a visual cue two or more steps away from the intersection point (RT-B, RT-C), they could control COM with the same spatial margin as pre-planned turning. In other words, healthy adults could adjust COM trajectory in their one-gait cycle and turn, even if they came across unpredictable events.

P-H-139: Effect of time-lag between heartbeat and postural sway on arterial blood pressure during quiet standing

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BACKGROUND AND AIM: The human bipedal posture is mechanically unstable. The postural control system maintains the postural equilibrium based on the sensory feedback information [1]. In addition, during bipedal standing, the blood tends to remain in lower limbs due to the gravity. This effect reduces the venous return, causing decrease in stroke volume and arterial blood pressure. Then, the cardiovascular control system works to maintain arterial blood pressure. Recent studies have reported the possibility that during quiet standing, these control systems cooperate with each other via postural sway and muscle pump function due to lower-leg muscle contractions [2]. Furthermore, it has been reported that when cardiac contraction and muscle relaxation synchronized, blood circulation becomes more efficient [3]. Accordingly, the purpose of this study was to explore the effect of time factor on the cooperation between these systems, by examining the effect of timing between heartbeat and postural sway on arterial blood pressure during quiet standing. METHODS: Twelve subjects performed a quiet standing task on a force platform with eyes closed for 330 s. During the trial, we recorded center of mass (CoM), electrocardiogram (ECG) and beat-by-beat arterial blood pressure. In occurring postural sway, the time-lag between ECG R-wave peak and forward CoM velocity peak [4] was successively obtained. The R-waves were categorized into 10 time sections from -500 ms to 500 ms according to the time-lag. The average systolic blood pressure (SBP) and diastolic blood pressure (DBP) for each time-lag section were calculated by ensemble averaging of the BP signals in each time section [5]. RESULTS: The number of R-waves attached was significantly different among time-lag sections ($P = 0.002$), and the number of R-waves was most in the time-lag section of 0 - 100 ms. SBP value was significantly changed by the time-lag ($P = 0.014$), and the forward CoM velocity peak after R-wave tended to lower the SBP value. CONCLUSIONS: The R-peak frequency in each time-lag section was different from that in electrically-induced muscle contractions with supine position [5], indicating the trend of synchronization between heartbeat and CoM velocity peak. Also, the change of SBP as a function of the time-lag suggests that the time factor influences the cardiovascular response. REFERENCES: [1] Masani et al., J Neurophysiol 90: 3774-3782, 2003. [2] Garg et al., Am J Physiol Heart Circ Physiol 307: H259-264, 2014. [3] Niizeki, Am J Physiol Integr Comp Physiol 288: R645-650, 2005. [4] Loram et al., J Physiol 564: 295-311, 2005. [5] Kimura et al., J Electromyogr Kinesiol 20: 572-579, 2010.

P-H-140: Investigating the neural correlates of proactive inhibition during a contextually-driven response task using high-density electrical mapping.

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BACKGROUND AND AIM: The ability to inhibit motor responses is critically important for the regulation of motor behaviors. According to the Dual Mechanisms of Control (Braver, 2012; Gonthier, Macnamara, Chow, Conway, & Braver, 2016), there are two underlying mechanisms of response inhibition. Reactive

control involves preparing and executing a response after an event has occurred. In contrast, proactive control uses contextual information to plan response inhibition in advance based on the expectation of a response inhibition cue. Individuals can be conditioned to exhibit these two kinds of control mechanisms by parametric manipulations of a contextually-guided keypress response AXCPT task. During this task, a sequence of letters appear on the screen individually and participants are instructed to respond to each letter by pressing a target or non-target key as fast as they can. Letters A and B are designated as cues that provide the contextual information to guide the response for the probe letters X and Y. Cues and probes are picked randomly and presented alternatively resulting in 4 possible sequences, i.e. AX, AY, BX, BY. METHODS: As a first step towards investigating the neural mechanisms underlying the interaction between proactive and reactive inhibition, we performed a modified version of the AXCPT task, where AX is designated to be the target sequence and appears with a very high frequency (70%). Through this design, participants (n = 48) should have developed a habitual target response and were therefore required to override it when presented with the non-target sequences i.e. AY, BX and BY 10% of the time each. We also expected participants to exhibit proactive inhibition, i.e., they should tend to prepare their responses based on the cues, thus resulting in a faster and more accurate response to BX than AY trials. RESULTS: This expectation was met, as indicated by greater average probe response error percentage (16% and 11%) and longer average probe reaction time (613 and 510 ms) for AY than BX trials, respectively. We analyzed additional measures to assess proactive inhibition: proactive behavioral index (PBI), d'-context and A-cue bias. CONCLUSIONS: All of the additional measures had positive values, indicating the presence of proactive control and a strong tendency to use contextual information to prepare a response. We are currently conducting these experiments while measuring electrical activity using high-density (256 channel) EEG and EMG to determine how the dual-mechanisms of control framework could account for our findings.

P-H-141: Postural control of hip and spine during unstable sitting: a spectral analysis

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BACKGROUND AND AIM: Postural performance has been studied in individuals with and without low back pain while sitting on a seat attached to a hemisphere. This unstable sitting paradigm challenges postural control of the trunk as spine movements are required to counteract seat tilting and maintain balance. Few studies have recorded spine kinematics during this task, and outcomes have been limited to the amplitude of movements. A deeper understanding about how the spine and hip are coordinated to maintain balance could offer insight into the mechanisms that underlie back pain. This study aimed to investigate how the spine and hip coordinate to maintain balance during unstable sitting. METHODS: Seventy-two pain-free participants were included (age: 27ą7 years, BMI: 22.3ą3.1 kg/m2). Participants sat as still as possible on an unstable seat fixed to a hemisphere (Figure 1) during trials with eyes open (EO) and closed (EC). Clusters with reflective markers were attached to the seat, left thigh, L5/S1, L2/L3, T12/L1 and T1, and were recorded using 3-D motion capture. Analyses were limited to the sagittal (AP) and frontal (ML) plane angular motion. Angular motion between the seat and each region corresponding to the hip, lower lumber, lumbar, upper lumbar and thoracic was quantified using a cross spectral analysis using amplitude spectrum (amount of movement), phase angle (timing) and coherence (consistency of timing) at frequencies between 0-1.5Hz. The threshold for coherence was set at 0.49.

Amplitude spectrum and coherence was modelled using generalized estimating equations with vision, frequency, and segment level as factors in AP and ML, separately. Phase angle between the seat and spine segments were descriptively reported. RESULTS: In AP, hip and lumbar segments had higher amplitude spectrums than upper lumbar and thoracic segments. Further, hip and lumbar segments moved out-of-phase with the seat at all frequency bands, opposite to the "in-phase" upper lumbar and thoracic segments. Hip segment motion was more coherent with the seat than other segments and the only segment with coherence considered significant (≥0.49) at all frequency bands (except at 1-1.5Hz in EO). In ML, lower lumbar and lumbar segments had higher amplitude spectrums, and were moving out-of-phase at all frequency bands with the seat whereas the hip, upper lumbar and thoracic segments were in-phase. Lower lumbar and lumbar segment motions were more coherent with the seat than other segments and the only segments above threshold at all frequency bands. In AP and ML, the amplitude spectrum ($P<0.001$) and coherence ($P<0.01$) of all segments were higher with EC than EO at all frequency bands. The mean phase angle was similar between EO and EC. CONCLUSIONS: Segments closer to the seat contributed more to maintenance of balance during unstable sitting than upper segments. The hip (in AP) and lumbar (in AP and ML) segments we most important for maintaining postural control. Similar analysis could be applied to study postural strategies between individuals with and without back pain to help build understanding of the mechanisms of back pain and predict those at risk.

P-I-142: Evaluation of Excitotoxicity in Amyotrophic Lateral Sclerosis Patients via Cutaneous Silent Period

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al., 2008). We analyzed CSP latency and duration from single motor unit recordings via discharge rate-based peristimulus frequencygram (PSF) method and probability-based peristimulus time histogram (PSTH) method. RESULTS: Paired t-test showed no significant CSP latency difference between affected and less affected hand groups (67.62 ms versus 62.37 ms for PSTH and 70.51 ms versus 78.91 ms for PSF analysis). However, affected hand CSP duration was significantly shorter compared with the less affected hand and control hand according to PSTH and PSF analyses (94.24 ms compared with 100.82 ms for PSTH and 123.12 ms compared with 132.76 ms for PSF analysis $p<0.01$ for both analyses). CONCLUSIONS: We found that the CSP duration is significantly shorter in affected hands compared with the non-affected and disease-free (control) hands. These results support the hypothesis that the depression of inhibition observed via a reduction in the duration of CSP may be an indication of excitotoxicity which can eventually weaken the functions of motoneurons. We suggest that the determination of the strength of inhibitory networks can be used to throw a light into the etiology of this debilitating disease. References Cengiz, B., Mercan, M., Kuruoglu, R., 2018. Spinal excitability changes do not influence the mechanisms of the split-hand syndrome in amyotrophic lateral sclerosis. Muscle Nerve. 58, 503-508. Gilio, F., et al., 2008. Influence of the corticospinal tract on the cutaneous silent period: a study in patients with the pyramidal syndrome. Neurosci Lett. 433, 109-13. Inghilleri, M., et al., 1997. The silent period in upper limb muscles after noxious cutaneous stimulation in man. Electroencephalogr Clin Neurophysiol. 105, 109-15. Kuwabara, S., et al., 2008. Dissociated small hand muscle atrophy in amyotrophic lateral sclerosis frequency, extent, and specificity. Muscle Nerve. 37, 426-30.

P-I-143: Effects of Persistent Inward Currents on Motor Unit Firing Properties and Coherence in a Biophysical Model of the First Dorsal Interosseous

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BACKGROUND AND AIM: Motor unit firing rates have been demonstrated to be nonlinearly influenced by persistent inward currents (PICs) generated by intrinsic ionic conductances within motoneurons. It has been recently hypothesized that PICs are differentially activated depending on the motor task, altering the synaptic input - motor unit output relationship (Johnson et. al 2017). In order to better understand how PICs affect motor unit recruitment, firing rate properties, and coherence, a model of the first dorsal interosseous (FDI) muscle was developed. METHODS: A closed-loop computational model of cortical spike trains, the motoneuron pool, and muscle force with proportional-integral control was developed and simulated in Python v. 3.7.4 and NEURON 7.7.2. The motoneuron pool consisted of 100 motoneurons, each modeled with a soma containing a persistent sodium conductance, and four dendrites, each containing a persistent calcium conductance (Powers et. al 2017). Motor unit forces were simulated using a phenomenological model (Fuglevand et. al 1993). The total force was compared to a target force trajectory and the strength of the synaptic inputs to the motoneuron pool were adjusted via a proportional-integral (PI) controller. RESULTS: Model simulations were performed at 10, 20, 30, and 40% of maximal voluntary contraction (MVC) under three conditions: a constant excitation, a ramping excitation, and a ramping excitation in response to a force-feedback trajectory using PI control. Model parameters were tuned to provide good agreement with experimentally recorded motor unit firing rate properties in healthy individuals. Changes in motor unit mean firing rates, firing rate

distributions, and recruitment were assessed under all three conditions for varying PIC strengths. The effect of PICs on the motor unit coherence spectrum was then analysed within the full model. CONCLUSIONS: This study presents a biophysical model of the FDI that was used to assess changes in motor unit firing properties in the presence and absence of PICs, under different types of excitation. PI control was implemented to simulate motor unit responses to a target force trajectory and compared to experimental data gathered during finger abduction tasks in the FDI. The full model was used to investigate the sensitivity of the motor unit coherence spectrum to intrinsic persistent conductances.

P-I-144: Motor unit identification using surface EMG at the wrist during finger flexions

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BACKGROUND AND AIM: Electromyography (EMG) decomposition is a well-established signal processing method to extract motor units' (MU) action potentials from EMG signals [1]. While surface EMG signals are interference signals affected by volume conductor noise and multiple acquisition factors, the outputted timings of the MU firings represent pure neural information [1], and thus can potentially be used as supreme inputs for myocontrol. EMG recordings in the upper limb have so far focused on the forearm as to target the belly of the extrinsic muscles responsible of wrist and hand movements. Nevertheless, no prior study has evaluated the decomposition output from the wrist, which has been recently found to be the preferred location for a wearable device [2]. Therefore, the aim of this study is to assess if MUs can be reliably extracted at the wrist level during finger flexions in order to later be used for myocontrol and ultimately improve the transferability and acceptance of this technology. METHODS: Subjects (n = 4) were instructed to perform isometric contractions during individual and combined finger flexions at 15% and 30% maximum voluntary contraction (MVC) in a closed-loop visual feedback task. Two 64-channel high-density EMG matrices (ELSCH064NM2, OT Bioelettronica) were placed on the circumference of the wrist and connected to a benchtop amplifier (Quattrocento, OT Bioelettronica - 2048 Hz sampling) for EMG acquisition. Force levels were recorded from five micro load cells (0-5kg CZL635, Phidget - 10Hz sampling) located in an adjustable platform below the fingers. The recorded EMG signals were digitally band pass filtered between 20-500 Hz and fed into a blind source separation decomposition algorithm [3]. Thereafter, the number of MUs, the discharge rate (DR), the coefficient of variation (CoV) of the inter-spike intervals and the pulse to noise ratio (PNR) were calculated. Finally, the number of MUs exclusively active during each finger contraction was computed for each subject. Two MUs were considered the same if the cross correlation between their action potential maps exceeded 0.8 cross-correlation coefficient. RESULTS: Preliminary results show similar number of detected MUs at 15% (mean ą standard deviation, 5.33 ą 1.12) and 30% MVC (5.07 ą 1.04) averaged across fingers and subjects. The obtained MUs, exhibit high PNR in both conditions (38.18 ą 0.95 dB and 38.34 ą 0.95 dB, respectively). Similarly, the obtained DR is within the physiological range of 6-25 Hz (11.74 ą 0.77 Hz and 12.01 ą1.17 Hz, respectively) and the CoV is below 30% (24.57 ą0.67 % and 25.07 ą 1.24 %, respectively). Finally, exclusively active MUs were found during all force levels and finger contractions (1.14 ą 0.72 and 1.47ą0.48 average number of exclusively active MU per finger for 15% and 30% MVC, respectively). CONCLUSIONS: These results evidence that MUs can indeed be detected at the wrist level at multiple force levels despite the challenging anatomical conditions (i.e. reduced recording surface and scarce muscle tissue). In addition, the preliminary results on the number of exclusively

active MUs suggest that finger flexions might exhibit maximum discriminative power at the wrist, making it a suitable signal source for myocontrol. Future work should validate these results in a larger subject pool. REFERENCES: [1] D. Farina and A. Holobar, "Characterization of Human Motor Units From Surface EMG Decomposition," Proc. IEEE, vol. 104, no. 2, pp. 353-373, Feb. 2016. [2] Y.-M. Fang and C.-C. Chang, "Users' psychological perception and perceived readability of wearable devices for elderly people," Behav. Inf. Technol., vol. 35, no. 3, pp. 225-232, 2016. [3] F. Negro, S. Muceli, A. M. Castronovo, A. Holobar, and D. Farina, "Multi-channel intramuscular and surface EMG decomposition by convolutive blind source separation," J. Neural Eng., vol. 13, no. 2, p. 026027, Apr. 2016.

P-I-145: Does indirect vibration stimulation alter beta band motor unit synchronisation in the human upper limbs- a high density EMG study?

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BACKGROUND&AIM:Acute indirect vibration delivered through upper or lower limbs can enhance force, power, flexibility, balance, and proprioception[1].However, the neuromuscular mechanisms underlying vibration exercise's potentiating effects have yet to be firmly established. We have shown that vibration exercise induces significantly higher neuromuscular loading resulting in higher fatigue in the upper limbs[2].It is also known that muscle fatigue increases beta-band coherence between the firing times of simultaneously active motor units[3].Therefore, the objective of this study was to assess whether fatiguing vibration exercise alters beta band coherence in the upper limb muscle compared to isometric fatiguing exercise (control); noting the fact that there likely different types of coherence inputs to the motoneuron pool during vibration. METHODS:4 healthy human participants completed a single experiment session. All measures were assessed under VIB (Indirect vibration; 30 Hz; 0.4mm displacement) and CON (No vibration) conditions. Vibration was delivered to the upper limb muscles via custom-built device[4]that participants held throughout the experiment. Each participant performed sustained isometric fatiguing elbow flexion via the device at 10%, 20%, 30% and 40% of their MVC under VIB and CON conditions. Participants maintained the contraction at the target level until task failure (the point at which force dropped below 5% of the target value). High density EMG data were recorded (128-channel electrode array, BioSemi, electrode radius 1mm, inter-electrode distance 2mm, sampling 4096Hz) placed on the flexor carpi radialis. Convolution Kernel Compensation (CKC) method[5]was used to decompose the HDEMG signals into MU spike trains and all the MUs with Pulse-to-Noise Ratio (PNR)<28 dB [6]or less than 50 identified MU firings were discarded. Coherence between both CSTs was calculated using Welch's averaged periodogram method. RESULTS: Coherence in the frequency range 15-27Hz increased from 0.221 (+/- 0.033) to 0.247 (+/- 0.045), 0.232 (+/- 0.055) to 0.291 (+/- 0.073), 0.273 (+/- 0.027) to 0.296 (+/- 0.050), and 0.284 (+/- 0.057) to 0.299 (+/- 0.047) with vibration at 10, 20, 30 and 40% respectively. Whereas coherence in the frequency range 28-32Hz increased from 0.243 (+/- 0.040) to 0.395 (+/- 0.091), 0.191 (+/- 0.028) to 0.392 (+/- 0.153), 0.241 (+/- 0.057) to 0.344 (+/- 0.039), and 0.265 (+/- 0.064) to 0.379 (+/- 0.049) with vibration at 10, 20, 30 and 40% respectively. CONCLUSIONS:These results suggest that vibration-induced fatigue may alter beta band coherence. Additional subjects will be added to investigate whether the changes observed are statistically significant. [1]M.Cardinal, et al., Br. Menopause,Mar2006[2]A.N.Pujari, et al., Royal Society

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P-I-146: Antagonist tendon vibration dampens estimates of persistent inward currents in motor units of the human lower limb

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BACKGROUND AND AIM: The control of normal motor behaviors involves complex interactions between excitatory, inhibitory and neuromodulatory commands to motoneurons. The effects of altered inhibition on neuromodulatory commands has not received much attention in humans. Yet, motoneuron firing patterns can be readily measured from the muscle fibers they innervate, collectively known as motor units (MUs), due to their one-to-one spike ratio. Reciprocal inhibition is essential for the control of persistent inward currents (PICs) in the cat. Here, we set out to test the efficacy of Ia reciprocal inhibition to control estimated PICs by applying a tonic vibratory input to antagonist tendons in humans. METHODS: MU firing patterns of the tibialis anterior (TA), soleus (SOL) and medial gastrocnemius (MG) were discriminated using high-density surface electromyography array electrodes and a convolutive blind source separation algorithm. PICs were estimated using the paired MU analysis technique, which quantifies discharge rate hysteresis (ΔF) by comparing the onset and offset of a high-threshold MU with respect to a low-threshold MU, providing an estimate of neuromodulatory drive to the MU. Participants performed isometric plantarflexion and dorsiflexion triangular ramp contractions with a peak of 30% of maximal voluntary contraction, and 10 s ascending and descending phases. In half of the trials, we applied vibration (128 Hz) to the distal TA tendon (plantarflexion) or Achilles tendon (dorsiflexion) with a constant force of 15 ± 2 N. RESULTS: There were large decreases in ΔF for both the SOL (28.7 ± 7.94%, $p = 0.006$, $d = 0.81$) and MG (20.2 ± 10.36%, $p = 0.008$, $d = 0.9$) during plantarflexion contractions with vibration applied to the distal TA tendon, and there was a moderate decrease in ΔF for the TA (15.4 ± 8.79%, $p = 0.009$, $d = 0.63$) during dorsiflexion with vibration to the Achilles tendon. The relative reduction in ΔF was greater for SOL than TA ($p = 0.0431$). CONCLUSIONS: These findings suggest that Ia reciprocal inhibition from the antagonist muscle can reduce the discharge rate hysteresis, providing insights about the interactions that occur to produce normal human motor behaviors.

P-I-147: THE INFLUENCE OF MUSCLE LENGTH ON THE CONTROL OF MOTOR UNITS IN THE TIBIALIS ANTERIOR MUSCLE

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BACKGROUND AND AIM. The force generated by a muscle depends on its resting length. Several authors (Bigland-Ritchie et al., 1992; Pasquet et al., 2005; Vander Linden et al., 1991) have investigated the central nervous system contribution to the control of motor units during isometric contractions at different muscle lengths. However, the identification of the discharge characteristics of the same motor unit at different muscle lengths have been considerably challenging due to the non-stationarity of the

motor unit action potentials (MUAPs) in intramuscular recordings. The purpose of this study was to overcome these limitations by the use of high-density surface EMG (HDsEMG) decomposition and track the behaviour of the same motor units during submaximal contractions at different muscle lengths. METHODS. The experimental protocol was performed on seven healthy young adults. The right leg was fixed in a custom-made ergometer and the force output was detected using a load cell. After maximal voluntary contraction (MVC) assessment, the volunteers performed two submaximal contractions (10% MVC and 20% MVC) at five different ankle angles: from 90° of plantar flexion to 100°, 110°, 120° and 130° of plantar flexion. One 64-channel electrode grid was used to record HDsEMG signals. The electromyography signals were decomposed by convolutive blind source separation (Negro et al. 2016) and the MUs were matched by cross-correlation of MUAPs at the different angles (Martinez-Valdes et al., 2017). The mean discharge rate, the variability of the inter-spike intervals, the recruitment and derecruitment threshold forces and the initial and final discharge rates of the matched units were computed and compared across ankle angles. Moreover, within the same angle, the variations (slopes) in the mean discharge rate of the matched motor units at 10 and 20 % MVC were calculated. RESULTS. We identified 75 and 81 matched MU across the five angles, at 10% and 20% MVC respectively. All parameters extracted from the matched MUs showed no statistical differences across all ankle angles. Interestingly, we found a significant difference between the discharge rate slopes in the ankle angles corresponding to short (90°), neutral (110°) and long (130°) muscle lengths across the two force levels (0.29□0.09 pps/%MVC for 90°, 0.13□0.07 pps/%MVC for 110° and 0.22□0.08 pps/%MVC for 130°, $P<0.05$). Specifically, the 110° ankle angle resulted in the minimal variation of mean discharge rate across force levels. CONCLUSIONS. Our results demonstrated that HDsEMG can be used to track motor unit behaviour across different muscle lengths during low and moderate isometric contractions. Interestingly, the discharge statistics of the tracked motor units did not change with muscle length. On the other hand, the central nervous system seems to modulate force at the different lengths in a different way, requiring less variation in the excitatory input to the motor pool to increase force output at the optimal/neutral length.

P-I-148: Effect of jaw-clenching on persistent inward currents: a preliminary study

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Background and aim: The mechanisms by which jaw clenching can enhance muscular force production are unclear, although facilitation of persistent inward currents (PICs) from brainstem derived serotonin could be involved. Serotonergic neurons project diffusely to motor pools, and previous research suggests that voluntary contraction of one muscle may lead to serotonergic enhancement of PICs for another muscle. Thus, we examined the effect of jaw-clenching on PIC strength in plantar flexor motor neurones, estimated through the well-established paired motor unit analysis technique. Methods: High-density surface electromyography (HDsEMG) of the gastrocnemius medialis was recorded from an adhesive grid of 32 equally spaced electrodes (inter-electrode distance: 10 mm). Low-level, isometric 20-s ramp contractions of plantar flexors (to 20% of maximal voluntary torque) were performed by 7 participants (3 females) in the chair of a motor-driven dynamometer. Three trials were performed in

each condition: control and jaw-clenching, for which participants were asked to clench their teeth on a plastic mouthguard as hard as they could during the trial. HDsEMG signals were decomposed into individual motor unit (MU) discharge timings and tracked between conditions. These discharge times were converted to spike trains and manually inspected. Two trials from each condition were selected for the estimation of PIC strength through a paired motor unit analysis, which quantifies MU recruitment/derecruitment hysteresis (ΔF). The hysteresis of a higher threshold MU (test unit), with respect to a lower threshold MU (control unit) is quantified by the difference between the instantaneous firing frequency of the control unit at test unit recruitment and the instantaneous firing frequency of the control unit at test unit derecruitment. A repeated measures nested linear mixed-effects model analysis of the whole sample of test units was conducted to examine the effect of jaw-clenching on ΔF. Results: A total of 119 MUs were decomposed, with 251 pairs (61 test units) being considered for the ΔF analysis, and tracked between conditions. The estimate of PIC strength (ΔF) in the control condition was 3.11 Hz (95% CI: 2.48 to 3.81 Hz). There was no significant change of the ΔF values from control to jaw clenching, with a mean difference of 0.05 Hz (95% CI: -0.17 to 0.27 Hz, p = 0.634). Conclusion: These preliminary findings do not support an effect of jaw clenching on PIC strength of the gastrocnemius medialis motor neurones during a low-intensity contraction. Speculatively, as the performance of the ramp contraction already increases descending serotonergic drive, a ceiling effect might occur, decreasing the likelihood of further neuromodulation of limb motor neurones during jaw-clenching. Future research is needed to confirm these preliminary findings, and whether there is any regionalization of these potential effects of serotonin on the gain control of motor neurones.

P-I-149: Qualitative difference in muscular activity with the region of the rectus femoris muscle

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Anatomical studies reported that the rectus femoris muscle(RF) is comprised of two different muscle-tendon units or neuromuscular compartments. Watanabe showed the region neuromuscular regulation within human RF by using high-density multi-channel surface electromyography(SEMG). The purpose of this study is to verify the differences in the quality of proximal part of RF activity and that of distal part by the frequency analysis of SEMG. The subjects were four healthy young men with no history of orthopedic disease in the lower limbs. The SEMG of RF was recorded when the isometoric voluntary contraction of knee extension or hip flexion was applied with increasing load reaching 80%MVC in 10 seconds. SEMG was detected using eight pairs of electrodes. Each electrode had a structure in which two silver wires of 1mm in diameter and 10mm in length were arranged at 10mm intervals. Electrodes were placed along the RF longitudinal axis between the anterior inferior iliac spine and the superior edge of patella. SEMG signals were sampled at 1000Hz. Using the recorded SEMG signals, we calculated the median power frequency(MDPF) of the frequency power spectrrum every 0.512 seconds and plotted the change of the MDPF with the load increase in a scatter plot. MDPF is an index of the activities of the motor unit, which is the muscular functional smallest unit. The MDPF during hip flexion was compared between the proximal and distal part. The same analysis was performed for the knee extension. Results showed that the MDPF tended to be higher in the proximal part than in the distal part during hip flexion.

However, during knee extension, there was no significant difference between the proximal and distal MDPF. From the above results, when the RF acts on hip flexion, it is possible that in the proximal part of the RF, an increase in motor unit activity in the hig frequency region and an increase in firing frequency may occur at a low load.

P-I-150: Low-frequency neural input to the muscles can be estimated by interference surface EMG

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AIM: Limitation of benefits of rectified surface EMG for estimating the strength of low-frequency common neural input to the motoneuron pools has still been pointed out because studies using simulation model showed distortion of neural oscillation information in interference EMG with amplitude cancellation, owing to overlapping of motor unit (MU) action potentials. The purpose of this study was to reexamine if low-frequency rectified surface EMG can accurately reflect the strength of low-frequency neural input evaluated by semi-directly detected MU discharge frequency in the experimental model. METHODS: Based on the research purpose, we employed concurrent contractions between antagonistic muscles to assess common neural input between muscles. High density surface EMG (HDSEMG) with 64 channels and standard surface EMG with bipolar configuration were measured from the medial gastrocnemius (MG) and tibialis anterior (TA) muscles to obtain MU instantaneous discharge frequency and EMG amplitude (aEMG) to estimate muscle activation level, respectively. First, 15 male participants (21.5yr) performed maximal voluntary contractions of plantarflexion and dorsiflexion to measure maximal aEMG of MG and TA, respectively. Then, the participants performed concurrent contractions of MG and TA at each 10% of maximal aEMG with visual guidance for ~15 s. To quantify the representative low-frequency neural input for each muscle, first principal component (FPC) was calculated by principal component analysis using instantaneous discharge frequency of five MUs, which were randomly chosen from MUs identified by 64ch-HDSEMG in each muscle. Rectified EMG at low frequency (< 3Hz; rEMG) for both muscles were calculated by using surface EMG signals with double-differential configuration which were detected from three adjacent channels along with fascicle direction of HDSEMG. The strength of common neural input to the antagonistic muscles were estimated by calculation of cross correlation function between FPC of MG and TA and between rEMGs of MG and TA. Regression analyses were performed between the peak CCF of FPC pairs and peak CCF of rEMG pairs across participants. Also, intraclass correlation coefficient (ICC) were assessed between peak CCF of FPCs and peak CCF of rEMGs. RESULTS: Significant and distinct CCF peak at around zero time lag was found in both CCF of FPCs and CCF of rEMGs. There was a high correlation between peak CCF of FPCs and that of rEMGs (r = 0.87) across participants. The good ICC (0.74) between peak CCF of FPCs and that of rEMGs was also found. CONCLUSION: The results suggest that strength of low-frequency common neural input to the antagonistic muscles can mostly be estimated by rectified surface EMG as comparable to assessment by MUs instantaneous discharge frequency at low contraction intensities.

P-I-151: The effects of vibration on motor unit firing rates during isometric contractions of the biceps brachii that include slow or fast linear increases in force

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BACKGROUND AND AIM: Previous research indicates that motor unit firing rates at steady force are higher for isometric contractions performed with faster in comparison to slower linear increases in force. It is hypothesized that muscle spindle activity may vary between slow and fast increases in force and result in differences in firing rates at steady force. Therefore, vibration was applied to the biceps brachii during isometric contractions of the upper arm that include either slow or fast linearly increases in force to diminish muscle spindle activity. METHODS: Eight (six males and two females) healthy individuals (age=20.1ą3.0 years; weight=76.6ą7.8 kg; height=1.8ą0.1 m) completed four isometric trapezoidal contractions at 60% of maximal voluntary contraction (MVC). Isometric trapezoidal contractions included a linearly increasing force at 5% MVC/sec (SLOW) or 20% MVC/sec (FAST), a steady force segment of 12 sec, and a linearly decreasing force of 10% MVC/sec to baseline. The isometric contractions of the biceps brachii were performed with (VIB) or without (CON) vibration in random order. Continuous VIB of 55 Hz was applied using a massager (Techno Concepts, France) tightly secured to the upper right arm. Surface electromyography was recorded from the biceps brachii via a 5-pin sensor (Delsys Inc., USA) and decomposed into action potential trains of individual MUs. The mean firing rates (MFR) of MUs during steady force were regressed against recruitment threshold (RT, expressed as %MVC) for each individual and contraction with the y-intercepts (pps) and slopes (pps/%MVC) calculated. Two 2-way repeated measure ANOVAs (linear increase [SLOW vs. FAST] x treatment [VIB vs. CON]) were used to examine potential differences between the y-intercepts and slopes. Alpha was set at 0.05. RESULTS: There were significant two-way interactions for the y-intercepts (P=0.035) and slopes (P=0.050). The post-hoc dependent samples t-tests indicated that the y-intercepts were significantly greater (P=0.016, P=0.004) for the FAST-CON (45.7ą8.4 pps) than the SLOW-CON (38.6ą10.6 pps) and FAST-VIB (38.2ą10.3 pps). There were no significant differences (P=0.554, P=0.670) for the y-intercepts between the SLOW-VIB (40.0ą11.3 pps) and the FAST-VIB or SLOW-CON. The slopes were more negative for the FAST-CON (-0.59ą0.15 pps/%MVC) than the FAST-VIB (-0.47ą0.17 pps/%MVC) with no other significant differences between conditions (P range=0.158-0.313). CONCLUSIONS: Firing rates were greater at steady force during the FAST-CON in comparison to the SLOW-CON. In addition, VIB applied during the FAST resulted in similar firing rates in comparison to the SLOW-CON and SLOW-VIB. The results from the present study would suggest that muscle spindle activity increases firing rates during a faster linearly increasing isometric contraction, whereas, muscle spindle activity may not influence firing rates to the same extent during a slower linearly increasing isometric contraction.

P-I-152: The steadiness of co-contractions of antagonistic muscles depends on strength of temporal correlations of low-frequency oscillations in motor units discharge frequency between the muscles.

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AIM: The intended concurrent contraction of the antagonistic muscles, namely co-contraction is predominantly controlled by low-frequency common neural inputs to the motoneuron pools in these

muscles. However, it is not well known if common neural inputs affect the accuracy of motor performance during co-contractions. The purpose of this study was to examine the relation between strength of the common neural inputs to the antagonistic muscles and steady co-contraction performance. METHODS: Sixteen young male (21.5 ą 1.4 yrs) were participated in this study. High density surface EMG (HDSEMG) was recorded with 64 channels from the medial gastrocnemius (MG) and antagonist tibialis anterior (TA) muscles to obtain instantaneous discharge frequency of multiple motor units (MUs) for estimating of common neural oscillations. Standard surface EMG with bipolar configuration was also measured to obtain EMG amplitude (aEMG) for real-time visual guidance during co-contraction tasks. The ankle joint angle was fixed at 90°. First, participants performed maximal voluntary contractions of plantarflexion and dorsiflexion to calculate maximal aEMG of MG and TA, respectively. Participants then performed steady co-contraction tasks of MG and TA at each 10% of maximal aEMG with visual guidance for ~15 s as accuracy as possible. The middle 8 s during co-contractions was used for subsequent analyses. To quantify the representative low-frequency neural inputs for each muscle, first principal component (FPC) was calculated by principal component analysis using instantaneous discharge frequency of randomly selected five MUs of each muscle, which were consecutively discharged during the tasks. Then, the strength of common neural inputs to the antagonistic muscles was assessed by peak value of cross correlation function (CCF) between FPC of MG and TA. To assess the steady co-contraction performance, variance of aEMG of MG and TA was calculated during co-contractions (VAR-EMG). Linear regression analysis was performed between peak value of CCF and VAR-EMG across participants. RESULTS: There was a significant and distinct positive peak of CCF (0.22-0.63) between FPC of MG and TA with a few millisecond time lag except for 2 participants. There was a moderate positive correlation between peak value of CCF and VAR-EMG across all participants (r = 0.54, P < 0.05). CONCLUSION: Finding of a temporal correlation of low-frequency oscillations in MUs discharge frequency between antagonistic muscles should support the notion that there is a low-frequency common neural inputs to antagonistic muscles during co-contractions. The results in the current study suggest that lesser common neural inputs to the antagonistic muscles tends to induce steadier co-contractions.

P-J-153: Contribution of muscle fiber recruitment to the stability of muscle synergies spatial patterns

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BACKGROUND AND AIM: The definition of muscle synergies explains how movements are integrated and coded in the spinal cord during motion learning processes. However, during motion, other neural processes like reflexes and neural adaptations contribute to motion together with the synergetic behavior observed. When certain resistance is added to the motion, to maintain the same performance, there should be an increase on the recruitment of muscle fibers. The goal of the following work is to evaluate if the extra muscle fibers used during resistance conditions are recruited by the neural modules in charge of generating the synergetic behavior or if they come from different neural processes. To do that, the evolution of the stability of muscle synergies will be study during pedaling motions with different levels of resistance. METHODS: Muscle synergy stability will be computed by correlating the spatial patters of the synergies extracted from consecutive pedaling cycles on a static bicycle. A subject

was asked to perform 2 pedaling trials under 3 different resistance conditions. An inertial measurement unit located in the rotational axis of the pedals was used to provide real time feedback about pedaling speed. Subject was requested to keep a constant speed of 20 km/h during the 3 resistance conditions that were presented in a random order to avoid queueing bias. Trial duration was fixed on 30 seconds to avoid fatigue related effects on the muscle fibers. The subject performed 30 cycles of the motion on each trial after fixing trial duration and speed. In total 60 motions cycles were recorded for each experimental condition. Vastus Lateralis, Biceps Femoris, Tibialis Anterior and Gastrocnemius Medialis sEMG signals were recorded during the experiment. Signals were high-pass filtered at 10 Hz, rectified and low-pass filtered at 10 Hz prior to synergy computation. Individual repetitions were segmented according to the periodic activations of each muscle. From each repetition 2 synergies were extracted and their stability was computed as the mean value of the correlation between a set of spatial patterns and the spatial patterns of the rest of the segments. RESULTS: Correlation coefficients extracted from motions performed under different resistance conditions show significant differences. In addition, the median values show an increase in the correlation of the spatial patterns when the resistance of the motion becomes higher. CONCLUSIONS: Results show an increase on the muscle synergies stability when there is an increase in the recruitment of muscle fibers which suggest that the extra fibers are recruited by muscle synergies rather than by other neural processes. This work is a preliminary study in which the experimental set up and protocol was tested with a single subject. The number of subjects will be increased in the future to increase the significance of the results obtained.

P-J-154: Are morphology of transverse abdominal muscle and multifidus associated with functional ability in patients with low back pain? A systematic review.

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BACKGROUND AND AIM: Previous studies have investigated the association between the core muscle morphology and functional ability in low back pain patients. However, the results are conflicting. Therefore, the objective of the review is to evaluate the association between morphology of transverse abdominal muscle (TrA) and multifidus and functional ability in low back pain patients. METHODS: An electronic search strategy was conducted in PubMed and EMBASE of literature published until January 2020. The outcome measures of the studies including two aspect. One is the functional ability of low back pain and the other is the morphology of TrA and multifidus. Besides, this two kinds of measurements should be analyzed the correlation. RESULTS: A total of 9 articles are included. There are three types measurements which are cross sectional area (CSA) by MRI, fat infiltration by MRI and dynamic contraction by ultrasound of the multifidus morphology. The measurement of TrA morphology is only dynamic contraction by ultrasound. The functional ability measurements including Oswestry disability index (ODI), Roland-Morris disability questionnaire (RMDQ), Chronic pain grade questionnaire, lumbar range of motion and Timed up and go (TUG). CONCLUSIONS: In low back pain patients, multifidus morphology by measuring fat infiltration and dynamic contraction but not CSA are associated with functional ability. There is limited evidence of the relation between TrA morphology and functional ability. Fat infiltration and dynamic contraction are more representative than CSA for muscle quality.

P-J-155: The Supinator and Pronator Muscles Activities at Grounding with the Hand in the Falling down

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Objective/hypothesis Main function of a muscle is to produce joint motion. In addition, muscles which are adjacent to a ligament having a function of joint stability may play a role as the dynamic stabilizer by muscular contraction. The supinator and the pronator teres locate on the lateral and medial side of the elbow joint and are adjacent to the collateral ligament, so that we hypothesized that these muscles have specific activities for stability of the elbow joint. However, it is not obvious how these muscles relate to the stability of the elbow joint. The purpose of this study was to examine activities of the supinator and the pronator teres before and after grounding with hand in the falling down. Materials and Methods The experiments were carried out on 8 normal human subjects (26-59 years). They all gave their informed consent for the experimental procedure. The experimental tasks were the grounding with hand in the imitation falling down positioning in forearm pronation and mid position. The?@ electromyography (EMG) activities were detected through bipolar Teflon-coated tungsten steel wire electrodes from the supinator and the pronator teres (ulnar head and humeral head) of the right side. The analysis section was 500 ms before and after grounding. The integrated EMG (IEMG) value was calculated every 100 ms and normalized with the IEMG value during maximum voluntary contraction (NIEMG). Results In the forearm mid position the NIEMG values of the supinator and in the forearm pronation the NIEMG values of ulnar head of the pronator teres increased with steep and reached to 45 % at 100 msec before grounding and sustained the values to 500 msec after grounding. The NIEMG values of the ulnar head of the pronator teres was significantly greater than the humeral head (P<0.05). Conclusions These findings suggested that the supinator in forearm mid position and the ulnar head of the pronator teres in forearm pronation contributed to the stability of the elbow joint and these activities just before grounding might be a rational control to stabilize the elbow joint effectively.

P-J-156: Motor neuron synergies controlling extrinsic and intrinsic muscles of the hand

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We propose a novel motor control paradigm that consider motor neurons instead of muscles as the basic element of synergistic motor control and we assess this paradigm on 14 extrinsic and intrinsic muscles actuating the hand. We implement two dimensionality reduction steps from EMG, the first non-linear, i.e. decomposition, and the second linear, i.e. factorization. We define as motor neuron synergies the time-invariant weights extracted by Non-Negative Matrix Factorization (NMF) from motor neuron smoothed discharge rates (SDR) and propose an anatomical graphical way to represent these weights. Seven healthy subjects executed seven grips with different combinations of fingers by performing isometric sinusoidal contraction at 1 Hz for 30 s. Four of these tasks consisted in a grip with a single finger in opposition with the thumb, while the other three involved more than two fingers. High-density

surface EMG was recorded by six 64-electrode grids, for a total of 384 channels, placed over extensor digitorum, extensor carpi radialis, extensor carpi ulnaris, flexor digitorum superficialis, flexor carpi radialis, flexor carpi ulnaris, the four dorsal interossei, abductor digiti minimi and the three muscles composing the thenar. The grip force was measured by a load cell pressed by the combination of fingers in opposition with the thumb. Motor neuron spike trains extracted by decomposition were represented as binary sequences of '0' (no activation) and '1' (discharge instants), which were then smoothed by low-pass filtering to obtain the SDR. The SDR were factorized with NMF algorithm. We chose a number of factors (synergies) equal to 5 (R(2) = 0.79±0.03) with a criterion based on the change in slope of the R(2) curve of reconstruction computed from 1 to 10 synergies. For each subject, four of these synergies were assigned to one finger opposing the thumb. Across all subjects we found an average cross-correlation with force >0.8 for each synergy associated to one finger during the task involving that finger only, except for the synergy associated to the ring finger (0.68). Motor neuron contribution for each synergy reflected the recruitment of muscles which are expected to actuate the finger associated to that synergy. We also compared these results with those obtained by NMF applied on EMG envelopes (conventional muscle synergies). The dimensionality of the EMG factorization was only 3 (R(2) = 0.91±0.01). Moreover, it was not possible to associate any of the muscle synergies with individual finger movements and the association with force was significantly lower than for motor neuron synergies. This confirms that conventional muscle synergies do not represent the neural control strategies as directly assessed by motor neurons. These results are promising to be interpreted from a neurophysiological perspective, to develop biomarkers assessing motor impairments and to create a new motor-neuron-based framework for myoelectric control.

P-J-157: Modular Control during archery shooting of elite recurve archer

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BACKGROUND AND AIM: Muscle synergies are neural coordinative structures that function to alleviate the computational burden associated with the control of coordinating movement. Evidence suggests that muscle synergy can be modulated during years of skill training. The purpose of our study was to investigate muscle synergies during archery shooting of elite archer. METHODS: One elite-level female recurve archer from Chinese national archery team completed two sets of six shots to a 30m target. Surface EMG activity was recorded using a wireless EMG telemeter system (Delsys, USA) at 2,000hz from 14 muscles on drawing arm (the arm used to draw the bow string backward), bow-arm (the arm used to hold the bow) and trunk. The muscles on the left side of the body included the following: flexor digitorum superficialis (FDS), extensor digitorum (ED), biceps brachii (BB), long head of the triceps (LoT), posterior deltoid (PD), middle deltoid (MD), latissimus dorsi (LD), upper trapezius (UT), middle trapezius (MT). The muscles on the left side of the body included the following: anterior deltoid (AD), biceps brachii (BB), long head of the triceps (LoT), lateral head of the triceps (LaT) and latissimus dorsi (LD). The sagittal view of the archer from Bow Hold, Drawing, Aiming, and Follow-through phases were synchronizing recorded by a high-speed camera (Sony, Japan) at 95hz. Muscle synergies were extracted from surface electromyography signal of 12 shoots using the classical gaussian non-negative matrix factorization algorithm. RESULTS: We could reproduce the EMG profiles of all recorded muscles by combining four muscle synergy activation coefficients with appropriate muscle synergy weights

(R2=84%). The muscle synergies extracted play different functional roles. We found that Synergy IV were avtivitied in the aiming, and releasing phase and was characterized by the activity of flexor digitorum superficialis on the drawing arm and right latissimus dorsi. Previous researches have shown that most archers release the bow string through a relaxation of the muscle (flexor digitorum superficialis) that maintain the flexed position of the fingers around the string. Additionally, Chinese archery coaches usually emphasize their archers should use their back muscles during aiming and releasing phase. Therefore, this synergy reflected the character of releasing the bowstring. CONCLUSIONS: Our results suggest that muscle synergy can reflect the shooting technique character of the elite-level archer. Within this framework, coaches can find elements of technique that are perceived as interfering with performance.

P-J-158: Immediate Changes in Shoulder Muscle Coordination as a Result of Constraining Wrist Flexion

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Background: Wrist orthoses are commonly used to treat wrist and hand musculoskeletal disorders but the upstream effects of constraining the wrist on proximal joint mechanics are not well understood. Intuitively, one can imagine altering shoulder and elbow joint motion to account for the reduced motion at the wrist. Altered proximal motion may make it possible to achieve specific tasks with a constrained wrist but may also result in use-related injury at the shoulder. Because wrist orthoses are common, it is essential to understand how they may affect shoulder health. We hypothesize that use of a wrist orthosis leads to altered activation of the shoulder muscles relative to normal upper extremity coordination. Testing this hypothesis is the first step in evaluating the long-term effects of wearing a distal wrist constraint. Methods: Eleven subjects (Age: 28.9 6.0, 8 F, 3 M) without prior upper extremity injury performed 8 functional reach-to-grasp tasks in which they manipulated and moved different sized objects. Tasks were selected from the Action Research Arm Test and were performed first without and then with the orthosis. Muscle electromyograms (EMGs) were recorded from twelve shoulder muscles (biceps brachii, triceps brachii, anterior-, middle-, and posterior deltoid, pectoralis major, teres major, upper-, middle-, and lower trapezius, serratus anterior, and latissimus dorsi). Non-negative matrix factorization was used to estimate muscle synergies that allowed us to evaluate how groups of muscles were coordinated with and without the orthosis. Data from all subjects were pooled for this analysis. Results: The twelve muscles analyzed were able to be described by 6 synergies for the off and on conditions, as well as when the two conditions were pooled, accounting for >90% of the variance (92.8% on, 91.9% off, 91.6% pooled). How subjects activated these muscle synergies was influenced by the wrist constraint. In particular, activation of the synergy most responsible for elevating the humerus (deltoids + scapular upward rotators) was more active when wearing the wrist constraint. The two tasks that required wrist pronation (pouring and drinking water) had higher mean activation throughout the tasks ($p<0.001$). The other six tasks, which involved a reach-and-grasp starting from a rest position with the hand on a table in front of the subject, had higher activation mainly while the hand was in the rest position ($p<0.001$). Conclusions: We observed that shoulder muscles, particularly those responsible for humeral elevation, were more active with the orthosis on. Increased activity of these muscles may result in fatigue or overuse at the shoulder and should be considered during treatment to prevent future

injury. The above effects were observed with immediate use. Further study is required to understand how long-term orthosis use would affect shoulder muscle coordination.

P-J-159: Shoulder complex muscle synergies for straight arm elevation across multiple planes

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BACKGROUND AND AIM: The shoulder joint functional complexity relies heavily on the coordinated muscle activity for normal movement due to its limited osseous congruency. Research completed on upper extremity muscle synergies focused on coordinated functional movements of the arm and hand ignoring the scapulothoracic motion and its control. A detailed understanding of the coordination at the shoulder complex is essential as the foundation to the development of effective/evidence-based treatment strategies for shoulder pathologies. This study aimed to identify shoulder muscle synergies responsible for the scapulothoracic and glenohumeral motion during seated arm elevation between frontal and sagittal planes. METHODS: Twenty male adults (age 24.4 ą1.27 years) with no history of shoulder pathology participated. Subjects performed arm elevations to 120° and back, using their right dominant arm (elbow extended), on 10 randomly ordered elevation planes. Motion capture tracked arm elevation at 120Hz. Surface electromyography (sEMG) data was recorded (1200Hz by a 16-bit A/D) using an MA-300 system on 11 muscles: upper (UT), lower (LT) and middle (MT) trapezius, serratus anterior (SA), long (LB) and short (SB) heads of biceps, anterior (AD), middle (MD) and posterior (PD) deltoid, and clavicular (CP) and sternal (SP) parts of the pectoralis major. Activation patterns were demeaned, band-pass filtered (10-450 Hz), and RMS processed using MATLAB. Four trails per plane of elevation were ensemble-averaged. RMS data was normalized to across all planes peak sEMG value. Motion capture tracked arm elevations and utilized the thorax, scapula, & humerus reference frames to calculate the actual elevation plane and the beginning and end of the arm elevation task. Non-negative matrix factorization (NNMF) was used for synergy identification and structure comparisons. RESULTS: Typically, 3 synergies were required to reconstruct the individual muscle activation patterns across all 10 arm elevation planes for all participants, determined on the minimum number of synergies that achieved variance accounted for (VAF) > 90%, with less than 3% VAF increase upon another synergy addition. The total VAF with three synergies was 95.9 ą1.4%. The distribution of muscle weights for the three synergies, generally speaking show, an arm elevation/lowering (antigravity) synergy (VAF 86.5 ą0.9%), reflecting the coordinated activation of UT, LT, AD, MD, SA, and LB; and two region of arm elevation specific synergies with the additional activation of; (a) the CP and SB (flexion synergy), and (b) the PD and MT (abduction synergy) for 5.5 ą0.7% and 4.0 ą0.9% VAF, respectively. CONCLUSIONS: Our data identified 3 muscle synergies, accounting for coordinated motion of the glenohumeral and scapulothoracic joints, for the arm elevation task between the frontal and sagittal planes. Interestingly, the UT and the MD contributed to abduction rather than the flexion synergy. Not ignoring the sEMG inherent limitations, it is proposed that such detailed understanding of the normal shoulder function can be valuable in the development of targeted evidence-based rehabilitation strategies, considering the questioning of the role of surgery in shoulder pathologies (e.g. subacromial impingement syndrome).

P-J-160: Effect of aging and knee osteoarthritis on muscle synergy

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Introduction Neuromuscular system abnormalities with muscle strength loss occur with aging, and their progression lead to pathological physical conditions such as osteoarthritis. The characteristic musculoskeletal change in knee osteoarthritis (KOA) is simultaneous muscle contraction, but this phenomenon is also associated with aging. Therefore, this study aimed to clarify whether the neuromuscular system is altered by musculoskeletal degeneration, including knee osteoarthritis, by using a muscle synergy analysis. Method Subjects in this study included: eleven young controls (YC), ten elderly controls (EC), and ten KOA patients (KOA). Gait assessments were performed on a treadmill at 3 km/h. Surface electromyography (EMG) data from 16 muscles on the trunk and unilateral leg were collected at 1000 Hz by a wireless EMG system. The 16 muscles included the paravertebral muscle (PVM), opposite paravertebral muscle (opp PVM), gluteus maximus (GMAX), gluteus medius (GMED), tensor fascia latae (TFL), adductor magnus (ADD), rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL), semitendinosus (ST), biceps femoris (BF), peroneus longus (PL), tibialis anterior (TA), gastrocnemius medialis (MGAS), gastrocnemius lateralis (LGAS), and soleus (SOL). A non-negative matrix factorization was applied to the electromyogram data matrix to extract muscle synergies. Further, joint angles were calculated to compare the kinematic data between groups determined by the number of synergy module. Results The number of muscle modules were significantly fewer in the EC and KOA groups than in the YC group (the mean number of modules: YC=3.3, EC=2.4, KOA=2.4). The findings of participants who showed fewer muscle modules indicated the merging of modules at the stance phase and co-contraction of multiple muscle activation. Furthermore, results showed that, during the early stance phase, the number of modules decreased with increased knee flexion and ankle dorsiflexion angles. Discussion Our results showed that the EC and KOA groups had fewer muscle modules than the YC group. The finding that fewer muscle modules some participants had indicated the merged modules and co-contraction of multiple muscles at the stance phase. These results indicate that muscle synergy may reflect the alteration of the neuromuscular system with aging regardless of the musculoskeletal degeneration associated with KOA. Also, the characteristic differences at fewer muscle modules group were a greater knee flexion angle and ankle dorsiflexion angle during the early stance phase in comparison with other subjects. This result suggests that the elderly with KOA could not perform anti-gravity extension with the knee joint and supported the knee by muscle co-contraction around knee joint. Thus, neuromuscular system alterations may be influenced by gait kinematics changes associated with aging, regardless of joint degeneration. In this study, the number of module in muscle synergy was used as a biomarker for changes in physical function associated with aging.

P-K-161: Does manual muscle testing of the middle and lower trapezius preferentially recruit these segments?

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INTRODUCTION: Clinicians routinely test the strength of the trapezius muscle (TR) as part of the assessment of the shoulder complex due to its role in scapular stabilization and movement. Reduced or elevated activity of different regions of the TM alters scapular kinematics and increases the risk of the shoulder complex to injury. As the TR has three defined segments (upper, UT; middle, MT; lower, LT) with varying actions, clinicians use multiple positions of glenohumeral abduction to selectively recruit and assess the strength of the different regions using manual muscle testing. Notably, the ability of these common manual muscle tests to preferentially activate specific regions of the TR is unknown. As such, the purpose of the current study was to determine the validity of adapted muscle tests to preferentially recruit the MT and LTs, and whether contraction intensity may affect this. METHODS: Twenty adults (n=9 males; n=1, not listed) performed 5 repetitions of 2 different muscle tests (TEST) for the MT and LT at 30% and 60% of maximum voluntary isometric contraction (MVIC). High definition surface electromyographic data were recorded from the MT and LT using 2, 32-electrode grids. Root mean square (RMS) was analyzed as a measure of muscle activity. Separate 2(MST)*2(MVIC) repeated measures ANOVAs were conducted for grid RMS of the MT and LT. RESULTS: There was a main effect of MST, F(1, 14) = 56.183, p < .001 partial n² = .801, and intensity, F(1, 14) = 19.645, p = .001, partial n² = .584 on RMS MT. RMS MT during MT-TEST (M= .059, SE= .007 V) was less than RMS MT during LT-TEST (M= .083, SE= .007). RMS MT (M= .062 SE= .006 V) at 30% MVIC was less than RMS MT at 60% MVIC (M= .081, SE= .008 V). There was an interaction effect for LT RMS, F(1, 17) = 14.612, p = .001, partial n² .462. Simple main effects indicated that LT RMS at 30% MVIC was significantly lower during the MT-TEST (M= .026, SD= .042)V than the LT-TEST (M= .042, SE= .006 V), F(1, 18) = 7.851, p = .012. RMS LT was significantly lower during the MT-TEST at 30% MVIC (M= .031, SE= .004 V) than 60% MVIC (M= .042, SE = .005 V), F(1, 17) = 31.218, p < .001. DISUSSION: Although designed to preferentially recruit the MT, the MT-TEST produced less muscle activity in the MT than the LT-TEST. However, our results indicate that at 30% MVIC, the LT-TEST does preferentially recruit the LT muscle fibres. These results suggest that TEST may not target specific segments of the TR, specifically the MT. Rather, patients may rely on their own recruitment strategies to perform the TEST, which may or may not utilize the desired MT segment and be dependent on intensity. As such, clinicians should consider that commonly used adapted TEST to target specific regions of the TR my not be a valid assessment tool for targeting muscle recruitment of specific TR segments.

P-K-162: Force enhancement during voluntary eccentric knee extension contractions is not stretch-amplitude dependent

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BACKGROUND AND AIM: Eccentric muscle actions of the lower extremity are important for absorbing kinetic energy during landing tasks. For example, following an unexpected fall during human hopping, a 15° greater knee flexion range has been related to a 3% increase in the knee extensors' relative contribution to the total lower limb's negative mechanical power [1]. The greater knee joint flexion range may increase the forces produced by the knee extensor muscles due to a phenomenon called force enhancement (FE) [2], which might help these muscles to stabilise fall recovery. However, the effect of knee joint flexion range (i.e. stretch amplitude) on knee extensor torque output and the

corresponding FE within the human knee extensors remains unknown. METHODS: Sixteen participants performed maximum voluntary fixed-end and eccentric knee extension contractions whilst seated in a reclined (10°) position on an isokinetic dynamometer (IsoMed 2000, D&R Ferstl GmbH, GER). Fixed-end contractions were performed at dynamometer crank arm angles (0° = full knee extension) of 40°, 70°, 90° and 105° in a randomised order. Eccentric contractions were performed at 30°s-1 following a 95% of maximum preload torque at the same crank arm angles of 40°, 70° and 90°, and finished at a knee joint angle of 110°. Net knee joint torques and dynamometer joint angles were sampled at 1 kHz using a 16-bit A/D card within a Power1401-3 data acquisition interface (Spike2, CED, UK). Torques and angles were filtered offline using a digital finite-impulse-response filter with a respective 20 Hz and 5 Hz low-pass cut-off frequency. RESULTS: Four participants were excluded from analysis due to fatigue. Significant FE (n=12; P ≤ .0216) was observed at all tested knee joint angles, but FE was similar (P ≥ .286) at the same joint angle across the eccentric contractions. Mean FE ranged from 11.4ą7.6% to 30.4ą17.6% during the eccentric contractions. FE was not significantly related to the stretch amplitude (rho: 0.072; P = .550), but the 20° rotation (70-90°) produced significantly more FE than the 15° (90-105°; P = .030) and 30° rotations (40-70°; P = .042). CONCLUSIONS: With a maximum preload torque prior to active muscle stretch, we observed 20.2% FE on average, which is greater than that previously reported (3%) during voluntary eccentric knee extension contractions [3]. We did not find a positive relationship between stretch amplitude and FE contrary to previous literature [2], but we speculate that this may be due to differences in how muscle fibres are activated voluntarily vs. artificially. Our results suggest that FE can be substantial during voluntary contractions and this may be useful in everyday situations, such as to assist fall recovery during unexpected falls. REFERENCES: [1] Dick TJM et al., 2019. J R Soc Interface, 16: 20190292. [2] Cook CS & McDonagh MJN, 1995. Exp Physiol, 80: 477-490. [3] Westing SH et al., 1990. Acta Physiol Scand, 140: 17-22.

P-K-163: The bilateral limb deficit (BLD) phenomenon during leg press: An investigation into central and peripheral factors

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BACKGROUND AND AIM: Bilateral limb deficit (BLD) is defined as the reduction of force production during bilateral compared to the summed unilateral contractions of homologous muscles and has been observed during various exercises and populations. Studies examining peripheral mechanisms using surface electromyography (EMG) have shown mixed results, yet there are suggestions that BLD may be due to central mechanisms, such as interhemispheric inhibition. Electroencephalography (EEG) has been previously used to demonstrate changes in cortical dynamics reflecting BLD in upper limb tasks however, very few experiments have used EEG while simultaneously recording muscle activation during a given exercise to examine the origin of the deficit. The aim of this study was to investigate the potential peripheral and central neuromuscular factors responsible for the BLD in active, young adults during a leg press exercise using EMG and EEG, respectively. It was hypothesized that (1) bilateral force would be less than summed unilateral force during leg press, (2) EMG activity during bilateral contractions would be lower than during unilateral contractions and (3) there would be differences in neuronal activity (EEG) between the bilateral and unilateral leg press suggesting that the deficit is caused, at least in part, by the central nervous system. METHODS: Sixteen male and female participants

(age = 23.7 ± 4.7 years old) completed bilateral (BL), unilateral left (UL) and unilateral right (UR) isometric leg press exercises using a dynamometer fitted with a closed-kinetic-chain adapter (Cybex, Humac Norm, CSMI Inc., USA). Force was recorded in parallel with surface EMG and EEG data during all exercises. Bilateral limb ratio (BLR) was calculated similar to previous studies. During all contractions a wireless 14-channel EMG system (Trentadue, OT Bioelettronica, Torino, Italy) was used to collect muscle activity from the left and right rectus femoris, vastus lateralis, and vastus medialis and mean root mean square (RMS) amplitude was compared across muscles. A wireless EEG headset was used to record movement related cortical potentials (MRCPs) over the left and right motor cortex areas (C3 and C4, respectively) to assess brain activity asymmetries reflecting central factors. RESULTS: The BLD was present in ten of the sixteen participants (mean BLR=81.4%). Mean RMS activity (Figure 1) demonstrated a significant decrease in muscle activity of the left leg in the BL condition compared to the UL condition ($p<0.05$), but there were no differences found in the right leg between the BL condition and UL condition ($p>0.05$). No significant differences in MRCPs were observed between brain activity of the C3 and C4 electrodes in any of the conditions. CONCLUSION: This study found a BLD during bilateral and unilateral leg press and muscle activation differences. However, the results from the EEG do not support the potential cause for the deficit to be due to interhemispheric inhibition.

P-K-164: Biomechanical Muscle Stiffness Measures of Extensor Digitorum Explain Potential Mechanism of McArdle Sign

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BACKGROUND AND AIM: McArdle sign is a phenomenon of impaired gait and muscle weakness that occurs with neck flexion, immediately reversible with neck extension. A recent report demonstrated the specificity of this sign for multiple sclerosis (MS) by measuring differences in peak torque of the extensor digitorum between neck extension and flexion. The objective of this study was to demonstrate muscle stiffness and its associated neuromechanical error as further criteria to evaluate MS. METHODS: This substudy included 73 participants [29 MS, 25 Other myelopathies, 19 Controls; age 47.9 years (12.5)]. MS and Other participants had clinical finger extensor weakness, but were not selected based on presence of McArdle sign. Participants performed 5 trials of extensor digitorum isoinertial contractions with the neck positioned in flexion or extension. Torque and displacement data were post-processed in customized LabVIEW software to extract a linear fit of the stiffness slope (torque over displacement) during the epoch of active finger extension torque. Additional variables extracted were: 1) R-squared, 2) weighted mean square error (Residuals), 3) sum of squared error of prediction (SSE), and 4) root-mean square error (RMSE). These extracted values of the best fit stiffness slope during active torque development were additional indicators of neuromechanical error. Data were analyzed with JMP 14 Pro. RESULTS: Peak torque between extension and flexion was greater in MS patients ($F_{2,72}=18.373$, p<0.001) than Controls (p<0.001) and Others (p<0.001). MS patients also had greater neuromechanical error compared to Controls and Other myelopathies: root mean square error (p=0.002), residuals (p=0.002), and sum of the squared error of prediction (p<0.001). With predicative variables with FDR LogWorth<2.0 (ΔPeak Torque, ΔRMSE, ΔSSE, and ΔResiduals), neuromechanical error demonstrated an area under the curve (AUC) of 0.94 comparing MS vs Other (p<0.001) with an overall 92% specificity and 86%

sensitivity. CONCLUSIONS: Evaluation of metrics related to muscle stiffness obtained with neck extended to flexed (McArdle sign) with a torque-cell device differentiated MS from Other myelopathies with a 92% specificity and 86% sensitivity (AUC=0.94). The sensitivity-specificity balance for McArdle sign utilizing muscle stiffness is superior to that previously reported based on analysis of peak torque alone (AUC=0.84). Adding variables of neuromechanical error recorded from the same device increased the specificity/sensitivity for distinguishing MS from Other myelopathy or healthy Controls. The neuromechanical error is likely caused by a conduction block between the cerebellum and the motor neurons due to demyelination which is exacerbated by neck flexion. Adding measures of muscle stiffness to those quantitating peak strength to objective assessment of McArdle sign can potentially serve as an ancillary diagnostic tool and is worthy of further assessment.

P-K-165: The influence of length-dependent isometric resistance training on fascicle length and neuromuscular activation in the context of the history-dependence of force in human ankle dorsiflexors

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Introduction: The history-dependence of force is an intrinsic property of muscle characterized by decreases (residual force depression; rFD) and increases (residual force enhancement; rFE) in steady-state isometric force following active shortening and active lengthening, respectively, as compared to force from a purely isometric (ISO) contraction at the same muscle length and level of activation. Changing serial sarcomere number - which is believed to at least partly relate to fascicle length - will affect the amount of sarcomere shortening/lengthening. Previous studies on the modifiability of the history-dependence of force have been inconclusive, and none have used isometric resistance training biased to short (short-training) versus long muscle lengths (long-training), which have potential to respectively decrease and increase fascicle lengths. rFD and rFE are dependent on the amplitude of sarcomere length change, so it was hypothesized that short-training would increase rFD and rFE and long-training would decrease them. Methods: On a HUMAC NORM dynamometer, 13 healthy adults (7M, 6F) performed maximal 12-s dorsiflexion contractions in the order of rFD (25° shortening), ISO, and rFE (25° lengthening) before and after 8 weeks of maximal isometric dorsiflexion training 3 days/week. Participants trained one ankle at 0° of plantar flexion (short-training) and the other at 40° of plantar flexion (long-training). rFD and rFE were calculated as the steady state decrease/increase relative to ISO. Ultrasonography of the tibialis anterior assessed time-course fascicle length changes. Root mean squared electromyography (EMG RMS) normalized to Mmax of the tibialis anterior (agonist) and soleus (antagonist) assessed neuromuscular activation at the steady state of the rFD, ISO, and rFE contractions. Results: Tibialis anterior fascicle length decreased in the short-training group (P = 0.03) and increased in the long-training group (P = 0.01). Relative rFD did not change in either group (Short-training: P = 0.36; Long-training: P = 0.76), nor did relative rFE (Short-training: P = 0.24; Long-training: P = 0.23), with no relationships between change in fascicle length and changes in rFD (R2 = 0.01, P = 0.62) nor rFE (R2 = 0.0004, P = 0.92). Normalized agonist EMG RMS did not change in any contractions following either training mode, however, normalized antagonist EMG RMS increased in the rFD contraction following both training modes (Short-training: P = 0.03; Long-training: P = 0.01) and in the ISO contraction following long-training (P = 0.04). Conclusions: Our data indicate that the

history-dependence of force is not modified through training-induced fascicle length adaptations, so there may be an uncoupling between the expected changes in muscle architecture and the history-dependence of force based on known mechanisms. As well, isometric dorsiflexion training appears to increase antagonist coactivation, potentially to increase joint stabilization.

P-K-166: Muscle activity and gait stability during normal, wide base and narrow base walking

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BACKGROUND AND AIM: Controlling stable walking involves the integration of multiple sensory signals, motor patterns and corrective responses to perturbations. The gastrocnemius muscles play a relevant role at push off, while the trunk muscles serve to balance the trunk on the pelvis and are activated around heel strike. Moreover, activity of the gluteus medius muscle during the swing phase has been shown to be correlated to the next foot placement. Stepping in the direction of perturbations to adapt the width of the base of support is an adaptative behavior to achieve a stable gait. Increased step width is generally regarded as effective adjustment to increase stability during locomotion and narrow base walking has been shown to require increased control in the frontal plane. However, when looking at mediolateral local dynamic stability, it has been shown that walking with wide steps is less stable, whilst narrow base walking is more stable. Therefore, the aim of this study was to assess changes in activity of potentially stabilizing muscles during narrow and wide base walking. METHODS: Eleven young adults (four females, 28.5±2.85 yrs old, 71.6±8.62 kg and 1.77±0.10 m) walked on a treadmill at speed of 0.8 m/s, guided by a metronome at 78 steps/min for 8 minutes in three different walking conditions. During normal walking participants adopted their naturally preferred step width; for the wide base walking condition, they were instructed to increase their step widths beyond the approximate width of their hips; and during narrow base walking condition, participants were instructed to adopt a step width smaller than their usual step width and smaller than hip distance. Kinematic data from the spinous process of the sixth thoracic vertebra (T6), the posterior superior iliac spine, and the calcaneus bilaterally were recorded using a 3D motion system sampling at 100Hz. Surface electromyography was collected at 2000Hz bilaterally from the medial gastrocnemius, gluteus medius and erector spinae muscles following to SENIAM electrodes placement recommendations. Gait stability was assessed by the local divergence exponent (LDE) from mediolateral (ML) T6 marker velocities. We used SPM to test the conditions by statistically examining the whole EMG time-series for each condition. RESULTS: Narrow base walking was most stable, while wide based walking was the most unstable. Wide based walking lead to greater gluteus EMG during mid-swing. During the narrow base walking greater EMG activity of the gastrocnemius in the stance phase and of the erector spinae around heel strike were found. CONCLUSIONS: Greater gluteus medius activation was seen during wide base of support walking. This may be directly related to the wider leg placement. These wider steps may allow and by increasing external moments directly contribute to reduced stability of trunk movement. Increased ankle and trunk muscle activity may be related to achieving greater control over center of mass displacement required during narrow base walking.

P-K-167: The Effects of Acute Squatting Exposures on Neuromuscular Control during Jumping

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BACKGROUND AND AIM: Abnormal quadriceps muscle activation patterns increase the risk of developing knee osteoarthritis and/or sustaining a non-contact ligament injury [1,2]. Additionally, occupational exposure to frequent knee bending activities, like squatting or kneeling, is also associated with knee cartilage and ligament injury [3,4]. It is unclear whether squatting frequency or duration is more detrimental to knee joint health, or how acute exposures to squatting may affect neuromuscular control. Therefore, the aim of the study was to determine the effects of cyclic and sustained squatting exposures on muscle onset delay between vastii at jump takeoff and integrated EMG (iEMG) at landing. We hypothesized that the sustained squat exposure would cause greater decreases in neuromuscular control. METHODS: Twenty-six healthy, young participants (14F/12M) were included in the analysis. Kinematic data were collected at 100 Hz using a 3D-motion capture system. Marker clusters were placed on the dominant leg on the foot, shank, thigh and pelvis. Kinetic data were collected at 2000 Hz using two embedded force plates. Surface electromyography (EMG) was recorded at 2000 Hz on the dominant vastus medialis and vastus lateralis using a wireless system. Mean muscle onset delay between vastii was determined during jump takeoff, and integrated EMG was calculated during the deceleration phase of landing. A two-way mixed factor ANOVA was conducted to examine the influence of squat exposure type and sex on mean onset delay between vastii. For changes in iEMG a three-way mixed factor ANOVA was used with muscle type included as an additional factor. RESULTS: There were no significant main effects were found for squat exposure type ($F_{1,24} = 3.94$, $p = .059$) or sex ($F_{1,24} = 0.14$, $p = .708$) and no interaction ($F_{1,24} = 0.445$, $p = .511$) for mean onset of muscle activation. Although, sustained squatting caused a greater delay in muscle activation between the medial and lateral vastii (−13.20 ms vs. +10.15 ms). For iEMG, no significant main effects were found for squat exposure type ($F_{1,24} = 1.94$, $p = .177$) or muscle ($F_{1,24} = 2.30$, $p = .143$). A significant sex main effect occurred ($F_{1,24} = 4.88$, $p = .037$) for integrated EMG, with females showing decreases in iEMG activity and males increases (−5.693 mV·s vs. +0.955 mV·s, respectively). CONCLUSIONS: Females displayed a trend for reduced vastii activation, mainly medially, at landing. This acute change following squat exposures is related to a neuromuscular pattern associated with increased anterior shear forces and greater risk for injury [1]. While not statistically significant, exposure to sustained squatting may cause greater delays in muscle activation between the vastii at takeoff. REFERENCES: 1.Hewett et al. (2006). Am J Sports Med. 34(2), 299-311 2.Rutherford et al. (2013). J. Electromyogr. Kinesiol. 23(3), 704-711 3.Baker et al. (2003). Occup Environ Med. 60(10), 794-798 4.Coggon et al. (2000). Arthritis Rheum. 43(7), 1443-1449

P-K-168: Evaluation of abductor hallucis neuromuscular function and its potential role in postural control

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BACKGROUND AND AIM: The activity of the abductor hallucis (AH), an intrinsic foot muscle, is modulated by alterations in postural stability (Kelly et al. 2012, Clin Biomech, 27, 46-51). Architectural properties of the AH relate to postural sway during challenging tasks however, functional neuromechanical properties of AH (e.g., strength, voluntary activation and contractile twitch properties)

and their influence on postural control remain unknown. Therefore, this study aimed to quantify AH voluntary strength, voluntary activation and various whole-muscle contractile properties to determine whether AH neuromuscular function relates to postural sway. METHODS: In 10 healthy, young adults (7M; 27 ± 7 years) we assessed strength and voluntary activation while participants performed brief, maximal great toe abduction contractions. Voluntary activation was evaluated with the interpolated twitch technique. To quantify AH contractile properties, we calculated peak force, contraction time and half-relaxation time from electrically evoked twitch contractions that were induced via AH muscle belly doublet stimulation. Finally, to quantify postural sway, we measured antero-posterior and medio-lateral center of pressure (COP) displacement variability and velocity during eyes open, single-legged stance trials (60 seconds in duration). RESULTS: Peak twitch force was 5.8 ± 3.3 N while contraction time and half-relaxation time were 169.8 ± 32.3 ms and 124.1 ± 45.1 ms, respectively. AH strength was 37.0 ± 22.3 N and voluntary activation was 80.9 ± 30.7%. Seven participants achieved >90% activation while three achieved <65%. AH strength appeared to correlate with COP displacement variability however, voluntary activation did not correlate with any COP parameters. CONCLUSIONS: Our results indicate that high levels of voluntary activation are achievable in AH, however, training may be required in some individuals to achieve high activation levels of the toe abductor. AH strength correlated with some COP sway measures however voluntary activation did not, possibly due to low variability in our data (most participants achieved >90% voluntary activation). The twitch properties indicate that AH is a muscle with slow contractile properties, similar to soleus. Functionally, this may suggest that AH is designed for slower, ongoing motor tasks such as postural control. In healthy, young adults, AH neuromuscular functional properties appear to have some relationship with postural sway, however these properties may be more relevant in populations with deficits. Overall, our findings may provide insight for the role of intrinsic foot muscles during functional tasks such as postural balance.

P-K-169: Functional evaluation of upper limb movement and muscle strategies after cervical spinal cord injury

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Cervical spinal cord injury (cSCI) is a debilitating clinical condition that leads to a function loss below the injury level. Because of the severity and irreversibility of the lesion, there is a need to define effective rehabilitative treatments. To do so, we must first characterize the kinematic and muscular alterations induced by the injury. Clinical assessments like manual muscle test (MMT) and range of motions (ROM) are typically used to evaluate residual upper limb function as well as rehabilitation-related improvements, but these tests are often subjective and have reduced sensitivity and specificity. Therefore, current clinical tests should be integrated with specific protocols allowing quantitative evaluations of upper body kinematics and muscular activities. The aim of this study was to define and validate a protocol and a set of parameters to functionally evaluate upper limbs kinematic and muscular strategies adopted by individuals with different levels of cSCI. We recruited 10 chronic cSCI subjects (C5-C7) and 6 healthy control subjects in the same age range. All participants underwent a functional evaluation protocol which consisted of a clinical and an instrumental evaluation. For the clinical

evaluation, all the participants underwent the MMT and the assessment of the ROM for the upper limbs. During the instrumental evaluation, we recorded the upper limbs movements (optoelectronic system) and muscle activity (EMG), from 14 upper body muscles, while the participants performed the stabilization task of the Van Lieshout Test (VLT). The task required subjects to assume with the upper limbs 5 different poses of increasing difficulty. They had to start with the arms on their laps, then move both arms to the pose (execution phase), maintain the pose for 5 seconds (holding phase) and finally return to the starting position. The 5 poses were repeated 6 times. To assess the kinematic strategy adopted in the holding phase, we chose to analyse elbow and shoulder angles. While to describe the spatiotemporal organization of the muscle signals we estimated the muscle synergies and the spinal maps. When comparing these indicators between the control and cSCI groups we were able to identify and characterize the alterations in kinematic and muscular strategies induced by the lesion, especially regarding distal joints, elbows, and peripheral muscles, triceps. Moreover, we found a correlation between the kinematic and EMG indicators and the clinical tests proving that cSCI with the same level of lesion were adopting similar strategies. This study provided a preliminary validation of an instrumented evaluation protocol able to characterize motor strategies of cSCI subjects. Applying it in the clinical context will allow clinicians to identify the motor deficits of the patient, establish realistic rehabilitative goals and monitor the outcome of rehabilitative interventions.

P-K-170: Correlation of foot placement to preceding center of mass state in gait, active control or passive dynamics?

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Falls during walking constitute a common and serious problem. This may not be surprising given that walking challenges balance by movement of the relatively high body center of mass over a narrow base of support, especially in the mediolateral direction. A potential mechanism to stabilize gait in this direction is a well-coordinated placement of the foot at the end of each step. In normal gait, mediolateral foot placement is correlated to the mediolateral kinematic state of the body center of mass during the preceding step. Such coordination could ensure that body movement is adequately decelerated and reversed by the moment caused by the ground reaction force under the new stance leg. However, it has been debated whether adequate foot placement is achieved under active control, or emerges passively from mechanical coupling of the swing leg to the rest of the body. We present data from several experiments addressing this debate. First, changes in balance constraints, imposed by external mediolateral stabilization and wide and narrow paths, all affect the observed correlation. Second, sensory manipulations, causing an illusion of body movement, result in predictable deviations in foot placement. Third, swing phase Gluteus Medius muscle activity is larger and Adductor Longus muscle activity is smaller for relatively wide foot placements and vice versa for narrow foot placements. Fourth, when constraining the use of other balance control strategies, the observed correlations first decrease and then gradually increase above baseline. In conclusion, we provide evidence that coordination between foot placement and center of mass state in the preceding step is responsive to balance constraints and is achieved under active, neural control.

P-K-171: Effects of fatigue on neuromechanical delay during isometric periodical contractions of the tibialis anterior muscle

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Background and aim: Classical computation of electromechanical delay (EMD) is usually performed on muscle contractions occurring from a resting state by measuring the time gap between electromyographic activity (EMG) and exerted force onsets. However, recent studies show the possibility of computing neuromechanical delays (NMD) during frequency-modulated contractions giving additional insights in the time-course of the delays between the neural and muscular systems [1]. In this study, we evaluate how the NMD behaves under different fatiguing conditions and which are the neuromechanical implications of this behavior. Methods: 10 healthy subjects (9 male and 1 female) participated in the study. Participants were asked to sit on a table and perform a periodical isometric ankle dorsiflexion on an ergometer. A visual interface showed a sinusoidal trajectory with a frequency of 0.5 Hz, a mean level of 30% of the maximum voluntary contraction (MVC) and an amplitude of ą10% MVC. Subjects were asked to track this trajectory by dorsiflexing their foot during the maximum possible time until fatiguing. A 64-channel matrix was used to measure high-density electromyographic (EMG) activity on the Tibialis Anterior (TA) muscle. Force was measured with a power cell placed on the ergometer under the foot. Both force and EMG data were amplified using an OT-Quattrocento amplifier (OT Bioelettronica). To compute the NMD, the bipolar EMG signal of the TA was extracted and then cross-correlated with the exerted force (both filtered below 4 Hz). The cross-correlation was performed in segments of 10 seconds with an overlap of 0.5 seconds. Maximum correlation peaks and their time delay were detected and averaged across segments to compute EMG-Force correlation and NMD. Tracking accuracy was additionally computed by cross-correlating force and the tracked sinusoidal. Results: The results show that NMD usually has a range between 200 and 250 ms overtime. This is consistent with previous studies performed under similar conditions of the tracked sinusoidal [1]. Small bidirectional fluctuations are present for all subjects with deviations that are generally under 30 ms, showing that the NMD is not uniform overtime but relatively stable. This could be due to the inherent noise of the recordings or to physiological small variations in the recruitment of motor units. Contrary to what previous studies suggest in classical EMD estimations, we did not find significant variations in NMD between initial contractions and contractions close to muscle failure. As expected, NMD deviation decreases with higher EMG-force correlations which is generally consistent with tracking accuracy, meaning that, for subjects with more difficulties in following the sinusoidal, the NMD computation was less precise. Conclusion: Our preliminary results show that NMD fluctuates in a small-range overtime during the performance of frequency-modulated contractions. Also, the NMD mean level is uniform and does not change significantly with fatigue. This may indicate that the central nervous system can compensate for the decrease in force of individual motor units by recruiting motor units with faster twitches. Further decomposition of motor units and individual analysis of their behavior should be performed to explain the neuromechanical implications of these findings. [1] Central nervous system modulates the neuromechanical delay in a broad range for the control of muscle force, A. Del Vecchio, A. Úbeda, M. Sartori, J. M. Azorín, F. Felici, and D. Farina, Journal of Applied Physiology 2018 125:5, 1404-1410

P-L-172: Muscle Activity During Handwriting and Tapping Using Surface Electromyography and 18F-FDG Positron Emission Tomography

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BACKGROUND AND AIM: Surface electromyography (sEMG) is a popular tool to evaluate muscle activity. It can be operated easily and non-invasively, but there are also problems such as inability to measure deep muscles activity, being affected by crosstalk or skin conditions. On the other hand, Positron Emission Tomography (PET) allows to assess muscle activity including deep muscles without restriction of body movement by using glucose tracer; Fluoro-deoxy-glucose (FDG). The purpose of this study was to examine hand and forearm muscle activities during simple and complex motor tasks using sEMG and FDG-PET. METHODS: Ten healthy, right-handed male subjects participated in this study. Subjects were randomly divided into either handwriting (HW: 6 males) or tapping (TAP: 4 males) groups. In the HW task, the participants continuously traced the number from 0 to 9. In the TAP task, they tapped a key with index finger at about 180 beat par minutes. In both tasks, one session consists of 150 seconds, followed by 30 seconds rest. The participants repeated the session 10 times. sEMG was measured from seven hand and forearm muscles. Integral electromyogram (iEMG) and mean power frequency (MPF) were calculated for further analysis. PET/MRI scan was performed with a Biograph mMR (Siemens Healthcare, Erlangen, Germany) after the completion of each task. We evaluated muscle activity with standard uptake ratio of FDG. Regions of interest were specified by tracing the outline of each muscle on the T2 weighted MR image. We identify muscle activities from 6 hand and 12 forearm muscles with FDG-PET. RESULTS: MPF gradually decreased in the first dorsal interosseous (FDI) muscle during the HW task ($P < 0.05$). However, no changes were observed in iEMG of all muscles during HW and TAP tasks. These results indicate that muscle fatigue was observed in the FDI muscle during HW task. Glucose uptake increased in most hand and forearm muscles including deep forearm muscles during the HW task. In contrast, during the TAP task, glucose uptake increased only in extensor digitorum muscle that is related to the control of the tapping. In the FDI muscle, iEMG tended to be correlated with glucose uptake during the HW task. However, no correlations were observed between iEMG and glucose uptake in the surface forearm muscles. CONCLUSIONS: The present results suggest that handwriting required muscle activity including deep, small forearm muscles. The absence of correlation between sEMG and PET data in the surface forearm muscles support the notion that sEMG is affected by cross-talk from neighboring muscles. FDG-PET is a valuable tool to identify forearm muscle activities that require fine motor control.

P-L-173: Measurement of Psoas Major and the Correlation with Functional Performance

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Background and Aims: The psoas major (PM) has been considered as a marker of muscle wasting. Magnetic resonance imaging (MRI) is the main tool used for objective quantification of PM. Ultrasound imaging (USI) has the advantage of identifying dynamic characteristics in real-time; however, the reliability and validity of measuring PM using USI is unknown. Furthermore, whether the size of PM is

related to physical performance is also unknown. We aimed to investigate the test-retest reliability and validity of USI for measuring change in PM size during dynamic tasks, and to describe the relationship between the size of the PM as measured using MRI. Discuss the role of the PM during physical performance tasks such as the Sit to Stand (STS) and Time Up and Go (TUG). Methods: Six asymptomatic adults aged 23-26 years were measured two times in the same day by one operator using USI. The second testing session occurred 30 minutes after the first testing session. The PM was measured on the left and right sides at the L3 level. Three tasks, the pull-knee-approximate-hip (PKAH), short lordosis (SL), and active straight leg raise (ASLR), were performed on each participant, and the PM was measured by USI. The change in muscle thickness during these three tasks were measured and compared with the cross-sectional area (CSA) by MRI. The normalized cross-section area (NCSA) of the PM was crossed by the CSA of the vertebral body. MRI was performed in the supine position. STS and TUG were then assessed. Validity and reliability were evaluated using paired sample t-tests, intra-class correlation coefficient (ICC), and Bland-Altman plots. Linear regression was performed for NCSA (X) as a predictor of each measure of physical performance (Y). Results: The size of PM measured by USI in resting was PKAH: 3.58ą0.36cm; ASLR: 3.97ą0.44cm; SL: 3.76ą0.46cm. The thickness change of PM was PKAH: 0.81ą0.21cm; ASLR: 0.64ą0.12cm; SL: 0.68ą0.14cm. The NCSA of PM measured by was NCSA: 0.79ą0.23. Reliability for thickness change evaluation was good to excellent for PKAH (ICC=0.75-0.81); good for ASLR (ICC=0.61-0.66) and poor to good for SL (ICC=0.33-0.6). Correlations between the thickness change of muscle by USI in three tasks and NCSA by MRI (ICC=0.51-0.91), the greatest and the worst being PKAH and SL respectively. The association of TUG and measurements with USI and MRI were NCSA: R2=0.41, P=0.02; PKAH: R2=0.42, P=0.27; ASLR: R2=0.74, P=0.03; SL: R2=0.37, P=0.20. Furthermore, the association of STS and measurements were NCSA: R2=0.03, P=0.02; PKAH: R2=0.01, P=0.10; ASLR: R2=0.00, P=0.04; SL: R2=0.00, P=0.11. Conclusions: The study established the test-retest reliability and validity of the change in muscle thickness of PM measured using USI during three different tasks. Measures of change in muscle thickness using USI during PKAH and ASLR could be used for objective assessment of PM. In physical performance, NCSA of PM correlated with the performance of TUG, but not for STS.

P-L-174: Measurement of Psoas Major and the Correlation with Functional Performance in Asymptomatic Participants-a Dynamic Ultrasonographic Study

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Background and Aims: The psoas major (PM) has been considered as a marker of muscle wasting. Magnetic resonance imaging (MRI) scan is the main tool used for objective quantification of PM. Ultrasound imaging (USI) has the advantage of identifying dynamic characteristics in real-time; however, the reliability and validity of measuring PM using USI is unknown. Furthermore, whether the size of PM is related to physical performance is largely unknown. We aimed to investigate the test-retest reliability and validity of USI for measuring change in PM size during three dynamic tasks, and to describe the relationship between the size of the PM as measured using MRI, as well as discuss the role of the PM during physical performance tasks such as the Sit to Stand (STS) and Time Up and Go (TUG). Methods: Six asymptomatic adults aged 23-26 years were measured two times in the same day by one operator using USI. The second testing session occurred 30 minutes after the first testing session. The PM was

measured on the left and right sides at the L3 level. Three tasks, the pull-knee-approximate-hip (PKAH), short lordosis (SL), and active straight leg raise (ASLR), were performed on each participant, and the PM was measured using USI. The change in muscle thickness during these three tasks were measured and compared with the cross-sectional area (CSA) as measured using MRI. The normalized cross-section area (NCSA) of the PM was normalized by the CSA of the vertebral body. MRI was performed in the supine position. STS and TUG were then assessed. Validity and reliability were evaluated using paired sample t-tests, intra-class correlation coefficient (ICC), and Bland-Altman plots. Linear regression analysis was performed for NCSA of MRI (X) as a predictor of each measure of physical performance (Y). Results: The size of PM measured by USI in resting was PKAH: 3.58 ± 0.36cm; ASLR: 3.97 ± 0.44cm; SL: 3.76 ± 0.46cm. The thickness change of PM was PKAH: 0.81 ± 0.21cm; ASLR: 0.64 ± 0.12cm; SL: 0.68 ± 0.14cm. The NCSA of PM measured by was NCSA: 0.79 ± 0.23. Reliability for thickness change evaluation was good to excellent for PKAH (ICC = 0.75-0.81); good for ASLR (ICC = 0.61-0.66) and poor to good for SL (ICC = 0.33-0.6). Correlations between the thickness change of muscle by USI in three tasks and NCSA by MRI (ICC = 0.51-0.91), the greatest and the worst being PKAH and SL respectively. The association of TUG and measurements with USI demonstrated R2 of 0.42 for PKAH; 0.73 for ASLR and 0.37 for SL, and 0.41 for NCSA of MRI. Furthermore, the association of STS and measurements with USI demonstrated R2 of 0.01 for PKAH, 0.00 for ASLR and 0.00 for SL, and 0.03 for NCSA of MRI. Conclusions: The present study has established the test-retest reliability and validity of the change in muscle thickness of PM measured using USI during three different tasks. Measures of change in muscle thickness using USI during PKAH and ASLR could be used for objective assessment of PM. In physical performance, NCSA of PM correlated with the performance of TUG, but not for STS.

P-L-175: Ultra-high-field (7 Tesla) magnetic resonance imaging of the foot: advanced neuromuscular imaging to quantify intrinsic foot muscle volume and composition.

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BACKGROUND AND AIM: The intrinsic muscles of the foot are key contributors to normal foot function and are important to evaluate in lower limb pain, injury and disease. The borders of the small intrinsic muscles in the forefoot are difficult to differentiate on 3 Tesla (T) MRI. Ultra-high-field (7T) MRI provides sufficient signal to evaluate the morphology of the intrinsic foot muscles, and, when combined with chemical-shift sequences, measures of muscle composition can be obtained. Ultra-high-field MRI has unique challenges. Here we aim to optimize 7T MRI to: (i) enable segmentation of individual intrinsic foot muscles; and (ii) quantify intrinsic foot muscle morphology and composition. METHODS: This single case study recruited a healthy 39-year-old female (mass 65kg, height 1.73m). A T1-weighted VIBE - radio-frequency spoiled 3D GRE - sequence of the whole foot was acquired on a Siemens 7T MAGNETOM scanner (repetition time 11 ms; echo time 2.04 ms; flip angle 3 degrees; field of view 175 x 224 mm; in-plane-resolution 0.5 x 0.5 mm(2); 0.5 mm contiguous slices; Bandwidth 429 Hz/Px), as well as a 3T MAGNETOM Prisma scanner (repetition time 15 ms; echo time 2.45 ms; flip angle 10 degrees; field of view 220 x 220 mm; in-plane resolution 0.6 x 0.6 mm(2); 0.6 mm contiguous slices; Bandwidth 430 Hz/Px) for comparison. Acquisition time was standardised for comparability (7T: 4 mins 50 s; 3T: 4

mins 47 s). A high-resolution fat/water separation image was also acquired using a 3D 2-point DIXON sequence at 7T (repetition time 11 ms; echo time 3.06 ms and 5.61 ms; flip angle 3 degrees; field of view 111 x 223 mm; 0.38 x 0.38 mm(2); 0.38 mm contiguous slices; bandwidth 434 Hz/Px; acquisition time 11 min 12 s). Using 3D Slicer software, regions of interest were manually contoured for each muscle. Muscle volumes and percentage of muscle fat infiltration (MFI) were calculated (MFI % = Fat/(Fat+Water)x100) for each muscle. RESULTS: Figure 1 provides example images acquired from 7T and 3T scanners. Compared to the 3T images, the 7T images provided superior resolution, particularly at the forefoot, to facilitate segmentation of individual muscles. Consistent with reports from anatomical dissections, the largest muscle volumes in this group were observed for abductor hallucis (17.3 cm(3)), adductor hallucis (19.8 cm(3)), abductor digiti minimi (17.3 cm(3)) and the combined interossei (23.9 cm(3)), with the smallest volumes observed for the lumbricals (1.5 cm(3)) and flexor digiti minimi (4.4 cm(3)). Percentage MFI was low, ranging from 9.3% to 15%, which is comparable to what has been reported in other muscles from healthy individuals. CONCLUSIONS: This proof-of-concept study demonstrates a feasible method of quantifying muscle structure and composition for individual intrinsic foot muscles using advanced 7T MRI techniques.

P-L-176: Imaging recruitment of motor units in voluntary skeletal muscle contractions using decomposition and ultrafast ultrasound imaging. A pilot study

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BACKGROUND AND AIM: The central nervous system coordinates movement through forces generated by motor units (MUs) in skeletal muscles. Today, the MUs and their function are studied using electromyography (EMG) for applications in, e.g., neuromuscular diagnostics, rehabilitation medicine, and sports medicine. Typically, these methods access only a small muscle volume (1 mm3, needle EMG) or only a superficial (< 1 cm, high density surface EMG) volume of the muscle. Recently our research group demonstrated a method to separate and identify the mechanical response of individual active MUs, from a large part of a muscle (4x4 cm, cross-sectional) under voluntary contractions. The method is based on ultrafast ultrasound imaging and spatiotemporal decomposition (Rohlén et al., 2020 IEEE Access). In the present work we aimed to use this method to explore MU territory recruitment patterns at low force levels in the biceps brachii. As of today, there are no methods available to study simultaneously active units and their spatial locations in voluntary contractions from the whole muscle. METHODS: We recorded 2-second long ultrafast ultrasound image sequences from eight healthy subjects at 1, 2.5 and 5 % isometric MVC of the biceps brachii. Our method was used to extract the territories and twitch train signals of active MUs. We color-coded and manually labeled the individual units that were present at the different force levels. RESULTS: Figure 1 illustrates identified MUs territories (cross-sectional view of the muscle) at the different force levels. On average, 6, 9 and 12 units were identified at the different force levels. At higher force levels newly recruited units appeared in new spatial locations, which had previously been void of active units. We found that 26% of the active units at the first level were present in all subsequent force levels. In addition, 44% of the active units at 5% MVC were active at 1 or 2.5% MVC. Thus, a unit active at lowest level was not necessarily active at the consecutive levels. This may be caused by failure of the method to detect all active units. However, it is well known that simultaneous agonist-antagonist activation strategy used by the motor system (co-

contraction) to facilitate movement accuracy and produce weak forces, and this could result in variation in the activated pool of MUs at the different force levels. CONCLUSIONS: Electrophysiological methods are well-established techniques that have been used for over 60 years to help our understanding of muscle physiology. The present study demonstrates non-invasive neuromuscular imaging that enables identification of mechanical units and provides functional information on quantitative spatial characteristics of active MUs in the whole muscle in vivo.

P-L-177: Impact of transducer position on shear elastic modulus measurements of the iliotibial band

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Background: Shear wave elastography (SWE) has the potential to provide information on the in-vivo mechanical properties of biological tissues, such as the iliotibial band (ITB). Estimation of shear elastic modulus depends on the isotropy (similar physical properties in all directions) of the tissue. To minimise the impact of anisotropy of body tissues, it is recommended that SWE is measured with the transducer aligned parallel to the tissue fibres. However, the influence of the transducer orientation on estimates of connective tissue properties has not yet been systematically quantified. This study aimed to quantify the influence of the transducer rotation (relative to estimated connective tissue fibre direction) and tilt on shear elastic modulus measurements of the ITB. Methods: Ten healthy volunteers (6 males and 4 females, mean ą SD age of 30 ą 4 years, mass 69.8 ą 11.7 kg, height 1.7 ą 0.1 m, and body mass index 23.0 ą 2.1 kg/m2) were recruited from the local community. Shear elastic modulus (as an index of tissue stiffness) was measured unilaterally (dominant limb) using SWE in the middle region of the ITB at rest. A 3-dimensional video system was used to assess the position of the transducer with respect to the thigh, which allowed real-time feedback of the probe. Shear elastic modulus was measured at different rotation angles (longitudinal to the ITB fibres, 10, 20, 30, 40, 50, 60, 70, and 80 degrees, and transverse to the ITB fibres) and tilt (medial, lateral, anterior, and posterior). Shear elastic modulus was compared between angles and between tilts using a repeated measures ANOVA (p-value set at 5%). Results: As expected shear elastic modulus was greatest when the transducer was parallel to the assumed direction of ITB fibres (longitudinal: 112.0 ą 37.8 kPa) and was lowest when perpendicular (transverse: 39.1 ą 28.9 kPa) (Figure 1). Significant differences ($p<0.01$) were found between the longitudinal direction and all rotations, except for 10 degrees. The data also highlight that values can be influenced by tilt of the transducer. From the longitudinal position, the values increase for posterior (MD = 15.5 + 3.5), medial (6.6 + 0.7), and lateral tilt (MD = 5.9 ą 3.8), and decrease for anterior tilt (MD = -6.2 ą 4.2) (Figure 1). These differences were not statistically significant ($p>0.05$). Conclusion: Shear elastic modulus values change predictably as a function of the rotation angle of the transducer in relation to the assumed direction of fibres of the ITB. These findings support the notion that transducer orientation requires careful control when making measures of biological tissues and that shear elastic modulus changes predictably with orientation relative to fibre direction.

P-M-178: Interpretable machine learning models for classifying low back pain status using functional physiological variables

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BACKGROUND AND AIM Being able to predict the clinical course of LBP is highly relevant to clinical practice. Increasingly, researchers are turning towards advance statistical learning techniques to develop accurate prediction models for people with LBP using information from high-dimensional, multivariate biological signals. Despite their predictive value, one prohibitive barrier towards a more generalised integration of advance predictive models into routine clinical practice, is that current statistical techniques do not produce solutions that are easily interpretable. We aim to develop clinically-interpretable prediction models using EMG and kinematic predictors collected during a low-load lifting task. Herein, we used a state-of-the-art machine learning technique, termed functional data boosting (FDboost). METHODS Motion capture with electromyography (EMG) assessment was performed on 49 participants (healthy control (con) = 16, remission LBP (rmLBP) = 16, current LBP (LBP) = 17), whilst performing a low-load lifting task. Three statistical models were developed using functional data boosting (FDboost), for binary classification of LBP statuses (model 1: con vs LBP; model 2: con vs rmLBP; model 3: rmLBP vs LBP). After removing collinear variables and inclusion of the covariate sex, the final number of predictors (EMG and kinematics each from lifting and lowering phase) was 31, 31, and 32, for models 1, 2, and 3, respectively. RESULTS Seven predictors (two lifting, five lowering) were selected in model 1 (con vs LBP), which achieved an out-of-bag AUC of 90.4%; nine predictors (three lifting, six lowering) were selected in model 2 (con vs rmLBP) which achieved an out-of-bag AUC of 91.2%; and seven predictors (one lifting, six lowering) were selected in model 3 (rmLBP vs LBP) which achieved an out-of-bag AUC of 96.7%. The time-varying β coefficient plots for each predictor in each model can be found in Figure 1. The predictor with the largest magnitude of β coefficient was the BF muscle with peak β of 0.047 at the early phase (0% cycle) of lowering in model 1 (Figure 1), the Deltoid muscle with peak β of 0.052 at the late phase (100% cycle) of lowering in model 2, and the Ileoc muscle with peak β of 0.16 at the early phase (0% cycle) of lowering in model 3. CONCLUSION Our approach of using functional kinematic and EMG variables collected in a simple, yet clinically relevant task such as lifting, in conjunction with FDboost, produced clinically interpretable models that retain good to excellent predictive capability. If the approach used presently can be extended to include predictors collected using wearable sensors, than our models could have great promise in delivering the breakthrough in predictive performance that can be feasibly implemented in a busy clinical environment.

P-M-179: Using non-invasive electrically evoked ankle pain to study gait adaptations: a new model of musculoskeletal lower limb pain.

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BACKGROUND AND AIM: Pain following musculoskeletal (MSK) injuries might cause gait modification to avoid further damages or pain. It has been proposed that such modifications, even if they might have a beneficial aspect on the short term, may result in maladaptive plasticity and lead to pain chronicization.

Actual MSK pain models (e.g. intramuscular saline) are quite invasive and do not always reproduce the phasic (i.e. movement-related) nature of MSK pain. The first aim of this study was therefore to develop a non-invasive movement-related MSK pain model using nociceptive electrical stimulation. A second aim was to assess the effect of controllable versus uncontrollable pain duration on gait modifications. Our hypotheses were that 1) phasic pain would alter the gait pattern and 2) gait adaptation would differ for fixed versus movement-dependent pain. METHODS: 15 healthy participants were tested during a 2-hour session. They were asked to walk normally on a treadmill at 4 km/h for 6 bouts, including 2 painful bouts. The pain conditions (controllable duration that is proportional to right heel contact pressure or uncontrollable duration) were randomized across participants. Right and left foot pressure duration and peak heel contact (HC) pressure were measured using instrumented insoles. Using electrodes placed on the right lateral malleolus, trains of nociceptive electrical stimulation were delivered when the sensor placed under the right heel was triggered during heel contact. The McGill pain questionnaire was used to qualify pain sensation. 2-Way repeated-measure ANOVAs were used to examine foot pressure distribution between pain conditions and baseline. RESULTS: Mean intensity of the stimulation was 14.4 ą 3,1 mA and was described as an electrical, sharp, tender or tingling pain around the right malleolus. Regardless of the pain condition, gait modifications were observed. On the painful side, right heel loading duration decreased up to 10.0% during painful bouts and right HC peak load decreased up to 24% when compared to baseline. For the contralateral foot, no significant change was found for these variables when compared to baseline. There was no group effect regarding the pain intensity rating during the pain bouts. CONCLUSIONS: These results suggest that non-invasive electrical stimulation can be used as a model to study pain-avoidance strategies or musculoskeletal-like pain. Regardless of pain duration (fixed or movement-dependent), our model successfully modified gait parameters. Following this study, the non-invasive electrically evoked phasic pain model will be used to study gait adaptation in MSK-like pain experiments.

P-M-180: The effect of dry needling and cutaneous receptors on pain relief

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Background and Aim:Physical Therapists use dry needling to inactivate trigger points to reduce pain and improve range of motion. Preliminary research supports that dry needling improves pain, reduces muscle tension, and normalizes dysfunctions of the motor end plates; the sites at which nerve impulses are transmitted to muscles. However, studies on its efficacy have been inconclusive. The aim of this study was to determine the effects that dry needling trigger point therapy (DNTT) has on pain threshold and pain tolerance in people with identified painful infraspinatus trigger points. A second aim was to ascertain if pain relief from DNTT was due to the influence of skin receptors when the needle penetrates the skin rather than from the release of the active trigger point within the muscle. Methods: Twenty-five participants were recruited. All participants signed an informed consent and were randomly placed in 5 equal groups: Groups 1 and 3 received DNTT. Group 3 additionally had the skin anesthetized by iontophoresis of lidocaine Hcl(IHcl). Group 2 received placebo dry needling (DNp) without IHcl, while, group 4 received DNp with Ihcl. Group 5 received DNTT with iontophoresis of saline (Is). The DNTT method used in this study was the "piston" technique. DNp was similar to the DNTT except the needle was superficially inserted into the skin and quickly removed without ever penetrating into the muscle.

Other than the depth of needle penetration, the researcher mimicked the "piston" maneuver in every way. Inclusion criteria were that all participants were between 18-55, had identifiable painful trigger points in the infraspinatus muscle and had no other neuromuscular injuries. Pain was assessed using pressure algometry into the trigger point before and at 1 and 5 minutes post DNTT. Participants indicated their pain level by pressing a button that place a time stamp on the algometer force recording when pain was first felt and again when it became intolerable. Dependent variables measured were the amounts of time and the amount of force produced at the beginning of each time stamp. Data Analysis: Two one-way ANOVA with 2 repeated measures (threshold/tolerance for time and force) was used to determine significance with an alpha of p =.05. Cohen's-d was also calculated on each of the 5 groups for both time and force values. Results: ANOVA and Cohens-d show no significant difference or effect size in any of the 5 groups tested. In fact not one person showed any changes in pain levels with DNTT whether the skin was anesthetized or not. Conclusions: Neither DNTT, skin anesthesia nor both had an effect on pain threshold and/or tolerance in this study. These unexpected negative results may have been due to the short duration after DNTT that pain was assessed. It is possible that DNTT effects take longer than the 5 minutes post treatment time assessed in this study. Future studies need to look at the effect that DNTT has on pain after longer times post treatment.

P-N-181: Muscle activity of Zigzag Nordic Pole Walking in water

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Walking not only requires the execution of biomechanical functions such as body support, forward propulsion and leg swing, but it also requires the ability to change direction and navigate obstacles during turning. Turning motion is important in daily living that involves both the acceleration of the center-of-mass (COM) towards the center of curvature and the rotation of the pelvis towards the new heading of direction. It was well known the inability to change direction within the same step was not due to a limitation of reaction time but to the incapacity of muscle to rotate the body and translate it along the mediolateral axes. It was quite primitive applying water waling with Nordic pole for rehabilitation. However, it is not clear which individual muscles are responsible for the observed changes in the water, due to basis overland with gravity conditions. The purpose of this study was to investigate an electromyogram (EMG) analysis performed during Nordic walking in water with zigzag task condition. Five normal subjects (5 female) with ages ranging from 19 to 22 years participated in this experiment with informed consent. The experiment consisted of same protocol to obtain data for each strategy of zigzag to the right and left from both water and land walking. It was measured EMG during straight ahead Nordic walking at 8m longitudinal and zigzag walking 2.7m width. The subjects were asked to walk with a comfortable gait speed in all trials. The eight EMGs of whole body was recorded by bipolar surface methods in biceps brachii, triceps brachii, tibialis anterior, medial gastrocnemius, rectus femoris (both sides) and biceps femoris muscles (both sides). The level of significance was set at a = 0.05, with $p < 0.05$ regarded as statistically significant. The major finding was that zigzag walking has difficult motor strategy due to decrease load legs added to Nordic poles handing. However, it was increased dramatically upper arm EMGs by using Nordic pole in water. There was performed increasing EMG activity in rectus femoris each meter distance of zigzag walking. Therefore, it could be considered that it was an effective motor strategy task as exercise program for the elderly who could walk by upper

limb muscle activities without requiring muscle activities of the lower limbs as much as land, reducing posture threat. In water environment walking with Nordic pole could have been to walking stability rehabilitation option.

P-N-182: Improvement in palmar flexion and dorsiflexion ranges of motion in patients with wrist contracture using an artificial muscle splint for the wrist joint

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[Background] Recently, the dart throw motion (DTM) has been attracting attention as a functional and novel movement. In addition, this motion pattern has effectively improved wrist joint contractures. The effectiveness of passive movement following DTM has also been reported, with the wrist joint manually pulled toward the tip of the hand. To date, researches that investigated wrist joint splints with respect to traction function and DTM with a single orthosis have been limited. Therefore, we devised a new artificial muscle-type dynamic traction splint (ADTS) that incorporates this novel movement pattern. In this report, we present our findings on the use of this splint in patients with wrist contractures. [Subjects] Four hands in three patients diagnosed with wrist joint contracture in a clinic were assessed. All of them were women with an average age of 70.5 years. The average splint usage period was 5 weeks. Details of their diseases were as follows: one patient had distal radius fracture in one hand, one patient had Galleazzi fracture in one hand, and one patient had hand pyogenic tenosynovitis in two hands. The wrist joint range of motion and grip strength were evaluated at baseline and after 5 weeks. The wrist joint range of motion was evaluated over an average of 6 weeks. The splint was required to be worn four times: in the morning, at noon, after bathing, and before going to bed. The traction force started at 500 kPa and was changed appropriately in accordance with the patient's symptoms. The study was approved by the Ethics Committee of Kansai University of Social Welfare. [Results] The mean direction of palmer flexion was 21.3 ą 5.4° at baseline and 43.8 ą 9.7° at 5 weeks, showing a significant improvement of 23.8°. The mean dorsal flexion was 16.3 ą 4.4° at baseline and 45.0 ą 6.9° at 5 weeks, showing a significant improvement of 28.8°. The grip strength improved from 15.7% at the initial healthy side to 72.5% after 5 weeks. [Discussion] The treatment period was shortened substantially, and, both, the palmar flexion and dorsiflexion ranges of motion improved compared to that reported in previous studies (Raymond et al.). Wrist joint contractures are known to be susceptible to carpometacarpal joint (C-L joint) limitation. The C-L joint is highly relevant to the direction of dorsiflexion, and therefore, such patients sustain a restricted dorsiflexion range of motion. Sandra Kay et al. reported the importance of hand therapy, which improved the dorsiflexion angle to 16° from 25° as instructed by the hand therapist, whereas only Home Ex improved the dorsiflexion angle to 21° from 15°. These results were almost the same as those for rehabilitation, instructed by a hand therapist, for dorsiflexion and palmar flexion. Thus, AMDS is assumed to be pertinent to the C-L joint. These results suggest that AMDS may be an effective splint for the management of wrist joint contracture.

P-N-183: Effects of Foot Orthoses and Treadmill Training on Balance Control in Children with Down Syndrome: A Case Series

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BACKGROUND AND AIM: Children with Down syndrome (DS) frequently have development delays, impaired balance control and deviations of motor performance as a result of neurological, physiological and biomechanical alterations, including hypotonicity, ligamentous laxity, joint hypermobility, muscle weakness as well as orthopaedic problems such as flatfoot and metatarsus primus varus. Foot orthoses (insole) had been applied to correct the foot biomechanics by mechanical support to the feet, promotion of the plantar somatosensory feedback, and adjustment of the forces passing through the foot, suggesting a potential for motor improvement in children with DS. Treadmill training had been adopted as early exercise intervention for DS children to improve muscle tone, muscles strength and propulsive capability of the legs. This study aimed to quantify the balance control in children with DS before and after an 8-week intervention of foot orthosis combined with treadmill training. METHODS: This 8-week prospective case series recruited DS children with a mean age of 9 years. A custom-fit insole with medial arch support was prescribed to position the participant's subtalar joints into neutral, and was worn for 8 hours per day, 5 days per week during the 8-week intervention period. The treadmill program consisted of walking at 10% upward inclination and at a speed below the threshold of breathlessness but as fast as the participant could comfortably tolerate for 10 to 15 minutes per day, three days per week. Participants undertook the evaluation at pretest (week 0) and posttest (week 8). In the evaluation, participants performed three trials of quiet standing on a foreceplate (Advanced Mechanical Technology Inc., USA) with feet together, arms relaxed by the body sides and eyes open for 30 seconds. The position of the center of pressure (COP) was calculated from the ground reaction forces measured by the forceplate. The elliptical sway areas, the lengths of the major axis and minor axis, and the major axis angles (the angles between the major axis and the mediolateral axis of the trunk) were then calculated following Ho et al (2012). A major axis angle of 0°/180°and 90° indicated a predominately mediolateral and anterioposterior sway, respectively. RESULTS: The averaged sway area in posttest evaluation (37.8 mmē) was significantly smaller than that in pretest evaluation (72.2 mmē). In addition, the mean lengths of both the major and minor axes in posttest evaluation (4.7 & 2.5 mm) also reduced when compared with those in pretest condition (6.3 & 3.6 mm). The participants displayed a predominately anterio-lateral sway with an averaged major axis angle of 125.5° before intervention, and showed a predominately anterioposterior sway in accordance with an averaged major axis angle of 93.0° after the 8-week intervention. CONCLUSIONS: The improved balance control in terms of the reduced COP sway in posttest evaluation suggested that an 8-week intervention of custom-fit foot orthoses and treadmill training might be a good choice in a training protocol aimed at reducing the risk of falling in the children with DS, especially for whom having high risk of sideway falls.

P-N-184: Neuromuscular changes over 24-weeks of Robotic Locomotor training during the 6-minute walk test in persons with spinal cord injury (SCI).

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Background and Aim Robotic Locomotor Training (RLT) focuses on retraining motor function and recovery through stimulation of spinal neuronal circuits (1) using weight-bearing overground walking.

Few studies have investigated the impact of overground walking on skeletal muscle activity in persons with spinal cord injury (SCI). We therefore aim to evaluate the efficacy of 24 weeks RLT on improving back and leg muscle activity in persons SCI during submaximal performance tests. Methods 8 participants, between 18 - 65 years, with chronic (>1 year) traumatic incomplete spinal cord injury (C1-C7; ASIA C-D) attend rehabilitation three times per week for approximately 45 minutes per session, for a total of 24 weeks. RLT involved walking in the Ekso bionic suit with walking times ranging 10 - 30 minutes and accumulating 50 - 1000 steps. Participants performed 6 minute walk tests (6MWT) in the Ekso at baseline, 12 weeks and 24 weeks of the intervention. Participant's most dominant side of the body (side with most motor and/or sensory recovery), was used for unilateral surface electromyography recordings (sEMG) of Lateralis Dorsi (LD), Erector Spinae (ES), Gluteus Maximus (GM), Vastus Lateralis (VL) and Medial Gastrocnemius (MG). Distance covered, heart rate and rating of perceived exertion were also measured. Comparisons between variables are reported by means of Repeated Measures ANOVA, for Trials (Baseline, 12-week and 24-week) by Time (1min-6min) interactions. Significance was accepted at $p<0.05$. Results sEMG decreased signifcantly from baseline to 24 weeks in GM (101.2 ą 33.5%; 82.1 ą 14.3%; $p<0.007$) and LD (110.8 ą 26.0%; 98.7 ą 10.4%; $p<0.02$) muscles. VL showed a significant decrease in activity only within the first 12 weeks (97.8 ą 14.3%; 87.5 ą 11.3%); $p<0.02$) of the intervention. Walking distance increased significantly from Baseline (68.3 ą 11.3 m), 12 weeks (98.2 ą 7.4m) and 24 weeks (109.9 ą 19.6 m); $p<0.003$. However, HR decreased significantly from Baseline 122.6 ą 20.1 bpm to 104.1ą 33.8bpm at 24 weeks. RPE only showed a decrease in the first 12 weeks (Baseline 15 ą 2 to 12 ą 2). Conclusions Neuromuscular patterns changed significantly during the intervention, were leg muscles which are activitated by spinal tracts below the lesion level (C5-C7), significantly decreased over the intervention. Further, functional performance increased with reduced cardiavascular demand. References: 1) Smith.C and Knikou.M. A review on locomotor trainingafter spinal cord injury: Reorganisation of spinal neural circuits and recovery of motor function. Neural Plast. 2016;2016:1216258.

P-N-185: Design isometric force rotating task for EMG normalization of stroke patients

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Electromyography signal is representatively used for stroke patient's motor execution measurement. However, the EMG signal does not have its own unit. Also, the EMG signal is fragile from electrode attachment and the subject's skin condition. Thus, EMG signal's normalization is necessary for evaluating stroke patient's status using the EMG signal. One of the most commonly used EMG signal normalization methods is Maximal Voluntary Contraction (MVC). MVC measures maximum activation value for each muscle by producing maximum force task. On the other hand, according to stroke onset place, stroke patient's motor control ability is changed. This change makes stroke patients do incomplete MVC task. Therefore, the EMG normalization method is needed which can be done by stroke patients. In the rehabilitation of stroke patient's upper limb in reaching plane, 8 direction reaching task is conventionally used. However, some stroke patients cannot perform several directions target reaching task. To deal with these problems, this study suggests different kind of isometric force inducing task. The task suggested in this study is the rotating task. Unlike the 8-direction task, where the target direction is fixed, the rotation task uses the target which rotates around the reference force level in reference

angular velocity. In the rotating task, the subject should place the cursor controlled by the endpoint force in the target. Therefore, the subject could do the rotating task in reference target's pre-settled condition. In this study, the rotating task was performed. The subject's hand was constrained by the handle attached at 6 degrees of freedom force sensor and the subject controlled the endpoint force cursor on the screen in isometric condition. Data from 6 DoF force sensor was filtered by low pass filter and presented as visual feedback to the subject. The subject's EMG signal was measured by 10 channels EMG sensor. For reducing co-contraction, randomized 64 conditions (2 rotation directions, 8 starting points in reaching plane and 4 force levels) were pre-settled. And these conditions were separated by 8 blocks. To replace the MVC normalization method, 4 levels of endpoint force (5N, 10N, 15N and 20N) were used for rotating normalization. After the rotating task, the endpoint force was converted to a joint torque of shoulder and elbow by the Jacobian matrix. This joint torque was used to estimate a straight line from the minimum value of the EMG data to find 100% raw EMG value at 80Nm. We did the rotating normalization based on joint torque level and compared normalized results from the MVC method. In the case of normalization using MVC, the normalized value of all channels was bigger than 100%. On the other hand, the normalized value of all channels was less than 100% in the case of rotating normalization. This means that the rotating normalization method worked properly. Conversely, the normalized result of the MVC task could not be used for comparing muscle activation between subjects and within-subject. Furthermore, there was a difference in the result of normalization between 8 direction task and rotating task. The data from 8 direction task couldn't be used in normalization because there was no tendency in the minimum value of EMG data. Otherwise, in the case of the rotating task, there was a relatively clear tendency in the minimum value of EMG data according to joint torque.

P-N-186: Efficacy of the sensorimotor approach for elementary school students with handwriting difficulties: A literature review

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BACKGROUND AND AIM Handwriting is an essential ability for elementary school students. Students required by the teacher to write their tasks, take notes from the board during a lesson, and to do homework (Paula Kramer, 2010; Case-Smith, Holland, & Bishop, 2011). Students with handwriting difficulties are frequently handed on to Occupational Therapists, who recommend a type of intervention programs (Weintraub, Yinon, & Bar-Effrat Hi, 2009). Based on previous research sensorimotor approach or an eclectic intervention are more commonly used by Occupational Therapist (Denton, Cope, & Moser, 2006). This study aims to identify the efficacy of the sensorimotor approach for elementary school students with handwriting difficulties and determine the effective duration for an intervention program. METHODS Keywords "sensorimotor intervention" OR "sensorimotor approach*" OR "sensorimotor treatment" AND "handwriting" OR "writing" AND "children" were used in this study using three databases; PubMed, Scopus, and EBSCOhost (CINAHL Plus with full text and MEDLINE). Inclusion criteria used are experimental study, published between 2010 until 2019, published in a peer-reviewed journal, research articles, original articles in English language, elementary school students, children 6-12 years old and full-text articles. The review conduct from October 2019 to December 2019. RESULTS Records identified through database searching found a total of 12.591 articles after included the inclusion

criteria, excluded duplicate title, removing irrelevant titles and full-text screening, finally 3 articles had a significant relationship with the aim was carried out. Two studies found that the sensorimotor approach has a significant improvement compared to the control group while one studies state that Computer-assisted program has a significant effect compared to the sensorimotor program. Two studies that have a significant improvement at the sensorimotor program have a five to six-week intervention program, with twice a week meeting frequency, and 45-50 minutes for each session. CONCLUSIONS This literature review shows that the sensorimotor approach is effective to improve the handwriting performance of elementary school students if compared to the control group. On the other hand, if it is compared to the computer-assisted program, the sensorimotor group does not have a significant improvement. While for the efficiency of the sensorimotor program, it can be concluded that at least a total of 10 sessions with 45 minutes duration of each session will have a significant improvement of handwriting performance for elementary school students. However, in this literature review only found three studies that mention about sensorimotor as an intervention program for handwriting, in the future, it needs to investigate with more number of studies to compare.

P-N-187: MyotonPRO; a reliable device to evaluate Achilles tendon mechanical properties.

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BACKGROUND AND AIM: MyotonPRO is a hand-held myotonometer able to detect tissue mechanical properties by means of a mechanical impulse to the skin overlying the target structure and the oscillatory response of the tissues underneath the probe. This technology has largely been used to evaluate muscle stiffness; however, less is known about the capability of this device to analyze tendon stiffness. Therefore, the aim of this study was to evaluate the intra and inter-rater reliability of the MyotonPRO and its construct validity for the assessment of Achilles tendon mechanical properties. METHODS: Eighty Achilles tendons of forty healthy participants were analyzed using the MyotonPRO in an intra and inter-rater reliability study. Tendon was evaluated in a relaxed position, in standing and at 0° plantarflexion. Moreover, participants were asked to perform different isometric contractions (0kg, 0.5kg, 1kg, 2kg, 3kg). and stiffness values were calculated from the different contraction intensities. Reliability was calculated using intraclass correlation coefficient (ICC and 95% confidence interval) standard error of measurement (SEM) and minimal detectable change (MDC). Construct validity was evaluated between the different positions and the different contraction intensities using Friedman test. RESULTS: Intra-rater reliability was very high ICC2,k, 0.87-0.98. The reliability of the 0.5kg contraction was moderate with an ICC2,k of 0.59. Inter-rater reliability ranged from high to very high with an ICC2,k of 0.76-0.86. The reliability of the 0.5kg, 1kg contraction and the standing position was moderate with an ICC2,k of 0.55, 0.54 and 0.56 respectively. Inter-session reliability ranged from high to very high with an ICC2,k of 0.70-0.89. The reliability of the 0.5kg contraction was moderate with an ICC2,k of 0.54. Construct validity was demonstrated between different contraction levels and different positions. Significant differences ($p<0.01$) were found between all contraction levels except for 0 kg-0.5 kg ($p=0.9$); 0.5kg-1 kg ($p=0.9$); 1 kg-2 kg ($p=0.7$) and between the different positions. CONCLUSION: Intra and inter-rater reliability ranged from high to very high in most of the proposed conditions. Construct validity was supported by changes of tendon stiffness during the different position and the different contraction

levels. The transferability of this device from muscle to tendon tissue is feasible. MyotonPRO can be implemented, as a ready to use device, in the evaluation of tendon tissue mechanical properties.

P-N-188: Is the finger sensory function associated with an improvement of its motor function with surface electromyography in patients with chronic stroke?

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BACKGROUND AND AIM: Finger muscles are dominated by the motor cortex through the corticospinal tract (CST). The CST is frequently affected by stroke. Brain imaging could measure the extent of CST damage and predict the improvement of motor function. However, it has a prolonged acquisition time, and often, imaging might not be possible due to the presence of intracranial metal. The CST is anatomically close to the ascending sensory tracts. Therefore, hypothetically, the sensory function may reflect an index of the degree of CST damage. Moreover, assessment of sensory function is extremely easier than brain imaging. An association between the outcomes of sensory test and motor function improvement might favor its use as a predictive tool. This study investigated the association between a sensory function and motor function improvement. METHODS: Sixteen patients with chronic stroke participated in this study (10 men and 6 women; age, 51.88 ą 8.52 years; time since onset, 3.10 ą 1.40 years; Fugl-Meyer assessment upper extremity motor score, 12.25 ą 3.42). Sensory and motor functions were measured on the first day of the study and eleven days later. Patients underwent occupational therapy, including kinesthetic illusion therapy as a special treatment, for ten days (between the second day and eleventh day of the study). The sense of movement score was measured by sensory function assessment. In this test, the examiner moved the patient's index finger and asked the patient to specify the direction of finger movement; this procedure was repeated 10 times. Motor function assessment was performed during the motor task; the index was measured by surface electromyography (sEMG). In this motor task, patients extended and flexed their fingers every 3 seconds (total 13 times). sEMG was recorded from the extensor digitorum communis (EDC) and flexor digitorum profundus (FDP) muscles during the motor task. Root mean square (RMS) was calculated from EDC and FDP. Thereafter, the correlation coefficients between the recorded RMS signals and ideal model signals were calculated for 3 cycles of RMS signals by convolution for each point. Because of the task characteristics, a repeated peak value was obtained in the correlation coefficient time waveform, and the average peak value was used as the evaluation value of finger motor function (ccEDC, ccFDP). The change in ccEDC and ccFDP was calculated (ΔccEDC and ΔccFDP, respectively). The sense of movement score on the first day and changes in finger motor function (ΔccEDC, ΔccFDP) were analyzed using Spearman's rank correlation coefficient. RESULTS: ΔccEDC was correlated moderately with the sense of movement score (rs = 0.56; p = 0.02), while ΔccFDP showed no significant correlation with the sense of movement score (rs = 0.16; p = 0.56). CONCLUSIONS: Sensory functions in the fingers are correlated only with the improvements of the extensor motor functions of the fingers, but not that of the flexor. Our findings suggest that the sensory function may predict improvements in the finger motor functions. Thus, our findings may help create physiotherapy plans.

P-N-189: Difference of intersegmental coordination during gait using treadmill robot system.

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BACKGROUND AND AIM: Rehabilitation robot is known as most rapidly advancing fields in neurological rehabilitation. One of the rehabilitation robot devices is the 'KineAssist' which is designed to walk on a treadmill with body weight support by robot arm. One of the characteristics of this device is that the pelvic mechanism component of this device holds user's pelvis. This method ensures the safety of the user and enable to support any level of body weight. However, it has a possibility to interfere normal gait coordination due to limited pelvis motion. Thus, it is needed to clarify whether the pelvic mechanism of this device influences the gait coordination. In the aspect of gait kinematics, the intersegmental coordination is assumed as one of the most important viewpoints. The characteristics of intersegmental coordination during gait is represented as 3D scatter of the elevation angles of thigh, shank and foot. Previous reports suggested the figure of the gait loop exist on a plane. The purpose of this study was to clarify the feature of intersegmental coordination during gait using KineAssist, and to know better use for neurological rehabilitation. METHODS: Twenty healthy young adults participated in this study. They walked on the treadmill at comfortable or maximum speed (CM or MS, respectively) using the KineAssist system (Woodway, USA). The KineAssist system has two walking drive modes, those are the Assist mode (AM) which the treadmill belt moves at a fixed constant speed and the Self-Drive mode (SDM) which drives the speed and direction of the treadmill belt by horizontal forces applied to the pelvic mechanism. Furthermore, Participants walked without or with supporting 10%, 20% of body weight. Thus, they walked in a total of twelve condition. 3D motion capture system (OptiTrack, Acuity Inc., Japan) were used to measure kinematic parameters. Eight markers were attached on both sides of the hip, knee, ankle joints, and toe. Furthermore, elevation angles of thigh, shank, and foot segment were calculated from the marker position. The Principal component analysis on segment elevation angles was performed. From the result of obtained data, we defined the planarity index (PI) to evaluate lower limb coordination. Moreover, the second principal component (PV2) was calculated as indicator of the control of limb length. Finally, plane orientation (u3t) was estimated as the parameter of the energy expenditure. 3-factor ANOVA was used as statistical analysis. RESULTS: Although the PI was increased by gait speed, there were no differences between the AM and the SDM. It means that the pelvic mechanism didn't change limb coordination.The PV2 was higher and the u3t was lower in the SDM than in the AM. These results indicated that poor control of limb length and higher energy expenditure in the SDM. CONCLUSIONS: The SDM with the pelvic mechanism of the KineAssist may increase the effort of gait without change of limb coordination.

P-N-190: An exploration of muscle activity during inverted row, TRXŪ and pull up exercise in healthy participants

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Aim: The inverted row and TRXŪ exercises have been popularised in the fitness industry over recent years. However, there is a dearth of studies investigating muscle activity during these exercises.

Therefore, we aimed to investigate the difference in muscle activity during novel exercises (IR and TRXŪ) and conventional exercise, that is, pull up (PU) in healthy participants. Methodology: We measured the peak muscle activity during a series of maximum voluntary isometric contractions (MVIC) for rectus abdominis (RA), middle trapezius (MT), pectoralis major (PM), and latissimus dorsi (LD) muscles. This was followed by measuring the peak muscle activity during IR, TRXŪ and PU exercises. The MVICs were then used to normalise the raw data (expressed in %MVIC). We used Friedman test to compare the difference in muscle activity between the three exercises amongst healthy participants. Significant effects were followed up with Dunn-Bonferroni's post-hoc adjustment with multiple comparisons. Results: Thirty participants (23 male, 76.7%) with a mean (standard deviation, SD) age of 23.4 (4.28) years and body mass index of 22.67 (3.4) kg/m2 were recruited. The RA and PM muscle activities during PU was significantly greater than IR or TRXŪ ($p<0.001$). The MT muscle activity during either IR or TRXŪ was significant greater than PU ($p<0.05$). There was no significant difference in LD muscle activity between IR, TRXŪ and PU. Conclusion: These findings have clinical implications for upper-body rehabilitation. For example, the greater MT muscle recruitment during IR or TRXŪ exercise may help explain how such exercises work to improve rounded shoulder posture.

P-N-191: Evaluation of a pseudo-online motor unit based wrist joint angle estimation.

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BACKGROUND AND AIM: Motor unit (MU) discharge timings constitute the information-rich encoding of muscle activation. Such features can be obtained non-invasively with high-density surface electromyography (HD-EMG) measurements decomposed by convolutive blind source separation [1]. For rehabilitation technologies, MU activations may permit a more robust and intuitive control interface between patients and prosthetic devices. Recently, a method was developed to identify MU discharges in real-time [2], facilitating the 'on-off' activation of two degrees of freedom (DoF). In this study, a similar technique was adopted, analyzing the influences of the extension factor parameter, R, which affects the computational load, the number of extracted sources, and the processing window size, which affects online computation demands and system responsiveness. To pursue a more desired application, neural features were used to estimate continuous joint angles [3]. METHODS: The study was performed on two healthy male subjects (right-handed, ages 28 and 33) in accordance to the Declaration of Helsinki and approved by the research ethics committee of Aalto University. 192 HD-EMG channels (Quattrocento, OT Bioelettronica, IT) were recorded from the forearm of subjects along with wrist joint angles (MTw Awinda, Xsens Tech, NL) during 3 repetitions of single dynamic activations of the 3 wrist DoFs. After 3-fold data segmentation, each train set was batch decomposed to identify the active MUs in each motor task and used to train a linear regression (LR) for kinematics estimation. The discharge times of these MUs were then detected in corresponding test sets by the online algorithm where, to simulate real-time processing, EMG was decomposed using the offline parameters in windows (50ms steps). Resultant spike counts were then fed into LR for kinematics estimation. This was repeated for R=1-12 and for window lengths from 50-500ms in increments of 50ms (window overlap increases with length). Estimation accuracies were also compared to those obtained using root-mean-squared (RMS) envelopes as features. RESULTS: Results showed estimation accuracies to improve as R was increased while performance was relatively insensitive to varying window lengths. In terms of root-mean-square

error (RMSE), neural features outperformed RMS (9.12 ą0.65 degrees) for R>5 with RMSE of 8.26 ą0.95 degrees for R=11. In terms of the goodness of reconstruction, neural features with R=11 (0.88 ą0.01) marginally exceeded the performance of RMS (0.87 ą0.02). The median processing time of the algorithm at the highest loads was 47ms (Intel Xeon 3.60GHz 32GB RAM, MATLAB 2019a, Mathworks, USA) which was within the update rate of the proposed system. CONCLUSIONS: The results indicate the feasibility of the proposed algorithm for real-time extraction of MU activity in the forearm for proportional wrist kinematics estimation. Furthermore, this estimation can be done with lower extension factors for decomposition than those commonly used for physiological studies [1]. REFERENCES: [1] Negro, F. et al., 2016. Multi-channel intramuscular and surface EMG decomposition by convolutive blind source separation. J Neural Eng. [2] Barsakcioglu, D.Y., Farina, D., 2018. A real-time surface EMG decomposition system for non-invasive human-machine interfaces. IEEE BioCAS. [3] Kapelner T, et al., 2019. Predicting wrist kinematics from motor unit discharge timings for the control of active prostheses. J NeurEng Rehab.

P-N-192: Push(ing) up the evidence in muscle activity during variations of exercise amongst healthy participants

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Aim: The variations in push-up, such as the 'biceps', and diamond push-up, have been popularised by exercise enthusiasts in recent years. Albeit the purported increase in muscle activation during certain push-up variant, there is a dearth of studies investigating muscle activity during these push-up variants. Therefore, this study aimed to investigate the difference in muscle activity during standard, biceps and diamond push-up in healthy participants. Methodology: We measured the peak muscle activity during a series of maximum voluntary isometric contractions (MVIC) for biceps, pectoralis major (PM), and triceps muscles. This was followed by measuring the peak muscle activity during standard, biceps and diamond push-up. The MVICs were then used to normalise the raw data (expressed in %MVIC). We used Friedman test to compare the difference in muscle activity between the three variations of push-up amongst healthy participants. Significant effects were followed up with Dunn-Bonferroni's post-hoc adjustment with multiple comparisons. Results: Fifty-five participants (44 male, 80.0%) with a mean (standard deviation, SD) age of 22.75 (2.93) years and body mass index of 23.7 (4.21) kg/m2 were recruited. The biceps muscle activity during biceps push-up was significantly greater than the standard or diamond push-up ($p<0.001$), whilst the triceps muscle activity during diamond push-up was significantly greater than standard or biceps push-up ($p<0.001$). There was no significant difference in PM muscle activity between all three push-up variants. Conclusion: These findings have clinical implications for upper-body rehabilitation. The variations in push-up exercise may be adopted as a horses for courses approach to target specific impairments.

P-N-193: Effect of different insole types on weight distribution and centre of pressure excursion during upright standing

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BACKGROUND AND AIM: Bipedal standing is a highly unstable condition, whereby small perturbations, triggered internally or by environmental factors, may lead to falls if not compensated for. It is a common experience that different subjects may respond differently to these perturbation, in particular when standing on different surfaces. It has been suggested that when our foot sole is in direct contact with natural composites, skin receptors are facilitated, providing a more accurate source of sensorial input likely to help subjects in standing more stably. Our goal here is to test this hypothesis on a sample of healthy subjects. METHODS: Thirty six healthy (14 females) volunteers were asked to stand on two force-plates for 30 s while wearing two different pairs of insoles, one at a time. One insole was made of polyethylene (control) while the testing insole was made of polyethylene and natural by-products (Si28). Four stabilometric trials were applied while subjects stood with each of the two insoles, one at a time: 1) eyes open without force plate vibration; 2) eyes closed without force plate vibration; 3) eyes open with force plate vibration at 30 Hz; 4) eyes closed with force plate vibration 30 Hz. Rest periods of Trials were conducted at the order just described and roughly 1 min intervals were provided between trials. Feet position over the force plate was kept constant across the testing conditions, minimising any potential geometric effect on the stabilometric descriptors [1]. Two stabilometric descriptors were considered to assess the effect of the insoles: the total CoP excursion [2] and the asymmetry of weight distribution between limbs. RESULTS: A main effect of the Si28 material was observed during eyes closed (ANOVA; F=4.14; P=0.038) though not during eyes open (F=2.05; P=0.15). This result indicates the size of postural sways, quantified through the total excursion of CoP, was significantly smaller with the Si28 than the control material, regardless of whether subjects stood with or without force plate vibration. Similarly, even though body weight was more symmetrically distributed when subjects stood with the Si28 material, a statistically significant difference was observed only for the eyes closed condition, without force plate vibration (F=5.01; P=0.023). CONCLUSIONS: Results reported here confirm the hypothesis that when the feet are in contact with natural composites (Si28), subjects sway to a lesser extent and are able to more symmetrically distribute their weight between limbs. REFERENCES 1. Chiari, L.; Rocchi, L.; Cappello, A. Stabilometric parameters are affected by anthropometry and foot placement. Clin. Biomech. 2002, 17, 666-677. 2. Prieto, T.E.; Myklebust, J.B.; Hoffmann, R.G.; Lovett, E.G.; Myklebust, B.M. Measures of postural steadiness: Differences between healthy young and elderly adults. IEEE Trans. Biomed. Eng. 1996, 43, 956-966.

P-N-194: Effect of inhibitory kinesio-tape to the upper trapezius on lower trapezius muscle activation: A pilot study

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BACKGROUND AND AIM: Shoulder pain has a lifetime prevalence of up to 70%. Interestingly, individuals with shoulder pain exhibit an increase in upper trapezius (UT) activity and a decrease in lower trapezius (LT) activity, which alters scapular position and motion. Kinesio-tape (KT) is a therapeutic modality proposed to facilitate or inhibit muscle activation. Despite inconsistent reports regarding its

effectiveness, KT is frequently used to modify activation levels of UT and/or LT to help reduce shoulder injury risk and to help rehabilitate injured shoulders. The purpose of the current study is to determine if inhibitory KT to the UT increases LT activation and if load alters the magnitude of change in activation observed in the LT with KT. METHODS: Fifteen (n= 15, 6 female) participants with healthy shoulders (24 ą5 years) completed 10 repetitions of a repeated arm elevation task during three taping conditions (no tape [NT]; experimental KT [E-KT; 25% tension]; sham KT [S-KT; no tension]) and two loading conditions (no load and loaded [5 pounds]). High-density surface electromyography was collected from LT using a 32-electrode grid during the repeated arm elevation task. Whole-muscle (mean grid) and distribution (grid row) of activation as measured by peak root mean square (RMS) over the 1.5-second interval for each arm elevation repetition. RESULTS: There was a main effect for the loaded condition on grid RMS, F (1,14)=41.84, p<.001, partial η²=.749. Grid RMS was significantly higher 0.02V (95% CI, .014 to .027) in the loaded condition compared to the no load condition. One-way ANOVAs of grid rows (spatial distribution) across taping conditions during the loaded condition reached significance (p < .05) for rows 4, 5, 6 and 8. However, post-hoc pair-wise comparisons did not. CONCLUSIONS: While preliminary findings demonstrate KTs ability to alter the distribution of activity within an antagonist muscle, pair-wise comparisons of spatial distribution were not significant. Therefore, our findings suggest inhibitory KT to the UT does not shift the distribution of activation, nor alter whole-muscle activation in the LT during a repeated arm elevation task. Our findings add to a growing body of literature that question KTs effectiveness and continued use to alter muscle activation. While our results suggest that inhibitory KT is not an effective method of altering muscle activation within healthy shoulders, it is possible that KT may be only effective in populations with altered muscle activation due to injury. Thus, future research should incorporate participants with injured or "unhealthy" shoulders. Additionally, analysis of activity within specific ranges should be integrated as LT contracts at different magnitudes throughout the range of arm elevation/depression, which may be be altered by KT.

P-N-195: Reliability and minimal detectable change for gait variables using trunk acceleration data analysis in patients with Parkinson's disease.

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BACKGROUND AND AIM: Sensor-based gait analysis is useful to evaluate gait conditions in patients with neurological disorders. In the previous study, we reported that dynamic load factor (DLF) which represents gait load related to the stride factor, and power spectrum entropy (PSEn) which represents the smoothness of gait, calculated from the power spectrum density obtained by the fast Fourier transform (FFT) for trunk acceleration data, were helpful to assess the gait condition in patients with neurological disorders. However, it is unclear that reliability and minimal detectable change; the smallest amount of difference in an individual that represents true change, in patients with Parkinson's disease (PD). The purpose of this study were: (1) to determine test-retest reliability for DLF and PSEn; (2) to quantify the MDCs for DLF and PSEn in patients with PD. METHODS: Subjects were fourteen hospitalized patients with PD and instructed to walk a 10m-walkway twice with comfortable gait speed. Trunk acceleration data were recorded during each trial using a tri-axial accelerometer attached over the third lumbar vertebra spinous process. All recorded acceleration data were transferred to a laptop

computer through a USB connection, and we extracted gait cycles data based on a method described by Zijlstra et al. The peak anteroposterior (AP) acceleration during heel contact was set as the baseline. Signal processing was performed using the MATLAB 2012b software (Mathworks, Natick, US). FFTs were performed on the acceleration data in the vertical directions, excluding the first two gait cycles, to obtain the power spectrum. DLF and PSEn were calculated from the power spectrums based on the method proposed by Yoneda et al. and Inoue et al., respectively. Intraclass correlation coefficient (ICC(1,2)), standard error of measurement (SEM) and MDC at 95% confidence level (MDC95), were calculated for each index. RESULTS: The DLF and PSEn showed excellent test-retest reliability. The ICC(1,2), SEM and MDC95 for DLF were 0.906, 0.038 and 0.104, respectively. The ICC(1,2), SEM and MDC95 for PSEn were 0.814, 0.44bit and 1.23bit, respectively. CONCLUSIONS: DLF and PSEn were found to be highly reliable indices in patients with PD, whose gait condition was easily changed. The results showed reference values regarding each index that may help clinicians and researchers determine whether a change in a patient with PD is a true change. Further study should investigate reliability and MDCs according to symptom severity of PD with a larger sample size.

P-N-196: Motor imagery of all finger extension on the affected side with all fingers extension movement on the unaffected side was effective in a hemiplegic patient with increased muscle tone of affected thumb flexor muscles

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BACKGROUND AND AIM: Motor imagery are used to improve the function of the finger on the affected side in hemiplegic patients with cerebrovascular disorders. In this study, we performed several kind of motor imagery of affected finger movement combining voluntary of unaffected finger movement side in a case with difficulty of voluntary movement due to increased muscle tone of affected thumb flexor muscles. We tested the effect of exercise therapy using F wave, excitability of spinal motor neuron function and movement function of fingers, especially thumb using video analysis. METHODS: Case was a patient with right hemiplegia due to left cerebral hemorrhage (putamen), which showed higher muscle tone of thumb flexors and no voluntary movement. We performed 4 methods of excise therapy combining voluntary movement of the upper limb of the unaffected side and motor imagery of the upper limb of the affected side as follows; task1:motor imagery of thumb extension on affected side, task2: motor imagery of all fingers extension on affected side, task3:motor imagery of thumb extension on affected side with thumb extension movement on unaffected side and task4:motor imagery of all fingers extension on affected side with all finger extension movement on unaffected side. Each task was conducted for 1 minute and 5 minute break was taken between tasks. F-waves were recorded from the affected thenar muscles with the median nerve stimulation before and during tasks. RESULTS: The amplitude ratio of F/M in all tasks is tended to decrease compared that before task. The amplitude ratio of F/M in task 4 is decreased compared to other tasks. Movement of affected thumb function was slightly improved with excise therapy in task4 for 3 month using video analysis. CONCLUSIONS: It was suggested that the method of motor imagery using extension of all fingers on the affected side according to all finger extension movement on the unaffected side was effective in patients with higher muscle tones of the thumb flexor muscles. Continuous thus excise therapy must be recovery of affected thumb movement.

P-N-197: Relationship between spinal motor neuron excitability in the upper limbs and voluntary movement with different difficult tasks performed with the lower limbs

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BACKGROUND AND AIM: It is important to understand the effects of remote muscle contractions on other muscles during physical therapy. Previous studies have shown that the facilitatory effects of muscle contractions in remote regions, such as the upper and lower extremities, on other regions are affected by the contraction intensity and the number of muscle spindles. However, few reports have evaluated the effects of qualitative differences in movements, such as task difficulty, on muscles other than the contracting muscle. This study aimed to examine the relationship between spinal motor neuron excitability in the upper extremity and voluntary movement with various difficult tasks performed with the lower extremities. METHODS: Twenty right-footed healthy adults (mean age, 25.7 ą 6.2 years) with no orthopedic or neurological abnormalities participated in this study. F waves were derived from the right abductor pollicis brevis muscle during rest, and the bilateral lower limbs' motor tasks were evaluated using the VikingQuest EMG system (Nicolet Biomedical, Madison, WI, USA). The subjects were seated on a chair during the test. In the lower extremity movement task, the participants alternately stepped to the left and right under four different difficulty levels. In Task 1, the participants' feet randomly landed. In tasks 2, 3, and 4, two targets were set, and the participants were asked to land on the said targets with their big toes. The targets were 7.5 cm Ũ 10.0 cm (width Ũ length) for task 2, 5.0 cm Ũ 10.0 cm for task 3, and 2.5 cm Ũ 10.0 cm for task 4. Moreover, they were set 20 cm apart for all tasks, with an exercise frequency of 1 Hz. In this way, we manipulated the degrees of task difficulty by changing the target width. Each task was performed with the right and left lower extremities. During the lower extremity movement task, electrical stimulation for F wave derivation was provided when the hip joint was adducted. The F waves were analyzed for the F/M amplitude ratios. Furthermore, the amplitude ratios of F/M during the rest and movement tasks were compared using Dunnett's test. Statistical significance was accepted for values of $p < 0.05$. RESULTS: During the right lower extremity tasks, the F/M amplitude ratios significantly increased in Tasks 1, 2, and 3 compared to that at rest, whereas during the left lower extremity tasks, the F/M amplitude ratios significantly increased in Tasks 2 and 3 compared to that at rest. CONCLUSIONS: Our findings suggest that spinal motor neuron excitability in the right arm was increased during voluntary movement of the lower extremities. The excitability of the spinal motor neurons might be increased by the facilitatory effect at the spinal and cortical levels. Further, the facilitatory effects of difficult tasks might be larger than those of simple tasks at the cortical level. However, the most difficult task might be affected by the facilitatory and inhibitory effects of the central nervous system.

P-N-198: The effect of EMG biofeedback on the activity of upper trapezius muscle during strength training exercise

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BACKGROUND AND AIM: A recent concern is the education of correct upper trapezius activation during exercise to reduce the risk of developing shoulder and neck pain [1]. Verbal comands to correct scapular posture are commonly used. However, biofeedback based on electromyograms (EMGs) has been effective to re-educate scapular muscles' activity and posture during different circumstances [2]. This study aimed at investigating whether the EMG biofeedback is a promising technique to reduce the hyperactivity of upper trapezius during a strength training exercise. METHODS: Eight male volunteers were instructed to repeat ten consecutive times the wide-grip seated row exercise, where they pulled (concentric) and returned (eccentric) the bar to starting position at a fixed cadence in two different ways: (i) with verbal postural correction, i.e. scapular retraction and depression; and (ii) with the real-time EMG biofeedback of the upper trapezius displayed on a tablet screen. Subjects were instructed to reduce the EMG peak-to-peak amplitude while performing exercise with EMG biofeedback. EMGs from the serratus anterior and from the three portions of trapezius were sampled with a pair of surface electrodes (3 cm inter-electrode distance). EMGs were segmented in concentric and eccentric phase of each cycle of exercise from a tri-axis accelerometer positioned to the bar. For each phase, the normalized Root Mean Square (RMS) amplitude of EMGs was computed over the whole phase duration (providing 10 RMS values) and averaged across cycles to assess the degree of muscle activity for each muscle. The non-parametric Wilcoxon signed-rank test was used to verify whether the degree of activity was different between conditions for each muscle independently, considering the significance level of 5%. RESULTS: The scapular muscles' activity varied significantly with the EMG biofeedback. EMGs with lower amplitude (~10%) were sampled from the upper trapezius with EMG biofeedback than with verbal correction, regardless of phase (P=0.035; Fig. 1A,B). There was a trend towards lower EMG activity for the serratus anterior muscle during the eccentric phase while subjects performing the exercise with than without the EMG biofeedback (P=0.068; Fig. 1B). CONCLUSIONS: Results revealed the EMG-biofeedback was effective to reduce the level of activity of upper trapezius and serratus anterior muscles during exercise, with implications on the prevention of musculoskeletal disorders. The extension of the study to a higher number of subjects and exercises is ongoing. Figure 1. (A) EMGs collected from the scapular muscles in both conditions. (B) Boxplots are shown for the normalized RMS amplitude of EMGs collected from scapular muscles computed in both phases of exercise of each condition. Asterisk indicates significant differences between conditions (P<0.05). REFERENCES: [1] Juan J, et al. J Biomech. 2016; 49:1881-1886; [2] Gaffney BM, et al. Appl Psychophysiol Biofeedback 2016; 41:181-189.

P-N-199: Application of constraint force paired with enhanced sensory feedback induces forced use of the paretic leg and improves gait symmetry in individuals post-stroke

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Background. Many individuals post-stroke used a compensatory strategy by relying more on their non-paretic leg and using less on the paretic leg during walking, which might due to the muscle weakness,

motor control deficits, and impairments in sensory feedback of the paretic leg. Sensory afferent feedback plays an important role in regulating ongoing limb movements and in reducing unintended irregular gait patterns while walking. Our previous study indicated that the application of the constraint force might induce a forced use of the paretic leg. It's unclear whether enhanced sensory feedback from the paretic leg would further enhance the forced of the paretic leg that was induced by the application of the constraint force during walking in individuals post-stroke. Objective. To determine whether applying perceptible electrical stimulation to the foot of the affected leg paired with the application of constraint force applied to the pelvis and non-paretic leg during walking would enhance muscle activities of the affected leg and reduce gait asymmetry in individuals post-stroke. Methods. Eleven individuals post-stroke were recruited in this study and were tested in two conditions, i.e., treadmill walking with the application of the constraint force paired with electrical stimulation or without stimulation. The order of two testing conditions was randomized across subjects and a 10-minute sitting break was inserted in between. The constraint force included a backward resistance force applied to the non-paretic leg and a lateral assistance force applied to the pelvis during the stance phase of the paretic leg. The constraint force was delivered using a custom designed cable-driven robotic system. Electrical stimulation was applied to the bottom of foot of the paretic leg during the stance of the paretic leg. EMG from 8 muscles of the paretic leg and ankle and pelvis position data were also recorded. Overground gait speeds and other gait parameters pre and post treadmill walking were also measured. Results. The application of constraint force paired with sensory stimulation induced a significant increase in hip abductor and adductor magnus muscle activities on the paretic leg and a decrease in step length asymmetry ($P < 0.05$), compared with the application of constraint force without stimulation ($P > 0.06$). In addition, individuals post-stroke exhibited a greater increase in overground walking speed after treadmill walking with the application of the constraint force paired with electrical stimulation ($P = 0.04$), but exhibited no significant change in gait speed after treadmill walking with the application of constraint force only ($P > 0.4$). Conclusion. Enhanced afferent sensory feedback induced by applying electrical stimulation paired with the application of the constraint force during treadmill walking may further enhance the forced use of the paretic leg and induce a more symmetrical gait pattern in individuals post-stroke.

P-N-200: Myofascial release of the pectoral fascia: Effect on shoulder posture and muscle activity

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BACKGROUND AND AIM:Neck-shoulder pain (NSP) is a common health problem, especially in female office workers. Forward shoulder posture (FSP) is a postural deviation affecting up to 73% of the general population where the scapula is protracted and the acromion translates anteriorly. This results in scapular protractors (i.e. pectorals) that are shortened and hypertonic and retractors (i.e. trapezius) that are lengthened and inhibited, leading to an altered scapular retractor-protractor activity ratio. FSP is a risk factor for the development of NSP. One common approach to reduce FSP is myofascial release (MFR), a group of manual techniques that elongate and soften restricted fascia. While these techniques improve scapular resting position and FSP, it is not known if MFR to the pectoral fascia improves the scapular retractor-protractor activity ratio.METHODS:Three female participants (N=3; 22

years ą 1) attended two randomized experimental sessions that consisted of one of two 4-minute treatment conditions: MFR and a soft-touch control (CON). Both treatment conditions were performed by the same Massage Therapist by applying a cross-hand technique to the right pectoral fascia; moderate pressure was applied for MFR and no pressure was applied for CON. FSP and scapular retractor-protractor activity ratio measures taken before (PRE) and after (POST) each treatment. FSP was measured using the double-square method and muscle activity ratio was measured through surface electromyography of the trapezius (upper, middle, and lower) and pectoralis major while completing a reaching task. Root mean square (RMS) for each muscle was averaged for the length of the reaching task and mean RMS for the trapezius was divided by the average protractor RMS to yield the scapular retractor-protractor activity ratio. A two-way repeated measure ANOVA was run to determine the effect of treatment condition on FSP and scapular retractor-protractor activation ratio.RESULTS:There was no statistically significant interaction or main effect between treatment condition and time for FSP (PRE-MFR 137ą7mm, POST-MFR 133ą12mm; PRE-CON 133ą11mm, POST-CON 133ą10mm). There was a significant two-way interaction between treatment condition and time for scapular retractor-protractor activation ratioF(1, 2) = 75.491, p= .013, n²=.974. However, simple main effects revealed no significant findings (PRE-MFR 1.1ą0.6A.U., POST-MFR 1.5ą0.8A.U.; PRE-CON 1.2ą1.0A.U., POST-CON 1.4ą1.2A.U.). CONCLUSIONS:With only three participants, our pilot data indicate trends for MFR to decrease FSP and increase the scapular retractor-protractor activation ratio in comparison to CON. This suggests that only 4-minutes of MFR is capable of altering shoulder posture and the level of activation within muscles of the shoulder complex, which highlights its potential use as an effective, time-efficient preventative technique for individuals at risk of NSP.

P-N-201: Towards restoring scapular position and motion through mapping muscle activation in the trapezius: a pilot study

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BACKGROUND AND AIM: The scapula is a major connection between the arm and thorax allowing full range of motion of the upper extremity. Alterations in scapular position and motion (scapular dyskinesis) are risk factors for shoulder injury and often present clinically in those with shoulder pathology. The trapezius muscle has three distinct regions with differing fibre orientation and is an important scapular stabilizer. Given the multi-directional forces of the muscle, differences in activation within these regions likely influence scapular position. Correcting the activation of scapular stabilizers is understood as essential for restoring normal scapular kinematics. However, little evidence exists demonstrating the efficacy of this intervention. This suggests we lack a complete understanding of the neuromuscular mechanisms underlying scapular dyskinesis and the appropriate strategies to correct scapular position. The purpose of this study was to further comprehend the role of the trapezius in scapular dyskinesis. METHODS: Fourteen healthy right-handed participants were assessed to determine the presence of scapular dyskinesis using the scapular dyskinesis test: seven had normal scapular motion (CON; 5 Female, 29±11 years) and seven had subtle dyskinesia (DYS: 5 Female, 26±5 years). Participants completed five repetitions of shoulder flexion and abduction while holding a dumbbell determined by bodyweight (<150 lb.=3 lb., >150 lb.=5 lb.). High definition surface electromyography was collected throughout the movements from each region of the trapezius (upper [UT], middle [MT], lower [LT])

using 32-electrode grids. The ratio of muscle activation between regions of the trapezius (UT:MT, UT:LT, MT:LT) were compared by calculating root mean square (RMS) of each electrode. Comparison of muscle activity during the first 0.5 seconds of movement (approximately 0-30°) between groups (CON and DYS) was performed using independent samples T-tests. RESULTS: No significant difference ($p > .05$) in ratio of mean RMS was determined between groups. Means and standard deviations for each ratio during abduction were: UT:MT 1.40±0.53 CON, 1.09±0.55 DYS; UT:LT 2.97±1.84 CON, 2.82±2.4 DYS; MT:LT 2.10±0.88 CON, 2.21±1.01 DYS; and during flexion: UT:MT 1.53±0.98 CON, 1.09±0.56 DYS; UT:LT 1.69±1.89 CON, 1.13±0.65 DYS; MT:LT .91±.41 CON, 1.02±0.37 DYS. CONCLUSIONS: Ratio of muscle activation of the three regions of the trapezius was unaffected by the presence of scapular dyskinesis during the initial 30° of concentric motion. A larger sample size and analysis of different concentric/eccentric ranges may reveal greater distinctions between groups. Determining the trapezius' role in scapular position and motion may help identify strategies to correct altered scapular kinematics, informing shoulder rehabilitation.

P-N-202: The immediate effect of Mobilisation-with-Movement on neuromuscular control of forearm extensors in chronic lateral epicondylalgia: An analysis using multi-channel electromyography

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BACKGROUND AND AIM: Impaired activation patterns of forearm extensors during gripping have been reported in people with lateral epicondylalgia (LE). Current evidence substantiates the application of Mobilisation-with-Movement (MWM) techniques to improve pain and grip strength, however, its effect on neuromuscular control of forearm extensors remains unknown. This single cohort study examined changes induced by MWM (sustained lateral glide) on pain-free grip strength (PFG) and activation patterns of extensor carpi radialis [ECR], extensor digitorum communis [EDC] and extensor carpi ulnaris [ECU]). METHODS: Forearm extensor activity during a 15% maximal handgrip task was measured using a 64-channel surface electromyography (EMG) in 35 participants with chronic LE. PFG and EMG amplitude during a grip task were compared before and after two conditions, MWM and Sham-MWM, applied to the symptomatic elbow. RESULTS: There was a significant decrease in PFG after Sham-MWM ($p=0.006$) and a significant decrease in ECU amplitude after MWM ($p=0.01$). 26/35 participants were identified as positive-responders who exhibited an average of 16.6% increase in PFG post-MWM. Subgroup analysis within the MWM condition showed a significant increase in ECR activity for positive-responders compared to negative-responders ($p<0.001$). CONCLUSIONS: MWMs applied to the affected elbow resulted in differential changes in forearm extensor activation pattern with a decrease in ECU activity for the whole group and an increase in ECR activity in positive-responder subgroup. Differential responses in neuromuscular control of forearm extensors in people with LE substantiate the importance of subgroup analysis when studying efficacy and mechanisms involved in clinical interventions. KEYWORDS: lateral epicondylalgia, Mobilisation-with-Movement, forearm extensors

P-N-203: sEMG Spatial Distribution Patterns of Trunk Muscles During Pushing Tasks

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BACKGROUND AND AIM: Many tasks require workers to push and/or pull industrial carts and it has been shown that approximately 9 - 18% of all reported trunk injuries are caused by these tasks. The design of the industrial cart used contributes to the development of trunk pain in these workers. Industrial cart handle design can vary an individual's capacity to push by up to 9.5%. However, few studies have studied the trunk muscles during these tasks using surface electromyography (EMG) and the results to date have been mixed. Furthermore, while recent research has used high-density (HDEMG) to better understand the spatial distribution of muscle, this technique has not been used extensively in ergonomic studies. The aim of the current study was to examine the impact of handle design, specifically handle height and orientation, on muscle activity of the trunk during typical pushing tasks. It was hypothesized that there would be a significant difference among trunk (erector spinae, rectus abdominis, and oblique's) muscle patterns between the six handle designs. METHODS: Twenty male (n=10) and female (n=10) participants (mean age = 24.25 ± 4.28 years) completed 18 trials, pushing 215 kg using six different combinations of handle orientation (vertical/horizontal/semi-pronated) and handle height (hip/shoulder) over a distance of five meters. Multichannel HDEMG (Sessantaquattro, OT Bioelettronica, Italy) data were recorded at 1024 Hz using semi-disposable 32-channel electrode grids placed over the left and right rectus abdominis, erector spinae and external obliques. Spatial distribution was estimated using the Root Mean Square (RMS) and 2-Dimensional (2D) maps were developed to examine spatial features. A primary spatial feature examined in the present study was modified entropy which examines alterations in muscle heterogeneity and pattern. A repeated measures Analysis of Variance (ANOVA) was used to compared HDEMG data between handle condition and muscle with the alpha level set to 0.05. RESULTS: Mean RMS activity revealed significantly lower muscle activity using the HH handle design than the HS ($p<0.05$) and SV ($p<0.0001$) handle design (Figure 1), regardless of the trunk muscle or muscle side at the initiation of the push. Furthermore, mean RMS of all left-sided muscle was significantly greater pushing with the SV handle design than pushing with several other handle designs ((HH: $p<0.001$); (SH: $p<0.001$); (HS: $p<0.001$); (HV: $p=0.01$)).The results also showed that the modified entropy of left side trunk muscles were significantly higher using the HH handle design than the SS and SV handle design ($p<0.001$) at the initiation of the push suggesting that a greater proportion of the muscle was being used with said handle designs. CONCLUSION: This study found an increase in the homogeneity of the trunk muscles occurred at the initiation a loaded push, indicating that a greater proportion of that muscle was active based on the alterations of the spatial distribution pattern of sEMG. However, the mean RMS during both phases of the push support the effect that the greater muscle involvement during the task did not correlate with greater muscle activity.

P-N-204: The effects of eccentric exercise on mechanical sensitivity and forearm muscle activation in lateral epicondylalgia

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BACKGROUND AND AIM: Altered mechanical sensitivity and forearm muscle activation are commonly displayed in people with lateral epicondylalgia (LE). Eccentric forearm extensor exercise has been advocated to promote pain and functional recovery. This study investigated changes in pressure pain threshold (PPT) and forearm muscle activation during gripping tasks and submaximal isometric wrist extension tasks, before and after a 5-week home-based eccentric forearm extensor program in participants with chronic LE. METHODS: Forearm muscle activation expressed in EMG amplitude (% MVC) and relative contribution between three extensor and three flexor forearm muscles during handgrip tasks (pain-free grip (PFG), 15% and 30% MVC) and isometric wrist extension tasks (15%, 30% MVC) were measured using bipolar EMG in 7 participants with an average of 3.2 years' history of LE. Pain intensity (0-10), functional disability (Patient-Rated Tennis Elbow Evaluation) and PPT were also compared pre- to post-exercise. RESULTS: Pain and disability ($p=0.038$) but not PPT ($p>0.05$) significantly improved post-exercise. A significant increase in extensor carpi radialis brevis amplitude during PFG, decrease in flexor carpi radialis amplitude and increase in flexor carpi ulnaris amplitude and its relative contribution during 15%- and 30%-MVC grip were also found post-exercise. CONCLUSIONS: A 5-week home-based eccentric exercise program promoted functional recovery in LE, and was characterised by an adaptive activation strategy in selected forearm muscles. Further research should investigate the effects of an eccentric exercise program of a longer duration and as a component of a multi-modal intervention to better understand its efficacy and underpinning mechanisms in managing LE.
KEYWORDS: lateral epicondylalgia, forearm muscle activation strategy, mechanical sensitivity

P-N-205: Cryo-stretching acute effects on hamstring isokinetic strength in female young

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BACKGROUND AND AIM: Adequate flexibility promotes greater muscle strength, range of motion, speed and fluency of the movement. Here, we used muscle passive cooling (cryotherapy) associated to the agonist contract-antagonist relax proprioceptive neuromuscular facilitation stretching, which involves passive stretching to the possible limit and the maximum voluntary isometric contraction agonist followed by the antagonistic maximum concentric isotonic contraction and observed the effects on the isokinetic force production. The study`s aim was to measure the acute effects of dyanmic stretching with superficial cooling on the isokinetic strength in young women. METHODS: Ten young women (22.1±2.07 years) underwent cryo-stretching of the hamstrings bilaterally with 500g of ice compression for 20 minutes and then applied the strecthing technique, 15 seconds of contraction of the agonist muscle against a resistance provided by the clinician while simultaneously stretching and 15 seconds of relaxing the antagonist muscle during four consecutive series. Static flexibility was measured by the average of 3 attempts on Wells' bench. The isokinetic muscle strength was performed using the Biodex 4 PRO isokinetic dynamometer at speeds of 60°/s and 180°/s following the equipment`s guideline. The data were paired compared between moments before (pre) and after (post) cryo-stretching. RESULTS: There was no significant difference in flexibility between the moments (pre: 28.6±707 cm; post: 30.73±7.09 cm). The hamstring peak torque hasn't shown statistically significant between pre and post moment ($p> 0.05$), although it has increased for both limbs and velocities. On the other hand, the hamstring total work generated throughout the range of motion has shown to be facilitated after the cryo-stretching. This reduction was seen during the velocity 60°/s (right limb: pre: 6.86 ± 3.02; post: 5.14±1.73 - $p=0.015$;

left limb: pre: 6.22 ± 2.46; post: 4.87±2.49 - p=0.041) and for the velocity 180°/s (right limb: pre: 17.43±9.26; post: 10.58±7.01 - p=0.03; eft limb: pre: 14.74±9.51; post: 8.77±4.78 - p=0.043). CONCLUSIONS: There was reported a positive relationship between muscle flexibility and motor performance, increasing the risk of injury during exercise. The acute neuromuscular effects of flexibility exercise associated to muscle cooling presented slight influence in the strength production (i.e peak torque), but showed a direct effect on total work for neuromotor control of the the knee flexion in slow and intermediated angular velocities.

P-N-206: Are psychological factors associated with protective motor behavior in people with low back pain? A Meta-Analysis.

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BACKGROUND AND AIM: Following injury, pain serves as a protective mechanism that changes movement. Reduced spinal mobility and trunk muscle guarding are common in people with Low Back Pain (LBP), and this motor behavior may contribute to ongoing disability via sub-optimal spine and tissue loading. Why this behavior persists, however, remains unclear. Current evidence supports the view of LBP from a biopsychosocial perspective. While psychological factors are robust predictors of future disability in LBP, their relationship with protective motor behavior is unknown. The aim of this review was to examine whether levels of pain-related fear and pain catastrophizing are associated with reduced spinal mobility and trunk muscle guarding during functional tasks, in adults with LBP. METHODS:This review was conducted as per PRISMA guidelines. Five databases were searched for relevant literature to November 2019. To be included, studies had to measure the association between pain-related fear or pain catastrophizing and either (i) mobility of the lumbar spine, or (ii) trunk muscle activity, during a functional task, in adults with LBP. Two independent reviewers extracted all data. The Newcastle-Ottawa Scale assessed for risk of bias. When possible, correlation coefficients were pooled using the random-effects model. Heterogeneity was assessed using I(2) and T(2) statistics. RESULTS: 26 studies were included in four separate meta-analyses. Pooled analyses showed small negative association between lumbar flexion and both pain-related fear (13 studies, r=-0.213, 95% confidence interval=-0.331 to -0.089, P<0.05) and pain catastrophizing (6 studies, r=-0.255, 95% confidence interval=-0.416 to -0.077, P<0.05). No significant association was observed between spinal extension and pain-related fear (3 studies, r=-0.158, 95% confidence interval=-0.333 to 0.026, P>0.05). Separate analyses found a moderate association between pain-related fear and smaller flexion-relaxation ratios of erector spinae during spinal flexion (2 studies, r=-0.401, 95% confidence interval=-0.548 to -0.230, P<0.05), but no association with erector spinae activity in standing (2 studies, r=0.120, 95% confidence interval (-0.097 to 0.325, p>0.05). A link between pain catastrophizing and erector spinae activity during gait was also observed (2 studies, r=0.247, 95% confidence interval=0.063 to 0.423, P<0.05). Sensitivity analyses did not alter our findings except when performed for spinal flexion and pain-related fear. These suggested that the tool used for pain-related fear should be considered when examining this relationship. CONCLUSIONS: Our findings suggest that pain-related fear is significantly associated with reduced mobility and greater erector spinae activity during lumbar flexion, in people with LBP. Similarly, pain catastrophizing was associated with reduced lumbar flexion and greater trunk muscle activity during

gait. This may provide insight into why some people with LBP continue to guard their spine following injury.

P-N-207: Adaptation of corticospinal excitability due to transcutaneous vagus nerve stimulation and paired visuomotor training in humans

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BACKGROUND AND AIM: Diminished motor function comes with advanced age and with neuromotor disorders such as stroke and spinal cord injury. Pairing neuromodulatory interventions with rehabilitative training can enhance the benefits of this training and facilitate motor recovery. Afferent vagus nerve stimulation (VNS) via implanted electrodes during motor training improved motor recovery and retention in rat stroke models and also facilitated neural plasticity in the motor cortex in non-injured rats. VNS may affect the neuromodulators secreted in the brainstem (e.g. norepinephrine), and consequently neuromotor performance and adaptation. To translate from invasive VNS in rat models to humans, more feasible noninvasive alternatives need to be explored. The purpose of this study was to examine the acute effect of transcutaneous VNS (tVNS) on corticospinal excitability in healthy human adults and the adaptation of the effect after a period of visuomotor training with tVNS. METHODS: Sixteen healthy young adults were pseudo-randomly assigned to either the tVNS group or Sham group. The visuomotor task consisted of using index and little finger abduction forces in the right hand to accurately follow complex trajectories. Subjects trained for 170 trials over the span of five days, with weak electrical stimulation administered to the outer ear during each trial. During the training and excitability testing, subjects in the tVNS group received stimulation at the tragus, while those in the Sham group received stimulation at the earlobe. Corticospinal excitability for resting hand muscles was assessed on the first and last days of the experiment. To measure excitability, single-pulse TMS was applied over the motor cortex of the left hemisphere to examine the resultant motor evoked potentials (MEPs) in the first dorsal interosseus (FDI) and abductor digiti minimi (ADM) muscles. MEP amplitude was normalized to the maximal amplitude of M-wave in the corresponding muscle. RESULTS: The tVNS group showed greater MEP amplitudes on Day 1 compared to the Sham group for both FDI (57% higher, $P < 0.05$) and ADM (112% higher, $P < 0.01$). On Day 5, these differences were diminished and no significant difference in MEP amplitude was observed between groups. Stimulation intensity was comparable across days. CONCLUSIONS: These results suggest that tVNS acutely heightens corticospinal excitability for resting muscles, but extensive training paired with tVNS across multiple days may yield diminishing effects for the same stimulation, possibly due to adaptation to the repeated intervention. Our findings demonstrate the efficacy of using tVNS for acute central neuromodulation for the motor system as well as its adaptation after repeated administration during visuomotor training in healthy humans. These results will pave the way for future research that continues to examine the underlying mechanisms for the effect of VNS in neuromotor adaptation in healthy and clinical populations. Supported by NIH Grant (R03NS106088).

P-N-208: Flexion-extension MVC of the Index-Thumb Complex in the general population. A Cross-Sectional Study to gather normative data.

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BACKGROUND AND AIM: Flexion (PP-MVC) and extension (E-MVC) maximal voluntary contraction offers a quick way to estimate the level of hands' impairment and to monitor its evolution throughout time in many musculoskeletal and neurologic conditions. This study aims at establishing normative data of PP-MVC and the E-MVC in the Italian population and evaluating their correlation with hand dominance and anthropometric factors. METHODS: 303 healthy subjects (150 F, 153 M) were recruited. Age, gender, hand dominance, height and weight were acquired. Each experimental trial consisted of performing PP-MVC and E-MVC tests per hand, conducted by using a digital pinch-meter (EMAC S.r.l., Genova, Italy). The device was associated with desktop software to guide participants during the tests, providing them with visual feedback of their delivered force. T-test was used to analyze MVC means between genders and between hands. One-way ANOVA was conducted to compare MVC means in male and female populations stratified by age (18-29, 30-44, 45-59, 60-74, +75). Pearson's correlation analysis was performed to investigate the correlation between the two tests and the anthropometric variables (height, weight). RESULTS: T-test showed a significant difference between genders ($p<.05$) in both tests and between the dominant (DH) and non-dominant (NDH) hands ($p<.001$) only in the PP-MVC test. The One-way ANOVA test showed the highest statistically significant difference ($p<.05$) between the age group 30-44 (Males in PP-MVC sample: DH 5.65±1.12, NDH 5.33±1.27; in E-MVC: DH 1.93±0.35; NDH 1.82±0.43; Females in PP-MVC: DH 3.85±0.96, NDH 3.56±0.83; in E-MVC: DH 1.14±0.29, NDH 1.08±0.34) compared to the +75 (Males in PP-MVC: DH 4.76±1.12, NDH 4.26±0.82, in E-MVC: DH 1.43±0.34, NDH 1.34±0.44; Females in PP-MVC: DH 3.26±1.24, NDH 2.76±0.98, in E-MVC: DH 0.78±0.28, NDH 0.75±0.27) for gender and dominance of the hands. The reported normative data are expressed as means and standard deviations in Kg unit. Pearson's correlation analysis showed a moderate correlation between tests and weight and height for both hands and genders. CONCLUSIONS: As expected, males showed a higher force level than females in all tests. Interestingly, the difference between genders was higher in E-MVC than in PP-MVC. Fingers extensors are physiologically weaker than flexors, but the greater E-MVC difference found between genders could be justified by considering the different muscle fibers architecture. In both the tests and gender samples, the highest MVC values were found in the 30-44 age group and the lowest ones in the oldest group (>75 y.o.). This data is in line with the normal process of ageing that also entails muscle fibers and with the reduction of daily life activities in the elderly. Lastly, we found a positive correlation between these measures and the anthropometric data.

P-N-209: Relationship between distal latency and grip or pinch strength in patients with carpal tunnel syndrome

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【BACKGROUND AND AIM】 Carpal tunnel syndrome (CTS) is the most frequent entrapment neuropathy. CTS has the relationship between severity, such as graded by distal latency (DL), and grip or pinch strength. However, there are few reports on the relationship between medial nerve conduction

velocity deficits and functional and life impairments. The purpose of this study is to determine the relationship between DL measured by motor nerve conduction velocity test (MCV), grip or pinch strength and activities of daily living in patients with CTS. 【METHODS】 The subjects were 62 patients with CTS (unilateral cases) indicated for surgery (age 67.1 years, 16 males and 46 females). We measured DL and grip, lateral abdominal pinch and finger abdominal pinch compared with the healthy side, disabilities of the arm, shoulder and hand (DASH) score. The entire patient group and DL were divided into two groups: the severe group (DL: more than 6.5 msec) and the mild group (DL: less than 6.5 msec) based on Bland's seven-step classification. 【RESULTS】 There was no correlation between age, DL, grip strength, pinch strength, and DASH score in the overall patient group. And, there were no correlations between DL, grip strength, pinch strength and DASH score for each group. 【CONCLUSIONS】 Regardless of DL delay, there was no relationship between DL and grip or pinch strength. There was no relationship between medial nerve conduction velocity deficits and functional and life impairments. It is necessary to deal with each individual patient while considering the results of electrodiagnostic and functional test. In the future, we would like to increase the number of cases and conduct further studies.

P-N-210: Effects of neuromuscular training on knee proprioception in individuals with anterior cruciate ligament injury with or without reconstruction: a systematic review

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BACKGROUND AND AIM: Neuromuscular training may have the potential to enhance knee proprioception in individuals with anterior cruciate ligament (ACL) injuries. To date, there is however no systematic review on the effects of such training on restoring knee proprioception (if deficient) following ACL injury. Our systematic review summarizes the level of evidence for the effects of neuromuscular training programs on knee proprioception compared to other comparator interventions in individuals with ACL injury managed with or without reconstruction (PROSPERO registration: CRD42018107349). METHODS: Six different databases (PubMed, Cumulative Index to Nursing & Allied Health Literature [CINAHL], SPORTDiscus, the Allied and Complementary Medicine Database [AMED], Scopus, and Physical Education Index [via Proquest]) were searched from their inception until February 2020. Two reviewers independently screened and extracted data, and assessed risk of bias of the eligible randomized clinical trials (RCTs) using the Cochrane RoB2 tool. Overall certainity in evidence was determined using the Grading of Recommendations Assessment Development and Evaluation (GRADE) approach. RESULTS: Of 2706 articles (544 duplicates) retrieved, only nine RCTs, including 327 individuals with an ACL reconstruction, met the inclusion criteria. Neuromuscular training interventions varied across studies: whole body vibration therapy, Nintendo-Wii-Fit training, dynamic joint stability exercises, balance board exercises, muscle strengthening exercises, plyometric exercises, agility drills, sport specific exercises, backward walking on a treadmill, etc. Knee-specific proprioception measures included joint position sense (JPS; n = 7), thresholds to detect passive motion (TTDPM; n = 3), or quadriceps force control (QFC; n = 1). Overall, we found conflicting findings for reducing errors associated with JPS (one or more target angles) or TTDPM, and no effect on QFC following neuromuscular training. Moreover, there was either a high risk of bias or some concerns associated with the proprioception measures. Owing to serious concerns with two or more GRADE domains (risk of bias, inconsistency, indirectness, or imprecision associated with the findings) across studies for JPS, TTDPM, and QFC, the certainty of evidence found

was very low. CONCLUSIONS: The existing nine studies on individuals with an ACL reconstruction using heterogenous interventions and knee-specific proprioception measures revealed a very low certainty in current evidence for employing neuromuscular training programs to improve knee proprioception. The studies had a high risk of bias or some concerns, and conflicting findings. Well-designed RCTs with homogenous populations (having ACL injury managed with or without reconstruction), neuromuscular training interventions, and reliable and valid proprioception measures are warranted to substantiate conclusive evidence in this area.

P-N-211: Corticospinal excitability during transcutaneous vagus nerve stimulation in humans

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BACKGROUND AND AIM: Motor recovery after stroke is accelerated and enhanced when motor rehabilitation is performed with concurrent application of afferent vagus nerve stimulation in rats, possibly due to increased central neuromodulators such as norepinephrine. In humans, transcutaneous vagus nerve stimulation (tVNS) has been employed with an expectation to induce persistent neuromodulation, whereas heightened corticospinal excitability was not observed after tVNS was terminated in healthy adults. The purpose of this study was to clarify if corticospinal excitability is heightened acutely during an application of tVNS in healthy adults. METHODS: Corticospinal excitability for a resting hand muscle was assessed with transcranial magnetic stimulation (TMS) to the primary motor cortex on experimental and control days in 9 healthy young adults in randomized order. Subjects received sham stimulation to the earlobe or tVNS to the tragus of the left ear depending on the condition. On the experimental day, subjects received sham stimulation in the first trial and tVNS in the second trial. To account for the potential effect of repetition and time, the same subjects received sham stimulation in both first and second trials on the control day. During application of tVNS or sham stimulation, single-pulse TMS was applied to the left motor cortex for the resting first dorsal interosseous muscle in the right hand. RESULTS: On the experimental day, peak-to-peak amplitude of motor evoked potential (MEP) in the higher TMS intensity range (i.e. 130-160% of resting motor threshold) was greater during the tVNS trial compared with the sham trial by 28%, on average ($P < 0.05$). MEP amplitude in the lower TMS intensity range (100-120% of resting motor threshold) was not different between the tVNS and sham trials. MEP amplitude was not significantly different between the two sham trials in either TMS intensity range on the control day. There was no significant difference in background EMG across trials and days. CONCLUSIONS: The greater MEP amplitude during tVNS in only the higher TMS intensity range is in line with the literature in which vagus nerve was indirectly stimulated with orthostatic stress or noradrenergic function was facilitated pharmacologically. The findings indicate that cortical excitability is heightened during tVNS in a high TMS intensity range in healthy young adults, possibly involving the effect of increased central norepinephrine due to tVNS.
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P-N-212: Effects of 8-week eccentric heel drop exercise on muscle strength, muscle thickness and tendon stiffness in young men

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BACKGROUND: Achilles tendinopathy is an overuse injury that is difficult to treat, but eccentric heel drop (ECC-HD) exercise is often used as a primary treatment. However, the effects of ECC-HD exercise on muscle strength, muscle thickness and tendon stiffness have not been systematically investigated, and its protocol in terms of training volume has not been established. Therefore, the present study examined the effects of an 8-week ECC-HD exercise training on plantar flexion muscle strength, muscle thickness of medial gastrocnemius muscle (MG), and Achilles tendon stiffness, in comparison to concentric heel raise exercise without eccentric heel drop performed by the opposite leg. METHODS: Sixteen sedentary healthy young (20.9ą0.2 y) men participated in the study, and their body mass ranged 52-72 kg. Their each leg was randomly allocated to either concentric heel raise followed by ECC-HD exercise or concentric heel raise exercise only (CON-HR). In the exercise, each participant was instructed to stand on a 20-cm box and raise both heels from maximum dorsiflexion to plantarflexion in 1 s, then lower the heel of one leg to the dorsiflexion position in 3 s. The training was performed twice a week, and the volume was increased progressively over 8 weeks from 1 set of 5 reps to 7 sets of 10 reps. Outcome measures included maximal voluntary isometric plantarflexion strength, muscle thickness of MG and Achilles tendon stiffness, which were measured before and 3-5 days after the last training session. A split-plot analysis of variance (ANOVA) with two factors [ECC-HD vs. CON-HR, time (pre- and post-training)] was performed for changes in the measures. A difference between pre- and post-training was also assessed by a paired t-test. Relationships between the relative training load calculated by the ratio: body weight / plantarflexor muscle strength at baseline, and the changes in the measures in the ECC-HD leg were analyzed by a Spearman's correlation. A statistical significance was set at $P<0.05$. RESULTS: Plantarflexion strength (from 129.7ą38.0 to 163.6ą30.3 Nm) and muscle thickness (from 2.00ą0.23 to 2.16ą0.19 cm) increased ($P<0.05$) only for the ECC-HD leg, and both legs showed no significant changes in tendon stiffness from pre- (17.33ą10.1 N/mm) to post-training (15.97ą13.7 N/mm). A significant positive correlation ($r=0.738$, $P<0.01$) was found between the relative training load and the magnitude of change in plantarflexion strength (the heavier the body mass relative to the strength, the greater the increase in the strength), but no significant correlation was found between the training load and muscle thickness ($r=-0.03$) or tendon stiffness change ($r=0.03$). CONCLUSIONS: It was concluded that ECC-HD exercise was effective for increasing the plantarflexion strength and MG muscle thickness, but did not affect tendon stiffness. Since the effects were greater with relatively higher training load, it may be better to perform ECC-HD exercise with an extra load.

P-N-213: High-density surface electromyography for the functional evaluation of plantar and dorsiflexion of the foot in stroke patients

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BACKGROUND AND AIM. Stroke can affect the function of the upper and lower limb muscles with a significant negative impact on autonomy in daily life activities. The neurological outcomes of the pathology and the physical deconditioning caused by the inactivity of leg muscles following the acute

phase prevent the ability to perform a safe and efficient walk (Macko et al., 2005). Specifically, the co-activation of the agonist and antagonist muscles involved in the plantar and the dorsiflexion of the foot decrease mobility in stroke patients. Therefore, an objective evaluation of pathological co-activation during the early stages of the rehabilitation procedure is essential in future recovery. Decomposition of High-Density surface Electromyography (HDsEMG) may provide neural markers of such impairment. In this study, we evaluated the amount of activation of the tibialis anterior (TA) during plantar (in which TA works as an antagonist) and dorsiflexion (in which TA works as an agonist) of the foot in acute stroke individuals. METHODS. Twelve patients between 19 and 90 years old were recruited in the acute phase of the disease (<12 weeks from the onset). Each patient underwent three tests during hospitalization and physical therapy sessions. The first test was administered at T0 (detectable ankle dorsiflexion), the second at T15 (15 days after T0), and the third at T30 (15 days after T15). In each session, patients were required to perform three maximum voluntary contractions (MVC) and then to perform both tasks at 10 and 30% of the MVC. The muscle studied with HDsEMG was the TA. Motor unit decomposition was performed using convolutive blind source separation (Negro et al., 2016). Data on a subset of four individuals is reported. RESULTS. The main benefits of rehabilitation therapy in the acute phase were shown by TA motor unit behavior. During dorsiflexion, the average number of identified MUs increased from 6±10 to 14±16 from T0 to T30. Interestingly, their discharge rate increased from 10.3±1.7 to 11.4±0.9 pps ($P<0.05$). During plantarflexion, a clear decrease in the identified MUs was observed after T0. These results show promise for the use of motor unit behavior extracted from HDsEMG decomposition as an objective biomarker of motor disability in this patient population. CONCLUSIONS. HDsEMG demonstrated capability in providing specific information regarding the dynamics of muscle co-activation and its evolution during physical therapy in subjects affected by stroke in the acute phase. The technique may also be efficient in understanding if physical therapy is effective for the CNS to recover a normal muscle activation strategy. The reduction of co-contraction, especially in dorsiflexion, is essential for the recovery of a normal walking pattern.

P-N-214: Ultrasound videos analysis of the brachial biceps as hand moves from pronation to supination and vice versa .

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INTRODUCTION: With its 2 heads and individually innervated compartments, the brachial biceps (BB) can be the source of more electromyographic signals (EMG) than usually considered. With many available EMG signals, an upper limb amputee can produce many daily life movements with a modern prosthesis. In experiments with normal subjects where many surface electrodes had been placed across their right BB and below its middle, ultrasound (US) videos were collected and information on the changes occurring to the biceps cross-section when different hand postures are now analyzed. METHODS: The US probe was placed across the biceps at the level where electrodes had been placed. Subjects were seated with the elbow at 90° or standing up with the arm extended horizontally in the frontal plane; during those acquisitions, a 0 or a 500 g load was held in their hand. Videos of 7 subjects where cephalic and basilic were visible in each frame were analyzed. A custom program tracked positions of the cephalic (Vc) and basilic (Vb) veins and the humerus' top (H) on each frame of the videos. Data obtained consist in the distance between each vein, their distance from the humerus' top,

the anti-clockwise angular position of each vein and area of the triangle formed by the center of each vein and the humerus' top. RESULTS: In the seat posture with a 500 g load and hand moving to the right (P2S), mean distance between the veins increased by 2.4 mm and was reduced by 1.7 mm for hand movement to the left (S2P). The distance increase is associated, mainly to the greater Vc angular position change of 8.2° and partly to the smaller increase of Vb (1.2°). As for the 1.7 mm decrease, it is due to an angular position reduction which was similar for each vein (Vc: -3.1°; Vb: -2.0°). For P2S, veins' angular changes resulted in an increase of the triangle's surface (23.5 mm2) and a reduction (156.9 mm2) for S2P. In the Stand posture with 500 g, mean distance between the 2 veins increased by 1.8 mm during a P2S movement and for S2P was reduced by 0.9 mm. For P2S, surface of the triangle increased by a mean value of 27.3 mm2 and was reduced by 0.7 mm2 for S2P. The surface increase for P2S movements was associated by increases in angular veins posture which was larger for Vc than for Vb (7.2° vs 4.2°). For the surface decrease during S2P movements, they are due a quite similar reduction of angular position of Vc and Vb (-6,2° vs -4,2°). CONCLUSION: With 3 landmarks representing biceps' morphology modifications as hand posture changes, a width increase, and a thickness decrease of the muscle were observed during P2S while the inverse occurred, with different amplitudes, during S2P hand movements. For the analysis of such non-linear changes, techniques more efficient than those used here are considered such as affine transformation and optical flow. This will eventually lead to the ability to collect many different EMG signals from a multifunctional muscle such as the brachial biceps.

P-N-215: Does Forward Shoulder Posture Influence Muscle Activation of the Scapular Retractors and Protractors: A Pilot Study

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BACKGROUND AND AIM: Forward Shoulder Posture (FSP) is common in individuals with neck-shoulder pain. FSP is characterized by scapular protraction and anterior translation of the acromion and glenohumeral joint. This positioning is thought to result in, or create a reduction in activity of the scapular retractors (SR) and an increase in activity of the scapular protractors (SP) resulting in an imbalance of the activation ratio between the two muscle groups. Interestingly, it is not known whether the magnitude of FSP influences the activation ratio between the SR and SP. Thus, the purpose of this study was to examine the relationship between FSP and the activation ratio between SR and SP in asymptomatic individuals. METHODS: Three right-handed participants (22 + 1 years) were included in this study. FSP was determined by computer analyzing photos taken of the participants. The photos were taken from a right anterolateral angle to include the right acromioclavicular joint (AC), C7, and sternal notch anatomical landmarks. The horizontal distances between C7 to AC (HD1) and C7 to sternal notch (HD2) were measured using large vertical lines that were placed on each landmark. The relative FSP measurement was obtained by dividing the distances of HD1 by HD2. Bipolar surface electromyography was collected from the sternal fibres of pectoralis major (Pec) and the upper, middle, and lower fibres of the trapezius (UT, MT, and LT) during a reaching task. Average Root Mean Square (RMS) during the reaching task was calculated for each muscle. Each trapezius RMS values was divided by the Pec RMS value to create 3 different ratios of SR and SP activation (UT/Pec; MT/Pec; LT/Pec). In order to determine a correlation between FSP and each activation ratio a Pearson's correlation was used. Strength of the correlation was determined by 0.1 < | r | < 0.3 = low, 0.3 < | r | < 0.5

= moderate, | r | > 0.5 = strong. RESULTS: There was no statistically significant correlation between FSP and the 3 SR/SP ratios (UT/Pec: r=-.968, p=.162; MT/Pec: r=-.826, p=.381; LT/Pec: r=-.688, p=.517). CONCLUSION: The results of this study suggest that the magnitude of FSP influences muscle activation in the SR and SP. Although the results were not statistically significant, there was a trend towards a strong negative correlation between relative FSP and each of the SR/SP ratios. While very preliminary, this suggests that as FSP increases the muscle activity in each of the trapezius fibres will decrease relative to pectoral activity. As results from this pilot study were determined from only three participants, results must be interpreted cautiously. However, the negative correlations observed suggest that future research is warranted with a larger sample size.

P-N-216: The association between total knee arthroplasty and physical activity patterns in individuals with knee osteoarthritis: Data from the Osteoarthritis Initiative

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BACKGROUND AND AIM: Osteoarthritis (OA) is a major contributor to pain, decreased quality of life and functional decline in older adults. Approximately 5M Canadians suffer from OA and >80% of cases affect the knee, which can further impair mobility and is linked to poorer overall health. Clinical OA management has focused on pharmacological pain relief while waiting for end-stage treatment (i.e. total knee arthroplasty, TKA). Approximately 70,000 TKAs are performed annually in Canada despite clinical practice guidelines highly recommending physical activity for overall health benefits. Walking-based exercise has previously been shown to improve pain, physical function, and quality of life; however, longitudinal patterns for objectively measured physical activity in individuals with knee OA who do, versus do not, undergo TKA is unclear. Therefore, the purpose of this study was to quantify physical activity patterns at baseline and 2-year follow-up in individuals who do, versus do not, undergo TKA. METHODS: Data was obtained from 1152 participants in the Osteoarthritis Initiative (OAI) ancillary accelerometry study who had complete accelerometer data at the 48- and 72-month visits. Participants were divided into groups based on TKA status, including a no TKA control group (n=1068), and three surgical groups including pre-TKA (n=40), post-TKA (n=24), and mid-TKA (individuals who underwent TKA between the two time points, n=20). The pre-TKA group underwent surgery ~1 year later (84-month OAI visit) and the post-TKA group were within 2 years of surgery (24-to-30-month OAI visits). Physical activity was measured using the Physical Activity Scale for the Elderly (PASE) and accelerometer data to calculate average daily minutes of moderate to vigorous (MVPA) and light (LPA) physical activity. A repeated measures ANCOVA was used to determine differences over time and between groups while controlling for significant demographic differences between groups (age and BMI). RESULTS: No significant interaction or main effects were observed, but distinct patterns were apparent. At the 2-year follow-up, the post-TKA group had the greatest decrease in MVPA (-2.6 min/day) and LPA (-21.4 min/day), and the pre-TKA group had the smallest decrease in MVPA (-0.19 min/day) and LPA (-6.9 min/day). The mid-TKA group had the largest decrease in PASE score (-15.7 points) but more time spent in MVPA (+1.7 min/day) highlighting the discordance between subjective and objective physical activity measures relative to patient expectations. Findings were limited by small sample sizes in the surgical groups but warrant further investigation of longitudinal physical activity patterns before and after TKA.

CONCLUSIONS: Better understanding of the responsiveness to first-line treatments across the continuum of care for OA management will help inform tailored physical activity prescription with potentially positive effects on wait times, rates of comorbidity, and overall healthcare costs.

P-N-217: Brain excitability at the onset of voluntary wrist movement can be enhanced with concurrent tongue movement

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BACKGROUND AND AIM: A tongue-operated rehabilitation robotic system has been developed, in which limb movement is assisted by an exoskeleton that is commanded by voluntary tongue motion (Tongue Drive System, TDS). The engagement with this system involves intention of initiating a concurrent motion with the tongue and limb. We hypothesized that an addition of voluntary tongue movement enhances brain excitability that is associated with the initiation of limb movement. Initiation of voluntary movement accompanies a desynchronization of neural oscillations that are observed in EEG over the sensorimotor cortex (event-related desynchronization). The purpose of this study was to examine if event-related desynchronization for the upper-limb area is enhanced with concurrent initiation of tongue and wrist movement in healthy adults. METHODS: Six healthy participants had their right forearm rested with the flexed wrist on an arm rest. They performed three different motor tasks: tongue protrusion, wrist extension with the right arm, and concurrent initiation of the tongue protrusion and wrist extension. Each task had 50 trials, and the tasks were performed in pseudo random order across subjects. The onset of wrist and tongue movements was detected from EMG recorded from the wrist extensor muscle and the above and below opposite corners of the mouth, respectively. EEG of the sensorimotor area for the right arm (C3) was epoched based on the movement onset. In EEG, the degree of desynchronization around the movement onset was quantified by the power reduction in 10-12 Hz compared with the baseline (from -2.5 to -1.5 s in reference to the onset of movement) across trials. RESULTS: Reductions in 10-12 Hz power around the movement onset were observed in all three tasks across subjects. On average, the largest reductions were observed around 0-1 s in reference to the movement onset. The greater reductions with the concurrent movement compared with the independent wrist or tongue movement were observed before and/or after the onset of movement in all subjects. When the reductions before the onset were summated, ERD during the concurrent wrist and tongue movement (26.8%) was greater than the wrist (21.2%) and tongue (2.7%) movement, on average. Similarly, ERD after the onset (from 0 to 2.0 s) was greater during the concurrent movement (76.9%) than the wrist (62.7%) and tongue (29.0%) movement, on average. CONCLUSIONS: The preliminary observation of a tendency for a greater event-related desynchronization with concurrent tongue movement implies facilitation of brain excitability for limb movement, which may contribute to enhanced rehabilitation outcome in stroke survivors using TDS with motor rehabilitation (Zhang et al. 2015). In conclusion, the preliminary results showed a tendency of a facilitatory effect of adding tongue movement to limb movement on event-related desynchronization in EEG, implying enhanced brain excitability.

P-N-218: The validity of the Index of Postural Stability in sitting for patients with spastic cerebral palsy

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BACKGROUND AND AIM: This study aimed to assess the validity of the Index of Postural Stability (IPS) in sitting for patients with spastic cerebral palsy. METHODS: A cross-sectional study was conducted. Participants were recruited from three hospitals and medical centers in Tokyo and Kanagawa. The inclusion criteria were as follows: (1) diagnosis of spastic diplegia CP; (2) ability to sit alone; (3) the ability to communicate and follow instructions. The exclusion criteria were orthopedic intervention or botulinum toxin injection to the lower extremities within the past 6 months. Twenty nine participants with spastic CP who met the inclusion and exclusion criteria were included in the study. Participants and their parents provided informed consent for participation. The Ethical Review Board of the affiliated institution approved the study (authorization number: E19HS-001). The IPS in sitting, Trunk Impairment Scale (TIS) (static sitting balance, dynamic sitting balance, coordination, and total score), Pediatric Evaluation of Disability Inventory Functional Skills Scales (PEDI-FSS) and PEDI Caregiver Assistance Scale (PEDI-CAS) in mobility and self-care domains measurements were carried out according to the previous study. From the measurements, IPS in sitting was calculated as "log[(area of stability limit + area of postural sway)/area of postural sway]." IPS in sitting has no unit. The area of stability limit was defined as the "center movement distance between anterior and posterior positions Ũ the distance between right and left positions." Area of postural sway was defined as "measurement value in 10 seconds as average of the 5 positions of sway area (center, anterior, posterior, right and left)." The PEDI is a measure used for assessing a child's capabilities and performance in three domains: self-care, mobility and social functioning in daily life. Functional capability as measured by PEDI-FSS describes a person's potential and includes 193 items rated as either capable (score 1) or incapable (score 0). Whereas actual performance as measured in PEDI CAS (6-point ordinal scale) describes the extent of help a parent gives in daily functioning. In this study, only the scaled scores in the mobility and self-care domains of the PEDI-FSS and PEDI-CAS were used. The PEDI was evaluated by trained physical therapists through a structured interview with the parents. The IPS in sitting and all parameters were assessed for each side using Spearman correlation coefficient. The analyses were performed using IBM SPSS Statistics for Windows (version 19.0); $p < 0.05$ was considered statistically significant. RESULTS: Correlations of the IPS in sitting and all parameters are presented in Table 1. IPS in sitting moderate correlated with TIS dynamic sitting balance, TIS total score and FSS mobility. CONCLUSIONS: It revealed a good relationship for validity between the change in score for the dynamic sitting balance, total TIS scores and FSS mobility. The IPS in sitting was found to be valid for patients with spastic cerebral palsy.

P-N-219: Muscle activity of Nordic Walking environment in water and ground

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The walking with poles, called Nordic Walking (NW) was as a simple and safe form of exercise and easy to implement even for beginners in endurance sports. NW was induced higher work intensity than, clearly increased upper muscle activities. A water environment was different exercise environment than ground and had clinical benefits for patients with motor dysfunction because of the known physical characteristics of water. The Water Nordic Walking (WN) was established in Japan, it was performed Nordic Walking in water pool. The purpose of this study was to determine what muscle activity Water Nordic walking had. Thirteen healthy volunteers (male: age 23.00 ą 1.00 years, female: age 20.78 ą 0.92 years) performed 20-minute treadmill trials of W and NW at comfortable speeds and WN at water pool. The electromyography activity (EMG) of seven whole body was recorded each trials. Seven EMG activities were recorded by bipolar surface methods in biceps brachii, triceps brachii, deltoideus, tibialis anterior, medial gastrocnemius, rectus femoris and biceps femoris muscles. The level of significance was set at a = 0.05, with $p < 0.05$ regarded as statistically significant. The study was approved by the local Ethics Committee. Our results confirmed that use of NW poles increased upper arm muscle activity but decreased lower limb EMGs in comparison with W. In the integrated electromyogram(iEMG) of each muscle for 20 minutes, when W was normalized as 1 for each subject, WN was significantly increased than W ($p <0.05$) for lower limb muscles. In upper limb muscle activities, it were increased with WN rather than W ($p <0.05$). In TB, muscle activity was increased in WN than in ground NW($p <0.05$). In WN, lower limb muscle activities decreased significantly compared to the other two trials because of non-weight bearing, buoyancy. Our results demonstrate that Nordic walking in water for 20 minutes showed decreased lower limb muscle activity and increase in upper limb muscle activity compared to Nordic walking on land. It was confirmed that WN was more active in upper limb muscles than on ground W, with less strain on the lower limbs. Since these results, it could be considered that it was an effective movement as exercise program for the elderly who could walk by upper limb muscle activities without requiring muscle activities of the lower limbs as much as land, reducing burden on cardiopulmonary function.

P-N-220: Does the use of wrist rests change the horizontal movement and upper limb muscle activities during typing?

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Background and Aim Workers are at risk because repeated use of computers increases the risk of developing musculoskeletal symptoms and disorders, such as hand fatigue, pain, and tendonitis. Previous studies have demonstrated that typing using a wrist rest is recommended to avoid extreme wrist positions and upper limb loadings (Cook, 2004) (P.K. Nag, 2009). However, previous studies have mainly considered the movement of the wrist on the sagittal plane with few studies focusing on the horizontal plane. Therefore, the purpose of this study was to examine whether the use of a wrist rest could change the horizontal movement and upper limb muscle activities during typing. Methods The participants included five healthy men and five women (mean age, 20.2 ą 0.4 years; mean height, 168.2 ą 7.58 cm; mean weight, 58.4 ą 7.68 kg) without orthopedic history. We used a 3D motion analysis system (manufactured by VICON) and surface electromyogram (Delsys) to analyze the typing movements. The measurement operation consisted of 10 typing movements. The subjects first pressed the Enter key, typed "saitamakenritudaigaku," and finally pressed the Enter key again. They performed

typing movements (A) without a wrist rest and (B) with a wrist rest. The comparison items were (1) right side of the superior fibers of the trapezius (RTRA), anterior part of the deltoid (RDEL), biceps brachii (RBI), triceps brachii (RTRI), extensor carpi radialis (RECR), flexor carpi ulnaris (RFCU), and extensor carpi ulnaris (RECU) muscle activity between conditions (A) and (B); (2) the upper limb joint (shoulder, elbow, wrist, and finger) angle; (3) locus lengths of the back of the hand and metacarpophalangeal and proximal interphalangeal markers; (4) typing times; and (5) typos. For the statistical analysis, a Student's t-test or Wilcoxon signed-rank test was performed ($p<0.05$). This research was approved by the ethics review committee (approval No. 29976). Results In the wrist rest condition, muscle activities of the RDEL, RBI, and RTRI tended to decrease and that of the RTRA decreased significantly. In addition, activity of the RFCU, a wrist joint flexor, decreased and that of the RECR and RECU, which are wrist joint extensors, tended to increase. The joint angle did not show any significant change between the conditions and did not show a certain tendency. On the contrary, the total, horizontal, and vertical trajectory lengths of all markers significantly decreased. Moreover, regarding typing performance, typing time reduced significantly. Typos did not show a significant difference between the conditions and did not show a certain tendency. Conclusions Using a wrist rest could change not only the movement on the sagittal plane and the muscle activity that generates the movement, but also the movement on the horizontal plane and the associated muscle activity. These results suggest that typing with a wrist rest has the benefit of reducing hand replacement and control by the proximal limb muscles and the disadvantage of increasing control by extensor wrist muscle activity.

P-N-221: Kinematic analysis of the motion of descent of steps under different foot landing positions

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[Purpose] Although the motion of descending stairs is quite common, it is one of the difficult tasks for the disabled in rehabilitation. Eccentric contraction on the quadriceps and gradual control of the center of mass (COM) are needed while descending steps. The purpose of this study was to analyze and understand the descending of steps under different foot landing positions using 3D motion capture systems and multiple wireless surface electromyography. [Subjects] The subjects were ten adult women without a history of serious illness. [Method] Motion data were obtained using a VICON motion analysis system and four force plates. Two simple steps with a rise of 20 cm and tread of 25 cm were used. The descending movements of two conditions with different foot positions on steps followed: toe to touch the ground without protruding the toe from the tread (Full Grounding), and protruding from the tread and grounding (Protrusive Grounding). The descending movement was performed with bare feet, and the speed of the movement was kept constant with a metronome. The first step of the descending movement unified with the left leg. After sufficiently practicing the step-down movement under each condition, the measurement was performed three times each. The calculated data were the maximum values of the joint angles of hip flexion, knee flexion, and ankle dorsiflexion on the stance side; maximum values of forward and downward acceleration of the COM; and integral values of muscle activity of the rectus femoris and gastrocnemius muscle. [Results] The maximum joint angle of the knee and ankle was significantly smaller in the Protrusive Grounding condition than in the Full Grounding

condition. The maximum value of the forward acceleration at the COM was significantly larger in the Protrusive Grounding condition. The peak of the forward acceleration in the Full Grounding condition occurred during the single-leg support period; however, in the Protrusive Grounding condition, this occurred during the double-leg support period. The maximum values of the downward acceleration of the COM showed no significant difference between the two conditions. Muscle activities of the rectus femoris and gastrocnemius were not significantly different between the two conditions. [Conclusion] While descending steps in the Protrusive Grounding condition, the lower limb joint angle is smaller than that in the Full Grounding condition, and the COM moved smoothly. The non-disabled individuals commonly used this strategy for energy efficiency. In contrast, the Full Grounding condition needs more advanced body function. Because the peak of the forward acceleration of the COM occurred during the single-leg support period, deep joint control is needed. However, many disabled individuals selected the Full Grounding strategy in rehabilitation exercise because of the feeling of stabilization on a larger base of support. Our results suggest that we must re-consider the rehabilitation strategy for disabled individuals on descending movement. Further kinematical and kinetical analyses are needed for optimal practice in rehabilitation.

P-N-222: Evaluation of the effect of physical training in patients with Secondary Progressive Multiple Sclerosis - Quantitive evaluation using a sole pressure sensor -

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[Introduction] Rehabilitation in patients suffering from Secondary Progressive Multiple Sclerosis (SPMS) maintains their gait ability. However, few reports have objectively evaluated change over time in gait. Here, we report change in gait by physical training evaluated by sole pressure sensors. [Subject and Method] The subject, a 37-year-old male, was diagnosed with SPMS 8 years prior to the present study. Magnetic resonance imaging scans revealed multiple high signal areas around the ventricles, cerebellum, and posterior spinal cord. Before physical training, his condition was quantified using Expanded Disability Status Scale (EDSS) in which he scored 6.0 points, and Scale for the Assessment and Rating of Ataxia (SARA) where he scored 7.5 points, and isometric knee extension muscle strength where he achieved Right leg 45%/Body weight, Left leg 56%/Body weight. He was prescribed physical training from about two months after starting to use a walking cane. The training included crawling on all fours, and stretching and balance exercises in sitting and standing positions to be performed as home exercises for 20 min each day for 25 days. Before and after the 25 day regimen, measurements were taken of body sway, lower limb load, and plantar pressure during 10-m comfortable walking using a body sway meter (ANIMA BALANCE CORDER BW-6000) and a plantar pressure sensor (PARAMOUNT BED Waltwin). The sole pressure of seven parts of <the left foot was/ the right foot was/ both feet were> analyzed during 10 cycles of 10-m walking before and after the 25-day regimen for change over time. [Results] Pre-and post-regimen measurements of sole pressure (% gait) were: the heel (0 and 0), lateral sole (5 and 8), toes (6 and 22), hypothenar eminence (8 and 8), ball of the foot (26 and 32), and middle forefoot (27 and 26). In both evaluations, there was no load on the foot arch. Pre-post intervention changes included change in load transfer from the heel to the toes of his right foot. Body sway velocity and area (cm2): Eyes open 12.68 ?Ļ 5.10, speed (cm/sec), 3.22 ?Ļ 2.03, total trajectory length (cm): Eyes

open 96.68 ?Ļ 60.9, decreased . Lower limb load average: Left 59.73?Ļ53.44%/Body weight, right 45.84?Ļ54.55%/Body weight. The difference between left and right decreased. SARA score improved from 7.5 to 5.0 points and EDSS from 6.0 to 5.5. There was no significant pre- post-training difference in number of steps, stride length, walking speed, or muscle strength. [Conclusion] Walking can be evaluated by change over time using a sole pressure sensor, which was shown useful for evaluating the effect of exercise guidance.

P-N-223: Strength training for the infrasupinatus by the shoulder adduction

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Objective It is reported that the infraspinatus muscle (ISP) is the second most likely to occur in degenerative rupture of the rotator cuff of the shoulder joint.Postoperative strength training is important, and various reports have been reported to control the compensatory movements of the surrounding muscles.In this study, we focused on the adduction of the shoulder joint, which is an antagonistic effect, and investigated whether it could be used for muscle strength training of the ISP. Material and Method In this experiment six health volunteers participated. They all signed an informed consent form. The experimental task were MVC during three motions. ER1; isometric shoulder external rotation, with the shoulder and forearm in neutral position and the elbow flexed 90°. ER2; isometric shoulder external rotation, with the shoulder abduction 90° and external rotation 90° and the elbow flexed 90°. ADD; isometric shoulder adduction, with the shoulder abduction 90° and external rotation 90° and the elbow flexed 90°. Muscle activity during task was recorded by surface EMG. We assessed the ISP, upper and middle trapezius (TrP.u, TrP.m), middle and posterior deltoid (Del.m, Del.p). The integrated EMG (IEMG) values were calculated and normalized with the IEMG values during MVC in manual muscle testing position. A one way ANOVA followed by Tukey-Kramer test was performed using the mixed procedure to determine whether difference existed in NIEMG of each muscles between tasks. Result Significant differences were found for ISP, TrP.m, and Del.p. ISP showed higher muscle activity in ER1 (114.5 ą 22.7%) than in ER2 (81.7 ą 5.0%) and ADD (60.7 ą 0.4%). TrP.m showed higher muscle activity in ER2 (103.6 ą 2.6%) than in ER1 (71.4 ą 5.3%) and ADD (58.7 ą 4.4%). Del.p showed higher muscle activity in ER2 (75.5 ą 5.7%) than in ADD (28.9 ą 2.4%). Conclusions It was suggested that ADD can suppress compensatory movement to the same extent as ER1 without directly loading ISP. This method is useful in patients with reduced scapular stability due to muscle weakness, or early postoperatively where direct loading cannot be applied.

P-N-224: Electromyographic activity in deep hip muscles during back bridge exercises with isometric hip abduction/adduction

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BACKGROUND AND AIM: Back bridge exercise is used to strengthen the trunk and hip muscles. A previous study reported that incorporating hip abduction/adduction into back bridge exercise is useful for enhancing trunk muscle activity. (Park et al., 2014) However, the effect of back bridge exercise with hip movement on deep hip muscles is not clear. The purpose of this study was to examine the muscle activity of the trunk and deep hip muscles, including the gluteus minimus (Gmin) and piriformis (PIRI), during back bridge exercise with isometric hip abduction/adduction movement. METHODS: Twelve healthy men participated in this study. They performed 3 types of back bridge exercises: normal back bridging (BB-n), back bridging with isometric hip abduction (BB-abd), and back bridging with isometric hip adduction (BB-add). Isometric hip abduction/adduction torque was set to 15 kgf, using a handheld dynamometer. Muscle activity was recorded using surface and fine-wire electromyography (EMG). Surface electrodes were placed on the right side of the gluteus maximus (Gmax), gluteus medius (Gmed), tensor fascia latae, rectus femoris, biceps femoris, adductor longus (ADD), erector spinae (ES), multifidus, external oblique (EO), and the bilateral internal oblique (RtIO and LtIO). Fine-wire EMG electrodes were inserted into the anterior and posterior parts of the Gmin (Gmin-a, Gmin-p) and PIRI on the right side. Normalized EMG data were expressed as a percentage of maximum voluntary contraction (%MVC) for each muscle. Dunnett's test with BB-n as a control exercise was used to compare the %MVC of the 3 types of back bridge exercises. RESULTS: The %MVC values of the Gmax, Gmed, Gmin-a, Gmin-p, and PIRI during BB-abd were 23.5ą17.2 %MVC, 22.1ą12.1 %MVC, 23.6ą13.2 %MVC, 26.5ą16.6 %MVC, and 57.6ą37.1 %MVC, respectively. These values during BB-abd were significantly greater than those during BB-n. In contrast, the BB-add produced significantly higher activation in the LtIO (24.4ą21.9 %MVC), ES (41.4ą15.6 %MVC), EO (9.8ą6.8 %MVC), and ADD (34.2ą19 %MVC) than the BB-n. CONCLUSIONS: Our results showed that BB-abd enhanced activation of the hip abductors, especially the PIRI. The BB-abd task in this study involved hip abduction and external rotation in the hip-flexion position. In this position, the orientation of the muscle fibers in the PIRI was similar to that in the hip abduction axis. Therefore, the increase in PIRI activity was considered remarkable during BB-abd. BB-add increased the activation of the trunk muscles. A previous study reported that bridge exercise with hip adduction using a sling increased trunk muscle activity (Lee et al., 2015), as in our study. In conclusion, back bridge exercise with hip abduction enhanced the activation of the hip abductor, especially deep hip muscles such as the PIRI and Gmin. In contrast, back bridge exercise with hip adduction activated the trunk muscles as well as the ADD.

P-N-225: Relationship between dynamic postural control during the transition from two-leg to one-leg standing and functional disability in subjects with knee osteoarthritis.

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BACKGROUND AND AIM: Postural control is critical for functional activities of daily living. However, previous studies showed that the center of pressure (COP) movement during static standing was not associated with functional disability in subjects with knee osteoarthritis (OA). There is a possibility that dynamic postural control may be associated with functional disability in subjects with knee OA. The purpose of the present study was to examine the relationship between dynamic postural control during the transition from two-leg to one-leg standing and functional disability in subjects with knee OA.

METHODS: Thirty subjects (25 females) diagnosed with knee OA participated in this study (age 72.9 ą 8.3 years, height 153.0 ą 7.5 cm, weight 64.5 ą 12.2 kg, Kellgren-Lawrence grade 3 or 4). Each subject was instructed to stand on a force plate and then to perform the transition from two-leg to one-leg standing. Since this task imposes the center of mass movement mainly in the medial-lateral direction, the COP movement was calculated only in the medial-lateral direction. Analysis was performed for the following two phases: (1) the anticipatory postural adjustments (APA) phase; (2) the transitional phase. The APA phase was defined as the time from the onset of COP movement toward the swing leg to the maximum displacement toward the swing leg. The transitional phase was defined as the time from the end of the APA phase to the first peak of the COP movement toward the stance leg. The mean velocity and excursion of the COP movement in each phase were calculated. Functional disability was evaluated using the Knee Injury and Osteoarthritis Outcomes Survey (KOOS) subscales including symptoms, pain, activities of daily living (ADL), quality of life (QOL). Spearman's rank correlation coefficients were used to test the relationships between postural control variables and KOOS subscales. Statistical significance was set at P < 0.05. RESULTS: KOOS-pain was significantly correlated with the mean velocity in the transitional phase and the excursion in the APA and transitional phases (Table 1). KOOS-ADL was significantly correlated with the mean velocity in the APA phase and the excursion in the APA and transitional phases. KOOS-QOL was significantly correlated with the mean velocity in the transitional phase and the excursion in the APA and transitional phases. There were no significant correlations between KOOS-symptoms and postural control. CONCLUSIONS: The present study revealed that dynamic postural control during the transition from two-leg to one-leg standing associated with functional disability in subjects with knee OA. Therefore, these findings suggest that the COP movement during the transition from two-leg to one-leg standing is one of the important indicators that reflect functional disability in subjects with knee OA.

P-N-226: Longer electromechanical delay in paretic triceps surae muscles of chronic stroke survivors

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BACKGROUND AND AIM: Electromechanical delay (EMD) is the time delay between the onset of active state in skeletal muscle, estimated from the onset of the surface electromyogram (sEMG), and the onset of voluntary torque development. This delay appears to be associated with voluntary muscular contraction efficiency, because earlier findings have shown that the EMD increased significantly with advancing age and with fatigue. However, limited evidence is available for patients with neuromuscular disease, such as stroke survivors. Stroke leads to motor impairments that are associated with measurable, substantial and progressive changes in muscle architecture and in muscle material properties. Considering that such muscular changes emerging after stroke may result in additional deficits limiting voluntary muscle force generation, it is likely that EMD in stroke-impaired muscles may covary with the severity of voluntary force generation. Accordingly, this study aims to quantify the EMD in paretic and non-paretic triceps surae muscles of chronic stroke survivors, and to investigate whether the EMD is associated with alterations in voluntary force-generating capacity. METHODS: Nine participants were seated to seat upright with the knee flexed to ~10° and the foot secured to a dynamometer. sEMG electrodes were placed on the muscle belly of the medial gastrocnemius (MG),

lateral gastrocnemius (LG), and soleus (SOL). Tibialis anterior (TA) sEMG was also recorded to monitor potential co-contraction during isometric plantarflexions. Each subject performed isometric plantarflexion at four different ankle torques: 0, 20, 40, and 60% of maximum voluntary isometric contraction (MVIC) and at five different ankle angles (ranged maximum plantarflexion between maximum dorsiflexion), while ankle torque and sEMG signals were collected at a sampling rate of 2 kHz. All sEMG signals were processed by applying a zero-phase fourth-order bandpass Butterworth filter (bandwidth: 20-450 Hz), followed by a full wave rectification. A zero-phase fourth-order low pass Butterworth filter with a cut-off frequency of 50 Hz was applied to all rectified sEMG signals and the raw torque signals. The onset of the processed sEMG and torque signals was then defined as a time event when the amplitude of the signals was greater than 3 standard deviations from the mean baseline noise observed for each signal. The EMD of each trial was determined as the longest value among triceps surae muscles. Trials were rejected from further analyses, when the signal-to-noise ratio of each torque signal was too low to detect the torque onset, due to small magnitude of voluntary torque generated by the paretic muscles. Linear mixed-effects models were used to test whether the EMD is affected by side, ankle angle, and joint torque. RESULTS: The EMD was significantly different between side (non-paretic: 63.5 ms; paretic: 102.8 ms; $p < 0.05$), but no significant effect was recorded by either ankle angle ($p > 0.05$) or ankle torque ($p > 0.05$). No significant interaction was found either between side and angle or between side and torque ($p > 0.05$). In addition, the maximum torque-generating capacity on the paretic side (32.1 N m) was significantly reduced by approximately 50% when compared to the non-paretic side (79.4 N m) ($p < 0.05$). Finally, a strong negative relationship was found between the EMD and the maximum torque-generating capacity ($r = -0.817$, $p < 0.05$). CONCLUSIONS: This study found that not only the EMD in the paretic triceps surae muscles is longer than in the non-paretic muscles of chronic hemispheric stroke survivors but also the longer the EMD, the smaller the maximum torque-generating capacity. These findings imply that the EMD may be a useful biomarker, in part, associated with altered muscular changes. Future studies are required to investigate how such muscular changes could contribute to such an elongated EMD. (NIDILRR 90SFGE0005; Davee; NIH R01HD089952)

P-N-227: Muscle activity of medial and lateral gastrocnemius muscles on the acceleration phase during progressive velocity walking.

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Objective: The difference between medial and lateral muscle activity of the gastrocnemius muscle during muscle training is clear because their functions are different. However, their difference during walking is not clear because there are few studies that measurement both parts simultaneously in previous. The purpose of this study was to clarify the characteristics of muscle activity of the medial and lateral gastrocnemius in relation to increases in walking speed to find the difference in effect for training. Methods: 10 healthy adult males, who did not show any abnormality in neurological function and musculoskeletal composition, volunteered to participate in this study. The surface electromyography of the medial and lateral gastrocnemius was measured while natural standing at rest on a floor and walking on a non-motorized treadmill. First of all, the speed was increased from 0 km / h to 2.5 km / h, and kept 2.5 km / h during 10 gait cycles. Acceleration phase during progressive velocity walking was set 2 periods. During first stage of acceleration, the speed was increased from 2.5 km / h to

4.0 km / h (acceleration phase I), and kept 4.0 km / h during 10 gait cycles. Next, the speed was increased from 4.0 km / h to 5.5 km / h (acceleration phase ?U). The value of integrated electromyography (IEMG) of the gastrocnemius in the first 3 gait cycles of the both acceleration phase was calculated. Then, %IEMG was calculated by dividing IEMG of the medial and lateral gastrocnemius muscles on natural standing at rest. The differences between medial and lateral %IEMG were tested using the unpaired t-test. And comparisons of the %IEMG at each acceleration phase were examined with the paired t-test. A level of significance of 0.05 was selected for all statistical tests. Results: There was no significant difference between 3 cycles at both acceleration phase I and ?U. And, %IEMG of the medial showed significantly higher than that of the lateral at both acceleration phase I and ?U ($p < 0.05$). In addition, %IEMG of the medial and lateral were significantly higher in acceleration phase ?U compared with phase I ($p < 0.05$). Discussion and Conclusion: The non-motorized treadmill made it possible to observe muscle activity during the acceleration phase when compared to a motorized treadmill because the non-motorized treadmill has characteristic that subjects create driving force themselves. The gastrocnemius muscle and the soleus muscle exert about 80 % of ankle plantarflexion torque. Most of the gastrocnemius muscle also consists type ?U fiber and has a role to create driving force. Further, cross sectional area of medial gastrocnemius muscle has bigger than lateral gastrocnemius muscle. The medial and lateral gastrocnemius muscles have function to plantar flexion the ankle joint. However, their activation depends on the scene it's like whether it needs driving force or not. Therefore, it's necessary to concern the difference between medial and lateral gastrocnemius muscles during progressive velocity walking, because the difference reported histologically were also observed on the acceleration phase.

P-N-228: Study on the angle of hip joint during walk wearing hip bands

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BACKGROUND AND AIM: Physical therapists use manual contact to help patients regain correct gait in stroke rehabilitation. However, it is impossible to apply manual contact in the absence of a physical therapist because approach to apply it varies from therapist to therapist. Therefore, it is highly important to develop a method that enables a patient to regain correct gait all by himself. We thought that a band made of elastic cloth may affect hip joint during walk. The purpose of this study was to analyze the effect of walking exercise wearing bands that rotates hip joints internal and external rotation with the help of a three-dimensional motion analyzer. METHODS: We analyzed 10 healthy adult males (Age: 21-22 years old) for the study. We asked them to perform unguided normal walk without bands (NW), guided external rotation walk wearing bands (ER), and guided internal rotation walk wearing bands (IR) seven times in this order. We analyzed each walk and used the average of the maximum extension angles of left and right hip joints for statistical analysis. We used the Kruskal-Wallis test and Mann-Whitney U test. Analyses were performed with IBM SPSS ver. 25, with $p<0.05$ being considered significant. RESULTS: The maximum angle of hip joint extension (average ą standard deviation) was 16.35ą2.44 degrees in NW, 17.51ą3.14 degrees in ER, and 16.15ą2.92 degrees in IR. That is, it was significantly larger in ER than in NW and IR ($p=0.025$, 0.021). CONCLIUSIONS: This study indicates that ER increases the range of motion of the maximum angle of hip joint extension during walk. That is, it shows the possibility that ER is effective to increase the range of motion of the maximum

hip joint extension in physical therapy. However, further study is necessary because we did not clarify the relationship between the increase in the range of motion of hip joint extension and the amount of muscle activity of the hip extension muscle group.

P-N-229: Trunk Rotation Muscle Strength in Patient with Low Back Pain

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BACKGROUND AND AIM: Trunk muscles are important spinal mobilizers and stabilizers and compensate for low back pain-induced dysfunction. And it is important to clarify trunk muscle conditions in the patient with low back pain (LBP). As for the muscle strength in the patient of LBP, many studies on flexion and extension, but few reports on side flexion and rotation. In this study, to clarify the relationship between trunk muscle strength and LBP, we compared the trunk muscle strength with or without LBP. METHODS: The subjects are consisted of 20 male LBP patients without any neurological symptoms and any difference in trunk flexion and extension muscle strength from the control healthy subjects, and whose conditions of LBP were as follows; pain had continued for >3 months, and diagnosed fascial lumbago (n=9), lumbar disc disease (n=7), lumbar disc hernia (n=2), and lumbar facet arthritis (n=2). The direction of their motion pain was as follows: flexion (N=3), extension (N=5), rotation (N=7), flexion and rotation (N=2), and extension and rotation (N=3). And, their mean Japanese Orthopedic Association Back Pain Evaluation Questionnaire were 71 points of LBP, 50 points of lumbar function, 79 points of walking ability, 51 points of social life function and 61 points of mental health. The degree of their pain using visual analogue scale were as follows: 44 mm of LBP, 52 mm of buttock and lower limb pain, and 0 mm of numbness. All subjects provided written informed consent for study participation and the publishing of their data. We measured isometric muscle strength of left side flexion, right side flexion, left rotation, and right rotation of trunk using Tergumed 3D (Proxomed) without pain situation, and calculated peak torque percent body weight (Nm/kg). RESULTS: A significant difference was noted in the peak torque %BW of rotation between the painful (1.53 ą 0.07) and no-pain sides (1.65 ą 0.10) (paired t-test, $p<0.01$). There was no significant difference in the side flexion. CONCLUSIONS: As a result, it was acquired that a significant difference in rotation torque only between the painful and no-pain sides. Trunk rotation torque in the direction of the pain side was significantly lower than that of the no-pain side. Although subjects did not feel pain during the measurement and flexion and extension strength was as well as healthy subjects, only rotation muscle strength to the painful side was reduced. It was thought that this result was affected by disuse muscle atrophy of agonist because of the stereotyped movements of daily life due to avoiding pain. On the other hand, side flexion torque has no deference. In this regard, sufficient muscle contractions are possible in the large volume muscle with various synergists contraction. Regarding strength training in patients with LBP, both safety isometric training to prevent disuse atrophy and the demonstration of muscle strength in various contraction styles under pain control are needed.

P-N-230: Pragmatic trial investigating effects of 4 weeks of spinal manipulation plus physical therapy Vs physical therapy alone, on motor function in stroke patients.

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Study Objectives: The primary objective of this study was to investigate the effects of 4 weeks of spinal manipulation plus physical therapy, compared to physical therapy alone, on motor function in chronic stroke patients. Methods and material: This pragmatic parallel-group randomised controlled trial was conducted in a hospital setting in Rawalpindi, Pakistan. Participants, clinical assessors and data analyst were blinded to group allocation. One hundred stroke patients were enrolled, Fifty-five chronic (minimum time : >12 weeks post-stroke) patients, with ongoing motor weakness, participated in the trial. Participants were randomly allocated to receive either four weeks of conventional physical therapy alone or four weeks of conventional physical therapy combined with four weeks of spinal manipulation provided by a chiropractor. The primary outcome measure was the Fugl-Meyer Assessment of Motor Recovery after Stroke (FMA) assessed at baseline, after four weeks of care and post eight weeks (retention). Groups were compared using linear mixed regression models. Results: After four weeks of care the group receiving spinal manipulation plus physiotherapy improved by 23.2 points (95% CI 19.2-27.3) on the FMA and the physical therapy alone group improved by 17.1 points (95% CI 13.0-21.2). The between-group difference (6.1 CI 2.19-10.2) was significant (p=0.04) in favour of the group receiving spinal manipulation plus physiotherapy.At eight weeks there was no significant difference between groups. Conclusion: In a group of chronic stroke patients, 4 weeks of spinal manipulation combined with physical therapy, resulted in improvements in motor function compared to 4 weeks of physical therapy alone.

P-N-231: Electromyographic activities in trunk and deep hip muscles including the gluteus minimus and piriformis during different types of the quadruped exercises

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BACKGROUND AND AIM: Quadruped exercises with lower limb lifting are performed to facilitate the hip and trunk muscles. A previous study showed that abdominal muscle activation increases gluteus maximus (Gmax) activity during hip extension in the prone position (Oh JS, et al., 2007). Therefore, lifting the lower limb in quadruped exercises may facilitate the Gmax, but the effect on the deep hip muscle is unclear. The purpose of this study was to clarify the relationships of the trunk and deep hip muscle activities between different types of quadruped exercises. METHODS: Twelve healthy men performed the following four types of quadruped exercises: left arm and right leg lift (BIRD DOG), right hip abduction with 90°flexion of the knee (HIP ABD), right hip extension with 90°flexion of the knee (HIP EXT-KNEE FLEX), and right hip extension with knee extension (HIP EXT-KNE EXT). Electromyographic (EMG) data were acquired using surface electrodes for the Gmax, gluteus medius, tensor fascia latae, biceps femoris (BF), lumbar erector spinae (ES), lumbar multifidus (MF), rectus femoris (RF), external oblique (EO), and bilateral internal oblique (RtIO, LtIO) and using fine-wire electrodes for the anterior and posterior parts of the gluteus minimus and piriformis (PIRI). These muscle activities were measured

on the right side. EMG activities were normalized as an activity percentage during maximum voluntary contraction (%MVC) for each muscle. Quadruped exercises were divided into baseline, early concentric, late concentric (LCon), hold, early eccentric, and late eccentric phases. Two-way repeated-measure analysis of variance (tasks and phases) and a multiple comparison test were used to test the %MVC. RESULTS: There were significant interactions among Gmax, BF, RF, LtIO, EO, ES, MF, and PIRI. The %MVC values of the Gmax (LCon phase: 29.5ą15.3%MVC), LtIO (LCon phase: 46.1ą26.0%MVC), EO (LCon phase: 55.7ą27.1%MVC), PIRI (LCon phase: 70.6ą33.5%MVC), and RF were significantly higher during HIP ABD. In the hip extension tasks, the MF, ES, and BF during BIRD DOG; MF and BF during HIP EXT-KNEE EXT; and MF during HIP EXT-KNEE FLEX had significantly higher activities. CONCLUSIONS: Our results showed co-contraction between the hip external rotator (PIRI and Gmax) and abdominal oblique muscle (LtIO and right EO) during HIP ABD. PIRI and Gmax were activated because the muscle fiber direction approached the hip abduction axis. Moreover, the asymmetry activation for the IO and EO opposed the trunk rotation because of the hip abduction. Meanwhile, HIP EXT-KNEE EXT provided BF activity and BIRD DOG provided ES activity. The quadruped exercise that selectively activates the MF while controlling the ES and BF is HIP EXT-KNEE FLEX. In conclusion, quadruped exercises with hip abduction are related between the hip external rotator and asymmetry of abdominal muscles, and quadruped exercises involving HIP EXT-KNEE FLEX may produce selective activation in the MF.

P-N-232: Validity of a simple and non-invasive evaluation method for spinal alignment using the Kinect sensor

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BACKGROUND AND AIM Abnormal sagittal spinal alignment is associated with pain, decreased mobility, and respiratory problems. Although spinal alignment evaluation is very important during rehabilitation, there is no simple method for quantitative measurement. Recently, the depth cameras in Kinect sensors have been employed in various commercial and research projects in the healthcare field. The time-of-flight (ToF) technology of the Kinect sensor reconstructs a three-dimensional image of an object quickly and non-invasively. We hypothesized that quantitative spinal alignment evaluation would be possible by applying the ToF technology of the Kinect sensor. The purpose of this study was to develop a simple and non-invasive evaluation for spinal alignment using the Kinect sensor, and investigate its validity. METHODS Twenty-four healthy men (age: 20.7 ą 0.5 years, height: 175.1 ą 6.9 cm, weight: 65.8 ą 8.0 kg) participated in the study. Measurement outcomes were the thoracic kyphosis angle and lumbar lordosis angle in the standing position, using a Spinal Mouse (Index), the validity of which has been previously reported, and the Kinect sensor (Microsoft). An investigator palpated each participant's spine to identify the spinous processes of Th1, Th12, L1, and L5 as anatomical landmarks. In the measurement by the Kinect sensor, a program was created to obtain the three-dimensional coordinates of each point within an area marked on the monitor, and the sums of the curvature angles were calculated for the thoracic (Th1-12) and lumbar (L1-5) areas. In statistical analysis, Pearson's correlation coefficient was used to analyze the relationship between the Kinect sensor and Spinal Mouse measurements of thoracic kyphosis and lumbar lordosis angles. The level of significance was set at $p < 0.05$. RESULTS The thoracic kyphosis angle measured by the Kinect sensor was 33.3 ą 9.1 degrees, and that by the spinal mouse was

33.3 ą 7.4 degrees. There was a significant positive moderate correlation between devices in measuring the thoracic kyphosis angle ($r = 0.56$, $p < 0.05$). The lumbar lordosis angle measured by the Kinect sensor was 19.7 ą 14.3 degrees, and that by the spinal mouse was 12.9 ą 7.9 degrees. There was no significant correlation between devices for lumbar lordosis angle ($r = 0.25$, $p = 0.25$). CONCLUSIONS Our results demonstrated the validity of measuring the thoracic kyphosis angle using the Kinect sensor. This indicates that the depth camera in the Kinect sensor is capable of detecting abnormal thoracic alignment quickly and non-invasively, as a screening test in the medical field. In contrast, no significant correlation was observed between the lordosis angle measurements by Kinect sensor and Spinal Mouse, so it might be difficult to perform a similar quantitative evaluation of the lumbar area.

P-N-233: Quantification for freezing of gait in patients with Parkinson's disease using trunk acceleration analysis.

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BACKGROUND AND AIM: Freezing of gait (FOG) is a major motor symptom of Parkinson's disease (PD); however, a convenient method is unavailable for quantitative evaluation of FOG in clinical practice. We investigated whether only trunk acceleration analysis can quantify FOG. METHODS: We investigated five patients with PD hospitalized for deep brain stimulation, who performed the Timed Up and Go test (TUG) in the ON state (less likelihood of FOG) and the OFF state (in which FOG is likely to occur). A tri-axial accelerometer (sampling rate 200 Hz) attached to the L3 spinous process was used to record trunk acceleration data during TUG. The time required for the TUG and a frontal view of subjects were recorded using a stopwatch and a video camera, respectively. To extract features, we used sliding windows of 5s duration, and a 0.2s delay between windows multiplied on this waveform by the Hanning window, the power spectrum was obtained by fast Fourier transform. The FOG index (iFOG) was calculated by dividing the area square of 3-8 Hz by the area square of 0.5-3 Hz from the power spectrum. FOG was defined as iFOG ≥3. Based on this definition, the FOG frequency during each trial was calculated as the ratio of the FOG occurrence time to the time required for the TUG (%FOG_a). Two physical therapists assessed FOG based on the recorded video using the FOG severity scale. as follows; (0=absent, no freezing episodes; 1=mild, hesitation or episodic slowing; 2=moderate, at least one freezing episode; 3=severe, multiple freezing episodes; 4=unable to move, requiring assistance). Based on observation, the FOG frequency was calculated as the ratio of the FOG occurrence time to the time required for the TUG (%FOG_o). The %FOG_a was compared with the %FOG_o to confirm whether %FOG_a was correlated with observational evaluation, and we investigated the correlation between %FOG_a and FOG severity. Also, the iFOG was compared within a patient's ON and OFF states. RESULTS: Four subjects performed TUG trials twice, and one subject performed only one trial; FOG occurred in six of nine trials. The iFOG detected FOG in four of six trials, and the %FOG_a value was approximately similar to the % FOG_o. The FOG severity scale assessment score was 3 in three of six trials in patients with FOG and 1 in the other trials. The iFOG did not detect FOG in two trials in those with a FOG severity assessment score of 1. The iFOG was <3 in cases in which FOG did not occur. The within-subjects comparison showed that iFOG was higher in the OFF than in the ON state. CONCLUSIONS: We observed that trunk acceleration could detect high-frequency vibrations in the lower limbs during FOG, and the iFOG might represent differences in gait conditions with and without FOG in PD. Therefore, trunk

acceleration analysis can quantify FOG associated with lower limb trembling. However, trunk acceleration analysis may not detect complete akinesia-induced FOG or mild FOG without trembling.

P-N-234: Determining the optimal timing of visual stimulation and motor imagery to lead the sense of agency in the KINVIS paradigm

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BACKGROUND AND AIM: The sense of agency refers to the subjective experience of controlling one's actions and is essential for accurate movement control. The temporal consistency between intentions and effects is involved in inducing a sense of agency. Observing visual stimulation of limb movement causes the kinesthetic illusion induced by visual stimulation (KINVIS), even if the movement was not intended. We hypothesized that performing motor imagery prior to KINVIS would induce a sense of agency without voluntary movement, since to induce KINVIS following motor imagery implied that the KINVIS occurred just after the subject intended to move. However, the optimal timing of visual stimulation remains unclear. Therefore, the purpose of this study was to verify the optimal timing of visual stimulation that provides a sense of agency in the KINVIS task. METHODS: We enrolled 13 right-handed healthy adults (9 males, 4 females, age: 32.2 ą 7.8 years) who were confirmed to be able to experience KINVIS. For inducing KINVIS, visual stimulation by a video in which the participant's fingers were extended for 3 seconds was used. The image of the right hand projected on the monitor was adjusted to a position at which the participant recognized that the actual right hand was present on the spatial coordinates. The participants repeated the task of kinesthetic motor imagery of extending their fingers (MI) after resting (REST). During REST, an image was displayed on the monitor in which the right finger stopped at the flexed position, and they were instructed to stay relaxed without thinking. They performed MI when auditory stimulation was presented 5-6 seconds after the start of REST. After a certain time from the start of MI, visual stimulation was provided to induce KINVIS. There were 13 visual stimulation timings, from 0 to 1000 ms in 100-ms intervals, at 1500 ms, and at 2000 ms. All 13 trials were performed in random order and were repeated four times. In each trial, the participants selected the value closest to the intensity of the motor initiative on a 7-point Likert scale. At each visual stimulation timing, the average value of the intensity of the motor initiative for the four trials was calculated. RESULTS: Eleven of the thirteen subjects had valid responses. As a result of one-way analysis of variance within participants between 13 visual stimulation timings, the intensity of the motor initiative was significantly smaller at 1500 ms and 2000 ms than at the other visual stimulation timings. However, there was no significant difference between the 0 and 1000 ms timings. CONCLUSION: The results of the present study suggested that the timing gap, which is associated with the sense of agency in the KINVIS paradigm, should be set between 0 and 1000 ms depending on the individual subject.

P-N-235: Electromyographic activities in deep hip muscles including the gluteus minimus and piriformis during different types of the side bridge exercises

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Introduction: The deep hip muscles, such as the gluteus minimus (Gmin) and piriformis (PIRI), function not only as hip abductor but also as hip stabilizer. Side bridge (SB) exercises are performed to train the hip abductor muscles and to stabilize the hip joint however the deep hip muscles activity is not clear. Thus, the purpose of this study is to clarify the deep hip muscles activity during several SBs. Methods: Twelve healthy men performed 7 SBs; SB on right forearm and foot with and without lower extremity (LE) lift, SB on right forearm and knee with and without LE lift, SB on left forearm and foot, Copenhagen adduction exercise (CA) on right forearm and left leg, and CA on left forearm and right leg. Electromyographic (EMG) data were acquired using surface electrodes for the gluteus maximus (Gmax), gluteus medius (Gmed), tensor fascia latae (TFL), adductor (ADD) and using fine-wire electrodes for the anterior and posterior parts of Gmin (Gmin-A, Gmin-P), and PIRI on the right side. EMG activities were normalized as an activity percentage during maximum voluntary contraction (%MVC) and the activity during maintenance of the stationary position for 1 second during SBs was analyzed. Two types of two-way analysis of variance, 2 support positions (foot or knee) Ũ 2 LE positions (with or without LE lift), and 2 support sides (right or left) Ũ 2 SB types (SB or CA), were used to test the %MVC. Results: There was a significant interaction between support positions and LE positions for the TFL. The TFL activity during SB on foot with LE lift (60.1ą22.4%MVC) was higher than that during the other SBs. The main significant effect noted for support positions was that the Gmed activity during SBs on foot was higher than that during SBs on knee. Moreover, significant effects were noted for LE positions, and the activities of the muscles excluding the ADD were higher during SBs with LE lift than during SBs without LE lift. Significant interactions were noted between support sides and SB types for muscles excluding the Gmax and ADD. The activities during SB on right forearm and foot were higher than that during the other SBs. The main significant effect noted was that the ADD activity during CAs (right leg support; 56.2ą39.6%MVC, left leg support; 19.7ą16.1%MVC) was higher than that during SBs. Discussion: The TFL and Gmed activities during SB on knee were lower than those during SBs on foot, and this may influence the moment arm length, although the deep hip muscle activities were not influenced by support positions. These results indicate that surface hip muscles, like the TFL and Gmed are the main power producer for maintaining the posture during SB. Additionally, the activities of muscles excluding the ADD during SBs with LE lift were higher than those during SBs without LE lift due to the increasing external force to allow LE lift. In conclusion, SB on knee with LE lift can activate the deep hip abductor muscles while suppressing the TFL activity.

P-N-236: Examining the history of lower limb disorders and physiological and psychological limitations of knee flexion strength using percutaneous magnetic stimulation

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BACKGROUND AND AIM: The knee joint flexion exercise is performed using the hamstring as the main muscle, but we believe that it is difficult to fully evaluate the power exertion ability. In reference to the

index of power exertion, proposed physiological and psychological limits, we stimulate the sciatic nerve using magnetic stimulation to the gluteal region, and measure the induced contraction force to estimate the physiological limits of knee flexion strength. The purpose of this study was to clarify the effects of a subject's history of lower limb disorders on the physiological and psychological limits of knee flexion muscle strength. METHODS: The subjects were healthy adults and adults with a history of lower limb disorders. In percutaneous magnetic stimulation, a large circular coil was used to search for a stimulation site where a maximal knee flexion force was induced by stimulation. After the stimulus site was determined, the maximum voluntary contraction task and twitch interpolation were performed. In the twitch contraction method, the sciatic nerve was stimulated by magnetic stimulation of the buttocks at rest and during voluntary contraction, and the relationship between voluntary contraction force and activation was examined. The physiological limit was calculated from the obtained relational expression. RESULTS: Consequently, there was a difference in both psychological and physiological limits of knee flexion strength depending on whether there was a history of impairment. CONCLUSIONS: The use of magnetic stimulation may allow a more detailed evaluation of knee flexion strength.

P-N-237: Estimation of horseback riding therapy effects on low-birthweight children. A near-infrared spectroscopy study

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BACKGROUND AND AIM: A horseback riding therapy is one of the rehabilitation method for spinal injury or brain damage. Over the past few years a considerable number of studies have been made on the effects of horseback riding therapy. What seems to be lacking, however, is the method of quantitative evaluation for the horseback riding therapy. The aim of the present study is to evaluate the effect of horseback riding therapy on low-birthweight children diagnosed with cerebral palsy (CP) using a near-infrared spectroscopy (NIRS). METHODS: The subjects were two low-birthweight children with CP (6 years and 11 months old girl, 6 years and 10 months old boy, respectively) and two healthy children (8 years and one month old girl, 5 years 5 months years old boy, respectively) as a control. Two subjects with CP have treated with horseback riding therapy for over 5 years. A horseback riding intervention was approximatly15 minutes in duration and was performed once weekly. All subjects gave the intervention before measurements for cerebral blood oxygen levels on frontal cortex. The cerebra blood oxygen levels were estimated by the using of NIRS (NIRO-300, Hamamatsu Photonics, Japan). The subjects were exposed auditory and visual stimulus relation to the horseback riding therapy in the acoustic room for hearing test, the change in oxygenated hemoglobin (oxyHb) under the stimulus were measured and compared the children with CP with the healthy children. Ethical approval for the study was granted by the Institutional Review Board at Iwate Prefectural University, Japan. RESULTS: The figure shows the whole time series for level of oxyHb about one subject with CP. The oxyHb level of the frontal cortex was increased by the visual and auditory stimulus. OxyHb levels began to increase approximately 3 s after the stimulus, especially, the visual stimulus relation to the owing horseback riding images. The mean change of oxyHb level was 0.91ą0.38 ėmol / l for the children with CP, 0.87ą0.23 ėmol / l for the healthy children. The t-test for unpaired data (the Welch's test) showed no significant difference between the two groups (t₃₁ = 0.20, p = 0.42) . CONCLUSIONS: NIRS might be also useful index for evaluating cerebral activation with CP after the horseback riding intervention. These results

suggested that the horseback riding therapy enhanced the activation of frontal cortex with CP.
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P-N-238: Kinematic characteristics of foot and lower limb joint coordination for posture control during one leg stance on a wobble balance board

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Introduction An ankle sprain is a common sports injury with an extremely high recurrence rate due to a high probability of foot instability after recovery. Therefore, it is necessary to establish a treatment and rehabilitation strategy focusing on high-quality recovery and prevention of reinjury. A wobble balance board is commonly used for rehabilitation and training after ankle sprains. However, there is little scientific evidence that foot and lower limb coordination is improved with the use of a wobble balance board. The purpose of this study was to examine the kinematic characteristics of foot and lower limb joint coordination for posture control during one leg stance on a wobble balance board. Methods Our subjects were three male and five female university students who had no orthopedic injuries within the past year. As a measurement task, subjects were asked to stand on a wobble balance board on one leg for approximately 20 seconds, four times on each leg. We analyzed the angle change of the wobble balance board on the frontal plane, the right leg angle change of the calcaneus pronation and supination, hip adduction and abduction, the movement of the center of mass (COM), and muscle activity around the ankle joint (tibialis anterior, medial gastrocnemius, soleus, peroneus longus) during this task. Results The angle change amplitudes of calcaneal pronation/supination and hip adduction/abduction were directly related to the angle change of the wobble board. However, the movement of the COM was not related to the amplitude of the wobble board. Lower leg muscle activity had no relationship to the angle change of the wobble board. We ultimately focused on the two subjects experiencing the most significant change related to the angle of the wobble board, as well as the two subjects experiencing the smallest change. There was no inclination among the board angle amplitude, COM stability, and muscle activity. Discussion By studying the relationship between the angle change of a wobble balance board and the angle change of lower limb joints reacting to an instability condition, we observed two different compensation strategies: the lower limb offering support without moving the unstable plate, and the lower limb joint controlling posture while keeping the COM in a particular place. These results suggest that the task of maintaining posture control on a wobble balance board is not the best choice for rehabilitation or training to improve foot, lower leg, or trunk control. Moreover, we observed foot motion to be limited on the wobble board as a result of the foot synchronizing with the movement of the board. However, it was not possible to isolate how much compensation depended solely on muscle activity of the muscles around the ankle joint.

P-O-239: Estimation of muscle contraction performance by ratio of displacement-mechanomyogram and electromyogram during recumbent bicycle pedaling

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BACKGROUND AND AIM: Athletic performance in rehabilitation and sports situations are often evaluated quantitative items such as maximum voluntary muscle strength, repeat count, and best time, and do not directly evaluate the contraction ability of the target muscle. Mechanomyogram (MMG: reflecting mechanical activity of muscle) and electromyogram (EMG: reflecting electrical activity of muscle) are regarded as input / output signals of muscle contraction, and ratio of MMG and EMG (M / E ratio) may be interpreted as an indicator of muscle-specific performance. In this study, we aim to investigate the M / E ratio when the work rate during pedaling is changed using an MMG / EMG hybrid transducer system that could measure displacement-MMG (dMMG) and EMG simultaneously. METHODS: Ten healthy male volunteers (age: 20-22 years) in this study. The MMG / EMG hybrid transducer was attached to the vastus medialis of right, which was fixed by the dedicated belt. The subjects were seated on the recumbent bicycle (V67Ri, Senoh, Japan) and both feet fixed the on the pedal. The pedaling velocity was constant at 30 rpm, and the pedaling work rate was gradually increased to 30, 60, 90, 120,150 W, and passive pedaling (when the evaluator turned the pedal without the subject's voluntary contraction). The dMMG and EMG were measured for 30 seconds at sampling frequency 1000 Hz for each load. After the time-domain waveforms of dMMG and EMG were subtracted by the average value, the analysis values were directly calculated as the square sum every 2 seconds. The final results were the average of the square sum every 2 seconds (15 times). The dMMG and EMG of each load were normalized by the average of passive pedaling and maximum values, respectively. The M / E ratio was obtained by dividing normalized dMMG by normalized EMG. RESULTS: Normalized dMMG and EMG gradually increased with work rate, which reflected muscle strength commensurate for exercise load. The M / E ratio decreased with increasing work rate. There were a strong correlation between 30-90 W ($r = -0.783$, $p < 0.01$) but no correlation between 120-150 W ($r = 0.104$, NS). It believed that the M / E ratio represented the easiness of exercise against load, that is, the muscle contraction efficiency. Moreover, since the M / E ratio did not change at 120 W and over, this result may be suspected that it also indicates the reserve capacity of muscle for exercise load. CONCLUSIONS: The M / E ratio obtained by simultaneous measurement of dMMG and EMG during dynamic exercise using the MMG / EMG hybrid transducer system indicates the contraction performance of a specific muscle. The muscle contraction performance may be useful for evaluating motor functions such as sports and rehabilitation fields.

P-O-240: Estimation of walking ability using an insole-type thin-film force sensor

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[Introduction] There is a close relationship between walking ability and healthy life expectancy (Studenski et al, 2011), and it is important to monitor walking information such as ground reaction force (GRF) and center of pressure (COP) in daily life. To monitor walking information, small force plates are embedded in shoes or insole-type sensors with many film sensors are developed, but they are expensive for daily use. In addition, cables connected to a large number of sensors are expected to hinder walking and increase the risk of disconnection. The purpose of this study is to easily estimate GRF and COP using

an inexpensive system with film sensors. [Methods] This system uses seven polymer thick film sensors (FSR 402 Short, Interlink electronics Inc.) with a diameter of 13 mm per foot. The positions of the sensors are thumb, 1st MP joint, 5th MP joint, chorpart joint, and the heel. Three sensors were installed on the heel because the measurement area was larger than other areas. The signal of each sensor was amplified by an operational amplifier (LM324, National Semiconductor Inc.), and AD converter (MCP3208, Microchip Technology Inc.) with 12 bits resolution. The discretized signal was transmitted by a communication microcomputer (ESP32, Espressif Systems Inc.) to an Android OS mobile terminal at a sampling frequency of 100 Hz by a Wi-Fi method. [Results] One leg was placed on the Wii Balance Board (Nintendo Co., Ltd.) and the body was moved foot length direction and foot width direction in order to obtain the actual measured value of COP. The temporal change of the COP of the actual measured value and the presented system was shown in Figure 1. The difference values of COP between the actual value and this system in the foot width direction (COPx) and the foot length direction (COPy) were 5.67 ą 2.46mm mm and 24.7 ą 9.67mm, respectively. In addition, the correlation coefficients between the actual value and this system in the foot width direction (COPx) and the foot length direction (COPy) showed high correlations of 0.95 and 0.98, respectively. Next, we walked 10m at a free pace and estimated the COP from the GRF. The results of GRF and COP were similar to those obtained from insole type sensors with many film sensors (Horie et al., 2006). [Conclusions] In this study, we estimated GRF and COP using a small number of small film sensors. The proposed system obtained estimation results close to expensive and highly accurate insole sensors. Thus, it is possible to easily measure the daily walking information of the elderly and the like, and it is considered that this may be used for measures for extending the healthy life expectancy. [References] S. Studenski et al., Gait speed and survival in older adults, JAMA, 305(1), 50-58, 2011. N. Horie et al., An algorithm for estimating walking types using foot-pressure sensors, Transactions of the Japanese Society for Medical and Biological Engineering, 44(4), 621-627, 2006.

P-O-241: Simple alternatives for dry surface electromyographic electrodes

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BACKGROUND: In the research community, surface electromyography is gaining popularity, e.g., for control of neurorehabilitation robots and prosthesis, identification of anatomical structures within the muscle, or measuring physiological parameters as conduction velocity of muscle fibres. With the development of high-density electromyography (HD-EMG), even more applications are possible. For example, the recent development of HD-EMG decomposition methods paved the way for the extraction of neural information at the level of individual motor units. One of the impediments that prevent the use of HD-EMG in clinical practice are the recording electrodes. Experiments are usually conducted using the wet electrodes, i.e., electrodes that are filled with conductive gel which reduces the electrode-skin impedance and improves the recording quality. However, applying gel manually to each electrode is time-consuming and not comfortable for the subject or for the researcher conducting the recording, especially since occasionally the gel should be re-applied during the recording. It makes the HD-EMG technology impractical for autonomous and wearable use, and hinders the products based on this technology. METHODS: The aim of this work is to evaluate two cheap and practical types of electrodes

for HD-EMG recording without the use of gel. They are silver rivets (6 mm in diameter) and stainless-steel plates (6 mm in diameter). The electrodes were embedded in the non-stretchable fabric and were positioned in a quadrature grid with four rows and five columns, and 10 mm inter-electrode distance. Single differential signals were recorded between the consecutive pairs of electrodes within the same column of the array using a commercial amplifier. The electrodes were located over the biceps brachii muscle with rows of the arrays following the direction of muscle fibres during the isometric elbow flexion at three different effort levels. In total, nine subjects participated in the experiment. Recorded signals were processed, and the signal quality was evaluated visually and quantitatively. RESULTS: The results show that by using the proposed electrodes it is indeed possible to record the HD-EMG signals of sufficient quality to 1) visually identify the motor unit action potentials, 2) estimate the conduction velocity in normal physiological range, and 3) observe the change in mean frequency related to fatigue during the endurance exercise. CONCLUSIONS: The initial results are encouraging and open a possibility to use the low-cost dry electrodes for HD-EMG recording. The use of the electrode array that can be set-up quickly and without gel is certainly one step towards the use of HD-EMG technology in practice. However, the future work consists of additional tests, measuring the myoelectric activity of several muscles with bigger electrode arrays, performing the decomposition, and formalising the experiment.

P-O-242: Automatic Gait Segmentation Algorithm for Walking Bout Detection Using Shank-worn Accelerometers

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BACKGROUND AND AIM: Continuous activity monitoring of individuals has many potential applications in healthcare, particularly in those from vulnerable populations such as the elderly, individuals with neurological diseases, movement disorders or those recovering from injury. Clinical gait analysis, while providing valuable information in a controlled environment, is limited in its ability to estimate gait parameters under conditions more representative of the daily activities of individuals. To conduct detailed gait analysis in the home environment using wearable accelerometers, it is first necessary to automatically and accurately segment bouts of walking activity from the acceleration signal. This can be challenging due to the large data sets involved and variability of the data. To address this, an automatic algorithm that uses an adaptive thresholding approach to detect gait bouts from shank-worn accelerometers is presented. METHODS: Tri-axial acceleration was combined in the form of a signal vector magnitude (SVM) signal, band-pass filtered between 0.5 and 2 Hz. To reduce the instances of activity being detected during movement of a single leg such as during fidgeting, the dot product was calculated between the filtered SVM signals from both legs. This signal was smoothened using a moving mean window of length 2.5 seconds and an adaptive threshold based on Otsu's image thresholding algorithm was then applied to detect activity bouts. The presence of gait was confirmed by detecting a cyclical pattern with a frequency of that expected for gait in the autocovariance signal. If the detected bouts contained less than 6 steps, or were less than 4 seconds long, they were not considered as gait bouts. The accuracy of the algorithm was tested using accelerometer data recorded from the shanks of 15 healthy subjects during walking at self-selected slow, normal and fast speeds. RESULTS: All bouts of gait were correctly identified with any bouts of activity not considered as gait such as turns successfully removed. Intra-Class Correlation (ICC) exhibited high levels of agreement between bout onset/offset

times and durations estimated using the algorithm, experimentally recorded stopwatch times and manual annotation of the data (r=0.975 , p<0.001; r=0.984, p<0.001). Mean absolute errors (MAE) were also calculated to compare times determined by the algorithm to times determined from manual annotation of the raw accelerometer data. The MAE ranged from 0.91 ą 0.05 s to 1.08 ą 0.42 s for bout onset detection, 0.80 ą 0.23 s to 1.37 ą 0.18 s for offset detection and 1.27 ą 0.13 s to 2.45 ą 1.97 s for bout durations. CONCLUSIONS: A novel method for automatic detection of walking bouts from shank-worn accelerometers is presented. The algorithm performed well over a range of walking speeds in healthy individuals. Further analysis will be necessary to test the accuracy of the algorithm in patient populations or under free-living conditions.

P-O-243: A portable, smartphone-sized system for concurrent, high-density EEG, EMG, and closed-loop tCS

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BACKGROUND AND AIM: Increasing the channel count of electrophysiological recordings provides researchers with the tools to investigate increasingly complex neural circuits and provides greater insight to how the nervous system behaves as a whole. However, without advances in systems design, increasing channel count also introduces problems such as more difficult setup and increased noise, as well as making the system larger and more cumbersome. The latter is particularly problematic in studies such as motor control, decision making, and intention analyses, that require a highly mobile subject to effectively study. We have developed a miniaturized electrophysiological recording system which is better suited for high channel count data acquisition during freely moving tasks while eliminating noise by digitizing the signal directly at the electrode interface. METHODS: Building upon our previous Grapevine hardware, our Explorer line of products has been adapted specifically for both non-invasive and invasive, high-density electrophysiology for use in humans. Our diverse range of front end amplifiers are capable of recording electroencephalography (EEG), electromyography (EMG), and other physiological signals (such as electrocorticography, respiration activity, etc.), with the additional ability to deliver concurrent transcranial electrical stimulation (tCS). A reduction in the size and weight of our hardware was a crucial objective with portability in mind. RESULTS: The Pilot is a lightweight (150 g) electrophysiology system about the size of a smart phone which can record up to 256 channels of concurrent bio-signals at up to 30 kHz sampling rate. It is also capable of wirelessly communicating to a computer for real-time viewing and control of collected data, as well as autonomous operation using on-board memory to record several hours of electrophysiological data. Small and light-weight front end amplifiers can be mounted directly on an EEG cap or HDEMG electrode for noise immunity equal to active electrode systems, without the added bulk or fragility that active systems entail. On-board processing capabilities allow for custom algorithms for motor unit decomposition, modulation of tCS for closed-loop control, or communication with external devices through the analog and digital I/O. CONCLUSIONS: The portability of the system allows for more comfortable use over longer periods of time, which will be useful for prolonged human movement studies in active environments. The autonomous capabilities even allow long-term recordings while the subject is in their own home or completing activities of daily living. tCS can also be explored for the diagnosis, monitoring, or treatment of neuromuscular disorders.

P-O-244: The influence of contraction type and measurement duration on the amplitude of fine-wire EMG signals

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BACKGROUND/AIM: Indwelling EMG signal amplitude can attenuate after ~30 minutes of walking [1]. Any reduction in amplitude over time would impact upon conclusions drawn from long protocols. The aim of this project was to determine if there is a time dependent reduction in fine-wire EMG root-mean-square (RMS) amplitude when fine-wire electrodes are used to record EMG activation of the biceps bacchii muscle, and to determine if any such time dependent behaviour is impacted by the type of contraction. METHODS: Twenty healthy participants were recruited. Single use fine-wire electrodes (30 mm, 27 gauge, Chalgren Enterprises Inc., USA) were inserted bilaterally into the short head of the biceps brachii and interfaced with a pre-amplifier of bandwidth of 2 kHz. Delsys D.E. 2.1 surface electrodes were attached to the skin over the biceps brachii close to the insertion site. Over two hours, participants performed an isometric protocol of elbow flexion on either both arms, or the isometric protocol on one arm and a dynamic protocol on the other arm, whereby tasks were performed and data were recorded for 30 seconds every five minutes. The isometric protocol consisted of holding a 5 lb weight statically with the elbow flexed to 90^{o}, while the dynamic protocol involved holding the same weight while repeating a motion through the full range of motion at the elbow. EMG signals were rectified, smoothed using a moving RMS (600 ms), and normalised to the mean smoothed amplitude observed at the start of the protocol. Separate analysis of variance (ANOVA) models were used to determine the effect of time (0, 30, 60, 90 and 120 mins), and electrode on normalized EMG signal amplitudes for each contraction type. A Bonferroni post hoc correction was applied. RESULTS: For the isometric protocol (n=24) there was a significant effect of time ($F_{4,174}=9.25$, $p<0.001$) and a significant effect of electrode type ($F_{1,174}=8.41$, $p=0.004$). The normalised mean amplitude recorded with the fine-wire electrode was signficiantly reduced at 60 minutes (mean ąSD: 13% ą23%) and 120 minutes (mean ąSD: 22% ą25%) relative to the start of the protocol ($p<0.05$). For the dynamic protocol (n=10) there was a significant interaction between electrode and time ($p=0.004$) and between contraction type*time ($p=0.032$). With the fine-wire EMG, amplitude decreased on average by 21% ą11% after 30 minutes and by 30% ą15% after 120 minutes (Figure 1) while the surface EMG did not attenuate. DISCUSSION: The findings of this study suggest that signal attenuation over time can occur when recording EMG signals, particularly using fine-wire electrodes and in dynamic tasks. The implications of these findings is that protocols involving fine-wire electrodes to record EMG should accommodate these changes over time, through randomising task order, restricting protocol duration and/or building in regular normalization contractions. REFERENCES: 1. Reeves J., et al., ISPGR World Congress. 2019: Edinburgh, Scotland.

P-O-245: The Development of 3D-Printed Customized Smart-Insole for Real Time Measurement of Plantar Pressure, Temperature and Humidity

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BACKGROUND/AIM: Plantar foot measurement systems have been used to increase our understanding of foot biomechanics and function in order to prevent structural instability, discomfort and pain associated with foot pathology and injury. Instrumented insoles can provide important data on foot pressure distribution as well as environmental conditions within the shoe, which play an important role in the formation of foot ulcerations during gait in persons with diabetes. These types of systems have shown enough efficiency, flexibility, portability and reduced costs, but lack accuracy and customization for the foot of the patient. Therefore, a novel method to design and manufacture a custom instrumented insole using 3D scanning and printing technology for use in diabetic gait research was developed. METHODS: The proposed method is a straightforward, cost-effective, and fast option for the development customized smart-insoles. A Pro2 3D Printer (Raise 3D Technologies Inc, California, USA) and NinjaFlex flexible filament (Fenner Inc., Pennsylvania, USA) was used to create a 1.5mm thick custom insole with arch support. Eight force sensitive resistor sensors (FlexiForce A301, Tekscan Inc., Boston, USA) were placed on key areas of the foot to measure plantar pressure distribution during standing and gait tasks. Calibration and validation of these sensors was conducted using a force plate (Kistler 9281E, Kistler Instruments, Winterthur, Switzerland). The single SHT1x sensor (DFRobot, Shanghai, China) was used to measure the temperature and humidity of the shoe environment. A 3D white-light body segment scanner (TechMed 3D Inc., Quebec, Canada) was used to model the insole. A five-point point calibration for each sensor was conducted and linear regression analysis was performed to assess calibration. RESULTS: The design and manufacture of comfortable and flexible insoles was accomplished by the method here proposed. Several requirements reported in literature, such as lightness, sensor placement, low-cost, low power consumption, customization and accuracy, were fulfilled. The average correlation coefficient of the sensor calibration was R(2) = 0.9853. In addition, the comparison between the instrumented insole and force plate data showed a high average correlation (R(2) up to 0.99) in both x and y directions. The total weight of the insole was 200g. CONCLUSIONS: Custom instrumented insoles provide a low cost, portable solution to health monitoring and industrial and biomedical applications. This work presents a novel method for designing customized smart-insoles that facilitates the measurements of real time plantar pressure distribution, temperature and humidity in patients with diabetes.

P-O-246: Development of an algorithm to detect and prevent the occurrence of spasticity

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BACKGROUND AND AIM: Spasticity results from brain lesions and causes uncontrollable muscle spasms, muscle stiffness and pain, which hinders the performance of fluid, voluntary movements and thus reduces the quality of life. It is characterized as a velocity-dependent increase in tonic stretch reflex that limits the range of motion, and in severe cases, even reverses the direction of the intended movement. Currently, there is no cure for spasticity and existing treatments mostly focus on improving patients' capabilities. By addressing the velocity-dependent definition of spasticity, this study aims to develop an algorithm to detect and prevent the onset of spasticity during eccentric contractions at the elbow and to foster, through the use of an actuator, improved control of movement velocity. METHODS: Kinematic and surface electromyography data (sEMG) from 7 healthy subjects (3 male, 4 female, age 25.42 ± 3.5

years) and 7 patients (4 male, 3 female, age 46.33 ± 17.4 years) with impaired upper limb function due to spasticity were collected. sEMG was recorded from the biceps, brachioradialis, and triceps during active elbow extension at different angular velocities. In total, each healthy subject performed an average of 64 movement repetitions and each patient an average of 35 repetitions. Kinematic data (the type of movement, joint angle, and angular velocity) and sEMG data were analyzed in MATLAB in 250 ms window lengths. The recordings of the muscular activation were digitally bandpass-filtered (Butterworth, 9th order, 10-500 Hz), full-wave rectified and the mean absolute values (MAV) were obtained for each window. Previous studies have demonstrated that in patients with spasticity, both flexor muscles (biceps and brachioradialis) activate synchronously during eccentric contractions (increasing muscular activation with increasing angular velocity). Therefore, an algorithm was developed in MATLAB for defining the onset of spasticity in the data under the following conditions: 1) The window length corresponded to an extension movement in the range of 90-20° (0° being full extension) 2) Increase in the angular velocity (compared to the previous window) 3) Higher activation of the flexor muscles than the triceps (difference larger than 10 mV) Avoidance of the onset of spasticity was simulated by the addition of an external load that decreased the movement velocity. This was facilitated by using a servomotor (Servo Motor SG90). If the onset of spasticity was detected, the servomotor began to rotate in 2° increments in the opposite direction of rotation (from 0° to 180°). Thus, the servomotor acted as an external load whose torque opposed the rotational direction of the movement to decrease the angular velocity. RESULTS: The requirements considered for defining the onset of spasticity by using a time-domain feature, proved to be adequate for all the patients (300 events from ~200 movement repetitions) and for the correct activation of the servomotor following the velocity-dependence definition of spasticity. However, in three healthy subjects, the algorithm defined certain events as spasticity, specifically in small joint angles (100 events in ~200 movement repetitions). CONCLUSIONS: The present study provides a new algorithm that can be used in the development of technical devices with integrated controllers (e.g. myoelectric-controlled prostheses) so as to assist patients with spasticity to perform better controlled movements. Further testing will be performed in real-time to test the validity of the algorithms.

P-O-247: Proprioceptive dysfunction after chemotherapy is linked to self-reported movement dysfunction

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BACKGROUND AND AIM: Oxaliplatin (OX) is an effective treatment for colorectal cancer but can lead to neurotoxicity causing residual movement impairments such as dexterity loss, imbalance, and falls. These movement impairments are often attributed to impaired sensation resulting from OX-induced degeneration of sensory nerves in distal limbs, termed sensory neuropathy. Our recent animal studies, however, reveal that OX causes global signaling dysfunctions in muscle proprioceptors and that this novel mechanism may contribute to movement dysfunction independent of sensory neuropathy. Muscle proprioceptors are distributed throughout the muscles of our body, encoding the displacements and forces needed for accurate motor control. Unlike sensory neuropathy, changes to proprioceptors may not be restricted to distal limbs, but may also impair proximal muscles. The aim of this study was to quantify proximal proprioception in human cancer survivors using techniques that are more sensitive

than current clinical measures. We hypothesized that cancer survivors will display impaired proximal proprioception compared to healthy controls. METHODS: We recruited 13 cancer survivors (0 - 20 months post OX) and 7 age-matched controls. The dominant hand and wrist were fixed in an orthosis to emphasize elbow and shoulder use since these joints are proximal and less likely to have sensory neuropathy. We assessed proprioception for controlling upper limb position, force, and posture using target reaching, force matching, and postural stability tasks, respectively. Tasks were performed with and without visual feedback to differentiate contributions from proprioception and vision. Accuracy and trial-to-trial variability were quantified using a Haptic Master robot. We also assessed functional movement quality using the Action Research Arm Test (ARAT). For each ARAT item, movement duration and jerk were quantified using an IMU attached to the wrist. Self-reported symptoms and functional limitations were documented using the QLQ-CIPN20 questionnaire. Differences between cancer survivors and controls were assessed with linear mixed effect models. RESULTS: Without visual feedback, cancer survivors had significantly decreased accuracy ($p < 0.001$) and increased trial-to-trial variability ($p < 0.05$) in all motor tasks compared to controls. Deficits in force matching were correlated with motor dysfunction reported on the QLQ-CIPN20 (Fig. 1; $r = 0.87$, $p < 0.001$). All deficits relative to controls disappeared when vision was present. CONCLUSIONS: Proximal proprioceptive deficits occur in cancer survivors treated with OX. Although cancer survivors can compensate with the visual system for functional movement deficits of the upper limb, the link between deficits and perceived motor dysfunction suggests that OX-induced proprioceptive dysfunction may be a risk factor for motor impairments. This identified mechanism may present opportunities for future targeted interventions.

P-O-248: Measurement accuracy of an Upper Limb Tracking System based on IMU sensors: An Environmental Assessment

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Background and Aim: The analysis of the movement has a major importance in rehabilitation, as a key reference to plan the therapeutic intervention. However, despite being highly accurate, most of the available solutions on the market limit the analysis to the clinical environment relying on their costs and portability. With an optimal trade-off between costs and performance, recent evidence promote the use of Inertial Measurement Units (IMU) in ecological measures to improve the effectiveness of the treatment. IMUs allow to study joints with more degrees of freedom at once for prolonged periods and without hindering the natural movement of the person. In order to verify the applicability of this technology in the rehabilitation of a complex joint such as the shoulder, we present the development and performance of a device based on a pair of independent IMUs. Methods: 2 Bosch BNO080 IMUs were used for this study. One sensor was settled as reference with its absolute orientation provided as a quaternion. Relying on this value, the relative orientation between the two devices was calculated as yaw, pitch and roll angles. Multiple tests has been performed using a robotic arm, which executed a series of repeated movements to evaluate repeatability, accuracy and drift. These parameters were assessed under different values of speed, positions and accelerations, reproducing the everyday conditions that a wearable device must withstands on a patient in clinical phase. The sensors were also placed on a person in a realistic use scenario to evaluate the effects of magnetic disturbance due to the environment, i.e. fields generated by electronic devices. Results: In standard conditions, an accuracy of

(5.0±0.6) deg for the yaw, (5.4±0.6) deg for the pitch, and (1.3±0.3) deg for the roll has been measured. A repeatability of 1.95 deg for yaw, 0.84 deg for pitch and 0.22 deg for roll was estimated by calculating the SD on repeated measures. The average fused yaw measurement drift is reasonably low, being less than 2 deg/h. The results seems to be slightly less accurate for the yaw measurements when the device is subjected to continuous fast movements. In this case the accuracy decreases at values up to 10 deg. The limitations of the sensors are mainly related to magnetic disturbances such as hard and soft iron effects, which incidence can vary by the application. Conclusions: The potential of a device based on a pair of identical and independent IMUs was tested. Measurements can be affected by local distortions in the magnetic field, which can reduce accuracy. This can be avoided by keeping the device at least 30 cm from switched on equipment or containing ferromagnetic materials. The results confirm the validity of these devices for the clinical application targeted by our study, the shoulder rehabilitation. Their characteristics promote an approach to the analysis of movement increasingly oriented towards ecological measurements.

P-O-249: INCREASING SKIN TEMPERATURE INFLUENCES SENSITIVITY OF MECHANORECEPTORS IN THE FOOT

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Cutaneous mechanoreceptor input from the plantar foot plays a critical role in postural control and gait. Cooling techniques can simulate the sensory decline caused by aging and diabetic neuropathy in the foot sole, increasing whole body sway (1) and altering locomotor behaviour (2). More recently, single afferent recordings have shown that cooling decreases the firing rate in each class of mechanoreceptor (3), with changes unique to receptor type. Decreases were speculated to be related to a decrease in skin blood flow. In contrast, heating has a robust effect to increase cutaneous blood flow and has also been shown to improve vibratory detection thresholds (4). Whether cutaneous receptor firing patterns are altered with heating is unknown. We examined the firing patterns of each class of mechanoreceptor in response to normal force ramp skin indentations, before and after heating the plantar foot surface. We predicted heating would increase the firing rates for each mechanoreceptor type. We recorded from the tibial nerve within the popliteal fossa using microneurography. Single units were isolated and receptor type, sensitivity thresholds and receptive field (RF) sizes were then classified. Three indentations were applied over the RF using a 1 cm(2) probe in a ramp and hold profile. The load applied was based on body weight and normalized to force distribution of foot region during stance. Heat was then applied to the RF with a reusable heating pad until a skin temperature of 38-42 ºC was reached and the loading protocol was repeated. Dynamic index was measured by peak3; the average of the three highest frequency values during the ramp indentation and static sensitivity was evaluated using a 1 s average firing rate during force plateaus. Data were averaged across the three ramps and compared across temperatures. The 23 recordings that remained stable for the entire duration of the protocol were identified as fast-adapting (FA) or slowly adapting (SA) type I or II (FAI n=5, FAII n=3, SAI n=4, SAII n=11) (5). Heating increased skin temperature by 9.5 ºC on average (p=0.002). SAII receptor dynamic index significantly increased (p=0.031); whereas both SAI (p=0.05) and SAII (p=0.02) exhibited higher static hold firing rates upon heating. . FA responses were more variable, with no consistent direction of response in the few units located to date. These results show a relationship between heat and afferent

firing, which may support a link between cutaneous blood flow and sensory feedback. More importantly, heated SA receptors that resulted in increased dynamic sensitivity could compensate for the loss of FA receptors in aging and diabetes (6). Heating could be considered as a therapeutic application for falls prevention. References: [1] Nurse & Nigg (2001) Clin Biomech. 16;719-727 [2] Eils et al (2004) G&P 20: 54-60 [3] Lowrey et al (2013) J Neurophys 109: 839-850 [4] Schlee et al (2009) Clin Neurophys 120(8), 1548-1551 [5] Johansson 1982 [6] Pare et al (2007) J Comp Neurol 507, 543-567

P-O-250: HEART rate variability indicates physiological stress during office work with different periodic sit-stand changes

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BACKGROUND AND AIM: Individuals with compromised health and those who work with high occupational stress have lower Heart Rate Variability (HRV) than their colleagues. Since continuous sedentary work increases physical health risks including localised discomfort, metabolic risk and Cardiovascular disease, HRV indicators could indicate improved physiological characteristics when regularly changing between sitting and standing posture as experts recommend. HRV can be measured using non-linear variables: Poincaré plot standard deviation perpendicular to or along the line of identity (SD1, corresponding to short term HRV and diastolic blood pressure, and SD2, corresponding to short and long term HRV, respectively), and the ratio SD2/SD1 (corresponding to autonomic balance with sympathetic activation). This study measures the effect of varying standing period duration regularly during office work on non-linear HRV indicators. METHODS: In this study, fifteen participants' HRV was recorded over 1 hour when using workstations which automatically and regularly changed between sitting and standing heights in the sedentary worker's regular environment to determine potential significance. Six different standing durations within a 30-minute cycle were considered, covering from 0% to 50% standing in 10% increments, resulting in 0, 3, 6, 9, 12, and 15 minutes standing per period. Condition ordering was randomized, and each condition was experienced for at least 10 working hours prior to the HRV recording. During the recording, the participant worked normally while wearing the sensor. Heart rate was recorded using a Polar H10 thoracic belt and the signal was captured with Kubios HRV Standard software. Analysis was programmed in R, using Linear Mixed Effects (LME) models of non-linear HRV indicators, SD1, SD2 and SD2/SD1, with participant as a random factor and several two-level covariate variables (age, regular physical exercise and typical discomfort experienced in each body region over the year prior to the study). Results were significant when $p < 0.05$ and highly significant when $p < 0.01$. RESULTS: SD2/SD1 was significantly affected by the variations across the six table conditions (Table 1). Continuously sitting (0% standing) and standing 40% did not significantly increase HRV. Greatest improvements occurred with 10% and 50% standing. Table effects were less than age (over 40 years), years working in similar conditions (over 10 years), regular physical activity (more than 3 times weekly) and pre-existing discomfort in all areas except for the neck. These were highly significant for both SD1 and SD2/SD1, except for age and head (SD2/SD1) and upper back (SD1) discomfort. SD2 was significant for hand, lower back and ankle discomfort. Age had a negative effect (as expected), as did regular exercise (unexpected). CONCLUSIONS: HRV shows some ability to indicate improvements in physiology expected when regularly interrupting continuous sitting, although this is more limited than localised pre-existing discomfort perception. CONCLUSIONS: HRV shows some ability to indicate

improvements in physiology expected when regularly interrupting continuous sitting, although this is more limited than localised pre-existing discomfort perception.

P-O-251: Consensus for Experimental Design in Electromyography (CEDE) project: Electrode selection matrix

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The Consensus for Experimental Design in Electromyography (CEDE) project is an international initiative which aims to guide decision-making in recording, analysis, and interpretation of electromyographic (EMG) data. The quality of the EMG recording and validity of its interpretation depend on many characteristics of the recording set-up and analysis procedures. Different electrode types (i.e., surface and intramuscular) will influence the recorded signal and its interpretation. This report presents a matrix to consider the optimal electrode selection for recording EMG, and the process undertaken to achieve consensus. Four electrode types were considered: 1) conventional surface electrode, 2) surface matrix or array electrode, 3) fine-wire electrode, and 4) needle electrode. A draft matrix for recommendations for electrode selection was developed by a steering committee. The matrix included a description of general design features and considerations for each type of electrode; pros and cons of each method; and four clusters of recommendations based on common experimental questions. These clusters were: 1) What muscles can be recorded?; 2) What type of information can be estimated?; 3) Are the recordings representative of the entire muscle?; 4) What types of contractions can yield relevant data? For each experimental context, a recommendation of the appropriateness of an electrode type for a specific application was provided as "yes", "caution", "generally no", or "no", along with an explanation. The matrix was sent to the CEDE team for comment and feedback was integrated. A modified online Delphi approach was used to reach consensus among experts in three rounds. The final matrix was endorsed by the CEDE group and published in the Journal of Electromyography and Kinesiology. This matrix is intended to help researchers when selecting and reporting the electrode type in EMG studies, and for readers, reviewers and editors to understand the appropriateness of methods that have been selected in a study.

P-O-252: Preliminary Validation of Two Channel Surface EMG-based Periodic Limb Movements Home Monitoring for Developing Wearable Surface EMG Measurement Device Targeting Non-Experts

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BACKGROUND AND AIM: Periodic limb movement disorder (PLMD) is characterized by frequent episodes of sleep deprivation due to periodic involuntary movements mainly occurred in the lower extremities during sleep, which are referred to as periodic limb movements (PLMs); PLMs may finally cause perceivable poor sleep experience represented as difficulty in falling asleep, nocturnal awakening, or even excessive daytime sleepiness due to the sleep deprivation. Although potential PLMD patients

could follow the most prevalent sleep disorder obstructive sleep apnea, most of PLMD patients still remain undiagnosed due to the lack of appropriate monitoring devices for PLMs. This lack of devices could also disturb precise treatment of PLMD patients even after the definitive diagnosis. Since PLMD requires early detection and appropriate treatment based on the actual PLMs conditions, this research set a final objective as newly developing easy-to-use wearable devices for unaided surface electromyography (EMG) measurement by non-experts, which could enable physicians to conduct accurate PLMs home monitoring. Towards this final goal, we herein aim to clarify the target muscles of surface EMG measurement targeting surface EMG based PLMs home monitoring. METHOD: Assuming surface EMG based PLMs home monitoring involving non-experts, we this time focus on two channel surface EMG measurement targeting two individual muscles including tibialis anterior, which is the target muscle for PLMs evaluation in the gold standard method using polysomnography (PSG). In advance of primal prototyping, we investigate leg movements induced by PLMs once again in accordance with the following three steps; reconfirmation of PLMs inducing leg movements by visual observation after revisiting the definition of PLMs in the field of sleep medicine, listing of PLMs related muscles from the perspective of biomechanics, selection of the additional target muscle in consideration of its anatomical location together with its innervation. On the basis of these investigation results, we this time set abductor hallucis as an additional target muscle. To confirm the effectiveness of this combinative surface EMG based PLMs evaluation, we herein conducted comparative evaluation of PLMs monitoring between this combinative surface EMG and the de facto standard method using acceleration against possible PLMs-like events confirmed by visual observation. RESULTS: We confirmed that suddenly began repetitive muscle activation continued several dozen minutes occurred when we were able to confirm visually observable PLMs-like events. Focusing on the combination of activating muscles, we confirm that our targeting muscles were not necessarily activated at the same time, but could be activated alone; this indicates that our proposing combinative surface EMG would precisely monitor PLMs regardless of the combination of PLMs inducing movements. Aside from this, we also confirmed that PLMs evaluation based on the combinative surface EMG was more sensitive than that based on acceleration. CONCLUSIONS: Our proposing two-channel surface EMG measurement of abductor hallucis and tibialis anterior would provide sufficient performance in surface EMG based PLMs home monitoring, and developing the wearable surface EMG measurement device targeting these muscles for unaided home use by non-experts would play an important role for the realization of surface EMG based PLMs home monitoring.

P-P-253: The repeated bout effect in the human gastrocnemius muscle: factors that determine and mitigate exercise-induced muscle damage severity

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BACKGROUND AND AIM: Muscle fascicle stretch appears to be an important factor that determines the severity of exercise-induced muscle damage (EIMD), regulating the amount of protection conferred towards a subsequent exercise of the same kind (repeated bout effect, RBE). While repeated muscle stretches are often considered the main stimulus for inducing muscle damage, it has been shown that isometric contractions at stretched muscle lengths can also induce muscle damage. However, without valid controls for force or stretch amplitude, it is difficult to determine which induces the greatest

damage and whether the damage mechanism is similar such that the same level of protection is conferred in subsequent bouts of exercise. The aim of this study was twofold: to determine the effect of fascicle stretch elicited by different muscle contractions (eccentric vs isometric) on the magnitude of EIMD and the RBE whilst controlling for the same time under tension, average force and maximum stretch amplitude; and to determine if exercise modality is a factor to consider when conferring protection against subsequent eccentric EIMD. METHODS: Fourteen participants (age 27 ą 7 yrs, mass 74 ą 10 kg, height 177 ą 7 cm) performed in one leg an initial bout of isometric exercise at a long muscle length (ISO), whereas the contralateral leg performed a bout of eccentric heel drop exercise (ECC) while wearing a vest equivalent to 20% of their body weight. Seven days later both legs performed the ECC condition. One week later, a subset of participants (N=8) performed a third bout of exercise consisting of backward-downhill walking. Exercise volume was matched between exercise conditions (600s of time-under-tension). Ultrasonography, total twitch torque elicited by peripheral-nerve stimulation, electromyography and muscle soreness were used to examine medial gastrocnemius (MG) neuromechanical properties before, after and across the bouts of exercise. RESULTS: The results indicate that both ECC and ISO conditions elicited low to mild levels of EIMD and a RBE. However, the magnitude of damage and protection conferred by ISO is smaller in magnitude, short-lived, and mainly conferred in terms of muscle soreness. Also, we found that the RBE can be transferred between exercise modalities with different mechanical behaviour. Interestingly, neither of these findings seem to be explained by means of adaptations in contractile mechanics (e.g. fascicle length changes) or by neuromechanical adaptations (e.g. EMG changes) during the exercise bouts. CONCLUSIONS: These results suggest that the amount of fascicle stretch elicited by different contraction types has a low impact on MG biomechanical behaviour after EIMD, possibly due to the architectural features of MG (e.g. compliant Achilles tendon). This means that the mechanisms underpinning the RBE in this muscle are unlikely related to damage and adaptation in the contractile tissue (e.g. longer operating lengths). On the other hand, these results also suggest that controlled eccentric exercise may confer prophylaxis against further muscle damage elicited by eccentric exercise of different nature. Unlike what is seen in upper limb muscles, ISO contractions seem to not be an optimal strategy to confer protection towards subsequent EIMD on the MG.

P-P-254: Three-dimensional analysis of the changes in skating motion in the straight phase of an international 5000-m race for elite male long-distance speed skaters

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BACKGROUND AND AIM: The purpose of this study was to identify the characteristics of kinematic changes in skating motion in the straight phase during a race for elite long-distance speed skaters. METHODS: The data were collected during the Speed Skating World Cup conducted on November 18, 2016, in Nagano. Fourteen elite skaters who participated in the men's 5000-m race-division-A were investigated. Four synchronized high-speed cameras (300 fields/s) were used to record the skaters' motions at the mid portion of the inner finishing straight lane. The skating motion in the straight lane was analyzed at the initial phase (3rd or 4th lap), middle phase (7th or 8th lap), and final phase (11th or 12th lap).

The left leg kinematics were analyzed from the right blade off the ice to the left blade off the ice. The stroke was divided into gliding and push-off phases, on the basis of the onset of the push-off, which was defined as the instant that the angular velocity of the knee joint of the support leg exceeded 50 deg/s. Three-dimensional coordinates of the segment endpoints of the body and skate blade were calculated using a panning DLT technique. The body center of mass speed, stroke frequency, gliding time, push-off phase time, forward and sideward stroke length, and push-off angle were calculated. The push-off angle was defined as the angle between the line connecting the body center of mass and the ankle, and the horizontal velocity vector of the body center of mass at the end of the stroke. Kinematic parameters, such as segment angles (torso, thigh, and shank) and tilt angles (body and shank), were normalized by the time of each stroke. RESULTS: The body center of mass speed was significantly higher in the initial phase than in the final phase. The stroke frequency increased significantly as the race progressed. The gliding phase time was significant shorter in the final phase than in other phases. The forward stroke length significantly decreased as the race progressed. The sideward stroke length was significantly shorter in the final phase than in other phases. In the middle phase, significant positive relationships were observed between the body center of mass speed and the forward and sideward stroke length. The push-off angle increased significantly as the race progressed. The thigh during the push-off phase was closer to vertical in the final phase than in the other phases. The inside tilt of the body and shank were observed earlier in the stroke as the race progressed. CONCLUSIONS: These results indicate that under fatigue conditions, the gliding phase time decreases and the stroke frequency increases due to decreased outside tilt of a skater's body and shank during the early phase of the stroke. In addition, the changes caused by fatigue reported previously, such as decreasing forward stroke length and increasing stroke frequency and push-off angle, were already occurring in the middle phase of the race.

P-P-255: Effects of acute exercise on cognitive performance: an fMRI study

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BACKGROUND AND AIM: Acute aerobic exercise improves cognitive performance. A previous study suggested that enhanced activations in the dorsolateral prefrontal cortex are associated with cognitive improvement elicited by acute exercise. However, underlying mechanisms for cognitive improvement are not fully understood. In the present study, we used functional magnetic resonance imaging (fMRI) and examined brain regions that are responsible for cognitive improvement after exercise. We also tested the hypothesis that alterations in functional connectivity play an important role in cognitive improvement. The aim of this study was to clarify how acute exercise improves cognitive performance. METHODS: Participants were 22 healthy right-handed young men (age: 22.0 ą 1.3 yr., peak oxygen uptake: 44.1 ą 6.9 mL/kg/min). They performed the experiments in two conditions with a crossover design. In the Exercise condition, participants cycled at 40% peak oxygen uptake for 30 minutes, and fMRI scan was performed during the Go/No-Go task before and after exercise. In the Control condition, participants rested for 30 minutes instead of exercise. fMRI scan was performed in the same time course as the Exercise condition. We performed a seed region of interest (ROI) analysis to evaluate functional

connectivity using CONN toolbox (Functional Connectivity Toolbox) implanted in SPM12 running on MATLAB. We first analyzed regions specifically activated by exercise as region of interest and identified regions where functional connectivity was altered before and after exercise. We also identified regions where amount of alterations in functional connectivity was correlated with alterations in reaction time (ΔRT) of the cognitive task. RESULTS: In the Exercise condition, RT significantly reduced after exercise ($p < .001$). Acute exercise specifically activated the anterior and posterior cingulate gyrus during the cognitive task ($p < .05$, family-wise error corrected). Alterations in functional connectivity between i) frontal medial cortex and left superior parietal lobule ii) frontal medial cortex and left intraparietal sulcus ($r = -0.46$, $p = .003$; $r = -0.44$, $p = .022$, respectively) were correlated with ΔRT. CONCLUSIONS: The present results suggest that activation in anterior and posterior cingulate gyrus and altered functional connectivity between frontal medial cortex and other brain regions may be associated with cognitive improvement induced by acute exercise.

P-P-256: The effects of 4-week combined plantar intrinsic foot muscle exercise with FIFA 11+ on local foot biomechanics and functional performance in adolescent football athletes

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BACKGROUND AND AIM: In spite of a well-developed FIFA 11+ exercise program on injury prevention and warm-up purpose, there is an inconclusive scientific finding to support the effects in local anatomical structures and functional performance following this intervention with and without plantar intrinsic foot muscle (PIFM) exercise in adolescent elite football athletes. We aimed to examine the effects of local foot biomechanics and functional performance following the 4-week FIFA 11+ intervention with a novel PFIM exercise. METHODS: A total of 14 male adolescent football athletes has participated in this 4-week exercise intervention (7 days per week), which was consisted of the experimental group (FIFA 11+ with PIFM exercise, 7 subjects) and the control group (FIFA 11+ only, 7 subjects). A novel PIFM exercise using a 3-D printing exerciser was developed in this study. A battery of measurements was used to examine the variables of dynamic postural control (Star Excursion Balance Test, SEBT), agility performance (Illinois Agility Test, IAT), morphological (thickness, cross-sectional area of muscles CSA, sonographic imaging) and mechanical (the stiffness from ultrasound shear wave elastography, USWE) variables of selected intrinsic and extrinsic foot muscles between groups, and between pre-intervention and post-interventions. Repeated Measures ANOVA was used to examine the difference in all variables between groups and pre- and post- interventions. The significance level was set up as a level of 0.05. RESULTS: In the experimental group, the significant increases in length of reaching (SEBT) were found in anterolateral ($p=0.034$), posteromedial ($p=0.028$) and medial ($p=0.028$) directions in the dominant leg supporting condition compared to that of the control group. There was significant increase ($p=0.018$) in thickness of the Abductor hallucis (AbdH) in right leg between pre-intervention (1.238ą0.220 cm ²) and 4-week post-intervention (1.379ą0.256 cm ²). However, no significant changes in the stiffness of all foot muscles and agility were found in both groups. CONCLUSIONS: The integrated excise program, including foot core muscle exercise, may enhance the dynamic postural control after the 4-week intervention, regardless of no alterations in local foot biomechanics, such as the stiffness of extrinsic and intrinsic foot muscles.

P-P-258: Lower extremity joint moments during the posteromedial reach of the Star Excursion Balance Test in healthy people.

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BACKGROUND AND AIM: The Star Excursion Balance Test (SEBT) is an assessment of dynamic balance that was developed as a screening tool for lower extremity injury in athletes. A reduction in the posteromedial (PM) reach distance of the SEBT has been well documented to predict ankle sprains or to detect functional deficits in those who have ankle instability. Researchers have been searching for factors that contribute to the maximum reach distance (MRD) of the PM reach to better understand injury mechanism. To our knowledge, previous studies have been limited to angular displacements of the ankle, knee, and hip in the sagittal plane at MRD between those who have functional deficits and healthy people. However, the frontal and transverse planes joint moments that occur during the task are not known. Accordingly, in an effort to better understand factors contributing to MRD, we examined the external joint moments of lower extremity in the sagittal, frontal, and transverse planes during the PM reach. Therefore, our purpose was to examine the lower extremity joint moments in sagittal, frontal, and transverse planes during the PM reach of the SEBT in healthy people. METHODS: We recruited 20 healthy participants to reach as far as possible in the PM direction while performing the SEBT on a force plate. We measured the MRD and joint moment data via a Vicon 3D motion analysis system using the Plug-in gait model. We used a one-way repeated measures ANOVA to test for changes in joint moments across 10 phases of the PM reach (each phase was 10 %MRD). We used Bonferroni correction for post hoc analysis of significant main effects within each phase of MRD. RESULTS: There were significant differences in ankle, knee, and hip joint moments in all planes of movement during the PM reach ($p<0.05$). Knee flexion, hip flexion, and hip external rotation moments increased linearly across each phase of reaching. Ankle internal and knee varus moments were higher in late phases versus early phases of the reach distance. Hip adduction moments were lower in late phases than early phases. CONCLUSION: Frontal and transverse plane joint moments should be considered along with sagittal plane moments when assessing the PM reach distance of the SEBT. These results describe factors that contribute to the MRD of the SEBT and may provide helpful information when comparing compensatory movement strategies adopted by individuals after lower extremity injury.

P-P-259: Effect of home-based squat training at two different knee angles on muscle function, morphology, and physical function tests in older individuals

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BACKGROUND AND AIM: Age-related decrease in skeletal muscle mass and function is known as sarcopenia and dynapenia. Weight-bearing squats have been widely performed in older individuals as home-based resistance exercises for the thigh muscles because of easy to understand, safe, and cost-efficient. The knee angle during a squat (known as the squat depth) might be important for the

improvement of muscle physiological parameters; however, the effects of squats depth on muscle morphology and function were still not well investigated. The purpose of this study was to investigate the effect of home-based squat training at two different depths on muscle function, morphology, and physical function tests in older individuals. METHODS: Sixteen older men and women participants were randomly assigned to a shallow squat group (SS group; age, 72.1 ± 4.5) or a deep squat group (DS group, age; 69.1 ± 3.3). Participants touched the hip on 40-cm and 60-cm height chairs during SS and DS. They performed four sets of 70 reps of squats per day, 3 days per week, for 12 weeks at their home. Their knee extension peak torque at knee angles of 30°, 70°, and 110°, muscle thickness, and physical function tests (e.g., 5-m normal/fast walking test, and 1-repetition maximum for leg press and 30-second sit-to-stand) were measured at 0 (baseline), 4, 8, and 12 weeks after the training. RESULTS: There were no significant differences between the SS and DS groups with regard to age, height, body mass, muscle thickness, and physical function tests at the baseline ($p > 0.05$). All data was normalized by baseline. Maximum isometric knee extension peak torque, muscle thickness, and walking speed were not significantly changed after 12 weeks of training in either group ($p > 0.05$). The sit-to-stand repetition test was significantly increased after 8 weeks (SS group:128 ± 23%, DS group: 120 ± 6%) and 12 weeks (SS group:137 ± 26%, DS group: 127 ± 11%) compared with baseline in both groups ($p < 0.05$). One repetition maximum for leg press was significantly improved after 4 weeks (SS group:114 ± 10%, DS group: 128 ± 19%) and 12 weeks (SS group:118 ± 14%, DS group: 130 ± 14%) in both groups, and after 8 weeks in the SS group (116 ± 10%) compared with baseline ($p < 0.05$). CONCLUSIONS: These findings indicate that home-based weight-bearing squat training in older adults can be recommended to help maintain independent activities of daily living. However, the training effect was not different between two different squat depths.

P-P-260: On the difficulty of the backward giant swing in the parallel bars from the viewpoint of the central nervous system motor control strategy

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BACKGROUND AND AIM: The backward giant swing on the parallel bars shows a movement pattern similar to that on the horizontal bar. However, some gymnasts find it difficult to learn and acquisition because it is said that the backward giant swing on the parallel bars has difficulty in grasp and sliding. While that is said difference in the structure of the apparatus is a factor of difficult, when compared at the muscle activity level, it is possible that there are different motor control structures between the events which makes it factor of difficulty. In this study, we discuss the difficulty of the backward giant swing on the parallel bars based on the muscle synergy hypothesis proposed as a motor control strategy for the central nervous system. METHODS: Eight university gymnasts were selected as subjects. They perform of the backward giant swing was ten times on the horizontal bar and three times on the parallel bars as experimental task. Muscle synergy was calculated by non-negative matrix factorization (NMF), with 13 muscles contributing to upper limb, trunk and lower limb movements. The EMG signals were band-pass filtered (10-500 Hz, Butterworth filter, 2nd order), rectified smoothed with a low-pass filter (9 Hz, Butterworth filter, 2nd order), and time-normalized in order to obtain 200 data points for each backward giant swing. In the horizontal bar to extracted muscle synergy from the average of eight

consecutive backward giant swings except for the first and last backward giant swing. In the parallel bars to extracted muscle synergy from the one trial that the subject felt the best. RESULTS: The activity patterns of 13 muscles were reduced to three structures in the horizontal bar and five structures in the parallel bars. The lower extremity movement by the knee joint extension and flexion during the swing was shown the parallel bars. CONCLUSIONS: The backward giant swing on the parallel bars requires the knee to be bent swing during under the bars according to the instrument standard. However, it is clear that this is performed separately from the suspension operation, and it is necessary to perform more complicated motion control than the horizontal bar.

P-P-261: Do the characteristics of scapulohumeral movement during scaption correlate with that during front crawl swimming?

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BACKGROUND AND AIM: The front crawl swimming requires the highly coordinated control between trunk and bilateral upper extremities as the reciprocal movement, rather than the relatively symmetrical style, such as the butterfly style. Due to the over-use in swim training and competition as well as the wide range of movement as the anatomical feature of shoulder joint, the shoulder pain are common in competitive front crawl swimmers. The previous reports revealed that the most factors inducing shoulder pain may be the subacromial impingement syndrome or rotator cuff tendinopathy. However, the studies relating to the scapula dyskinesia in swimmers with shoulder pain was based on the evaluation of movement patterns of shoulder complex during arm elevation. The critical event resulting in the impingement for swimmers is the rotation of shoulder joint during swimming under water. It was doubtful whether the observation on land can be generalized to the swimming movement under water. Hence, the aim of this study was to investigate the relationships of the kinematic parameters between during front crawl swimming under water and during arm elevation in scapular plane. METHODS: Ten male competitive swimmers (age: 14.4ą2.8 year, height: 167.7ą12.3 cm, weight: 57.2ą11.9 kg) in school team without shoulder-relating disorders were recruited. The electromagnetic motion tracking device was used to measure the three-dimensional movements of trunk, humerus and scapula. To allow the motion tracking under water, the receivers were laminated with plastic film for waterproof. The participants were asked to perform scaption (three trials) on the land and swim with front crawl style against an elastic tube (continuous for 30 seconds) under water. The scapula kinematics during arm elevation and lowering of scaption will be analyzed within the range of arm elevation 0-120°. The scapula pattern during swimming cycle (four phases) was identified according to the relative position of receivers on trunk and humerus. The correlations of kinematic characteristics of scapula between scaption and swimming were examined by the coefficient of Pearson correlation. RESULTS: The external rotation during scaption shown the strong correlation with the external rotation during swimming ($r=0.75$, $p=0.02$), while the upward rotation during scaption shown the negative correlation with the posterior tipping during swimming ($r=-0.75$, $p=0.02$). CONCLUSIONS: The characteristics during scaption may be generalized to the performance during swimming at the critical events of swimming. Future studies should investigate the patterns in swimmers with shoulder disorders.

P-P-262: Comparison of Isometric Knee Extension Force Measured Using Three Assessment Methods

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BACKGROUND AND AIM: Measuring the muscle strength of lower extremity is a necessary examination for elderly and patients following injuries or interventions. Knee extension force is an important index to reflex the capability of functional activities. Isokinetic dynamometer (IKD) has been considered as the golden standard for strength measurement, however, the high cost and requirements of testing space limit the use in clinical practice. The handheld dynamometer (HHD) is an alternative device to obtain the isometric strength, but the reliability can be affected by factors such as tester strength or stability. Therefore, we designed a portable chair with fixed HHD system (CFD) to evaluate the isometric knee extension force, and compared the isometric knee extension force measured by three devices. METHODS: Sixteen subjects (8 males and 8 females; age=21.1 ą 0.8 years; height=164.4ą7.5 cm; weight=59.0ą11.2 kg) participated in the study. Knee extension strength of dominant leg was collected by IKD (Biodex system 4 Pro), HHD (MicroFET2), and custom-designed CFD. The surface electromyography system (Noraxon Inc.) with sampling rate of 1500 Hz was used to record the muscle activity level and the electrode was attached on the rectus femoris before testing. Subjects were given some practice trials to familiarize with the devices and the testing was conducted in random order. They were asked to sit upright with arms cross the chest to perform maximum isometric contraction of knee extension at 90 degrees of knee flexion position. Three trials for 5 seconds on each device, with 25 seconds of rest provided between trials. The strength data (kg) obtained from HHD and CFD was converted into Newton and multiplied by the shank length for further comparison. The EMG data was rectified, band-pass filter at 20-500 Hz, and smoothed with a moving average of 100ms. Repeated measure ANOVA was used to examine the differences among three measuring devices and all the analysis was performed using SPSS 24.0. RESULTS: The mean torque and range of knee extension measured with the IKD, HHD and CFD was 150.4 Nm (ranged from 80.2 to 230.2 Nm), 90.3 Nm (ranged from 57.7 to 153.2 Nm, and 87.2 Nm (ranged from 39.5 to 147.3 Nm), respectively. The peak activation amplitude of rectus femoris in IKD, HHD, and CFD was 0.39 ą 0.15 mV, 0.31 ą 0.17 mV, and 0.29 ą 0.13 mV, respectively. Significantly different torque values were found among devices ($F(2,14)=38.51$, $p<0.01$). The knee extension torque obtained with IKD was significantly larger than collected with HHD ($p<0.01$) and CFD ($p<0.01$). CONCLUSIONS: In the current study, we did not use strap to fasten the sensor and lower extremity while measuring with the CFD system. The measuring method is similar with the HHD. It might be the reason why the results showed no significant differences between the HHD and CFD, but the values were significantly lower than values obtained with IKD.

P-P-263: The factors of robotic surgery skill among the highly trained surgeons with multi-channel surface EMG signals

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BACKGROUND AND AIM: The purpose of this study is to measure the skill rate for surgical operation with the robotic surgical system between the highly trained surgeons. Previously, the authors have already reported to examine and show the possibility to be measurable for the skill rate with multi-channel surface EMG (msEMG). The skill rate was defined as the logistic regression analysis from the higher-order moments, variance, skewness and, kurtosis, of the specific frequencies in the EMG time-frequency domain distributions. In the previous study, the defined skill certainly succeeded to recognize the quality of the surgeons' skill level on the robotic surgical operation intuitively. However, it is not still clear what parameters used in our technique depend on the skill rate. In this paper, the authors are to examine the factors to the parameters by means of the statistical methods. METHODS: Four highly trained surgeons of robotic surgery participated in this study. The number of operations in this study is ten totally in the real total cystectomy operations. The msEMG signals were recorded on the FreeEMG system (BTS Bioengineering, USA) during their real operations with the robotic surgical system. The four msEMG electrodes attached near superficial flexor and extensor digitorum muscles of both the right and left hands of the subjects. The authors evaluated the skill rate only in the robotic-assisted laparoscopic radical prostatectomy 5 (LARP5) which executes the uretero-neocystostomy. Complex demodulation (CDM) was applied for the msEMG to calculate their time-frequency domain distributions. Then, the higher-order moments from the time-frequency domain distribution at the specific frequencies, ranging from 50 to 250 Hz per 50 Hz, were derived. Their totally sixty parameters were applied to calculate the skill rate with logistic regression analysis. RESULTS: The logistic regression analysis showed that the skill rate calculations for ten times could sufficiently present the reasonable quantities depending on the years of experiences among the surgeons with the high accuracy almost near 1 and also the errors almost near 0. Then, the authors apply the factor analysis to the sixty parameters to clarify what factors depend on the learning with the high performance. The factor analysis revealed the higher moments of each of four muscles are clearly separated in the tops of three principal components. The fact indicates that the logistic regression model can sufficiently present the differentiation among the skill level of the surgeons. CONCLUSIONS: Our methodology with the logistic regression model has the ability of the classification to perform the robotic surgical system in a highly trained group. However, this methodology can only classify their relative skill level. The authors will examine whether the skill rate during operations can be measured on the absokute space or not.

P-P-264: Spatiotemporal gait characteristics and ankle kinematics of backward walking in people with chronic ankle instability

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BACKGROUND AND AIM: Backward walking (BW) offers a unique challenge to balance and ambulation, thus, contemporary treatment paradigms recommend the implementation of backward gait training to improve locomotion in people with musculoskeletal disorders. Altered walking patterns are often described in individuals with chronic ankle instability (CAI). However, no previous study has fully assessed BW among people with CAI. Therefore, the aim of this study was to investigate the characteristics of spatiotemporal gait factors and ankle kinematics during BW in people with CAI. METHODS: Sixteen subjects with CAI and 16 able-bodied controls walked on a treadmill at their self-selected speed under backward and forward walking conditions. The spatiotemporal outcomes

examined were gait speed, cadence, the percent of the gait cycle spent in double limb support (%DLS), and stride time variability. Outcomes of ankle kinematics included the average peak and minimum angles in the sagittal plane during the stride (i.e., peak dorsi/plantar flexion), as well as peak frontal ankle angles (i.e., inversion) at initial contact (0-3% of stride), loading response (3-12% of stride), mid-stance (12-32% of stride), and terminal stance (32- 50% of stride). Two-way linear mixed model was performed for each gait outcome with the factors of group (CAI, healthy control) and walking condition. The interaction effect was evaluated to determine if there were differences between groups in their walking adaptation from forward to backward. RESULTS: The results of the linear mixed model are presented in Table 1. During BW, both groups had significantly slower gait speed, lower cadence, and greater stride time variability. In addition, under BW condition, subjects in both groups demonstrated increased dorsiflexion, reduced plantar flexion, and greater ankle inversion from initial contact to mid-stance. However, there were no differences between groups in any of the measured outcomes. CONCLUSIONS: The findings may indicate that subjects with CAI adapt to self-selected speed BW similarly to healthy controls. Yet, it is possible that while BW on a treadmill required some level of adaptation from both groups, it was not challenging enough to discriminate their gait performance. Assessments with more challenging tasks, such BW with dual task and BW at fast speed may be more appropriate for testing gait impairments related to CAI. Furthermore, the results should be interpreted with caution due to the heterogeneity of the CAI population. It should be noted there is a list of impairments that people with CAI as a group, are likely to demonstrate; however, each individual may present certain clinical and performance outcomes that are affected by personal and environmental factors.

P-P-265: Assessment of Isometric Knee Strength and Muscle Activities in Various Dynamometer Devices

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BACKGROUND AND AIM Sufficient knee strength is one of the determinants of functional activity level in our daily life. Isokinetic dynamometer (IKD) and handheld dynamometer (HHD) have been used commonly for measuring the muscle strength in clinic. However, IKD is expensive and lack portability, although it often refereed to as the golden standard. HHD is an alternative tool for muscle strength measuring in clinical practice, and sufficient strength of tester and well stability can provide better testing reliability. Therefore, our research group designed a portable measuring chair with a clamp to fix the handheld dynamometer (CFD) for measuring knee strength. The purpose was to assessment the isometric knee strength and muscle activities using three dynamometers. METHODS Sixteen volunteers (8 males and 8 females; age=21.1 ą 0.8 years; height=164.4ą7.5 cm; weight=59.0ą11.2 kg) participated in this study. Knee extension and flexion strength of dominant leg were evaluated by IKD (Biodex system 4 Pro), HHD (MicroFET2), and custom-designed CFD. The surface electromyography system (Noraxon Inc.) with sampling rate of 1500 Hz was used to record the muscle activation and the electrode was attached on the rectus femoris (RF), vastus lateralis (VL), vastus medialis oblique (VMO), and biceps femoris (BF). The testing device was conducted in random order, and participants were given several practice trials before measuring. They needed to sit upright with arms cross the chest to perform isometric contraction of knee flexion and extension at 90 degrees of knee flexion. Three trials for 5

seconds on each device, with 25 seconds of rest provided between trials. The strength data obtained from HHD and CFD (kgf) was converted into Newton and multiplied by the shank length. EMG data was rectified, band-pass filter at 20-500 Hz, and smoothed with a moving average of 100ms. Activation ratio of knee extension muscles (Activation of RF, VL or VMO / Sum of RF, VL, and VMO) was calculated. Repeated measure ANOVA was used to examine the differences among three devices and the software SPSS 24.0 was used to analysis. RESULTS: The knee extension torque measured by IKD (150.4ą48.1 Nm) was significantly larger than HHD (90.3ą31.1 Nm) and CFD (87.2ą31.6 Nm). The knee flexion torques obtained from IKD (66.4ą19.0 Nm) and HHD (66.6ą24.9 Nm,) were significantly larger than CFD (36.8ą11.8 Nm). The VL had largest activation ratio during knee extension in IKD (VL: 43%; RF: 35%; VMO: 22%), HHD (VL: 42%; RF: 35%; VMO: 23%), and CFD (VL: 45%; RF: 33%; VMO: 22%). The peak activation of BF IKD, HHD, and CFD was 0.21 ą 0.06 mV, 0.19 ą 0.08 mV, and 0.16 ą 0.07 mV, respectively. CONCLUSIONS: The current study provided the torque and muscle activation ratio of isometric knee flexion and extension obtained from 3 measuring devices. The values could help the researchers improve the design of testing system, and the reliability and validity between tests should be examined in the future.

P-P-266: Shoulder Muscle Activity during Manikin-Carrying in Young Elite Lifesaving Athletes

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BACKGROUND AND AIM: Lifesaving sport is a competitive water sport which involves many rescue techniques. One of the techniques is manikin carrying, in which athlete stroke with one arm and carry a manikin of 60 kg with the other arm throughout the swim. Stabilizing the manikin exerts great demand on shoulder muscles of the carrying arm. This study aims to investigate the muscle activation profile of the carrying shoulder and the possible factors associated. METHODS: This is a cross-sectional study design. 20 young elite lifesaving athletes were recruited from the Hong Kong Lifesaving Society with mean age 17.75+/-2.29 years (10 male and 10 female athletes). Each athlete was instructed to practice the 25-meter manikin carrying technique in an outdoor swimming pool. Muscle activity of Posterior Deltoid, Teres Major and Middle Trapezius were recorded with wireless surface electromyography (sEMG). The sEMG signals were recorded by the Wave Plus receiver (Cometa, Milano, Italy) at a sampling frequency of 2000 Hz and amplified by a gain factor of 1000. sEMG data and speed in the self-pacing manikin-carrying technique were record. The whole procedure was divided into and analyzed in 3 phase: initial, middle and end phases. Initial phase was defined as the period from the first swimming stroke to the end of the third stroke of athletes; Middle phase was defined as the period between the initial and end phase; End phase was defined as the period from the last third stroke to the last stroke at the 25-finishing line. First web space and grip strength were measured. Speed and number of inhalation were calculated. RESULTS: Posterior Deltoid showed muscle activity of 55.73%MVIC in initial phase and 40.21%MVIC in middle phase of the 25-meter manikin carrying. Teres Major showed muscle activity of 65.26%MVIC in initial phase and 64.35%MVIC in middle phase. Middle Trapezius showed 84.54%MVIC in initial phase and 68.54% MVIC in middle phase. Muscle activity of Posterior Deltoid was found negatively associated with speed (p=0.038) and first web space (p=0.029) in initial phase, while it is negatively associated with speed (p=0.020) and positively associated with number of inhalation (p=0.022) in middle phase. Muscle activity of Teres Major was found to have no association with first

web space, grip strength, speed, number of inhalation, upper arm length and forearm length in both phases. Muscle activity of Middle Trapezius was found negatively associated with first web space (p=0.002) and grip strength (p=0.005) in initial phase, while it is negatively associated with speed (p=0.001), first web space (p=0.001), grip (p=0.005) and positively associated with number of inhalation (p<0.001) in middle phase. CONCLUSIONS: Young elite athletes showed significant use of Posterior Deltoid, Tere Major and Middle Trapezius of the carrying arm during manikin carrying. The performance of those three muscles also serves as important indicators of the manikin carrying performance that worth to have regular evaluation. The muscle activity levels are correlated with first web space, grip strength, speed and number of inhalation of the athletes. The finding from this study gives reference for coaches on athletes' selection and skill training.

P-P-267: The Effects Head Injury on Motor-neuron Reflex Excitability and Motor Preparation

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BACKGROUND AND AIM: Persons who participate in high impact sports are prone to concussive injuries. When a concussion is suspected, an athlete is screened to assess the severity of the injury. These tests mainly target cognitive function and minimally assess the motor system. Testing the motor system is important for athletes whose performance and safety rely heavily on motor control and response time. The purposes of this study were to assess the effect that a head injury has on spinal motor neuron reflex excitability (MNRE), and spinal motor neuron excitability levels over time when preparing for a volitional movement (Motor Preparation). METHODS: Severity of Head injury was determined by comparing IMPACT and SCAT3 testing results before and after injury. MNRE was assessed using the standardized Soleus H-reflex technique. Motor preparation (MP) was evaluated by randomly eliciting a series of H-reflexes before and after a "Start to Move" signal was given to the participant. H-reflexes were evoked from 300ms before to 200ms after the movement initiation signal at 50ms intervals. Three H-reflexes were evoked for each of the time intervals and averaged. H-reflexes were elicited at 15-25% of Mmax, amplified 1000X and digitized at a sampling frequency of 5000Hz at a bandwidth of 3Hz - 10,000Hz. Seventy participants were baseline tested after signing a university approved informed consent. Post injury experiments were conducted before injury and at three separate times, 1-3, 6-10 and 10+ days post injury. Only, five participants returned for all three post injury tests. Data analysis was conducted on these five data sets. All results were plotted and compared with baseline data. Descriptive statistics were used to detect change due to the small sample size. RESULTS: MNRE showed no difference compared with baseline values for the three post-injury testing sessions. MP results showed a moderate to large facilitation across all H-reflex amplitudes intervals from 25-100% above baseline values. This facilitation was seen for the 1-3 and 10+ day post injury testing dates. For the 6-10 day testing session, MP was substantially depressed (~25%) for all intervals before and after the initiation of movement. The 150ms post movement time was the only exception (figure 1). Interestingly, this 25% depression was observed for every pre-movement initiation interval. This flat depressive response was not characteristic of the normal response observed at baseline testing and at the 1-3 and 10+ day testing sessions. There is usually a descending facilitation superimposed onto the underlying inhibition peaking at 100ms prior to movement initiation (figure 1). The characteristic response was observed for all 70 baseline participants tested. CONCLUSION: These preliminary results suggest that head injury may have a negative effect on

the normal development of motor neuron excitability in preparation for volitional movement at the 6-10 day post injury dates. Since MNRE was not affected in these individuals, results suggest that the change in MP has a supraspinal origin. Results of this study suggest further study is needed to determine what the functional outcome our results may impose on sports performance.

P-P-268: Countermovement jump of blind and sighted individuals

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BACKGROUND AND AIM: Jump height of countermovement jump (CMJ) depends on many factors such as muscle strength, velocity of movement, inter-segment/joint coordination and countermovement depth. Congenitally blind individuals are reported to have limited ability in sports, probably due to a lack of experience in sports and the strong link between motor control and vision. CMJ can be considered as a basic common skill for many sports, and therefore further understanding of CMJ by blind individuals would be beneficial. The aims of this pilot study were to compare the CMJ height of blind and sighted individuals, and to investigate which factors are different between groups. METHODS: A total of 13 (3 congenitally blind and 10 sighted) male young individuals were recruited. They were asked to jump on a force plate with markers on their body for motion analysis. Each session started with 4 trials of a control condition, and the subjects were then asked to vary the countermovement depth from that of the control condition. Each trial was performed with the maximal effort, regardless of condition. From the ground reaction force (GRF), the jump duration (from when the GRF < 95% of body weight to take-off), and eccentric and concentric phases in which the center of mass velocity is negative and positive, respectively, were determined. In addition, the maximal jump height, peak power, and an index of inter-segment/joint coordination were obtained. Lastly, a 2nd order polynomial regression model was used to predict whether the preferred countermovement depth in the control condition was optimal for the best jump height, using all trials with varied countermovement depth. Due to the small sample size, 3 individual values from each blind subject were compared with the mean of the sighted subjects (B01, B02, B03 and mean +- 1 standard deviation of sighted subjects). RESULTS: The normalized (to body height) maximal jump height was lower for the blind subjects compared to that of the sighted subjects (0.26, 0.25, 0.22 and 0.28 +- 0.03, no units). The jump duration was longer for some blind subjects than that of the sighted subjects (0.7, 1.0, 2.1 and 0.8 +- 0.1 s). The eccentric phase duration (relative to the jump duration) was longer for 1 blind subject compared to that of the sighted subjects (68.1, 68.7, 79.3 and 65.5 +- 2.1 %). The peak power in the concentric phase was in general lower for the bind subjects compared to that of the sighted subjects (3164, 3077, 1504 and 3653 +- 414 W). The inter-segment coordination between trunk and thigh seemed more synchronized for 1 blind subject compared to that of the sighted subjects (RMS amplitude of the difference in continuous relative phase angles = 19.9, 21.1, 10.7 and 20.4 +- 4.1 deg). The difference between the preferred and the optimal countermovement depths seemed similar between groups. CONCLUSIONS: These data suggest that blind individuals are inferior in jumping. It is possible that the slow countermovement of the blind subjects resulted in the loss of benefit from the eccentric phase.

P-P-269: Neuromuscular activation patterns vastus intermedius and superficial muscles in the quadriceps during isokinetic knee extensions

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Kazuhiro MAEDA¹, Norihiro SHIMA³, Hiroshi AKIMA^{1, 2} <p> 1. Graduate School of Education and Human Development and 2. Research Center of Health, Physical Fitness and Sports, Nagoya University. 3. School of Sports and Health Science, Tokai Gakuen University. <p> Purposes: It is reported that the vastus intermedius (VI) plays an important role at flexed knee joint angles during isometric [1] and isotonic [2] contractions based on surface electromyography (EMG). However, information on the neuromuscular activation patterns of the VI during isokinetic contractions are poorly understood. The purpose of this study was to assess the neuromuscular activation patterns of four synergistic muscles of the quadriceps femoris (QF), including the VI, during isokinetic concentric and eccentric knee extensions <p> Methods: Ten healthy men (age, 21.0 ą 0.6 years; height, 170.3 ą 4.8 cm; weight; 62.6 ą 6.4 kg) performed maximal voluntary isokinetic knee extension at knee joint angle between 80° and 160° (full extension = 180°). They performed isokinetic knee extensions twice at 30 deg/sec and three times at 90 and 120 deg/sec in a random order, while EMG was recorded from the four individual muscles of QF. The range of motion was divided into four subphases to clarify angle-specific activation patterns, i.e. 80° to 100°, 100° to 120°, 120° to 140° and 140° to 160°. The root mean square (RMS) during 30, 90 and 120 deg/sec was normalized to that of 30 deg/sec from 80° to 160° and expressed as relative values (%RMS) of the concentric and eccentric phases for each muscle. <p> Results: The normalized RMS amplitude of the VI was significantly higher from 80° to 100° during both the concentric and eccentric phases at all angular velocities compared to that of RF ($P < 0.01$). On the contrary, the normalized RMS amplitude of VI was significantly lower from 120° to 140° (VI, 88.8 ą 13.9%; RF, 110.4 ą 8.6%, $P < 0.01$) and 140° to 160° (VI, 72.3ą 13.4%,; RF, 106.0 ą 14.7%, $P < 0.05$) during isokinetic concentric contraction phase at 30 deg/sec compared to that of RF. <p> Conclusions: The higher neuromuscular activation suggests that VI could highly contribute at knee joint with flexed position [1, 2]. These results represent joint angle-specific neuromuscular activation exists in synergistic muscle of the QF, which may be related to the motor units firing properties and /or force-sarcomere length relationship of each muscle. <p> References 1. Akima, H., Saito, A. (2013) Inverse activation between the deeper vastus intermedius and superficial muscles in the quadriceps during dynamic knee extensions. Muscle Nerve, 47: 682. 2. Watanabe, K., Akima, H. (2011) Effect of knee joint angle on neuromuscular activation of the vastus intermedius muscle during isometric contraction. Scand J Med Sci Sports, 21: e412-e420.

P-P-270: Deep analysis of velocity behaviour intra and between front crawl cycles and corresponding reproducibility: a case study

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BACKGROUND AND AIM: To complete a pre-determined distance in the shortest time possible, swimmers should be animated of their maximum velocity. Attending to the characteristics of the aquatic environment and since human swimming is an unstable movement, propulsive forces should increase even when swimmers are submitted to high drag values [1]. The interaction between propulsive and resistive forces, as well as the changes of the body segments, results in intra-cycle accelerations and decelerations. As this phenomenon also might occur in-between cycles, affecting overall performance, we aimed to assess velocity variations in successive front crawl cycles and examine its reproducibility when performed at maximal intensity. METHODS: A high-level female swimmer (16 years old, 174 cm height, 64 kg weight) participated in the study that took place in a 25 m indoor pool. After a standardized warm-up, she performed two bouts of 25 m maximal front crawl, one in the beginning and another at the final of a training macrocycle (15 weeks). She was recorded in the sagittal plane for swimming velocity assessment using a double camera set-up (Go Pro 6, 120Hz) fixed and pushed on a chariot. Using a Matlab routine, eight cycles of each 25 m bout were analysed extracting the mean, minimum and maximum velocities (vmean, vmin, vmáx) and intracycle velocity variations (IVV; calculated by coefficient of variation of v) per upper limbs cycle. vmin, vmáx were also computed into relative velocities using the vmean as the 100% in order to define the amplitude of variation during each upper limb cycle. Trend analysis were conducted, and ANOVA repeated measures was used to verify differences in the above referred variables between evaluations and relationships between variables were examined with Pearson's correlation coefficient. The significance level was set at 5%. RESULTS: Figure 1 shows the variation of velocities of successive cycles and IVV of each cycle in the first (left panel, top and bottom, respectively) and the second evaluations (right panel, top and bottom respectively). Velocities and IVV decreased from the first to the eighth upper limb cycle, in both evaluations. Correlations between IVV and relative vmáx and vmin were strong (r=0.86 and -0.95, respectively; $p<0.05$). The means analysis showed an increase tendency in vmin and vmáx (± 0.03m/s) and a higher inter cycle variation from the first to the second moment of evaluation (vmean=1.74±0.04 and 1.74±0.05 m/s, vmáx=2.06±0.09 and 2.09±0.11 m/s; relative vmáx=118 and 120%; vmin=1.40±0.06 and 1.43±0.13 m/s; relative vmin=80 and 82%; IVV=9.66±1.19 and 9.75±2.81). CONCLUSIONS: Variations of velocity in successive cycles were observed and demonstrated a tendency to decrease along the 25 m in both evaluations. The first evaluation showed a stable vmean and also a stable magnitude of the velocity fluctuations, but the second evaluation showed a larger variability intra and between cycles. As expected, the variability of the vmáx and vmin was reflected in the IVV [2] and it is associated with a lower swimming efficiency. However, the vmean was the same between the evaluations, indicating a possible improvement of the physical capacities of the swimmer since more energy is necessary to keep a same velocity when the efficiency is lower. Results suggest that could be a challenge for young swimmers to adapt their swimming technique to the improvement of their physical capacities, keeping the swimming efficiency.

P-P-271: Distinct effects of movement speed on global EMG amplitude depending on muscle contraction type and muscle length

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BACKGROUND AND AIM: The control of movement speed during muscle shortening and lengthening is a highly relevant topic in human neuromechanics. It has been shown distinct control of concentric and eccentric muscle contractions through the use of surface electromyography (EMG). However, it is unknown whether changes related to movement speed during concentric and eccentric contractions may change depending on the length of the muscle during a dynamic contraction. Therefore, the aim of this study was to investigate the effects of contraction speed on the amplitude and barycenter of EMG signals recorded at different contraction types and ranges of motion (ROM). METHODS: Eleven healthy men (age; 26,4±4,2. height; 183,1cm±12,9; weight; 85,9kg±12,9) performed bouts of dynamic ankle dorsiflexion contractions on a dynamometer targeting a 20° ROM. Dynamic contractions were performed at 5°/s and 20°/s at a constant load of 25% of maximum isometric dorsiflexion. Surface EMG was recorded from the tibialis anterior muscle using two 64-channel matrices (8 mm inter-electrode distance). Root-mean-square (RMS, normalized by a 25% MVC isometric contraction [xISO]) and EMG barycenter along the longitudinal axis of the shank were computed from the first 20% (Long), intermediate 20% (Mid) and final 20% (Short) of the ROM for both concentric and eccentric contractions. A three-way ANOVA with repeated measures was used to assess the effects of contraction speed, contraction type and ROM on EMG RMS and barycenter. RESULTS: There was a significant speed vs ROM interaction for the RMS ($p<0.000$), where the concentric and eccentric RMS for the lengthened position at 5°/s (1.18±0.08 xISO) is significantly lower when compared to Mid (1.44±0.12 xISO) and Short positions (1.80±0.20 xISO) ($p<0.01$). There was also a speed vs contraction type interaction ($p<0.003$), where the RMS during eccentric contractions was significantly lower at 20°/s when compared to concentric contractions and 5°/s ($p<0.05$). Moreover, there was a significant main effect of ROM on EMG barycenter ($p<0.05$), with no influence of contraction speed or contraction type. CONCLUSIONS: These results show that increases in muscle contraction speed will affect muscle recruitment differently depending on the range of motion and contraction type. A more lengthened muscle demands lower MU recruitment during a low-speed contraction regardless of the contraction type. An expected reduction in RMS during eccentric contractions was also accompanied by a reduction at faster speed, which suggests that the central nervous system is efficient in reducing recruitment if speed is increased but load is maintained. Moreover, the lack of influence of contraction speed and contraction type on the EMG barycenter suggests that muscle activation patterns are maintained at different contraction speed and contraction types. However, the length of the muscle imposes the need to change recruitment strategies.

P-P-272: Acute cardiorespiratory exercise effects on upper-extremity motor learning and intermuscular coherence

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INTRODUCTION: Past work indicates that a bout of high-intensity interval cycling immediately after practice of an upper-extremity motor skill task can improve performance at 24-hour and 7-day retention tests. Notably, the neural substrates that support skill learning are dependent on how the skill is practiced. For example, off-line consolidation of skill learning may rely more on the motor cortex when practiced in blocks of one skill variation at a time rather than in a random order. Here, we examined the impact of cardiorespiratory exercise on motor learning with different orders of skill practice (i.e.,

blocked or random). Coherence in activity between muscles involved in skill performance was assessed to evaluate potential changes in common motor cortical drive. METHODS: Young healthy adults were allocated to one of four groups: 1) blocked skill practice followed by rest (BLK+REST), 2) random skill practice followed by rest (RDM+REST), 3) blocked skill practice followed by exercise (BLK+EX), or 4) random skill practice followed by exercise (RDM+EX). During motor skill practice, participants squeezed a pinch grip force transducer to track target force levels presented on a computer screen. Performance was determined by time spent within the force target levels. Four force target patterns were practiced in either a blocked or random order. Exercise consisted of a 20-minute bout of high-intensity interval cycling, while rest involved 20 minutes of sitting and quiet conversation. Skill tests were conducted immediately before and after practice, and at 24 hour and 7-day retention tests. To evaluate intermuscular coherence before and after practice and at each retention test, surface electromyography (EMG) was collected from the abductor pollicis brevis and the first dorsal interosseous while participants maintained a pinch grip of 10% of their maximum voluntary pinch grip force for 30 seconds.. The correlation in activity between the muscles within the beta frequency band (15-35 Hz) reflects the degree of common motor cortical drive transmitted to the muscles. RESULTS: Thus far, 12 individuals have been allocated to the BLK+REST group, 11 to the RDM+REST group, 9 to the BLK+EX group, and 10 to the RDM+EX group. Descriptive statistics indicate that change in performance on skill practice tests between the pre-practice assessment and the retention tests was similar between groups, with no evidence for an effect of practice order or exercise. Coherence values have been processed for 36 of the 42 participants. Although variable, maximum beta-band coherence values suggest a trend for a greater increase from pre to post practice in groups practicing the skill in a random order (mean±SE, BLK: 9±16% increase; RDM: 42±20% increase), as well as greater increase in coherence at retention tests in the rest relative to the exercise groups (REST: 59±26% increase; EX: 2±12% increase). CONCLUSION: The negligible effects of practice order and exercise on skill acquisition and learning were unexpected but align with some other work in the field. Trends for unique patterns of change in intermuscular coherence suggests that practice order and acute exercise may influence neural substrates supporting skill acquisition and learning; however, further data is needed to verify preliminary findings.

P-P-275: Kinematics and kinetics of amateur baseball pitching with standard and lightweight balls

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BACKGROUND AND AIM: Recent studies have investigated the mechanics involved when youth and college students pitch balls of various weights to clarify injury risk and training effects. The weight of a Japanese amateur baseball is 138 g, which is lighter than the balls used in high-school, college and professional baseball (145 g). Therefore, ball weight might affect pitching mechanics. The present study aimed to identify relationships between ball weight and pitching mechanics in adult amateur pitchers. METHODS: Twenty males (mean age, 26ą3.4 years; mean height, 1.7ą0.03 m; mean weight, 71.6ą9.5 kg) used an overthrow or three-quarter pitching style. Fourteen subjects were right-handed and six were left-handed and all were amateur baseball players with at least 2 years of pitching experience during high school or college. Participants pitched light (110 g) and heavy (145 g) balls with maximum velocity,

the order of which was randomized for each participant. A three-dimensional Vicon 612 motion analysis system (Oxford Metrics, Oxford, UK) with 10 cameras (250 Hz) captured pitching motion data. Kinematic parameters (elbow, shoulder, trunk angle and angular velocity, and ball velocity), kinetic parameters (elbow varus torque, shoulder internal rotation torque and torque efficiency, and ball reaction force), and temporal parameters were calculated. Kinematic, kinetic, and temporal parameters for light and heavy balls were compared using paired t tests. Two-tailed p values <0.05 were considered statistically significant. Data were statistically analyzed using IBM SPSS Statistics (Version 26). RESULTS: The results are shown as light vs. heavy balls. Maximum ball velocity reached a mean of 31.4ą3.3 vs. 30ą3.4 m/s (p<0.01). With respect to joint angle, shoulder abduction at maximum external rotation (MER) was 94.6°ą10.3° vs. 95.8°ą10.1° (p=0.02). With respect to joint angular velocity, shoulder internal rotation at ball release (BR) was 4051°ą1032.6° vs. 3800.2°ą1046.4°/s (p = 0.03). Maximum trunk separation was 504.5°ą136.6° vs. 530.7°ą119.8° s (p=0.03). Ball reaction force was 42.8ą6.4 vs. 52ą8.6 N (p<0.01). In terms of joint torque, elbow varus was 42.7ą10.4 vs. 42.9ą10.4 Nm (p=0.8) and shoulder internal rotation was 47.2°ą10.6° vs. 46.3°ą10.8° (p=0.2). In terms of joint torque efficiency, elbow varus was 1.35ą0.23 vs. 1.41ą0.24 Nm/ball velocity (p<0.01) and shoulder internal rotation was 1.49ą0.22 vs. 1.53ą0.22 Nm/ball velocity (p=0.032). Maximum ball reaction force timing was 89.9%ą2.4% vs. 87.8%ą5.1% of the pitching cycle (p=0.04) and maximum shoulder internal rotation timing was 104.9%ą2.2% vs. 105.7%ą2.2% of the pitching cycle (p<0.01). CONCLUSIONS: Increasing the weight of a baseball pitched by adult amateur pitchers increases ball reaction force, which results in reduced ball velocity and torque efficiency. Therefore, a heavier ball might confer increased injury risk for adult amateur baseball pitchers. Increasing the shoulder abduction angle might help to avoid elbow and shoulder overload when pitching a heavier ball.

P-P-276: Characteristics of upper limb stretch reflex in wrestlers

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Introduction In men's elite free-style wrestling, the "set up" before a leg attack improves the success rate of the leg attack and also increases the points awarded to the attacker（Ito et al., 2019）. When wrestlers execute set up, leg attack, and throw, they contact the opponent with their arms. Moreover, since they fight in a very close distance, they would use not only voluntary reaction but also reflexes to quickly react to the opponent's action. The reflex response is considered to change with experience in sports and training (Nielsen et al., 1992). The objective of this study was to clarify the characteristics of upper limb stretch reflex in wrestlers. We hypothesized that "reflexes" which occur more quickly than voluntary reaction, have been modulated in wrestlers as compared to non-wrestler subjects. Methods Participants were 10 wrestlers (18～22 years old) and 11 control subjects (22～25 years old). They sat on a dynamometer (Biodex), and the trunk and right arm were fixed to a dynamometer. Surface EMG activities of the right biceps and triceps brachii were recorded during the tasks. The experiment was divided into two sessions. In the biceps brachii session, participants conducted relax or flexion of the elbow if they feel the disturbance (abrupt elbow extension induced by a dynamometer), respectively, 30 times. In the triceps brachii session, participants conducted relax or extension of the elbow if they feel the disturbance (abrupt elbow extension), respectively, 30 times. The reflex components were divided into the three time frames: defined as M1 = 20~50ms, M2 = 50 ~ 80ms, and M3 = 80 ~ 100ms according

to the definition by Yamamoto & Ohtsuki (1989). The averaged background EMG activity just before the disturbance was subtracted from the EMG activity in each period. Resultant value was integrated to obtain reflex magnitudes of M1~M3. Results & Discussion In the triceps brachii, the wrestler group showed significantly smaller value in M2 than the control group (p = 0.049) in relax task, and the wrestler group showed significantly bigger value in M3 than the control group (p = 0.02) in extension task. There was no difference in M1 between the two groups. In the biceps brachii, three was no significant difference in any reflex component. Since wrestlers apply pressure to the opponents with their upper limbs, the triceps would have a role to detect the repelling pressure from the opponent. Additionally, triceps brachii appears to have important roles for making quick relaxion in response to the opponent rebound in order to collapse the balance of the opponent, or to extend to keep the distance to the opponent. Conclusion It was suggested that wrestler have specific characteristics of stretch reflex in triceps brachii so as to be modulated in competition-specific manners.

P-P-277: Kinematic measurement of long track speed skating performance using an IMU system

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BACKGROUND AND AIM: Little is known about kinematic features related to the performance of long track speed skating. We used an Inertial Measurement Unit (IMU) system to acquire kinematic data during the performance of speed skating. The objective of this study was to identify kinematic features related to the performance of speed skating. METHODS: Nineteen competitive speed skaters (mean age: 20.3ą1.7 yrs) performed 1000 m skating with 16 IMU sensors (myoMOTION, Noraxon) and 2-foot pressure sensors (F-Scan, Tekscan). IMU sensors were placed on head, upper spine (C7 level), lower spine (L1 level), pelvis (sacrum), and bilaterally on upper arms, forearms, hands, thighs, shanks, and feet. The performance of each stroke during 4 straights (400 m) and 4 curves (400 m), were analyzed, excluding initial and last straights and curve (total of 200 m) due to different skating strategies during these periods. Three events (initial contact [IC]; edge switch [ES], and toe-off [TO]) and two events (IC and TO) were identified during the skating movement of straight and curve, respectively, using foot pressure and foot acceleration (IC and TO) and knee joint angle (ES). The acquired kinematic signals were filtered with no time lag using Butterworth low-pass filter (cut-off frequency: 10Hz). We considered the push-off phase as the period from ES to TO for straight, and from IC to TO for the curve. The saggital acceleration of the lower spine sensor (LSacc) was used to infer saggital acceleration of the center of mass. Knee joint angle at each movement event, integrated LSacc, and peak LSacc during the push-off phase were computed. We also computed the cross-correlation coefficient (zero time-lag) between knee joint angle and LSacc. The mean values of strokes during each straight and curve were calculated separately for right and left. Those mean values were used for further statistical analysis. Pearson's correlation coefficient (r) was used to estimate the relationship between the time required to complete 1000 m skating (1000 m time) and kinematic outcomes. Pearson's correlation coefficient was also used to estimate the relationship between integrated LSacc and cross-correlation coefficient between knee joint angle and LSacc (α=0.05). RESULTS: For straight, 1000 m time was significantly correlated with knee angles at IC (Rt r: r=—0.229; Lt: r=—0.370) and ES (Rt: r=—0.304; Lt: r=—0.351) and peak LSacc (Rt: r=—0.508; Lt: r=—0.448). For curve, 1000 m time was significantly correlated with

integrated LSacc (Rt: r=—0.561; Lt: r=—0.632) and cross-correlation coefficient between knee joint angle and LSacc (Rt: r=0.545; Lt: r=0.429). Integrated LSacc was significantly correlated with cross-correlation coefficient between knee joint angle and LSacc for both straight (Rt:r=0.737; Lt: r=0.477) and curve (Rt:r=0.924; Lt: r=0.748). CONCLUSIONS: Our results showed that knee joint kinematics, particularly its coupling with the center of mass acceleration, may be important to effectively induce forward acceleration, leading to less time required to complete 1000 m skating.

P-P-278: Validation of an inertial measurement unit for the quantification of knee joint kinematics during simulated speed skate movements

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BACKGROUND AND AIM: Little is known about knee joint kinematics during a whole speed skating performance as the quantification of speed skating movement on ice using a traditional optical motion capture (OMC) system requires an enormous number of cameras. Inertial measurement unit (IMU) may be a promising measurement tool that enables kinematic data acquisition during the performance of speed skating on ice. However, the validity of an IMU system to measure the speed skating movement has not been examined. The objective of this study was to examine the validity of kinematic data acquired by the IMU system. METHODS: Eighteen competitive speed skaters (mean age: 20.5ą1.8 yrs) performed simulated skating on a sliding board of 3 m width for 10 consecutive strokes. The performance was measured using an IMU system (myoMOTION, Noraxon) and an OMC system (VICON, Oxford). We used 4 IMU sensors and 10 reflective markers mounted on the shank and thigh bilaterally to acquire knee joint kinematic data. The kinematic data were acquired following two calibration conditions (standing or sitting). Knee flexion angles were computed separately for IMU and OMC systems in two calibration conditions. We compared the knee joint angle between IMU and OMC systems using mean absolute error (MAE) and root mean square error (RMSE). We normalized the MAE using the range of angle displacement (normalized MAE). Cross-correlation coefficient with no time-lag between IMU and OMC was also calculated. MAE and RMSE were compared between two calibration conditions using the paired t-test (α=0.05). RESULTS: For standing calibration, MAEs of the knee joint angle were 3.6ą1.1š (5.0ą1.7%) and 7.3ą5.8š (9.4ą5.6%) for the right and left side, respectively. RMSEs of knee joint angle were 5.4ą2.0š and 8.4ą6.4š for the right and left side, respectively. For sitting calibration, MAEs of the knee joint angle were 5.1ą3.3š (8.8ą10.2%) and 5.0ą3.3š (6.9ą4.0%) for the right and left side, respectively. RMSEs of the knee joint angle were 6.9ą4.3š and 6.0ą3.6š for the right and left side, respectively. There were no statistical differences in MAE and RMSE between the two systems. Cross-correlation coefficient of the knee joint angles between IMU and OMC system was more than 0.99 for all participants for both calibration conditions. CONCLUSIONS: Knee joint angles obtained by the IMU system were comparable (normalized MAE < 10%) and tightly coupled (cross-correlation coefficient > 0.99) with those derived from the OMC system for both standing and sitting calibrations. Those results suggest that the IMU system provides comparable knee joint angles following both standing and sitting calibrations during simulated speed skate movements.

P-P-279: An example of muscle activity during golf swing in immersed condition

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BACKGROUND AND AIM: There is a water, which has a high density compared to the air, surrounding human body when immersed in water. In the immersed condition, the water drag force acts on the human body when moving any direction, which would enable muscle training with moving a target motion itself. This study aimed to show an example of muscle activity during golf swing in the immersed condition to discuss whether there is a possibility that the swing training in water is effective for muscle training to improve flying distance of golf ball for amateur and recreational golfers. METHODS: One amateur young male (21yr, 177.2cm, 73.0kg) was recruited for the present study as an example. He conducted golf swing in immersed condition with 1.1m depth of water (27.3°C) and land condition using a driver. The muscle activity of 15 muscles was investigated by electromyograph during the swing, and compared between two conditions. The swing was conducted 5 times for practice and 5 times for experiment on land condition, then 5 times for practice and 5 times for experiment in submerged condition, and 5 times for experiment on land condition. All swing was conducted with a maximum effort. The 4 swings of the 10 in total on land condition and the 4 swings of the 5 in immersed condition were adopted for analyze. The data from top to impact of each swing with a reference of wrist radial-ulner flexion angular velocity measured by inertial motion unit attached on the subject's left opisthenar. The sampling frequency of the electromyograph was set at 1000Hz or 2000Hz. After the data acquisition, band-pass filter with 10-500Hz was applied. RESULTS: The swing motion become slower in the immersed condition than in the land condition. The mean muscle activity was higher in the land condition than in the submerged condition except the external oblique abdominis. In the integrated muscle activity, the external oblique abdominis, the posterior deltoid, the flexor carpi radialis and the extensor carpi radialis showed higher value in the immersed condition than the land condition. DISCUSSION and CONCLUSIONS: The external oblique abdominis acts on trunk rotation and maintains trunk posture during golf swing. The deltoid assists shoulder girdle rotation from top to impact of golf swing. Also, the shoulder joint injury is one of the most golf-related injuries. The strong grip force is needed from top to impact of golf swing to control golf club which is connected with the forearm muscles activity. The forearm muscles, the posterior deltoid and the external oblique abdominis generate power to hit the ball for golf swing. This study would suggest that the golf swing training in immersed condition possibly be effective for improving golf performance to gain farther flying distance of golf ball. Further study with increasing subject number and analyzing details would be expected.

P-P-280: A method for assessing changes in biological functions using pedal force and electromyography during pedaling exercise

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Background and Aim: Some investigations about EMG threshold have been made since 1990s and researchers have thought EMG threshold can be used to estimate physiological parameters represented by LT non-invasively. During incremental exercise, blood lactate start to accumulate at particular workload, which leads reduction of the intracellular pH and decrease of the contraction force in each motor unit. The non-linear increase of EMG amplitude during incremental exercise is caused by

simultaneous occurrence of additional recruitment of motor units as a correspondence to increasing workload and as a compensation for decreased force. In general, the increase of recruited motor units leads the increase of muscular tension but it's not clarified whether the muscular tension is proportional to workload during incremental exercise which increase linearly. If the muscular tension shows similar increase to EMG amplitude during incremental pedaling exercise, it's expected that pedal force parameters change non-linearly, which may be able to estimate physiological parameters like EMGT and LT. Therefore, the purpose of this study is to investigate whether the breakpoints corresponding EMGT and LT are found from pedal force during incremental pedaling exercise. Methods: 8 subjects performed an intermittent incremental exercise on cycle ergometer. Blood lactate, EMG (GM, RF, VL, VM, BF, TA and GAS) and pedal force parameters were measured during exercise. Calculating the representative values of each measured parameter in each crank cycle, these data were arranged in ascending order of workload. After that, we judged whether there is a breakpoint in each arranged data using the least squares method and two straight linear fitting. Results: It was confirmed that LT was found from all subjects. EMGTs in RF and VL were also found from all subjects and they were correlated with LT. Regarding pedal force parameters, although the breakpoints were found not so many subjects, the normal direction force measured in the range from 0 degrees to 90 degrees of crank angle showed non-linear changes. Conclusions: We could find non-linear changes form pedal force parameters during incremental exercise so it's thought that it's not impossible to calculate characteristic value from pedal force parameters. And it's thought the cause that brought not so many subjects who show the breakpoint in pedal force parameters is that the arranged data consisted from the data measured at each trial during intermittent incremental exercise was used. Because of it, the data had poor continuity, which may become a misleading material when the linear fitting method was used. So it may be possible to find breakpoints from pedal force parameters in case that continuous incremental exercise is performed. Although the researches so far have not refer to changes of muscular tension during incremental exercise, in this study, it was suggested that the way of pedaling was changed, which leads the change of muscular tension. And it's expected that the non-linear increase of EMG amplitude reflects not only the compensation for decreased force but also non-linear increase of muscular tension caused by change of pedaling strategy.

P-P-281: Relationship between hip rotation and knee valgus of rugby players during jump landing

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BACKGROUND AND AIM: Rugby players have a higher incidence of injuries. In particular, they injure anterior cruciate ligament (ACL) quite frequently and often suffer non-contact type ACL injury during jump landing. Specifically, they damage their ligaments because they take a position of slight knee flexion, suffer tibia rotation, or receive valgus stress during jump landing. Internal rotation of hip also causes ACL injury. Although there are previous studies focusing on the hip rotation angle, few studies have verified the relationship between muscle strength of hip rotation and knee valgus during jump landing. The purpose of this study was to examine the relationship between hip rotational muscle strength ratio and knee valgus angle, and verify the difference between landing on one foot and that on both feet during jump landing with a view to preventing ACL injuries. METHODS: The subjects of the

study were 16 legs: both legs of eight members of a college rugby team (Age: 21.9ą1.2 year's old, Height: 172.1ą4.5 cm, Weight: 78.7ą5.0 kg, Rugby experience: 7.2ą3 years). We used a portable motion analysis system (PhysiMax System: Physimax Technologies) to shoot and analyze jump movements. We asked each of the eight members to perform repetitive vertical double leg jumps for 30 seconds and six consecutive one leg jumps. We calculated the results using the portable motion analysis system and adopted medians of extroversion of knee joint, flexion, and angle of internal rotation during each jump landing. Then, we measured muscle strength of hip rotation at hip flexion position of 60 degrees using a handheld dynamometer (HHD), and calculated muscle strength ratio of hip internal and external rotation by dividing internal rotation by external rotation. For statistical test, we used a paired t test for each value of landing on one foot and both feet, and calculated ratios of knee valgus and hip muscle strength to see if there is a correlation. We used IBM SPSS Statistics ver. 25 to analyze all data and set the significant level at 5%. RESULTS: We observed a strong positive correlation between knee valgus and hip internal rotation angle because the correlation coefficient between them was 0.796 (p = 0.00). Likewise, we observed a positive correlation between knee valgus and muscle strength ratio of hip rotation of landing on double leg jump because the correlation coefficient between them was 0.544 (p=0.03). However, no significant correlation was observed in jump landing on one leg. CONCLUSIONS: We found that the larger the internal rotation angle and muscle strength ratio of hip rotation, the grater the valgus and angle during jump landing on double leg. Therefore, it was clarified that it is necessary to improve the mobility of internal and external rotations of the hip and correct the imbalance of muscle strength to prevent ACL injuries.

P-P-282: Comparison of Different Ballet Pointe Shoes on the Center of Mass and Knee Rang of Motion during Ballet Arabesque

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BACKGROUND AND AIMS: Dancing on tip-toe is a common position in female ballet dancers. During ballet Arabesque, ballet dancers have to maintain their body alignment and stability in order to stand on a single leg and turnout position. Thus, proper ballet pointe shoes including design and material play an essential role to provide sufficient support to ballet dancers and may decrease risks of injury. Thus, this study was to examine the effect of ballet point shoes on the center of mass (COM) displacement and lower extremity range of motion (ROM) in ballet dancers. METHODS: Nine female ballet dancers with more than ten year of experience (mean age: 22.89ą3.37 years old; mean height:158.56ą4.00 cm; mean body weight:50.33ą5.77 kg) performed ballet Arabesque in the nondominant leg (right leg) with different pairs of ballet pointe shoes (Chacott and R-class pointe shoes). The COM displacement in three directions and lower extremity ROM were reported. Student pair t-test was used to compare the group difference between the two ballet dancer shoe conditions. RESULTS: The preliminary results showed a significant difference in medial-lateral COM displacement (p=0.030) (chacott 45.73ą14.23 mm and R-class 57.33 ą 3.22 mm) while there was no significant difference in anteroposterior and upward-downward directions. In addition, Chacott point shoes showed less knee abduction and adduction angle (p=0.034) (Chacott 2.45 ą 5.33 and R-class 6.48ą5.54) in the non-dominant leg (right leg) during ballet Arabesque. CONCLUSIONS: The results highlighted that the Chacott point shoes which have softer toebox than R-class had a small medial-lateral COM displacement and had lesser knee abduction-

adduction angle than the R-class point shoes. These results from this study suggest that even though the Chacott has softer toebox, it may have the potential to increase the foot support and body stability compared to R-class during ballet Arabesque. However, in the other hand, dancers with softer Chacott shoes may use relatively stiff posture to complete the task. Future studies should investigate the muscular contribution to the performance between these two ballet shoes.

P-P-283: Eccentric exercise-induced muscle damage leads to local changes in the amplitude of supramaximal M waves detected along biceps brachii muscle.

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BACKGROUND AND AIM: Previous evidence suggests site-dependent changes in the electromyograms (EMGs) may be triggered following eccentric exercise-induced muscle damage (EIMD) [1,2]. However, other factors not attributable to EIMD may contribute to this spatially localized activity, as the prolonged pain that accompanied eccentric exercise [3]. It seems therefore advisable to make sure the population of motor units recruited is the same when using surface EMGs to assess the local muscle adaptations resulting from EIMD. In this study, we combined supramaximal electrical stimulation of the musculocutaneous nerve with high-density surface electromyography (HDsEMG) to ask whether EIMD leads to local changes in the amplitude of M waves detected along biceps brachii. METHODS: Ten healthy, male subjects were submitted to following measures conducted immediately before and four consecutive days after 3x10 eccentric elbow flexions: (i) perceived soreness of right elbow flexors during passive stretching; (ii) acquisition of ultrasound images proximally and distally from biceps; (iii) recording of monopolar HDsEMG (64 electrodes) from biceps while 10 supramaximal pulses were applied transcutaneously to the musculocutaneous nerve; (iv) two isometric, elbow flexion maximal voluntary contractions (MVC) on a dynamometer. For each of 59 single-differential signals, M waves were averaged and their peak-to-peak amplitude was computed. The innervation zone (IZ) longitudinal location, the number of electrodes detecting the largest M waves (segmented channels; [4]) and their relative longitudinal position were assessed to characterize EIMD induced changes on M waves. RESULTS: The perceived muscle soreness increased with respect to baseline at 24, 48, 72 and 96 h after EIMD ($P<0.004$), while the MVC peak torque significantly decreased at 24, 48, 72 and 96 h after EIMD ($P<0.001$). The echo intensity of ultrasound images increased from 48 to 96 h with respect to baseline for both proximal and distal regions ($P<0.001$), while no differences were observed among regions at any time ($P=0.136$). No time effect was observed for the IZ location (panel A; $P=0.283$). The number of segmented channels significantly decreased (panel B) and the longitudinal coordinate of the centroid shifted towards the distal region of the muscle at 24, 48 and 72 h after EIMD (panel C; $P<0.032$ in both cases). CONCLUSIONS: The amplitude distribution of M waves changed consistently in the proximal biceps brachii region up to four days after EIMD. Our results therefore suggest a local effect of EIMD on biceps brachii muscle excitation and demonstrate the potential of HDsEMG to assess both spatial and temporal effects of EIMD on muscle function. REFERENCES: [1] Hedayatpour et al. 2008; Med Sci Sports Exerc 40(2):326-34. [2] Piitulainen et al. 2009; Muscle Nerve 40(4):617-25. [3] Madeleine et al. 2006; Clinical Neurophysiology 117(11):2436-45. [4] Vieira et al., 2010; J Biomech 43(11):2149-58.

P-P-284: Regional changes in gastrocnemius muscle activation after repeated bouts of eccentric exercise

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BACKGROUND AND AIM: The repeated bout effect (RBE) confers protection following unaccustomed eccentric exercise-induced muscle damage in such a way that the markers of muscle damage are reduced if the same bout of exercise is repeated days to weeks after. The aim of this study was to explore if neuromuscular adaptations, assessed as regional changes in activation, mechanical hyperalgesia and soreness, are associated with the RBE of the medial gastrocnemius (MG) muscle. METHODS: Twelve healthy sedentary male participants (age 23 ą 3 years, mass 71 ą 11 kg, height 173 ą 6 cm) performed two bouts (seven days between bouts) of eccentric heel drop exercise (20 repetitions per series that continued until exhaustion, 3 min rest between series) while wearing a vest equivalent to 20% of their body weight. High-density electromyographic signals (monopolar, 64 channels) were recorded from the belly of the MG muscle during an isometric contraction at 60% of the plantar flexor maximal voluntary contraction before (PRE), two hours (2H) and two days (2D) after both exercise bouts. EMG Root Mean Square (from single-differential signals computed in the cephalocaudal direction) and pressure pain thresholds were used to create amplitude and topographical pressure pain sensitivity maps (70 x 60 mm each) at each time point for each participant. Statistical parametric mapping (full factorial analysis with repeated measures) was used to identify RBE effects on muscle activity and mechanical hyperalgesia, using pixel-level statistics when comparing maps. RESULTS: The results show that that our exercise protocol resulted in the presence of a RBE, which manifested as a reduced increase in soreness (38% less increase) and a reduced drop in isometric MVC (24% less drop) after the second bout of exercise. The topographical maps of EMG activity (Figure 1) revealed that different muscle regions are activated 2H and 2D after the initial bout of exercise, with a larger region of muscle (16% larger) activated at 2H in comparison to 2D . However, no change in the activity pattern was observed following the repeated bout. Soreness levels were lower after the repeated bout, but no changes in mechanical hyperalgesia distribution were found. CONCLUSIONS: These findings indicate that muscle activation is unevenly distributed between the initial and repeated bouts, possibly to maintain muscle function during localized mechanical fatigue. However, the results do not reflect a strategy to confer protection by recruiting undamaged/non fatigued muscle fibers located in a different muscle region. Since previous studies suggest that mechanical adaptations are unlikely to explain the protection conferred to MG, adaptations in tissues other than active muscle fibers, for example connective tissue, may predominate as the underlying mechanism of the RBE in this muscle.

P-Q-285: Online Tracking of Phase Difference between Neural Drive to Antagonist Muscle Pairs of Essential Tremor Patients Using Digital Phase-locked Loops

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Non-invasive electrical stimulation has gained interest in tremor suppression applications. Co-contraction and out-of-phase stimulation strategies applied above or below motor threshold (an excitation level that could activate the muscle contraction) have shown significant success in attenuating tremor movements in laboratory tests (Gallego et al., 2013; Dosen et al., 2015; Dideriksen et al., 2017). However, recent research has revealed that the tremor-related neural drives to an antagonist pair of muscles are not always out- or in-phase but their phase relation varies over time (Puttaraksa et al., 2019). In order to improve the performance of this electrical-stimulation-based tremor suppression strategies, a precise control of the stimulation timing is required. Here we propose an online tremor phase and frequency tracking technique for the customized control of electrical stimulation, which is based on a well-known control system (a phase-locked loop; PLL). Surface electromyography (sEMG) signals were recorded from the wrist extensor and flexor muscle groups of 11 essential tremor patients. Postural tremor was evoked by asking the patients to outstretch their hands against gravity. The EMG signals were pre-processed and decomposed offline via the convolution kernel compensation (CKC) algorithm (Holobar & Zazula, 2003, 2007; Holobar et al., 2010) to discriminate motor unit (MU) spike trains. The summation of all the MU spike trains detected in a muscle generates a cumulative spike train (CST) representing the neural drive to the muscle. The rectified EMGs and the CSTs were bandpass filtered between 3 to 10 Hz to isolate the tremor related components of the neural drive and used as inputs to validate the ability of the PLL in following changes of the phase difference (PD) between the two muscles. The online estimated PD was compared with the PD values calculated offline using the Hilbert Transform (ground truth, GT), a standard phase calculation technique in order to calibrate the PLL system. The results show that our PLL was able to track the PD of tremor signals with an averaged correlation to the offline PD of 0.88 ± 0.09 for the CSTs and 0.84 ± 0.15 for the EMGs. The averaged difference between GT and the estimated PD of CSTs was 12.01 ± 14.98º and EMG was 15.48 ± 8.67º. There was no significant difference in PD estimation from the neural drives (CSTs) or EMGs (p-value = 0.90 and 0.13, T-test and Wilcoxon-Mann-Whitney test for correlation and averaged PD, respectively). Our results support the feasibility of PLL for online PD estimation.

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