## P1.1-A: Changes in mid-thigh muscle and adipose tissue cross sectional areas in older people: a seven years study

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Introduction: Aging is defined as a gradual decline in physical capacity, which results in a progressive decline in the performance of multiple organs. It has been suggested that habitual exercise prevents muscle mass reductions in older people. However, it is less clear how once-a-week exercise influences mid-thigh muscle mass and adipose tissue in older people. The purpose of this study was to examine the changes in mid-thigh muscle and adipose tissue cross sectional areas (CSAs) in community-dwelling older people.Method: The present cohort study (Fukuoka Island City Study: UMIN Clinical Trials Registry, registration number: 000036659) was conducted in 2015, 2017, 2018, and 2022. We used data from 20 participants (14 females, age: 70.3 ± 7.5 yr., height: 153.9 ± 8.2 cm, weight: 52.4 ± 11.1 kg, at the initial measurement) who completed all four measurements. The participants joined exercise class once a week. Quadriceps muscle and adipose tissue CSAs at the mid-thigh (50% of the femur) region were collected using magnetic resonance imaging (MRI). Muscle and intramuscular, intermuscular, and subcutaneous adipose tissue CSAs were analyzed using the sliceOmatic program (Tomovision, Montreal, Canada). We performed a repeated measures correlation analysis to examine the relationship between age and muscle/adipose tissue CSAs.Results: Repeated measures correlations revealed that the quadriceps muscle CSA (r = -0.623, confidence interval (CI) [-0.756, -0.440], p < 0.001) was negatively correlated with age. This indicates that muscle CSA decreased as a function of age. There were no significant correlations between age and intramuscular (r = 0.216, CI [-0.037, -0.444], p = 0.094), intermuscular (r = 0.180, CI [-0.075, 0.413], p = 0.165), subcutaneous (r = 0.121, CI [-0.135, 0.362], p = 0.353) adipose tissue CSAs. However, when expressed relative to muscle CSA, intramuscular adipose tissue CSA was positively correlated with age (r = 0.302, CI [0.054, 0.514], p = 0.018).Conclusion: The present findings suggest that once-a-week exercise did not prevent muscle atrophy in older people. Aging appears to affect mid-thigh muscle and intramuscular, intermuscular, and subcutaneous adipose tissue in a different manner.

## P1.2-A: Novel approach to highlight differences in balance control in young and older adults

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INTRODUCTION: Balance is a complex perceptual-motor capacity that relies on multiple systems and, as these systems undergo gradual declines related to aging, it makes it more difficult to maintain balance. It is imperative to identify and characterize important features associated with this decline in balance control to develop targeted interventions. Understanding both linear and nonlinear dynamics is key to fully characterizing postural control. Linear measures like sway path length and range assume balance operates through proportional, predictable responses to perturbations. However, balance is adaptive and complex, involving nonlinear interactions between sensory systems, muscles, limbs, and the environment. Small changes in one element can lead to large unpredictable effects overall. Nonlinear analysis can capture this complex variability in postural sway patterns over time, while linear approaches cannot. Here, we examine the control of balance of young and older adults during both simple and dual tasks using a method developed by our group that provides insights into nonlinear dynamics of human movement. The method uses simple algorithms to decompose movements into one-dimensional sub-movements within a Cartesian coordinate system.METHODS: We recruited 22 healthy young adults (23.4±5.6 years) and 23 healthy older adults (64.04±7.18 years). Anteroposterior and mediolateral movements were captured from an overhead camera during a simple bipedal standing task, with and without the simultaneous performance of a cognitive task (listing words starting with a specific letter). Each participant performed a total of X trials of 30s. Movement data was extracted from the video and segmented into the sub-movements. Several features of those sub-movements were then compared statistically between groups and tasks.RESULTS: The proportion of sub-movements that matched the theoretical model (homogeneous set) varied across groups and tasks. The average percentage (±SD) of sub-movements included in the homogeneous set was 46.0±6.0% and 44.4±8.0% for the young group during the simple and dual tasks, respectively. For the older group the distribution was 50.3±7.8% and 43.2±6.7% for the simple and dual tasks, respectively. A two-way mixed model ANOVA showed that the percentage of sub-movements in the homogeneous set was statistically larger for the simple task than for the dual task when groups were pooled ($p=0.005$) but that there was no difference between groups when both tasks were pooled ($p=0.306$). There was also a statistically greater percentage of sub-movements in the homogeneous set during the simple task than in the dual task in the older group ($p=0.008$). Additionally, specific features, including the number of sub-movements and the nonlinear factor between velocity and displacement, were significantly different between groups.DISCUSSION: These results highlight that both linear and nonlinear approaches to the evaluation of balance are important as they provide complementary information and nonlinear metrics were the most sensitive to changes in balance. Furthermore, our results show that the complexity of balance increases during the dual task, especially in the older group, highlighting the impact of the task on underlying control structures. Future work will focus on identifying how these linear and nonlinear features respond to interventions and if we can use those to personalize treatments.

## P1.3-A: Comparison of differences in arterial stiffness gradient according to the degree of unilateral arm exercise participation

Do-Yeop Kim, Incheon National University; Ruda Lee, University of Iowa; Moon-Hyon Hwang, Incheon National University

Comparison of differences in arterial stiffness gradient according to the degree of unilateral arm exercise participationDo-Yeop Kim, Ruda Lee, Moon-Hyon HwangINTRODUCTIONPulse wave velocity (PWV), a validated measure of arterial stiffness, is a clinical indicator to evaluate cardiovascular disease risk. Arterial stiffness gradient, a novel marker of cardiovascular morbidity and mortality, is the ratio of central (aortic or carotid to femoral, cf) PWV to peripheral (arm or leg) PWV. Regular physical activity reduces central arterial stiffness in various populations including chronic cardiometabolic disease patients. But its effect on peripheral PWV is still controversial. In addition, there are a handful of studies to investigate alterations in peripheral PWV in response to unilateral exercise. Therefore, the purpose of this study was to compare the differences in arterial stiffness gradient according to the degree of unilateral arm exercise participation.METHODTwenty-six young women participated in this study; eight elite-level badminton players (ELIT), ten club-level badminton players (CLUB), and eight age-matched sedentary participants (CONT). Carotid-femoral PWV (cfPWV) as the central stiffness was measured using SphygmoCor Xcel system. Brachial-radial PWV (armPWV) as the peripheral stiffness was measured using Doppler Flowmeters and the associated data was collected and analyzed by PowerLab data acquisition system including Labchart Pro V8 software. Arterial stiffness gradient was calculated as the ratio of cfPWV to armPWV at both dominant and non-dominant arm, respectively.  RESULTSIn the dominant arm, the arterial stiffness gradient of ELIT and CLUB were significantly higher than CONT (0.73 vs. 0.46, ELIT vs. CONT, P<0.001; 0.59 vs. 0.46, CLUB vs. CONT, P=0.04). The arterial stiffness gradient of ELIT was also significantly higher than CLUB (0.73 vs. 0.59, ELIT vs. CLUB, P=0.03).In the non-dominant arm, the arterial stiffness Gradient of ELIT was significantly higher than CONT (ELIT: 0.59 vs. CON: 0.44 P= 0.007), but there was no significant difference between ELIT and CLUB, and CLUB and CONT (0.00 vs. 0.00, ELIT vs. CLUB, P=...; 0.53 vs. 0.44, CLUB vs. CONT, P=0.09).CONCLUSIONThe more unilateral arm exercise accumulated in the dominant arm, the higher the arterial stiffness gradient. The transfer effect of training regarding arterial stiffness gradient is only seen in the ELIT. In active young adults, increased arterial stiffness gradient may be associated with reduced cardiovascular disease risk.

## P1.4-B: Sign language recognition system based on multi-channel surface electromyography

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This study introduces a novel Sign Language Recognition (SLR) system based on Surface Electromyography (sEMG) signals, designed to address the communication barriers faced by approximately 466 million people worldwide with hearing loss. Traditional SLR methods, mainly camera-based, face limitations such as dependence on lighting conditions, restricted detection range, and computational expense. Sensor-integrated gloves also present the inconvenience of usage.The sEMG sensors can overcome these problems, offering a more versatile and user-friendly approach. Wearable device is one of the current trend and focus of technology. Such sEMG-based devices can be utilized in many applications, including sign language recognition systems, gesture recognition, and prosthesis control.The primary objective of this research is to develop a sign language recognition system using a 32-channel EMG sensor, capable of estimating surface and deeper muscle activities through Independent Component Analysis (ICA). This system aims to accurately identify several alphabets and gestures from American Sign Language (ASL).Methodologically, the research involves data collection using a 32-channel electrode sleeve for EMG signals from participants performing sign language gestures. The preprocessing of this data involves filtering raw EMG signals to eliminate noise and artifacts, followed by ICA to extract a few components, allowing for the differentiation of surface and deeper muscle activities. The IC components with noise were removed, and the remaining clean components were used to reconstruct the original signal. The reconstructed signal was then rectified and processed with a lowpass filter to acquire the envelope. These preprocessing methods aim to remove noise and minimize input signals.Four features were calculated from the processed IC components, including root mean square, variance, integrated EMG, and mean absolute value. For the classification process, features were input into a Support Vector Machine (SVM) classifier, and five-fold cross-validation was performed to check the accuracy. With five stationary American Sign Language gestures, the SVM classifier achieved 96.6% accuracy on the raw EMG signal, and the accuracy improved to the highest 98.4% with the processed signal.

## P1.5-B: Error Movement Detection System for Baseball Pitching Using MediaPipe and LSTM-based Deep Learning

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In recent years, artificial intelligence and computer vision technology have been developing rapidly and have been widely applied in various research fields, such as medical rehabilitation, motion-sensing games, and sports quality monitoring. The focus of this study was to utilize human body pose recognition technology for error detection in baseball pitching movements. Seven college baseball players were recruited into this study, and each player performed 10 pitches in an outdoor setting. The camera was fixed at 2 meters to the side of the players for video recording. This study aimed to detect errors in the shoulder, torso, and lower limb positions from the foot contact to the arm cocking phase of the pitching process. Coaches evaluated four types of errors based on the players' motion videos, including: insufficient trunk rotation, the throwing elbow is not level with the line of the shoulders, the throwing arm is not level with or slightly behind the body, and insufficient stride length. In this study, Python programming language and MediaPipe's Python API was employed for images RGB color conversion and changed the images into a fixed resolution (1280*720) and frame (30 fps). Subsequently, the three-axis coordinate data of 12 landmarks on the body, such as the both side shoulder, elbow, wrist, hip, knee, and ankle, were extracted by using a pre-trained deep neural network model in MediaPipe. Before training and testing the model, the pose data were divided into 80% for training data and 20% for testing data. Finally, the long short-term memory (LSTM) was used to establish a pitch style classification model. The classification accuracy for the four types of error movements was 81.48%, 85.71%, 85.19%, and 88.89%, respectively. The results of this study showcase the viability of employing Human Pose Estimation and Machine Learning algorithms to automatically detect the players' error pitching movements. In conclusions, the findings of this study hold the promise of benefiting players, coaches, and researchers, thereby making a meaningful contribution to the instruction of baseball skills.

## P1.6-C: Comparing of lower limbs kinematics between 3D motion analysis and Inertial measurement unit during countermovement jump in healthy adults

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Background: Jumping is a crucial sporting skill that provides valuable information for treatment and rehabilitation assessments. Inertial measurement units (IMUs) have emerged as an alternative tool for evaluating joint kinematics during movement analysis. However, comparative data supporting the use of IMUs during countermovement jumps (CMJs) is lacking.Objective: To compare lower limb kinematics between 3D motion analysis and IMU

during CMJs in healthy adults.Methods: Thirteen healthy individuals (9 males, 4 females; age 21.85 ± 0.66 years) participated in the study. Kinematic data were collected using 16 retroreflective markers and eight IMU sensors attached to anatomical landmarks according to the lower limb Plug-in gait model. Participants performed three CMJs while kinematic data were recorded using 3D motion analysis and IMU systems. Paired t-tests were employed to compare peak ankle, hip, and knee joint angles between the two measurement methods. Bland-Altman plots were used to assess the agreement between the two methods.Results: No statistically significant differences were observed in peak hip, knee, and ankle angles (p > 0.05) between the two measurement methods, except for left hip abduction/adduction, right knee abduction/adduction, and both ankle dorsiflexion/plantarflexion angles (p < 0.05). Of the total measurements conducted between the two methods, 100% (1/19) of hip motion measurements fell within the limits of agreement, while 7.6% (1/13) of knee and ankle motion measurements did not fall within the limits of agreement.Conclusion: This study suggests that IMUs provide acceptable agreement with 3D motion analysis for assessing kinematics during CMJs. Further research is warranted to validate these findings in larger and more diverse populations.

### P1.8-C: **Role of the upper trapezius muscle on clavicular kinematics: an exploratory study**

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Background: The role of upper trapezius (UT) muscle in scapular kinematics demonstrated inconsistent findings in previous studies. One possible reason for the conflicts might arise from the influence of clavicular movement. The purposes of this study were firstly to establish the measurement reliability of clavicular kinematics, and secondly to explore the effect of the UT stimulation on clavicular kinematics.Methods: Eleven asymptomatic healthy adults between 20-30 y/o were recruited. Three-dimensional scapular and clavicular kinematics were collected using the Polhemus Liberty electromagnetic tracking system with the clavicular mini-sensor (CS) and the scapular sensor (SS). Scapular and clavicular kinematics were recorded with the subject's arm rest by side, and at scaption angles of 120, 90, 60, 30 degrees while the neuromuscular stimulation (NMES) of the UT was delivered. The NMES intensity was the maximal intensity that produced UT activation without activating the levator scapulae based on the real-time musculoskeletal ultrasonography. The between-day measurement reliability of clavicular kinematics was assessed using the intraclass correlation coefficients (ICC3,2). Paired t-tests were used to compare kinematics before and after ES.Results: Our results showed that the test-retest reliability coefficients of measuring clavicular kinematics were similar for CS and SS (CS: 0.62-0.91, SS: 0.63-0.98) with smaller standard errors of measurements (CS: 0.59-5.23, SS:0.48-7.08) and minimal detectable changes (CS: 1.07-3.2, 0.97-3.73) for CS. With CS, smaller clavicular elevation (CS: -3.38±4.54 to -6.31±6.66, SS: 0.14±9.64 to -8.77±11.38) and retraction (CS: -21.13±6.72 to -35.59±10.5, SS: -22.22±6.51 to -15±15.48) were observed during arm elevation, which was similar to data reported previously using the bone-pin sensor. NMES of the UT resulted in significant clavicular retraction at scaption 0, 30 and 60 degrees and posterior rotation at 30, 60, and 120 degree (p<0.05), and scapular upward rotation at 0, 30, and 60-degree of scaption (p<0.05).Conclusions: Using a clavicular sensor to record clavicular kinematics is recommended for it was a reliable and had smaller measuring errors when compared with the scapular sensor. Activation of the upper trapezius produced scapular and clavicular movement under 60 degrees of scaption; but only produced clavicular movement up to 120 degrees of scaption.

## P1.9-C: Robot-assisted weight relief for prevention of musculoskeletal pain among bronchoscopists

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IntroductionMusculoskeletal disorders (MSDs) are a common challenge among endoscopists due to prolonged awkward postures during procedures [1]. A study involving clinicians performning pulmonary endoscopic procedures, specifically bronchoscopists, revealed that 50.6% of survey respondents reported musculoskeletal pain [2]. Among endoscopists, the most severe regions of pain reported are the back, neck, and shoulders [2, 3]. This study investigated the effects of a robotic weight relief system for alleviating the physician's arm during simulated bronchoscopy to reduce MSDs.MethodsSix experienced bronchoscopists from the Department of Respiratory Medicine at Odense University Hospital participated in the study using a repeated-measures design. They each conducted two 40-minutes bronchoscopies on a GI-BRONCH Mentor endoscopy simulator, one conventional procedure and one using the robotic weight relief system, which was attached to the arm holding the bronchoscope. Bipolar surface electromyography (EMG) recordings were collected from the forearm and shoulder, and an Amplitude Probability Distribution Function (APDF) was calculated to find the static (10), median (50), and peak (90) levels of muscle activity. Changes in arm movement patterns were investigated using accelerometer data. Results and discussionThe APDF indicated increased forearm muscle activity during the weight-relieved bronchoscopy compared to the conventional procedure (see Table). This increase in muscle activity was likely due to the attachment of the robotic system to the wrist, requiring the subject to make ulnar deviation to maintain a stable and vertical position of the scope. For the shoulder, the APDF showed reduced muscle activity when performing the weight-relieved bronchoscopy, with statistical significance observed for the peak level for anterior deltoid and the static level for medial deltoid (see Table). Overall, the EMG analysis indicated that the robotic system was more demanding on the forearm and less demanding on the shoulder compared to the conventional procedure.The study found an average increase in arm elevation angle of 5.9 degrees during the weight-relieved bronchoscopy. This increase along with the decrease in shoulder muscle activity suggests that the robotic system may be effective in preventing MSDs in procedures that require elevated arm positions and allow for better flexibility and variation without increasing the shoulder load. ConclusionThe decrease in shoulder muscle activity along along with the changes in arm movement pattern indicated a positive impact of the robotic system. This provides an incentive for further development of the system to improve its effectiveness in reducing musculoskeletal pain among bronchoscopists.ReferencesKamani L, Kalwar H, Clin Endosc 54(3): 356-362, 2021 Gilbert CR, et al., J Bronchology Interv Pulmonol 20(2): 113-20, 2013Yung DE, et al., Expert Rev Gastroenterol Hepatol 11(10): 939-947, 2017

## P1.10-C: The laterality of the postural stability and the shock attenuation on legs: a comparison of dancers and non-dancers

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PurposeA number of studies have been done regarding postural stability and the shock attenuation ability in dancers because of their superior skills to non-dancers. However, the effect of dance experience on the laterality of these abilities between legs is still controversial. Therefore, this study aims to identify whether the dance experience affects the lateral bias by using questionnaires and kinetic measurements.MethodThirty-two Japanese female university students participated in this study. They were divided into two groups according to their dance experience regardless of the genre: a dancer group (D) with more than 5 years of dance experience and continuing that at least once a week (n=15) and a non-dancer group (ND) with less than 5 years of experience (n=17). They were asked to answer the Japanese version of the Waterloo Footedness Questionnaire (WFQ-R) (Elias et al., 1998) to evaluate their foot preference with numerical values from -20 to 20. After that, they performed a single-leg stance and single-legged drop landings on a force plate (frequency of 1000 Hz) under three conditions: eyes-open, eyes-open with a mirror and eyes-closed (not for the drop landing). Then, the center of pressure (COP) and the ground reaction force (GRF) were used for calculating the sum of COP displacement, the rectangular area of COP, the peak vertical GRF, the time to stabilization (TTS) (Scott et al., 1999) and the shock attenuation ability. The laterality ratio (LR score) was generated by dividing data from the left leg by data from the right leg. Then, the LR score was compared between two groups and among three conditions.Results and DiscussionThere were no differences in the result of the WFQ-R between groups, resulting in the dance experience did not influence foot preference. For the force plate experiments, the shock attenuation ability under the eyes-open condition showed a difference in the LR score between groups (p=0.044); specifically, group ND tended to have left-leg dominance, whereas group D was equal or right-leg dominance. However, no other significant difference was observed between groups or among conditions. Therefore, it might indicate that the dance experience influences the shock attenuation ability but not the postural stability, which contradicts previous studies. Based on this, the influence of dance experience on postural stability might be applied only to professional or pre-professional ballet dancers.ConclusionIn this study, the difference in the laterality between groups was observed in the shock attenuation ability, meaning that might be an element that the dance experiences across genres and training levels have influences on. In contrast, the effect on the postural stability might vary depending on the dance genre or intensity of the training. Further research on these skills in dancers would contribute to the usage of dance in clinical settings.

## P1.11-C: Beyond the left ventricle: exploring the impact of the right ventricle for commotio cordis

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Introduction: Commotio cordis (CC), sudden cardiac death due to chest impacts, has predominately been studied in the context of electrophysiology with a focus on the left ventricle1. Lacrosse, recognized as one of the leading sports associated with CC, serves as a unique setting for investigating the impact dynamics of the heart2. The traditional assumption

that the left ventricle is more vulnerable, particularly during the critical phase of repolarization, has guided much of the previous research3. However, this conventional view might oversimplify the intricate dynamics at play, overlooking the right ventricle during chest impacts. This study challenges the assumption that the left ventricle is solely responsible for CC incidents. By investigating the strain dynamics of both ventricles during lacrosse impacts, this study aims to provide a deeper understanding of the roles played by both ventricles in the occurrence of CC. Methods:Using the v4.0 THUMS (Total Human Model for Safety) Adult Male 50th Percentile computational model, we analyzed left and right ventricular involvement during CC inducing impacts. Simulating real-world CC scenarios in the context of sport, a 90-mph lacrosse ball impacted both ventricles during a 20 ms simulation, replicating the timeframe during which CC can occur4. This enabled an in-depth exploration ventricular dynamics during the development of CC. Results:Distinctive strain patterns were observed in both ventricles. In left ventricular impacts, the left ventricle showed higher strain accumulation with an average strain of 14.97% compared to 13.12% in the right ventricle (Fig. 1D). In right ventricular impacts, the left and right ventricular average strain was 11.83% and 14.82% respectively (Fig. 1C). Ventricular strain thresholds across both impact scenarios varied depending on impact location (Fig1. A, Fig. 1B), highlighting differences in strain distribution. This quantitative measure forms the basis for a detailed comparison of the two ventricles. A lateral view of the heart in initial state 0 ms (Fig. 1D) vs. peak compression from impact at 6 ms can be seen in Fig. 1E. Discussion:Our results suggest that the right ventricle exhibits strain patterns that warrant attention. The findings spark a discourse on the potential involvement of the right ventricle in re-entrant mechanisms. Understanding the strain dynamics in both ventricles becomes pivotal for knowledge transfer in cardiac electrophysiology. These findings challenge the conventional focus on only the left ventricle in CC studies, emphasizing the need for a comprehensive understanding of the right ventricular role. This research contributes valuable insights to the broader field of cardiac electrophysiology, advocating for a more inclusive approach when evaluating the cardiac consequences of chest impacts. References1. Link et al. JCC (2001)2. Maron et al. Heart Rhythm (2011)3. Bode et al. J Cardio Electro (2006)4. Link et al. N Engl J Med (1998)

## P1.12-E: The persistence of F-wave does not change with stimulus intensity from submaximal to supramaximal stimulation, but the shape of the F-wave waveform is completely different

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IntroductionF waves are one of the indicators of spinal cord anterior horn cell excitability, and the test of F wave is somewhat painful for subjects because it involves electrical stimulation of the alpha motor nerve with supramaximal stimulation. Therefore, we investigated whether it is possible to obtain results similar to those of the usual F wave test by decreasing the stimulation intensity. Stimulus intensity was 90-120% of the intensity at which the maximum amplitude of the M wave is obtained. In order to examine the reproducibility of the F wave data for each stimulus intensity, these trials were performed five times with an interval of at least one day, and the variability of the results was examined. As a result, no obvious changes in the persistence of

F wave. In the present study, we limited the stimulus intensity to 90-120% and examined the persistence of the repeater F wave using F wave waveform analysis software developed by Hanaoka et al. MethodsF wave was recorded from the abductor pollicis brevis muscle during median nerve stimulation in five healthy subjects. For stimulus conditions of median nerve stimulation, frequency was 1 Hz, duration 0.2 ms, and number of times of stimulation 64 times. The stimulation intensity was 90 to 120% of intensity at which the maximum amplitude of M wave was obtained, and F wave was recorded 4 times at 10% intervals. For recording conditions, the probe electrode was placed on the belly of the left abductor pollicis brevis muscle, reference electrode on the left basal phalanx of the left thumb, and the ground electrode at the center of the palmar side of the left forearm. F wave analysis items were the persistence of F wave and repeater F wave, and types of repeater F wave in all 5 trials of stimulation using F-wave waveform analysis software developed by Hanaoka et al. The coefficient of variation of F-wave data with the different stimulus intensity was obtained. We also examined whether repeater F waves appeared on different days at same intensity. This study was approved the Research Ethics Committee at Kansai University of Health Sciences (Approval No. 21-06). RESULTSThe variation in persistence of the F-wave with changes in stimulus intensity had a coefficient of variation of less than 0.08. The coefficient of variation of the frequency and types of repeater F wave with changes in stimulus intensity was 0.25 in one subject, while the coefficient of variation was greater than 0.6 in the four subjects. Repeater F waves appeared between trials with different testing dates in 3 subjects for 90% stimulation and in only 1 subject for 120% stimulation. No repeater F waves appeared with different testing date for 100% and 110% stimulation. DiscussionIn this study, we examined five trials of F waves with varying stimulus intensity from 90% to 120% on different days. Persistence of F wave was similar with varying stimulus intensity, but the frequency and types of repeater F wave differed significantly. From the result in this study, the excitability of anterior horn cells in the spinal cord was similar, but types of anterior horn cells to make up F wave was different with changes in stimulus intensity. And the type of spinal cord anterior horn cells to make up the F wave with the same stimulus intensity may result in completely different on different inspection dates.

## P1.13-E: A comparison of techniques to determine active motor threshold from lower limb transcranial magnetic stimulation (TMS)

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The determination of active motor threshold (AMT) is a critical step in transcranial magnetic stimulation (TMS) research protocols involving voluntary muscle actions. Defined as the lowest stimulator output intensity necessary to evoke reliable responses of the target muscle, AMT is frequently determined using an absolute electromyographic (EMG) threshold (i.e., 200µV peak-to-peak amplitude). However, absolute EMG values acquired during voluntary contractions vary greatly across participants, muscles, days, and recording systems. To overcome these limitations, TMS researchers have proposed using a relative threshold when quantifying AMT (i.e., 2× background EMG during the voluntary contraction), but these approaches have never been systemically compared in the lower limbs. PURPOSE: We sought to investigate the test-retest reliability of two methods commonly used to determine AMT in lower limb TMS, as well as

compare these approaches (absolute = 200μV vs. relative = 2× background EMG). METHODS: Eighteen young adults (9 males and 9 females; mean ± SD age = 23 ± 2 years) visited the laboratory on two occasions. All testing was conducted on the dominant knee extensors. During each laboratory visit, isometric maximal voluntary contraction (MVC) peak torque was measured, with all subsequent TMS procedures conducted as participants maintained 10% of MVC peak torque. AMT values were determined for each method using motor evoked potentials recorded from the vastus lateralis (VL). TMS pulses were delivered at a predetermined hotspot location while participants briefly activated their knee extensors at 10% MVC peak torque (~3-4 seconds), with ~10 seconds between TMS pulses. AMT was defined as the lowest stimulator output (%) needed to meet the specified criteria in ≥5/10 pulses. The order of the methods (i.e., absolute vs. relative) was randomized and counterbalanced. Intraclass correlation coefficients ($ICC_{3,1}$), standard errors of measurement (SEMs), and the minimal difference (MD) score were calculated to assess test-retest reliability of each AMT determination method. A dependent samples t-test was used to compare mean differences in acquired AMT values obtained during the second laboratory visit. RESULTS: Both the absolute and relative methods demonstrated good-to-excellent test-retest reliability ($ICC_{3,1}$ = .887 and .893, respectively), and the SEM/MD values were similar (absolute SEM = 7.9%, MD = 10.4%; relative SEM = 6.9%, MD = 8.9%). Differences between AMT methods were small and not statistically significant (absolute mean = 48.9%, relative mean = 47.4%; $p = .309$, Cohen's $d = 0.247$) (Figure 1). CONCLUSION: Quantifying AMT with an absolute threshold of 200μV peak-to-peak amplitude and 2× background EMG resulted in similar values for the VL. Lower limb TMS researchers can expect good-to-excellent reliability with both AMT determination methods. Given our findings, the use an absolute or relative AMT method may be considered on a case-by-case basis.

## P1.14-E: **Estimates of persistent inward current magnitude may predict upper limb function in people with incomplete cervical spinal cord injury**

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Motor commands are comprised of excitatory, inhibitory, and neuromodulatory components, and disruptions in descending inputs caused by spinal cord injury (SCI) affects all three of these components. The aim of this study was to determine if these disruptions alter motor unit discharge patterns in the upper limb muscles following cervical SCI, and whether motor unit properties were associated with upper limb function. Experiments were performed on twenty-one people with chronic, incomplete SCI at the cervical level, and fifteen non-injured control participants. High-density surface electromyographic arrays were placed over the biceps and triceps brachii and participants were seated with their arm secured to a force transducer. Elbow flexion and extension maximal voluntary isometric contractions (MViC) were used to normalize subsequent contractions. SCI participants were categorized into high-functioning and low-functioning groups based on MViC values. Participants performed submaximal isometric triangular ramps up to 30% MViC. Blind source separation was used to identify spike times of biceps and triceps motor units and persistent inward currents were estimated using the paired-MU analysis technique, which quantifies discharge rate hysteresis (ΔF). Preliminary results revealed that estimates of PICs were lowest in the low-functioning SCI participants and highest

in the high-functioning SCI participants. This suggests that PICs are impaired in low-functioning, but enhanced in high-functioning, SCI participants, and that enhanced motoneuron excitability may augment function in some people with incomplete SCI in the presence of disrupted motor commands.  These findings may help inform therapeutic strategies to enhance function in people living with chronic incomplete SCI.

## P1.15-E: Effects of operant conditioning of the motor evoked potential (MEP) on the tibialis anterior MEP and silent period in people with chronic incomplete SCI

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Background: After spinal cord injury (SCI), corticospinal excitability diminishes, resulting in weak voluntary activation of muscles below the injury and impaired motor control. However, such deficits are reversible at least partially, and an intervention that increases corticospinal excitability may enhance motor function recovery. Thus, operant up-conditioning of the motor evoked potential (MEP) to increase corticospinal excitability may improve the activation of the targeted muscle and improve motor functions in which that muscle participates. Previous studies indicated that up-conditioning of the ankle dorsiflexor MEP can improve locomotion in individuals with incomplete SCI (J Neurophysiol 2018:120:2745-60; 2019:121:853-66). As the first step in investigating the mechanisms of corticospinal plasticity and therapeutic effects associated with MEP up-conditioning, we are currently examining changes in MEP size and silent period (SP) after MEP, which reflects cortical inhibition at least partly, in ankle dorsiflexor tibialis anterior (TA) of people with chronic incomplete SCI.Methods: Adults with chronic (>1 yr post SCI) stable incomplete SCI are exposed to an MEP up-conditioning or control protocol that consists of 6 baseline and 24 up-conditioning or control sessions over 10 wk. In all sessions, 225 MEPs are elicited at ~10% above active threshold in the TA while the participant maintains ~30% maximum voluntary contraction (MVC) level of TA EMG activity. During baseline and control sessions, MEPs are simply measured. During conditioning trials of the conditioning sessions, the participant is encouraged to increase MEP size and is given immediate feedback as to whether MEP was larger than a criterion. Over the course of study, MVC, MEP size, and SP (measured as the period from the end of MEP to the recovery of EMG activity to the prestimulus level) are measured, and all values are compared between the 6 baseline sessions and the last 6 conditioning/control sessions. Results & Discussion: Over the course of 24 up-conditioning sessions (N=12), MVC changed by +11±6%, MEP by +44±6%, SP by -23±6%, and 10-m walking speed by 0 to +50%; whereas over the 24 control sessions (N=5), MVC changed by +25±9%, MEP by +23±19%, SP by +12±18%, and walking speed by -30 to +50%. These initial observations suggest that MEP up-conditioning increases MEP size and decreases SP duration, while MEP control protocol may increase MVC and MEP in some while producing no reduction of SP. Most striking observation is that SP-to-MEP ratio (indicating the balance between corticospinal inhibition and corticospinal excitation) decreases very clearly and persistently (-45±5%) with up-conditioning, whereas such changes are not obvious with control (-2±12%), indicating MEP up-conditioning specific effects on corticospinal inhibition. To understand the potential link between SP changes and function improvements, further studies and analyses are currently underway.

## **P1.16-F:** The increase in spinal excitability is modulated by NMES frequency in the flexor carpi radialis but not in the soleus muscle

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BACKGROUND AND AIM: Superimposing neuromuscular electrical stimulation (NMES) on voluntary contractions has proven to be highly effective for improving muscle strength and performance (Borzuola et al. 2022). These beneficial effects might be related to specific adaptations occurring at cortical and spinal level. Some authors suggested that the effects of NMES on corticospinal activation could strongly depend on the stimulation frequency and significantly differ between upper and lower limb muscles (Mang et al. 2011; Blazevich et al. 2021). The aim of this study was to investigate acute responses in spinal excitability, as measured by H-reflex amplitude of flexor carpi radialis (FCR) and soleus (SOL) muscles, after a single bout of NMES superimposed on voluntary contractions (NMES+) of FCR and triceps surae (TS) muscles, delivered at low and high pulse frequencies (40 and 80 Hz). METHODS: Twelve healthy young adults took part in a single experimental session which involved four experimental conditions: 1) NMES+ of FCR at 40Hz; 2) NMES+ of FCR at 80Hz; 3) NMES+ of TS at 40Hz; 2) NMES+ of TS at 80Hz. Each experimental conditions consisted of fifteen intermittent contractions (6s contraction/6s rest) at submaximal force level. Participants performed an assessment of the maximal voluntary isometric contraction (MVIC) of the wrist flexor and ankle plantar-flexor muscles. The intensity of the stimulation was set to achieve the 20% MVIC for each contraction. Surface electromyography (sEMG) was used to record the amplitude of H-reflex and motor waves from the FCR and the SOL muscles, following percutaneous stimulation of the posterior tibial nerve and the median nerve, respectively. A small motor wave was kept constant throughout the experiment, to accurately compare H-reflexes (Zehr et al. 2002) before and after the conditioning contractions. Each condition was preceded by assessments of a baseline H-reflex and followed by a post-treatment H-reflex assessment and MVIC. RESULTS: In the FCR, H-reflex amplitude increased after both NMES at 40 Hz (+43.2%, p = 0.001) and 80 Hz (+24%, p = 0.003) compared to baseline. Similarly, in the SOL, H-reflex amplitude increased following both NMES at 40 Hz (+11.3%, p = 0.003) and 80 Hz (+9.9%, p = 0.001) compared to baseline. Notably, in the FCR, the H-reflex amplitude was significantly greater in response to the 40 Hz compared to the 80 Hz condition (p = 0.02), whereas there were no differences in post-assessment H-reflex amplitudes between low and high frequency NMES (p = 0.435) in the SOL.CONCLUSIONS: These findings indicated that superimposing NMES on voluntary isometric contractions has an excitatory effect on spinal motoneurons in both upper and lower limb muscles with the largest response after low frequency NMES in the FCR. Such facilitation could be associated to enhanced somatosensory stimuli conjunctly with higher supraspinal downward commands. These findings provide novel information on the neurophysiological mechanisms underlying electrical stimulation and offer new perspectives on exercise-induced adjustment in spinal excitability, which could be valuable in designing rehabilitation and training protocols.

## **P1.17-F:** Neuromuscular electrical stimulation superimposed on voluntary contractions increases force steadiness by modulating the neural drive to the tibialis anterior muscle

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BACKGROUND AND AIM: Neuromuscular electrical stimulation (NMES) has become increasingly popular for its ability to preserve, restore, or enhance muscle mass and function in healthy individuals and those with injuries (Vanderthommen and Duchateau 2007). Evidence indicates that superimposing NMES on voluntary contractions (NMES+) promotes further improvements in muscle performance through specific neuro-physiological adaptations (Lagerquist 2016). Specifically, NMES+ seems to modulate motor unit (MU) discharge characteristics (Borzuola et al. 2023), potentially affecting the capacity to generate and sustain muscle force. However, the neural mechanisms underlying NMES+ need to be fully explored to provide key insights into the methodological aspects of NMES. The aim of this study was to investigate the changes in motor unit discharge characteristics and force steadiness following three acute experimental conditions: NMES superimposed to voluntary isometric contractions of the ankle plantar-flexor muscles (NMES+ISO); passive NMES; and voluntary isometric contractions only (ISO). METHODS: Ten healthy young adults participated in this study. They were instructed to maintain an ankle plantar-flexor torque of 20% of their maximum voluntary isometric contraction (MVIC) for 15 contractions (6s contraction/6s rest) during each experimental condition. NMES was delivered over the tibialis anterior (TA), while the intensity of stimulation was adjusted to achieve the 20% MVIC for each contraction. High-density surface electromyography (HDsEMG) was used to record myoelectric activity in the TA during steady force-matching contractions at 10% MVIC. The motor unit discharge rate (DR) was calculated from the decomposition of the HDsEMG signal. A coherence analysis was performed on the decomposed signals and the proportion of common synaptic input (pCSI) received by spinal motoneurons was estimated by computing the rate of change of the relation between average coherence values in the delta frequency band (< 5 Hz) and the number of identified MUs. Moreover, the coefficient of variation of the force (CoVF) was computed during the steady contractions to assess force steadiness. Linear mixed effect models were used to analyse and compare the evaluated parameters before and after the experimental conditions.RESULTS: NMES+ induced a significant increase in DR and pCSI compared to baseline levels (DR, p=0.001; pCSI, p=0.002), as well as compared to post-intervention values of NMES (DR, p=0.007; pCSI, p=0.027) and ISO (DR, p=0.005; pCSI, p=0.028). Moreover, CoVF was reduced following NMES+ compared to baseline (p=0.005) and post-NMES values (p=0.014). CONCLUSIONS: These findings suggest that superimposing NMES to voluntary contractions can enhance the neural drive to the muscle by acutely modulating DR and pCSI, at low force levels. These adaptations in response to NMES+ seem to positively contribute to force steadiness, likely by engaging filtering mechanisms which minimize the independent synaptic noise affecting motor control. Among the possible mechanisms, NMES+ could promote the recruitment of additional motor units which plays a key role in reducing synaptic noise and improve force steadiness. These findings provide new perspectives on the adaptations induced by NMES exercise and shed light on the intricate neuro-physiological mechanisms involved, enriching our knowledge of how the neuromuscular system responds and adapts to NMES-based interventions.

## P1.18-G: A new look in Electromyographic Fatigue Threshold - an approach based on firing stability alteration

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Electromyographic (EMG) signals can provide access to physiological processes that cause the muscle to generate force, i. e. when contractions are sustained, the EMG signal suffers a change in it amplitude and frequency, this have been called EMG fatigue threshold (EMGft) [1], this indicative have considerable application, since that the signal displays time-dependent changes prior to any force modification [2]. A current of thought has tried to correlate the EMGft with physiological thresholds as anaerobic threshold [3], since the increase in EMG could be due to the fact that type II muscle fiber are thicker and produces a higher action potential [4], despite its resemblance in time, to the date no paper found a good match on these variables. Which means that the changes in the EMG signal is not due to some biochemical change or selection of muscle fibers, the phenomenon is better explained by the synchronicity of motor units [5, 6], our hypothesis is that we can find a marker in the stability curve of MU firings, exacerbating the changes in EMG pattern, interpreted as EMGft, and that this occurs due to some changes in the motor drive events and by consequence alterations in the rhythm of firings. Since EMG signals are the result of a set of events of motor units (MU) firing, this means that the same output can be achieved with superposition of different MU and becomes indistinguishable with naked eyes. To overcome this issue De Luca & Cols created an algorithm of decomposition of EMG (dEMG) [7, 8]. Our proposal is to evaluate the stability threshold using an non-linear approach to evaluate stability in the signal. So, we calculated the largest Lyapunov exponent in a moving window of 1s with 0.9995 overlap window, achieving a resolution of 0.0005s, determining the instant at which the standard deviation of the stability curve changed abruptly [9, 10]. We further decompose the signal into individual MU to analyze its firing rate (MUFR), and calculate the median frequency of EMG (EMGfreq) and mean envelope (ENVm), to compare those variables before and after the EMGft. To induce fatigue, 10 male volunteers performed 30 isokinetic maximum concentric/eccentric contractions at 60º/s for knee extensors on dynamometer isokinetic. The signal recording consisted of a dEMG Galileo sensor electrode placed on the dominant lower limb, on vastus lateralis. The EMGfreq before EMGft was 85.64 ± 21.69 Hz compared to 75.36 ± 16.33 Hz after (p = 0.0129). The ENVm was 0.0465 ± 0.0211 mV before the EMGft, compared to 2.104e-7 ± 1.595e-6 mV after (p < 0.001). And regarding MUFR the average before was 11.91 ± 2.722 Hz and decreasing to 10.36 ± 2.429 Hz (p=0.0104). Conclusion: Our proposal shows that it's possible to find the point of critical changes in the firing pattern, which can be interpreted by some changes in the rhythm of motor drive firings, mainly showed by the alterations in EMGfreq and MUFR.Bibliography1. Moritani T, Takaishi T, Matsumoto T. Determination of maximal power output at neuromuscular fatigue threshold. J Appl Physiol. 1993;74(4):1729-1734.2. De Luca CJ. Myoelectrical manifestations of localized muscular fatigue in humans. Crit Rev Biomed Eng. 1984;11(4):251-279.3. Lucía A, Sánchez O, Carvajal A, Chicharro JL. Analysis of the aerobic-anaerobic transition in elite cyclists during incremental exercise with the use of electromyography. Br J Sports Med. 1999;33(3):178-85.4. Crozara LF, Castro A, De Almeida Neto AF, Laroche DP, Cardozo AC, Gonçalves M. Utility of electromyographic fatigue threshold during treadmill running. Muscle Nerve. 2015;52(6):1030-1039.5. Yao W, Fuglevand RJ, Enoka RM. Motor-unit synchronization increases EMG amplitude and decreases force steadiness of simulated contractions. J

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## P1.19-G: Regional neuromuscular modulation of the hamstring muscles during muscle fatigue tasks

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The semitendinosus (ST) and biceps femoris (BF) muscles of the hamstrings coordinate knee flexion movement. The hamstring muscles are susceptible to muscle injury during sports activities, and one of the risk factors is muscle fatigue. Recent reports have investigated the differences in activity between different regions of the hamstring using multi-channel surface electromyography. Our research focused on the fact that the ST is a biventricular muscle with a tendinous intersection, and the differences in muscle function between the ST and BF were investigated. Detailed characterization of muscle activity during muscle fatigue may provide basic data for estimating the changes in neuromuscular activity that occur under muscle fatigue conditions during sports activities, and for diagnosing affected individuals and preventing injury. This study aimed to characterize the region-dependent muscle activity of ST and BF during sustained knee flexion contraction.Ten healthy men participated in this study. The participants were placed in a supine position, and the maximum knee flexion torque (maximal voluntary contraction [MVC] torque) during maximal voluntary isometric contraction was measured in both legs. Next, the participants performed a submaximal voluntary isometric contraction task in which 50% of the MVC torque was maintained as a muscle fatigue task. The muscle fatigue task was defined as one that resulted in muscle fatigue at a 5% decrease relative to the target force. The measurement items were ST and BF site-specific surface electromyograms of the right lower limb, which were measured using a multichannel surface electrode. The electrodes were placed in a series, and surface electromyography was measured using monopolar induction from each electrode. During the application of the electrodes to the ST, the position of the muscle edges and the tendinous intersection at rest were confirmed using an ultrasound imaging system. The electrodes were applied to the BF so that the midpoint of the line connecting the sciatic tuberosity and the head of the fibula was at the center of the multichannel electrode. The electromyograms measured by 15 channels were obtained for all participants and were time normalized with the point at which muscle fatigue was achieved set at 100%. Root mean square (RMS) and median frequency (MDF) for each channel were calculated every 25% from the start of the exercise. Next, mean RMS and MDF values of all channels were calculated were calculated by dividing the electromyography electrodes into proximal, central, and distal regions. Friedman tests were performed to compare the results for different regions at each time point. The results showed that RMS tended to increase during the muscle fatigue task; however, no significant differences between the regions were observed. In contrast, MDF tended to decrease during the muscle fatigue task; no significant differences between the regions were observed. These results suggest that site-specific muscle activity in ST and BF may not occur during the knee flexion task in both legs.

### **P1.20-H:** Fast and Stable Decomposition of Unwhitened Surface EMG Signal by Random Projection [Poster Award]

Alexander Clarke, Imperial College London; Agnese Grison, Imperial College London; Irene Mendez Guerra, Imperial College London; Dario Farina, Imperial College London

The decomposition of surface electromyography (sEMG) signal into its constituent motor unit (MU) activity offers a non-invasive method of directly accessing the neural drive to muscles, providing an extremely clean control signal for human machine interfacing (HMI) applications. However, in practice, decomposition algorithms invoke a high computational burden, which can introduce an unacceptable latency in real-time HMI. A major contributing factor is that incoming sEMG signal must be whitened prior to source separation, which requires an expensive singular value decomposition (SVD) on an extended version of the time series. Current methods try to mitigate this by retaining and applying the whitening matrix used originally to estimate the separation vectors, but this will quickly begin to fail due to signal non-stationarities, eventually requiring expensive recalculation.We propose to sidestep the need for data-driven whitening entirely by using a convolution operation to output a generalised Achlioptas random projection of the signal. We demonstrate that this simple operation has a strong decorrelating effect on spatio-temporal windows of sEMG, allowing for efficient discovery of separation vectors without the associated preprocessing costs. The projection is then combined with an optimized convolutional independent component analysis procedure to create an extremely fast projection pursuit algorithm for sEMG decomposition. By tuning the dimensionality of the random projection, we demonstrate that source separation can be easily focused on either MU yield or speed. Finally, we show that ICA optimization on sEMG has an extremely high tolerance to the distortion introduced by a low-dimensionality random projection. We hypothesise that this is due to the sparsity of neurophysiological data, which reduces the distortion that might otherwise be expected for a given number of samples under the Johnson–Lindenstrauss lemma.The effectiveness of the proposed sEMG decomposition algorithm is robustly examined experimentally using paired intramuscular recordings for two-source validation. For both overall yield and rate of agreement with decomposed intramuscular data, no significant difference was found between the proposed method and a state-of-the-art decomposition algorithm which used data-driven decorrelation. Furthermore, by artificially perturbing the signal in a way that would normally require recalculation of the whitening matrix, we show that a random projection maintains its decorrelation capability without affecting the viability of a learned separation vector.In conclusion, we show that a computationally-expensive preprocessing step considered critical in the decomposition pipeline, SVD whitening, can be bypassed completely. We present a novel method of decorrelating sEMG signal in a data-independent way, removing a critical barrier to the use of spinal motor neurons as a control signal in non-invasive HMI applications.

### **P1.21-I:** Investigating the muscular activation of healthy subjects using an end effector robot-based assistive system during a simulated daily task.

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BACKGROUND AND AIM: The organization and control of human movement is managed by the brain's reciprocal perception-action loop. It unifies the proprioceptive and exteroceptive feedback systems with the neuronal interfacing to functional modules and reflects its sensitivity to external stimuli. The effect of the contextual environment e.g. person-robot interaction on this loop is vital for understanding movement performance, muscular activation and motor learning. This study investigated the changes in muscular activation due to the use of an end-effector robot-based assistive system during movement tasks. METHOD: 20 healthy subjects were recruited to exclude the effects of pathology (avg. age: 32.55 ± 12.66 yrs.). Subjects performed a simulated movement task: Cup to Box, Cup to Mouth (CBCM) with and without robot-assistance. The assistive system centered on an Iiwa 14 robotic arm (KUKA Robotics). While seated before the robotic system, subjects were connected to the robotic arm via a wrist splint (BORT Medical) with a bespoke magnetic connector. The investigator led the robot through the movement task with the subject connected to the robot. The robotic system, having saved the task's movement trajectories, could then assist subjects as they autonomously performed that task. The joint stiffness of the robotic arm was varied to provide 2 robot-assisted scenarios: partially supported (PS) and fully supported (MS). The third task was the free, unassisted CBCM task (FM). The task order was randomized to minimize fatigue or familiarization effects. Surface electromyography (sEMG) signals were collected according to SENIAM recommendations from M biceps brachii, M triceps lateralis and M. brachioradialis. DATA ANALYSIS: The SEMG data was sampled at 2000 Hz and bandpass filtered (range: 1 - 500 Hz). The data was then rectified, smoothed and a normalized SEMG envelope was determined. The root mean square (RMS) value of each muscle was determined for each scenario of CBCM. RESULTS: For all 3 muscles, the RMS values for FM were the lowest when compared with the scenarios PS and MS. Additionally, PS consistently showed the highest RMS values among the scenarios. DISCUSSION: It is to be expected that performance of the movement task while fully supported by the robot arm would result in the lowest level of muscular activation. However, the unfamiliar robot-assisted task presented new exteroceptive stimuli, which possibly modified existing functional models of the task and challenged both the learning and performance of the task. This resulted in higher RMS values than for FM. The highest RMS values were observed for PS. This may reflect subjects' greater uncertainty when executing tasks under PS. The RMS values suggest possible coactivation of the muscles during task performance. CONCLUSION: An end-effector robot-based assistive system has a marked effect on the muscular activation of healthy subjects and thus impacts motor control and motor learning.

## P1.22-I: Rhythmic galvanic vestibular stimulation modulates sensorimotor synchronization to auditory syncopation

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Sensory inputs from multiple modalities are integrated for better performance. Such multimodality sensory integration is reported to improve synchronized movements to rhythmic auditory inputs. Vestibular inputs are known to be involved in the spatial and temporal processing of auditory information. In addition, afferent signals from the vestibular system project to subcortical structures included in neural networks generating rhythmic movements. Although rhythmic vestibular inputs are reported to modulate auditory meter perception, it is unclear whether such vestibular inputs affect the quality of sensorimotor synchronization to rhythmic auditory inputs. The present research used galvanic vestibular stimulation (GVS) in a sensorimotor synchronization task to examine the involvement of the vestibular system in the neural basis for sensorimotor synchronization. Participants flexed their index fingers in the dominant hand to the beats in syncopated auditory sequences. In the real GVS condition, square-wave GVS pulses lasting 10 ms were applied at the intensity below the individual cutaneous thresholds. The train of GVS synchronized with the auditory beats. In the sham GVS condition, on the other hand, no GVS was applied. The participants were informed that they were under the GVS application in all experimental trials. At the same time, none of them perceived the stimulation in the real GVS condition. For quantifying the synchronization errors, asynchrony was defined by calculating the temporal gap between the timings of the meters and those of maximal flexion in the dominant index finger. The stability and accuracy of synchronization were assessed by calculating the standard deviation and the absolute value of the asynchrony. These three indices, asynchrony, the standard deviation of asynchrony, and the absolute value of asynchrony, were compared between the real GVS condition and the sham GVS condition. As a result, compared to the sham GVS condition, the asynchrony shifted toward negative values in the real GVS condition, i.e., finger flexion occurred earlier than the auditory beats. This result might be associated with the asynchronous perception of auditory and vestibular inputs: the subjective perception of vestibular sensation is known to occur earlier than the auditory one when these two sensory inputs are provided simultaneously. This study provides a new perspective on the involvement of the vestibular system in the neural basis for sensorimotor synchronization.

## P1.23-I: Validation of a Novel Motor Learning Task: Does Grip Force Tracking Induce Peripheral Muscle Fatigue?

Hailey Tabbert, Ontario Tech Univeristy; Nicholas Antony, Ontario Tech Univeristy; Paul Yielder, Ontario Tech Univeristy; Bernadette Murphy, Ontario Tech Univeristy

Previous work has examined motor skill acquisition using motor tracing tasks, simple typing tasks, and more recently tasks that require force modulation. The latter is more heavily reliant on proprioception and serves as a valuable tool to evaluate motor acquisition in populations with impaired proprioceptive processing. However, recent work using this task reported minimal improvements in motor performance from pre- to post-acquisition with no capacity for skill retention. This is likely due to a lack of complexity and the discrete nature of the task used. The purpose of this research was to develop and validate a complex and continuous, force-based motor learning task. 11 right-handed, healthy participants(6F) aged 22.6±2.5 had bipolar surface electromyography(EMG) recorded from the right extensor carpi radialis(ECR) and flexor carpi ulnaris(FCU) throughout the duration of a novel hand-grip force matching tracking task(FMTT). The FMTT was delivered in 6 phases: pre-acquisition, 3 acquisition phases (acq1, 2, 3), and post-acquisition completed on day one and retention 24 hours later. Task performance was measured as absolute error(AE) and standard deviation of error(SdE). EMG signals were bandpass filtered (20-500Hz) and mean power frequency(MnPF) and EMG amplitude (RMSa) were computed to measure fatigue. MnPF was calculated using a Fast Fourier Transform computed in a 0.5 second window with a 50% overlap across filtered signals. RMSa was calculated using a 250ms root mean square smoothing window across filtered signals. Repeated measures ANOVAs compared EMG variables and performance accuracy normalized

to baseline.   Relative to baseline performance, there was a significant effect of time post-acquisition where AE decreased by 21.1% (p<0.001) and SdE decreased by 23.9% (p<0.001). At retention, AE decreased by 3.04% (p=0.009) relative to post with no effect of time for SdE (p=0.73). ECR: Relative to baseline, there were no fatigue effects of time for MnPF at: acq1 (p=0.1), acq2 (p=0.1), acq3 (p=0.09), or post (p=0.08) or RMSa at: acq1 (p=0.16), acq2 (p=0.33), acq3 (p=0.31), or post (p=0.13) when compared to baseline.  FCU: There was a significant effect of time from pre to acq2 where MnPF increased by 6.38% (p=0.03), however there were no significant effects at acq1 (p=0.55), acq3 (p=0.12), or post (p=0.23). There were no significant effects for RMSa at acq1 (p=0.27), acq2 (p=0.3), acq3 (p=0.71), or post (p=0.21). Significant improvements in motor performance from pre-post indicate this task facilitated motor skill acquisition. Further improvements in absolute error from post-retention demonstrates that this task also facilitates retention of the acquired motor skill in healthy young adults. The absence of change in EMG variables in both muscles is evidence that this task does not induce muscle fatigue in healthy controls. This new FMTT can be used in future work to evaluate how motor skill acquisition is impacted in different clinical populations.

## P1.24-I: **A systematic review of electromyographic activity of trunk and pelvic floor muscles in pregnant women**

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Introduction: Most of pregnant women experienced low back pain and pelvic girdle pain. (Colla et al., 2017) Some previous studies have reported that activity pattern of trunk and pelvic floor muscles (PFM) in the pregnant women was changed with the pain. (Hatami, 1961; Kim et al., 2022) However, there are controversy issues how change muscle activity of trunk muscles and PFM in prenatal and postpartum. Therefore, the purpose of this systematic review was to investigate change in muscle activity of trunk and PFM during pregnancy period and post parturition, and suggest optimal exercise therapy for pregnant women.Methods: A systematic literature search was performed using PubMed and ICHUSHI. (Japan medical abstract database) Search phrases were (pregnancy or pregnant or parturition) AND (electromyography or muscle activity) AND (trunk or pelvic). Inclusion criteria was studies which measured electromyographic (EMG) activity of trunk muscles or PFM in pregnant women. The exclusion criteria were: 1) studies which did not show EMG amplitudes, 2) studies with subjects who delivered by C-section, 3) studies which used subjects with orthopaedic or medical disease, 4) review articles, 5) intervention studies. Two reviewers selected studies by 2 screenings of the title, abstract and full text independently. Selected studies were grouped into measurement muscles, and systematically organized by change in muscle activity for each muscle. Results: Sixteen studies were extracted by 2 screenings. These studies were grouped into measurement muscles as follows: 6 studies for the PFM, 5 studies for the internal oblique (IO), 4 studies for the rectus abdominis (RA) and external oblique (EO), 3 studies for the erector spinae (ES), and 3 studies for the anal sphincter and levator ani. Five out of 6 studies demonstrated that PFM activity in pregnant was significantly lower that in controls. (women without childbirth experience) Three out of 5 studies showed significantly lower activity in the IO during late pregnancy and postpartum than controls, while there were no significant differences in the RA and EO between pregnant and controls. Two out of 3 studies showed highest activity in the ES during late pregnancy. The muscle activity of the AS and LA significantly decreased in postpartum. Discussion: Most studies have shown decrease of the activity of the PFM and IO in pregnant women. The results suggest that pregnant women decrease the function for co-contraction of the PFM and deep abdominal muscles while controls have enough ability of co-contraction of the PFM and IO. (Larissa et al., 2013) In contrast, some studies showed that ES activity was higher during late pregnancy. Increase of lumbar lordosis with expansion of abdominal volume might result in hyper-activation of the ES in pregnant women. This systematic review implies that exercise therapy such as draw-in maneuver which enhance co-contraction of the PFM and deep abdominal muscles and inhibit the ES activity may be effective for pregnant women.

## P1.25-I: The effects of central sensitization on motor unit properties in the upper limb

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One in five Canadian adults live with chronic pain, 50% of which have lived with the condition for over ten years. The International Association for the Study of Pain defines chronic musculoskeletal (MSK) pain as persistent pain that lasts beyond the normal tissue healing time, typically at least 3 months duration. This implies that chronic MSK pain is mediated through the spinal cord and higher levels. Central sensitization (CS) is the increased responsiveness of nociceptors in the central nervous system (CNS) to normal or subthreshold afferent input. The least invasive method of inducing CS experimentally is through the use of topically administrated capsaicin cream. This method has been utilized to detail the underlying mechanisms in the development of chronic pain and investigate the maladaptive neuronal plasticity occurring within the spinal cord and supraspinal centers. Previous research suggests that CS may directly impact the ventral root of the spinal cord or motor unit (MU) excitability. Our current study uses capsaicin-induced CS methods to investigate the changes in MU excitability of subjects during a gripping task. CS was induced by applying Zostrix 0.075% capsaicin cream, while the control group has a placebo cream of similar consistency applied. Participants (n=13,7F) were divided into CS and control groups and were required to trace a ramp by gripping a force transducer up to 10% MVC. Either capsaicin or control cream was applied over the participant’s neck and shoulder during the study. HDsEMG was recorded from the flexor carpi ulnaris muscle (FCU), a wrist flexor, and extensor carpi radialis (ECR), a wrist extensor using a 64-channel HDsEMG electrode over each muscle belly, being careful to avoid the motor point. Muscle activity was recorded prior to, and 10-, 20-, 30- and 40-minutes post cream application. At each time point, the participant performed 4 blocks of 3 grips each. The purpose was to compare changes in HDsEMG properties relative to baseline. All EMG data was band pass filtered between 10 and 500 Hz, with 250 ms window, 0 ms gap. The Centroid of the root mean square (RMS) of EMG activity and sample entropy for the plateau phase of each grip were calculated and averaged for the pre, 10-, 20-, 30- and 40-minute time point and compared between groups. The centroid represents the spatial distribution of the EMG signals across the electrode array. Differences between CS and healthy were found in the forearm extensor muscles at 10- and 20-minutes post cream application for both RMS and sample entropy, with no difference between groups for the flexor muscles. These results can provide insight into the neural mechanisms which may initiate chronic pain, and their effect on MU recruitment

properties. This information could be valuable in both understanding and detailing the subsequent effects of CS, and chronic pain, on neuromuscular control.

## P1.26-I: Transcutaneous Spinal Random Noise Stimulation Facilitates Motor Memory Consolidation in Healthy Individuals

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Motor skill training transiently increases in the corticospinal excitability and the functional oscillatory coupling of the corticospinal drive to motoneurons. The change is thought to reflect changes in neuronal connectivity associated with improvements in sensorimotor performance, and also associated with consolidation of motor skills. We have reported that transcutaneous spinal random noise stimulation (tsRNS) over the cervical level can enhance corticospinal drive to spinal motoneurons in healthy individuals, and it could be induced by increasing ascending afferent input via the somatosensory cortex to pyramidal cells in primary motor cortex. We hypothesized that tsRNS can enhance motor skill acquisition process and facilitate motor memory consolidation. Here, we investigated the effect of tsRNS over the cervical level on motor performance in 40 healthy volunteers. Motor performance was assessed by visuomotor accuracy tracking task with rapid shifts in pinch force levels are required, and measured as the average percentage time on target. Motor performance was tested just before and after training (Day 1), 1 (Day 2) and 7 days after motor training (Day 8). During motor training, participants received real or sham tsRNS with maximum current of 3 mA for 20 min or 0.5 min, respectively. Electroencephalography and electromyography from the first dorsal interosseous (FDI) muscle were measured during tonic isometric contraction of thumb and index finger (pinch) for 2 min to quantify corticomuscular coherence (CMC). Motor training improved motor performance, but no significant difference was observed between real and sham tsRNS groups, suggesting that tsRNS did not affect motor performance in Day 1. A significant increase in beta-band CMC after training both groups, the changes tended to be larger in tsRNS group compared to sham group. Investigating the retention effects, tsRNS group maintained higher performance on days 2 and 8 compared to sham group. These findings suggest that tsRNS combined with motor training facilitates consolidation of motor skills.

## P1.27-I: Peak torque variability in the MVCs of the plantar flexors is associated with the resting systolic blood pressure

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BACKGROUND AND AIM: Variations in the peak torques often occur among multiple MVC trials and these variations would affect several motor performances. It has been suggested that there is a direct connection between motor control system and autonomic nervous system. Especially, higher motor output may be achieved by increased sympathetic nervous activity. The aim of the present study was therefore to investigate whether higher MVC peak torque is obtained when blood pressure is deliberately raised by the modulation of respiration.METHODS: Eight healthy young participants volunteered for this study. Surface EMG

(bipolar Ag/AgCl electrodes, pick-up diameter 4 mm, inter-electrode distance 20 mm) were obtained from the medial gastrocnemius (MG), lateral gastrocnemius (LG), and soleus muscles (SOL). The reference electrode was located on the lateral malleolus. Blood pressure was measured at the same time. The participants repeated 2-s isometric MVC of plantar flexors 14 times with sufficient rests (>4 min). The MVC trials involved two types of breathing pattern for 30 s just before the muscle contraction: (1) normal respiration and (2) rapid respiration. During the rapid respiration, the participants were instructed to breathe in time with a metronome at 1 Hz. Each breathing pattern was performed seven times at random order. For each MVC trial, the EMG RMS value (1-s window) at peak torque was computed in each muscle. The averages of the peak torque, EMG RMS for each muscle, and mean resting systolic blood pressure (SBP) for 30 s just before the MVC were calculated for each breathing condition in each participant, and they were compared between the breathing conditions.RESULTS: In the rapid respiration condition, peak torque and resting SBP were significantly higher than those in the normal respiration condition (P<0.05). Additionally, EMG RMS values in the MG and LG tended to be larger in the rapid respiration condition (P=0.05).CONCLUSIONS: The intentional modulation of SBP would achieve higher MVC peak torque in the plantar flexors.

## P1.28-J: **High-frequency firing of erector spinae motor units during arm-raised sitting in patients with subacute stroke**

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Stroke-induced motor paralysis extends from the patient’s limbs to the trunk. Patients are unable to hold their trunk upright, which accounts for half of their body weight. Approximately 25% of patients are unable to sit without assistance one month after stroke (W.C. Chen, 2022). In the present study, we investigated 1) the effect of electrical stimulation on the erector spinae, which acts in trunk extension during sitting. However, we could observe little activity in the erector spinae when simply sitting, and they relied on other tissues for support. Therefore, we investigated 2) whether erector spinae activity could be observed by voluntary arm movements from a sitting position and how the motor units were firing.Subjects in both experiments were patients with subacute stroke; 1) 13 and 2) 12 patients. Measurements were taken on average 1) 19 and 2) 20 days after onset of stroke. A High-Density surface ElectroMyoGraphy (HDsEMG, OT-Bioelettronica) was used as the research instrument; 64 electrodes were attached to the erector spinae (longissimus). The subjects were seated on the edge of a bed in a resting posture, leaning with their arms on the table in front of them. The subjects then 1) underwent electrical stimulation in the task posture with their hands floating off the table; 2) in the task posture with their arms raised above their heads or reaching forward without electrical stimulation.RESULT 1: The criterion for action potential detection was defined as the mean amplitude + 3 times the standard deviation for 3 seconds in the resting posture. Although 64 channels of each subject were investigated, the criterion was exceeded in 2/13 subjects in the task posture. These subjects showed activity both before and after electrical stimulation. The other subjects did not meet the criteria for activity before and after electrical stimulation.RESULT 2: Activity of the erector spinae was observed in the task posture. This was evident in the arm-raised posture, where 10/12 subjects were able to decompose the motor unit. In the arm-forward posture, 6/12 subjects were able to decompose the motor unit. In any case, only 1-2 motor units could be decomposed in each subject. Their average firing rate was 21.9 [fps] (range 11.8 -

42.9).Comparing results 1) and 2), we found that voluntary arm movements activated the erector spinae more than electrical stimulation while sitting. The number of motor units that could be decomposed from the erector spinae activity of each patient was small. On the other hand, the average firing rate of motor units was higher than in previous studies. In the previous study, it was 5.4 [fps] in healthy adults during sitting (L.R. Lothe, 2015) and 15.8-23.9 [fps] during maximum extension (M.F. Silva, 2017).CONCLUSION: Patients with subacute stroke do not rely on muscle contractions to hold a sitting position. When moving their arms from a seated position, a small number of their erector spinae motor units may increase the firing rate to produce adequate force.

### P1.29-K: Assessing intrinsic properties of human motoneurons during slow lengthening and shortening contractions

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It is unknown whether intrinsic motoneuron properties that regulate human motor unit discharge patterns are altered under dynamic conditions. Work in the decerebrate cat preparation have shown that movement of the limb can influence persistent inward currents (PICs) via activation of local inhibitory circuits. In humans, however, estimating intrinsic properties of motoneurons (i.e., PICs) have primarily been done under isometric conditions. The aim of this study was to explore the effects of slow isokinetic ramp contractions on estimates of PIC magnitude in healthy, young adults. Participants first performed dorsiflexion MVCs at 80°, 90°, and 100° of ankle flexion to establish a predictive algorithm, which was used to transform the torque feedback throughout the contraction and ensure relative efforts remained constant across joint angles. Next, using this transformed feedback, they performed triangular (5s up/down) dorsiflexion contractions to a peak of 30 and 50% MVC while the isokinetic dynamometer moved their ankle through plantarflexion (i.e., 80° to 100°) or dorsiflexion (i.e., 100° to 80°). High-density surface electromyograms were recorded and decomposed into motor unit spike trains. We then used a paired motor unit analysis technique to calculate discharge rate hysteresis (estimate of the magnitude of PICs; delta frequency [DF]) from smoothed discharge rate patterns. Discharge rates were higher during concentric contractions (22.7 [20.1, 25.4] pps) compared to eccentric (21.1 [18.5, 23.8] pps), and during 50% contractions (24.8 [22.2, 27.5]) compared to 30% (19 [16.4, 21.7] pps). There was also a reduction in DF during concentric contractions (3.93 [2.78, 5.08]) compared to eccentric (5.46 [4.31, 6.61]), and this effect was exemplified at higher contraction intensities. Since PICs are affected by local inhibitory circuits, and concentric actions necessitate lengthening of the antagonist muscle, which is likely to impart Ia reciprocal inhibition, these findings suggest that, even during slow length changes during concentric contractions, local inhibitory circuits can have profound effects of intrinsic motoneuron excitability in humans.

### P1.30-K: Noradrenergic perturbations modulate human motor unit discharge behavior and attenuate motor impairments in chronic stroke

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Persistent inward currents (PICs) augment excitatory synaptic input to motoneurons and are facilitated by monoamines (e.g., norepinephrine), setting a motoneuron's state. While the monoaminergic dependence of PICs is thought critical for human motor function, this dependence may facilitate motor impairments in chronic hemiparetic stroke where monoaminergic dysfunction is theorized. To investigate this interplay, we performed a series of experiments using single-dose noradrenergic pharmacological probes, high-density surface electromyography (HDsEMG), and novel mechatronic devices in both neurologically intact and chronic hemiparetic stroke populations.In the first experiment, eleven neurologically intact participants performed isometric elbow flexion, shoulder abduction (SABD), and index finger abduction contractions before and after taking tizanidine, yohimbe, atomoxetine, or a placebo. The isometric paradigms were designed to highlight PIC behavior, with motor units (MUs) decomposed from HDsEMG of the biceps brachii, deltoids, and first dorsal interosseus.In the second experiment, individuals with chronic hemiparetic stroke were interfaced with a novel robotic device and asked to generate isometric elbow flexion and SABD torque profiles. To highlight independent joint control, an additional task required simultaneous isometric elbow flexion while generating a dynamic SABD load. All tasks were performed before and after tizanidine, with MUs decomposed in the biceps brachii and deltoid muscles.Initial analysis indicates that noradrenergic probes modulate MU discharge profiles in both experiments. Furthermore, preliminary findings from the second set of experiments in chronic hemiparetic stroke suggest a potential decrease in estimates of PICs post tizanidine, with estimated decreases of 0.42 pps (d = 0.23) in deltaF and 5.01 %rTri (d = 0.26) in brace height. Overall, these findings provide insights into the acute effects of noradrenergic perturbations on human MUs in a neurologically intact population and highlight the potential noradrenergic dependence of motor impairments in chronic stroke.

## P1.31-K: Simulating Motor Neuron Diseases in Synthetic Muscles

Cathrine Nayrouz, University of Guelph; Andrew Hamilton-Wright, University of Guelph

Title: Simulating Motor Neuron Diseases in Synthetic MusclesCathrine Pierre Nayrouz, and Andrew Hamilton-WrightIntroduction: Motor Neuron Diseases (MNDs) are a wide range of diseases that can be split into three major classes, upper motor neuron diseases, lower motor neuron diseases (LMN), and diseases that contain both UMN and LMN degeneration, like Amyotrophic Lateral Sclerosis (ALS). These diseases are part of the same family where neuronal damage leads to the slow progression of muscle weakness, stiffness, and loss of control. The symptom presentation, areas of damage, as well as general disease progression can vary between the various classes, however, there is a commonality in their underlying mechanisms. Using muscle simulation, we can create synthetic muscles, and model diseases, such as MNDs, in order to better study, understand, and test varying hypotheses in a way that is simply not possible in a clinical setting. Using a muscle simulator would allow us to explore the linkage between cellular disease involvement and the effect on the signal produced by the model so that EMG-based diagnostic algorithms can be better utilized. Furthermore, there are obvious problems with performing an invasive, and mildly uncomfortable procedure to gain a better understanding of the signals released. This presents another valuable use case of having a simulated muscle model, where we can generate the interference pattern using the same firing rate, with exact needle positioning, however with restructuring due to disease – which of course is simply not possible in real life. By using a synthetic muscle, various hypotheses regarding interference patterns obtained under potential restructuring strategies may be explored. The resulting improved understanding of how a given disease state manifests opens up the potential for earlier diagnosis and a deeper understanding of the cellular reconfigurations occurring throughout the disease progression.Methods: A disease model is created that takes in a healthy muscle, and gradually increases the level of involvement of the disease as time progresses, modelling the removal of motor units from the muscle, forcing their fibres to either be adopted by nearby motor units, or in the case that no neighbouring motor units are available to take on fibres they gradually start to die off. As the fibres die off, a muscle compaction algorithm 'tucks in' the muscle towards the centre – both to make sure there are no 'holes' in the muscle, but also to simulate the atrophy that occurs over time. Since for some of these processes, the literature is not conclusive on how they occur in the human body, the results of several comparative experiments are presented, to test which method produced results closest to reality as described in the literature. Results: As seen in Table 1 we can see plots of the muscle as it progresses through the disease (0% to 50% motor unit involvement). As seen in the first graph (0 involvement) each motor unit centre is shown as a uniquely coloured square, with its attached fibres shown as dots of the same colour.  If the fibre gets readopted by a surviving motor unit, it becomes a star with the colour of its new parent motor unit, but shown as a black triangle. The resulting signals of the diseased muscle are then compared to those collected in a clinical setting, as well as validating that the fibre density and CMAP are comparable to real patients at that same stage in the disease as described in the literature.Conclusion The tool presented, while not perfect, is a first step towards a new model to explore potentially available diagnostic information related to these vicious diseases and will allow scientists and researchers to test hypotheses in a way that is novel for MNDs, based on this cellular level physiological model.

## P1.32-K: **A Particle Swarm Optimised Nonlinearity for High Yield Surface EMG Decomposition**

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Methods that can accurately decompose surface electromyographic (sEMG) signals into their constituent neural activity are critically important for motor neuroscience research as well as human-machine interfacing applications such as prosthetics, neurorehabilitation, and wearable consumer devices. The introduction of advanced high-density surface electrode arrays has made the simultaneous collection of hundreds of channels of neurophysiological time series possible, motivating the need for a new class of automated blind source separation algorithms that capitalize on the superior spatial resolution these arrays provide. However, whilst the theory of independent component analysis (ICA) presents a strong theoretical base for these algorithms, practical implementation challenges frequently lead to imperfect outcomes, especially with sparse sources. In particular, the non-linearity used to estimate independence is often sub-optimally selective for a given source. In this study we show that the most efficient non-linearity can vary per source in a recording, posing a significant challenge to the separation process if a high source yield is desired. We go on to demonstrate how the correct design of the contrast function can allow for the separation of sources with very similar motor unit action potential (MUAP) waveforms. Our findings indicate that employing a single non-linear optimization function in the ICA process for identifying spiking sources can adversely affect the process, hindering the effective isolation and accurate separation of all spiking sources within the signal. Using these insights, we propose a particle swarm methodology for sEMG decomposition, adaptively traversing a polynomial family of non-linearities that approximate the asymmetric cumulants of the sources. We robustly investigate the utility of the resultant algorithm experimentally using two-source validation between high-density sEMG (12x5 grid) signal and intramuscular EMG (2 bipolar wires) signal recorded concurrently from the Tibialis Anterior (TA) muscle. We processed the sEMG data using both the current gold standard in automatic decomposition, namely convolutive Blind Source Separation (cBSS), and the proposed algorithm, Swarm Contrastive Decomposition (SCD). For both methods, we refined the outputs automatically by eliminating duplicate units and filtering out units with either a coefficient of variation exceeding 40 or a firing rate surpassing 35Hz. Across 90 recording sessions, the cBSS and SCD methods identified 226 and 474 units, respectively. Additionally, we applied SCD to decompose the iEMG data, which led to the identification of 313 unique units. A significant number of the motor units identified from the iEMG were also detected from the independent decomposition of the corresponding sEMG signal. The presence of matching units between the two decomposition modalities serves as a reliable indicator of decomposition accuracy. In conclusion, we present a method for the decomposition of HD-sEMG data that improves on the current state-of-the-art by leveraging a source-specific independence estimator to separate it from the sEMG mixture.

## P1.33-K: Tracking motor units across wrist joint angles: characterisation of motor unit action potentials under muscle fibre shortening and lengthening

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Objective.Understanding the modulation motor units (MUs) undergo during dynamic contractions is essential to develop more accurate and robust neuromechanical models and neural interfaces.Approach.Here, we propose a novel sequential assignment algorithm that condenses spatial, temporal, and amplitude features to track MUs across different levels of muscle shortening and lengthening based on their motor unit action potentials (MUAPs).First, the algorithm compares two sets of MUAPs based on their normalised mean squared error (NMSE) after automatic temporal alignment and spatial channel selection. Then, the assignment process is carried out as a minimisation of the NMSE of the tracking paths for the MUAPs whose NMSE is below a predefined threshold. This process is sequentially repeated across consecutive and disjoint angles to track the full MUAP representation. To validate this, MUAPs detected at multiple wrist joint angles (every 10° from -40° wrist flexion to 40° wrist extension) were tracked with respect to the reference position at 0°, computed from high density EMG signals concurrently recorded from the forearm and the wrist during isometric contractions (individual and combined finger flexions at 15% maximum voluntary contraction) from 9 participants. Main results.Results showed that overall, more MUs were tracked at the wrist than at the forearm (178 vs 130 MUs, respectively) and over more angles (4 ± 2 vs 3 ± 1

count of tracked angles, respectively, mean ± std). This was explained by lower changes with muscle fibre shortening and lengthening in the non-propagating far-field potentials at the wrist than in the propagating components of the MUAPs at the forearm (up to 0.18 ± 0.09 n.u. and 0.26 ± 0.13 n.u. NMSE at -40° flexion, respectively).Furthermore, the NMSE between the tracked MUs was significantly lower than the NMSE between their respective second-best alternatives (0.08 ± 0.04 n.u. vs 0.57 ± 0.26 n.u., respectively, p<0.001). This shows that the selected tracking paths were outliers in the MU's (dis)similarity distributions and supports the notion that modulated MUAPs retain their uniqueness within the MU population in both locations.Significance.These findings showcase the effectiveness of the proposed assignment algorithm to track MUAPs across a wide range of motion, revealing physiological insights about their modulation during muscle shortening and lengthening. Furthermore, by matching the MUAPs across conditions (in this case, joint angles), the tracking approach also links the spike trains used to compute the MUAPs at each angle and their corresponding decomposition models, providing a non-invasive validation set for decomposition adaptation algorithms.

### P1.34-K: Developing a Stimulation-Free Remote Motor Unit Number Estimate in Motor Neurone Disease (REMUNE)

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Background: Motor Neurone Disease (MND) affects the motor neurones responsible for transmitting movement-related signals towards the muscles to produce movements. The current method used for monitoring disease progression and diagnosis is called Motor Unit Number Estimate (MUNE) and involves electrical stimulations to accurately estimate the number of functional motor units. However, this approach can cause extreme discomfort for some participants. These assessments also require individuals with MND to come to a clinical environment every 2-months. Developing a stimulation-free MUNE would enable more comfortable assessments leading to a greater amount of data collected, eliminate the need for specialised staff, and save time. Overall, it represents a first step in making these assessments remote and home-based in the future. Methods: This study involves people with MND (n ≥24), and healthy age-matched controls (n ≥12) attending six assessments over 12-months. During these assessments, 64-channels surface EMG sensors will be applied bilaterally over the thumb, index finger, little finger, and shin for a duration of 16-minutes. While recording their muscle activity, the participants will perform several muscle contractions at different force levels. Additionally, MUNIX (Motor Unit Number Index), a gold-standard MUNE, will be performed on the same muscles as a comparative measure of motor unit loss. Objectives: To reliably identify the active motor unit pool at varying force levels by combining HD-sEMG with an advanced motor unit decomposition technique. To seek physiological correlations between motor unit parameters, muscle power and MUNIX over time and across body regions in MND and control patients. To define a novel stimulation-free MUNE. To this date, the data from 14 participants (both healthy and MND) have been recorded over 3 visits resulting in approximately 11-hours of recording.

### P1.35-K: Antagonist vibration affects force output and underlying motor unit discharge behaviour

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Gain control of muscle force output is mediated by motoneuronal persistent inward currents (PICs), which are facilitated by diffuse monoaminergic inputs and highly sensitive to local inhibitory inputs. Recent work has shown that estimates of PICs in humans are dampened in the presence of Ia reciprocal inhibition via electrical stimulation of mixed nerves innervating the antagonist muscle, and vibration of the antagonist muscle tendon. A direct link between PIC magnitude and voluntary force control, however, has not yet been established. Thus, the goal of the present work was to determine if force control and underlying motor unit discharge behaviour is modified under conditions of reduced PIC magnitude. We recorded 64 channels of high-density EMG from the tibialis anterior while participants performed two subsequent isometric contractions with their ankle dorsiflexors per trial. In the first, they received visual feedback and were instructed to produce and hold torque at ~25% of their maximum for 5 seconds; and, in the second, we asked them to match the same level of effort required to produce torque in the first contraction while we blinded them to their actual torque output. Vibration to the Achilles tendon was applied during the first, second, or neither of the contractions in separate trials. We hypothesized that 1) vibration in the first contraction would reduce PICs, and cause participants to produce more torque in the subsequent contraction without vibration, and 2) vibration in the second contraction would reduce PICs, and cause participants to produce less torque when matching the effort required previously without vibration. We implemented mixed effects models to determine if the vibration predicted mean torque. Preliminary data (3 females; 5 males) indicate that compared to trials without any vibration (mean torque = 26.9% [23.2, 30.7]), vibration in the second contraction (without visual feedback) reduced voluntary torque output (22.4% (18.6, 26.1]), whereas voluntary torque was increased (28.7% [25, 32.5]) when vibration was applied in the first contraction. Our behavioural data support our hypothesis that implicates PIC magnitude as an important gain control mechanism that contributes to the perception of muscle force output in humans. Decomposition of EMG signals into motor unit spike trains and analysis is ongoing, and data will be presented at the congress.

## P1.36-K: Flexible High-Density Electromyography Microneedle Electrode Arrays

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High-density surface electromyography (HD-sEMG) enables detection of EMG signal distribution across the skin surface and, when combined with decomposition methods, bridges the gap between the information which can be extracted from surface and intramuscular EMG. Despite its advantages, care must be taken with skin preparation and electrode placement. Decomposition accuracy can also be affected by movement or shifting of the electrodes.  Here, we propose and demonstrate the efficacy of a novel dry microneedle array electrode (MNEA) for HD-sEMG. The MNEA yielded high-quality sEMG signals comparable to signals recorded using conventional flat surface electrode arrays, while providing better coupling between the electrode and tissue and without requiring prior skin preparation.A dry-use flexible microneedle

array electrode (MNEA) was fabricated comprising of a flexible backing layer with embedded microneedle electrode contacts made of biocompatible conductive materials integrated on-top of a flexible PCB backing. Functionality of the MNEA was assessed by examining EMG activity recorded from the biceps brachy during isometric contraction at a range of force levels, without prior skin preparation. The experiments were repeated using a conventional surface electrode array with the addition skin preparation. HD-sEMG signals detected using the MNEA exhibited low baseline noise, high signal to noise ratio and high signal spatial selectivity. Surface EMG amplitude intensity maps were generated from the MNEA data which also enabled motor unit decomposition and localization of the innervation zone. The signal to noise ratio and decomposition yield was similar or higher than standard electrodes without the need for any skin preparation or the use of an electrolyte gels. In conclusion, the developed dry-use MNEA can record high quality HD-sEMG without requiring skin preparation or electrolyte gel. MNEAs have the potential to expand the range of application areas of HD-sEMG by improving signal quality and ease of application, for example in clinical applications where stable and consistent placements are required and in protocols which call for consistent high-quality recordings for an extended period of time.

### P1.37-K: Effects of neuromuscular electrical stimulation on motor unit behavior during voluntary muscle contractions: A high-density surface electromyogram (HDsEMG) study

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Neuromuscular electrical stimulation (NMES) can be used to generate muscle contractions without central commands and while doing so modulate the excitability of cortical and spinal neural circuits by activating sensory and motor pathways. While the application of NMES has been successfully used to enhance motor function in the clinical population, the underlying neurophysiological mechanisms are yet to be fully understood. Specifically, the impact of NMES intervention on motor unit activity, a key determinant of neuromuscular control, remains largely unexplored. Therefore, the purpose of our current study was to investigate the effect of a single-session NMES intervention on motor unit behavior using high-density surface electromyography (HDsEMG) techniques. Ten able-bodied individuals participated in this study. During the intervention, NMES at the frequency of 25 Hz was intermittently applied (800 msec on / 800 msec off duty cycle) over the right common peroneal nerve to activate the tibialis anterior (TA) muscle and induce ankle dorsiflexion for a total of 10 min. NMES intensity was set to evoke 50% of the maximum M-wave response (Mmax) elicited by single-pulse common peroneal nerve stimulation. Motor unit behavior of the TA muscle was assessed by recording 64-channel HDsEMG during isometric ramp contractions targeting 35% of maximal voluntary contraction force. Assessments were conducted at baseline and immediately, 10 min, and 20 min after the NMES intervention. In offline analysis, HDsEMG signals were decomposed into single motor unit activity using blind source separation algorithms based on FastICA and the convolutional kernel compensation approach. Motor unit firing rate and recruitment and de-recruitment threshold were then computed from the identified motor unit activity. Results showed that the motor unit firing rate was significantly increased immediately after NMES intervention, and the effect lasted for at least 20 min (p<0.05). Specifically, the firing rates during the plateau and de-recruitment phase of the submaximal isometric contraction were increased after NMES intervention (p<0.05). Moreover, results showed that the de-recruitment threshold decreased 10 min after the NMES intervention, lasting at least 10 min, while the recruitment threshold was not affected. These findings suggest that even a short-duration / single-session NMES intervention can induce changes in motor unit activity, reflected in altered firing rate and de-recruitment threshold. Since NMES activates the sensory and motor nerves, it is possible that NMES-induced repetitive motoneuron activation through reflex circuits and/or direct motoneuron activation contributed to the observed modulation of motor unit activity after the intervention. Overall, our results proposed that alterations in the motor unit activity may underlie the mechanisms driving NMES-induced plasticity.

### P1.38-L: Neck Intermuscular Coherence in Chronic Neck Pain During Dynamic and Static Tasks

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BACKGROUND AND AIM: Chronic neck pain (CNP) often involves neuromuscular impairments, as observed in clinical settings [1]. This study extends the existing knowledge by hypothesizing that CNP affects the interconnectivity of neck muscles. Our aim is to examine how muscle coordination varies in individuals with CNP compared to asymptomatic individuals during dynamic neck movements and static tasks, including smartphone use. Through the use of intermuscular coherence analysis, this study seeks to shed light on how multi-muscle coordination in CNP patients differs during these activities.METHODS: Twenty asymptomatic individuals and 20 people with CNP participated in the study. Each participant performed three consecutive neck flexions followed by a standing task while using a smartphone to watch a 3-minute video. Electromyography (EMG) signals were collected from key neck muscles: the upper trapezius (UT), splenius capitis (SC), anterior scalene (AS), and sternocleidomastoid (SCM) bilaterally. Intermuscular coherence, measured through magnitude squared coherence (MSC), enabled the analysis of functional interactions and connectivity strength between muscles. This methodology produced weighted adjacency matrices for each participant, emphasizing significant connections while filtering out less relevant ones [2]. The study analyzed four frequency bands (δ, θ, α, β) to construct and compare functional muscle networks based on strength (ST) and betweenness centrality (BC), the last indicating crucial points of information flow within the network.RESULTS: The cervical flexion task showed significant differences in both BC and ST in the δ band between CNP and asymptomatic participants ($p = 0.01$ and $p = 0.03$, respectively). However, during the static task, no significant differences were observed in any frequency band or parameter ($p = 0.97$ and $p = 0.90$). Additionally, neck muscle networks during dynamic tasks revealed distinct graphical differences in the δ band, with CNP participants exhibiting reduced connectivity and localized activation in the SCM and SC muscles with a less symmetrical network, unlike the control group (Figure 1A). On the other hand, these differences were less evident in the static task networks (Figure 1B).CONCLUSIONS: Our findings indicate altered muscle synergies in individuals with CNP, particularly during cervical flexion and predominantly in the δ frequency band [3], known for its importance in force generation and control [4]. This study contributes to a deeper understanding of neuromuscular adaptations in CNP and highlights the potential impact of common activities like smartphone use on muscle coordination in this population.

## P1.39-L: Reconsideration of exercise trainings for the stair descent: A study using muscle synergy analysis

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Stair ambulation is a common activity of daily living, but one of the most challenging tasks for older people. Because 75% of falls on stairs occurs during descent, stair descent exercises are frequently conducted in rehabilitation. Stair descent exercises with stairs and steps may be difficult and risky of falling. Therefore, in some cases, exercise trainings such as squatting and lunging are introduced at a preparatory stage before attempting stair descent. However, it is unclear whether these activities are similar to stair descent in terms of muscle coordination. Exercise trainings with similar coordinated muscle activity may be effective. This study aimed to identify the similarity of muscle coordination between stair descent and exercise trainings, and to help develop programs for improving the ability of stair descent.Ten healthy adults (age: 21.5±0.5 years) were recruited in this study. Stair descent (DS) trials were performed on three-step stairs (step height: 20cm). In addition, double leg squat (DLS), single leg squat (SLS), and forward lunge (FL) were performed. During DLS, SLS, and FL, participants flexed their knee to approximately 60 [°]. The kinematics data were obtained using a three-dimensional motion analysis system, and the muscle activity data of 13 lower muscles of the dominant leg were measured using surface electromyography (EMG). A non-negative matrix factorization was applied to the EMG data to extract muscle synergies. The similarities between muscle weightings extracted from DS and exercise trainings were evaluated using cosine similarity. A pair of muscle weightings was considered similar if the cosine similarity were ≥ 0.8.The maximal knee joint flexion angles during tasks were 95.0 ± 3.1 [°] for DS, 59.6 ± 5.3 [°] for DLS, 60.7 ± 3.6 [°] for SLS, 58.4 ± 5.2 [°] for FL. Three modules were extracted from DS, two modules were extracted from DLS and SLS, and one module was extracted from FL. DS1 showed main contribution of rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM), and soleus (SOL) during mid-stance. DS2 showed main contribution of adductor magnus, biceps femoris, semitendinosus (ST), and tibialis anterior during late-stance. DS3 showed main contribution of gluteus max, gluteus medial (Gmed), and gastrocnemius medial (GM) during late-swing. DLS1 and SLS1 showed main contribution of RF, VL and VM during descent phase. DLS2 showed main contribution of tensor fascia latae, ST, and GM, and SLS2 showed main contribution of Gmed and GM during start and end of squatting. FL1 showed contribution of almost all muscles during forward transition. The pair of muscle synergies similar to DS1 were DLS1, SLS1, and FL1. In addition, DS3 was similar to DLS2 and SLS2. Muscle synergies similar to those found in stair descent were also identified in DLS, SLS, and FL. Exercise trainings such as DLS, SLS, and FL may be effective at a stage before stair descent in terms of muscle coordination.

## P1.40-M: Differences in Neuromechanical Factors Affecting Explosive Torque Production During Knee Extensions: A Preliminary Comparative Study of Males and Females.

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Background & Aim: The ability to generate explosive force is influenced by different neuromechanical factors. Prior research, mainly involving males, has shown that muscle

activation (measured with surface electromyography-EMG), contractile properties (assessed by electrical stimulation), and morphology (determined by muscle size) are key determinants of torque production. Additionally, muscle quality, gauged by echo intensity in ultrasound images, and muscle stiffness, measured with shear-wave elastography, may also impact torque generation. It is yet to be clarified if these factors vary between sex. Thus, this preliminary study aims to investigate whether the neuromechanical factors underlying explosive force differ between males and females.Methods: Twelve young adults (5 males; 27±2y; 1.68±0.7m; 69±21kg; X±SD) who did not consistently perform exercise visited the laboratory for a single session. Upon arrival, participants rested for 10 minutes before undergoing ultrasound measurements. B-mode and shear wave ultrasound images were taken from the vastus lateralis (VL) and rectus femoris (RF) muscles, with two images for each muscle while the participant was seated on an Isokinetic Dynamometer (HUMAC). EMG sensors were placed on the same muscles, following SENIAM guidelines for both the ultrasound probe and EMG placement. Electrical stimulation at rest was administered through femoral nerve stimulation to record maximal M-waves (MMAX) and twitch torque. EMG signals were processed according to ISEK standards. Participants performed three maximal isometric contractions of the knee extensors at a knee flexion of 90 degrees, and the highest contraction was selected for analysis. The rate of force development (RFD) was calculate from force onset to peak force, while VL and RF rate of activation (RoA) were calculated from EMG signal onset to EMG peak. An independent t-test was employed to compare sex differences in muscle thickness, stiffness, quality, MMAX, RFD (%MVIC), time to force peak, RoA (%MMAX), twitch force (%MVIC). Statistical analyses were conducted using SPSS software, with the significance threshold set at $P \leq 0.05$Results: RFD was not different between males and females. Muscle thickness in the rectus femoris (RF) ($P=0.039$) and vastus lateralis (VL) ($P=0.047$) was found to differ between males and females, with males exhibiting 30% (RF) and 44% (VL) greater muscle thickness than females. However, no other measured outcomes showed significant differences between males and females ($P \geq 0.052$). Although not statistically significant, MMAX was observed to be 46% and 55% higher in males than in females. Similarly, RFD, twitch force, RoA were 17% to 34% higher in males.Conclusion: This preliminary study showed that muscle thickness was the only variable that differed significantly between males and females. However, it is important to note that other variables were generally higher in males, although these differences were not statistically significant. Given the small size of the present cohort, the inclusion of more participants could potentially alter these findings.

## P1.41-M: Modulation of spinal and tendon reflex excitabilities of the soleus muscle during and after static stretching

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Static stretching induces neural changes in spinal reflex excitability and sensitivity of muscle spindles. These changes can be tested in the soleus muscle by evoking the Hoffman-reflex (H-reflex) and the tendon reflex. The H-reflex and tendon reflex are depressed during static stretching. After stretching, the H-reflex returns immediately to the state before stretching, but the tendon reflex remains depressed. These suggest that spinal reflex excitability is inhibited during static stretching, and long-lasting inhibition of muscle spindle sensitivity occurs with stretching. However, the effects of repeated static stretching on modulation of spinal and tendon reflex excitabilities are unclear. This study examined changes in the H-reflex and the tendon reflex of the soleus muscle during and after static stretching. Eleven healthy men were recruited. The participants were in the prone position with their hips and knees fully extended, and the foot in the anatomical position was attached to an isokinetic dynamometer. Static stretching involved five repetitions of 1-min stretching with a 1-min interval between repetitions at the maximal dorsiflexion angle. The H-reflex and the tendon reflex were recorded from the soleus muscle before and during stretching, at intervals between stretching, and 0, 2, 5, 10, and 20 min after static stretching. The H-reflex was evoked by transcutaneous electrical stimulation of the posterior tibial nerve, and stimulation intensity was adjusted to 5% of the maximal M-wave. The tendon reflex was evoked by a reflex hammer that was dropped on the Achilles tendon from a constant height. Peak-to-peak amplitudes of five responses of the H-reflex and of the tendon reflex were averaged, and time course changes of these responses from baseline (i.e., before stretching) were calculated. Measurements of the H-reflex and the tendon reflex were done on different days. Dorsiflexion angles during stretching were significantly increased with repeated stretching trials in both measurements. H-reflex amplitudes during stretching were 54.0-57.8% depressed (p < 0.05), and these depressions returned to baseline in the interval immediately following. Tendon reflex amplitudes during stretching were 74.2-78.8% depressed (p < 0.05), and these depressions were maintained in the interval immediately following. The recovery of significant depressions of tendon reflex amplitudes was observed at least 2 min after stretching. These results suggest that depression of spinal reflex excitability during static stretching disappears immediately after stretching, but long-lasting inhibition in muscle spindle sensitivity is induced by static stretching. Furthermore, there was no significant repetition effect on H-reflex and tendon reflex amplitudes during stretching. Repeated static stretching appears to have no modulating effect on spinal and tendon reflex excitabilities of the soleus muscle.

## P1.42-M: Influence of vibration therapy on the spinal reflex excitability of multiple lower limb muscles in able-bodied subjects

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Whole-body vibration (WBV) and local vibration are widely used as therapeutic interventions for individuals with central nervous system injuries. Although these vibration methods are shown to strongly suppress H-reflex excitability of the soleus muscle, the broader effects on various homologous and non-homologous muscle groups remain unexplored. Recently, a novel method using transcutaneous spinal cord stimulation (tSCS) was developed to evaluate spinal reflex excitability in multiple lower limb muscle groups. Using this method, the present study examined the effects of WBV on the spinal reflex circuits of the flexor and extensor muscles of the thigh and lower leg. The participants were seven healthy men who underwent assessments before, during, and after WBV and a control condition that included standing without vibration. Surface electromyography signals were unilaterally recorded in the right leg throughout the experiments. In the WBV condition, the intervention was applied for 1 min. In the control condition, the participants stood still for 1 min. Posterior root muscle (PRM) reflexes were elicited by tSCS and measured in four lower extremity muscles, including the tibialis anterior (TA), soleus (SOL), vastus medialis (VM), and biceps femoris (BF) before, during, and after the interventions. The effects of local vibration to the right Achilles tendon on the spinal reflexes were investigated in one participant in the sitting position. PRM reflexes were measured in the lower limb muscles before, during, and after the interventions. Our results showed that the peak-to-peak amplitudes of PRM reflexes of the TA, SOL, and BF muscles decreased significantly during the WBV intervention but returned to baseline after the intervention. The control condition has no effects. These results indicate that WBV has widespread inhibitory effects on reflex circuits in homologous and non-homologous muscles, excluding the SOL during WBV, but this effect is not sustained following a short-duration intervention. The characteristics of the suppression due to WBV were similar to those during local vibration. Overall, our results suggest that WBV and local vibration can be used effectively to temporarily decrease spinal excitability, which is relevant for treatment of spasticity in neurological disorders. Further studies are required to optimize the duration and frequency of these interventions to enhance and prolong their benefits in individuals with central nervous system injuries.

## P1.43-M: A new modular neurocontroller recombines synergies for stand-to-walk simulations [Poster Award]

David Muñoz, University College Dublin; Donal Holland, University College Dublin; Giacomo Severini, University College Dublin

Predictive neuromuscular models are a powerful tool for decoding the underlying architecture of the sensorimotor control and its neural activity. Applied to gait, these models can be categorised in CPG-based models (central pattern generators), which are good at modulating motor behaviours (i.e., gait speed), but lack neurophysiological representation in humans, and reflex-based models, which represent the principles of the legged mechanics, but the control of motor behaviour is a multidimensional problem. Also, these models are generally task-specific and mapping completely the skill space of a motion requires the tuning of all the parameters of the system. We here propose a modular model for posture and locomotion (MPL model). This model presents a modular architecture where synergies, coactivated muscle responses, are recombined by internal models (IMs) to display different motor tasks. The IMs are controlled by a hypothetical volitional signal generated by a higher structure, the mesencephalic locomotor region (MLR). The tuning of this signal allows to switch between IMs and, consequently, motor tasks. Specifically, we applied this architecture to a stand-to-walk motion. At a specific time of the simulation, the MLR switches the controlling signal, the controller breaks the upright posture, and the musculoskeletal model starts walking. The displayed gait matches human-like walking and the kinematics, ground reaction forces and muscle activation patterns are consistent to human data. Also, the modulation of the controlling signal has been shown capable of speed transition during walking. Once the model reaches steady walking at 1.3 ms-1, the MLR was able to map a new neural pathway and raise or lower the speed to 1.6 and 0.8ms-1, respectively. We hope that this preliminary implementation of the MPL model could be the first step to achieve a standardization of the modular representation of the human motor system. Thus, further development is needed to unblock the potential of the MPL model. As a start, we are developing an extension of the model to a walk-to-stand capability.

## P1.44-M: Effect of side dominance on lumbar muscle activation patterns: high-density electromyography insights

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BACKGROUND AND AIM: Previous research has indicated that the global activation of the lumbar erector spinae (ES) muscle is influenced by the trunk side dominance, determined with hand dominance [1]. Nevertheless, contemporary understanding acknowledges that the activation of ES muscles does not exhibit uniform spatial distribution across the cranio-caudal and medio-lateral axes. Recent studies have revealed distinctive side patterns of spatial activation in the lumbar ES muscles without a clear explanation in existing literature [2-3]. Therefore, it is hypothesized that the observed asymmetrical patterns of lumbar muscle activity may be partially attributed to the effects of side dominance. This study aims to investigate the impact of the trunk side dominance on the spatial distribution of muscle activation. METHODS: 43 participants (10 left-handed and 33 right-handed) took part in this study. The dominant side of the back was determined using the manual preference questionnaire [4]. A 20 second isometric back extension submaximal contraction was conducted. During the contraction, muscle activation strategies of the left and right lumbar ES were recorded using high-density surface electromyography (two grids of 8x8 electrodes). Spatial distribution was measured using the location of the centroid coordinates (medio-lateral and cranio-caudal) on both grids. The centroid represents the average position of the channels that had RMS values higher than 70% of the maximum value across all channels. A pairwise t-test was used to evaluate differences between the dominant and non-dominant sides of the ES muscle. Additionally, an independent t-test was performed to assess disparities between left-handed and right-handed participants. RESULTS: Dominance significantly influenced centroid location, indicating a more cranial activation on the dominant side ($p=0.016$). No medio-lateral differences were observed ($p=0.224$). Additionally, no distinctions were found between left- and right-handed subjects. CONCLUSION: Side dominance may induce uneven ES demands during daily tasks, potentially causing morphological adaptations over time. Such adaptations may result in heightened activation of the ES muscle on the dominant side, predominantly located in the cranial region, which could explain the more cranial activation observed on the dominant side [5]. Given these findings, we recommend that future studies assessing spatial distribution of ES muscle consider (I) evaluating both sides of the ES muscle and (II) assessing ES dominance.[1] PS Sung et al., Spine 29 (17), 1914 (2004).[2] Z Hao et al., Pain Research and Management 2020 (2020).[3] J Abboud et al., European journal of applied physiology 114, 2645 (2014).[4] G Dellatolas et al., Revue de psychologie appliquée (1988).[5] JE MACINTOSH and N BOGDUK, Spine 12 (7), 658 (1987).

## P1.45-M: Relationship Between Joint Angle and Patterns of Hamstrings Activation After ACL Reconstruction

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BACKGROUND/AIM: Individuals who have undergone anterior cruciate ligament reconstruction via hamstrings tendon autograft (ACLR-HT) exhibit persistent hamstrings weakness. Despite muscular deficits, biceps femoris (BF) and semitendinosus (ST) facilitation is reported during sub-maximal tasks (e.g., gait, stair ambulation). However, relative activation of the medial (ST)-to-lateral (BF) hamstrings has not been investigated during maximal effort, particularly as a

function of joint angle. Therefore, we aimed to compare the magnitude and ratio of medial and lateral hamstrings activity during maximal effort at different muscle lengths between limbs of individuals with ACLR-HT. METHODS: Electromyographic (EMG) activity of the BF and ST was recorded during a series of randomized maximal voluntary isometric contractions (MVICs) at 20°, 40°, 60°, and 80° of knee flexion in twenty-three individuals with primary, unilateral ACLR-HT (age=23±3.1 years, sex=14 females, time from surgery=46.9±26.3 months). Average root mean square amplitudes of raw EMG signals were recorded from the middle 1-second of MVIC plateaus and averaged across trials for each muscle and joint angle. The ratio of medial (ST)-to-lateral (BF) hamstrings activity was calculated using processed EMG signals and quantified at each joint angle. Separate 2x4 repeated measures ANOVAs were used to investigate isolated or interactive effects of muscle and joint angle for each limb, using Holm-Bonferroni correction for post-hoc testing where applicable. Paired samples t-tests were used to compare muscle activity between limbs at each joint angle. Cohen’s d effect sizes with 95% confidence intervals were used to quantify magnitudes of observed differences. Results are reported as percentage difference (%) in EMG activity. RESULTS: EMG activity differed by joint angle, but not muscle, for both limbs. In the involved limb, collapsed EMG activity was higher at 60° than 20° (26.2%, p<.001, d=0.71 [0.19, 1.23]). In the uninvolved limb, collapsed EMG activity was higher at 40° (16.6%, p=.043, d=0.29 [-0.6, 0.06]), 60° (44.7%, p<.001, d=0.79, [0.32, 1.27], and 80° (30.2%, p<.001, d=0.54 [0.14, 0.94]) than 20°, and at 60° than 40° (20.1%, p<.001, d=0.5 [0.11, 0.89]). Medial-to-lateral hamstrings activation ratios and BF EMG activity did not differ between limbs or joint angles. ST EMG activity was lower in the involved compared to uninvolved limb at 60° (-18%, p=.044, d=-0.45 [-0.87, -0.01]). CONCLUSIONS: Activation patterns were similar for the medial and lateral hamstrings across joint angles, with higher activation of both muscles observed at greater knee flexion angles. Lower ST activation of the involved limb near optimal fiber length may reflect a reduced neuromuscular capacity of the medial hamstrings at maximal effort, potentially due to this muscle serving as the graft donor. Thus, interventions targeting maximal effort medial hamstrings activation may be warranted in individuals with ACLR-HT.

## P1.46-N: Investigation of the mechanism behind corticomuscular communication based on bursts of neural activity

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Our nervous system achieves movement control and sensory information processing by appropriately sending and receiving electrical signals. Phase synchronization has been proposed as a mechanism that enables such efficient information transmission. Phase synchronization refers to the phenomenon where the rhythms of neural activity (neural oscillations) between different neural regions synchronize. Such phase synchronization is known to occur not only between brain regions but also between the sensorimotor cortex and muscles, which is called corticomuscular coherence (CMC). However, there are many unclear points regarding how such phase synchronization occurs and what specific benefits (functional significance) it brings to the nervous system. CMC is the optimal system for examining the mechanisms of phase synchronization and its functional significance because it is observed in a relatively simple system of sensorimotor cortex and muscles that is easy to measure and shows clear individual differences; CMC is not observed in about half of the participants. Therefore, our study focused on CMC to investigate the mechanisms of phase synchronization and its functional significance. We recorded scalp electroencephalograms over the sensorimotor area and surface electromyograms from the tibialis anterior muscle while human participants carried out ankle dorsiflexion. As a new analytical method, signals of the electroencephalogram were averaged on the timing of hundreds of electromyographic bursts. This indicates that bursts of muscle activity were used as events for event-related potentials in the electroencephalogram. As a result, a clear rhythmicity in the beta band (15–35 Hz), where CMC has traditionally been observed, was observed in the averaged waveforms (Figure 1). This result intuitively shows that the electromyographic bursts are strictly phase-locked to the beta oscillations of the sensorimotor cortex. Advantages of this method include the ability to examine the pattern of signal transmission from muscle to brain in participants where CMC is not observed, and the ability to examine how CMC occurs over time from the start of movement. Our presentation will discuss in detail the methodology and the signal transmission mechanism it suggests.  Figure 1: (Left) An averaged electroencephalographic waveform relative to 240 electromyographic bursts. (Right) Time-frequency map for the waveform.

## P1.47-N: **Femoral cartilage cross-sectional area in collegiate Archery, Badminton, Taekwondo, and Tennis players, and non-athletic individuals: a 12-month follow-up study**

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BACKGROUND: While most weight bearing sports activities accompany joint pressure loading, a cross-sectional comparison in sports with or without rotational joint loading would provide insight into early detection in joint degeneration. While time (aging) is the contributing factor, an interval assessment (e.g., 12 months) would be a surrogate of a process of an adaption of cartilage morphology. PURPOSE: To prospectively compared femoral cartilage cross-sectional area (CSA) morphology across Archery, Badminton, Taekwondo, Tennis players and non-athletic individuals over two years. METHODS: A total of 139 individuals, categorised by four groups (30 Archery, 42 racquet sport—Badminton and Tennis, 36 Taekwondo players, 31 non-athletic individuals) were studied between the first- and second-year measurements. After taken demographic information (age, height, weight, body mass index—BMI, dominant leg, and athletic careers) and functional outcomes of knee, subjects had a 20-min unloading period (seated with knees fully extended) to minimise effects of preceding weight bearing on the femoral cartilage CSA. Femoral cartilage CSA images on each side were obtained at the first- and second-year measurements using ultrasonography, then manually segmented to calculate the femoral cartilage CSA. Femoral cartilage CSA were nomalised by BMI (mm2/kg/m2). To test femoral cartilage CSA between groups over time, a two-way (group × time) analysis of variance and Tukey-tests were performed on each side separately (α=0.05). Cohen’s d (d) was calculated where statistical differences existed. RESULTS: The right side of the femoral cartilage CSA was different (group × time: F3,135=20.05, p<0.0001). At first year, racquet sport players (3.81 mm2) had a greater femoral cartilage CSA than Archery players (3.03 mm2, p<0.0001, d=0.6) and non-athletic individuals (3.09 mm2, p<0.0001, d=0.6); Taekwondo players (3.83 mm2) had a greater femoral cartilage CSA than Archery players (3.03 mm2, p<0.0001, d=0.7) and non-athletic individuals (3.09 mm2, p<0.0001, d=0.6). At second year, Taekwondo players (3.88 mm2) showed a reduction in femoral cartilage CSA relative to the first year (3.44 mm2, p=0.001, d=0.7). The left side of the femoral cartilage CSA was different (group × time:

F3,135=3.88, p=0.011). At first year, racquet sport players (3.68 mm2) had a greater femoral cartilage CSA than Archey players (3.01 mm2, p=0.002, d=0.7) and non-athletic individuals (3.09 mm2, p=0.01 d=0.6); Taekwondo (3.63 mm2) players had a greater femoral cartilage CSA than Archey players (3.01 mm2, p=0.0001, d=0.8) and non-athletic individuals (p=0.001, d=0.7). At second year, Taekwondo players (3.63 mm2) reduced to relative the first year (3.36 mm2, p=0.001, d=0.6). CONCLUSIONS: A femoral cartilage CSA reduction at both sides in Taekwondo at the second year might also be attributed to sports-specific characteristics (e.g., contact combat sport) relative to Archery and racquet sports.

## P1.48-O: Investigating regional flexion relaxation phenomenon changes in lumbar muscles under delayed onset muscle soreness

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BACKGROUND AND AIM: The flexion relaxation phenomenon (FRP) refers to the reduction of muscle activity in the lumbar erector spinae muscles when the trunk is fully flexed. Some individuals with chronic low back pain have shown altered FRP, indicating its potential as a biomarker for this condition. However, there is considerable variability in reported results, likely stemming from chronic low back pain confounding factors and assessment methods (bipolar EMG at different vertebral level). To mitigate this variability, experimentally induced pain can reduce variability by controlling those confounding factors, while high-density surface electromyography (HDsEMG) enhances precision and enables spatial mapping for a more comprehensive understanding of lumbar erector spinae muscle behavior. Notably, using HDsEMG, delayed onset of the FRP in the cranial region of the erector spinae muscle in individuals with lower back pain compared to healthy participants was observed [1]. Despite this observed regional delay in FRP onset, the impact of pain on the magnitude of FRP within different lumbar regions remains unknown. The aim of this study is to investigate how lumbar pain, induced with delayed onset muscle soreness (DOMS), influences the magnitude of the FRP regionally. METHODS: This study involved twenty healthy adults. Participants underwent five trunk flexion relaxation contractions in two sessions. The first session occurred without DOMS, while the second occurred 24-36 hours after inducing DOMS. To evaluate DOMS induction, pain, soreness, maximal voluntary contraction, and pressure pain threshold in the lumbar muscle were assessed. During the flexion-relaxation contractions, muscle activation strategies of the left and right lumbar erector spinae were recorded using HDsEMG (two grids of 8x8 electrodes). The flexion/relaxation ratio characterized the magnitude of FRP, calculated on each channel of both grids using 1 second of maximal root mean square muscle activity during flexion and relaxation. Contraction phases were identified using 3D kinematics markers on the lumbar and hip regions. Repeated measure ANOVA was conducted to assess the extent of FRP occurrence (mean ratio for all channels) and its location using centroid coordinates (spatial distribution of FRP ratio values on the grid) between the two sessions. RESULTS: Preliminary findings (n=10) found a cranial shift in FRP with DOMS on the left side only (Left p=0.049; Right: p=0.272). However, no significant difference was observed on the extent of FRP occurrence (Left: p=0.710, Right: p=0.879). CONCLUSION: These preliminary findings suggest that DOMS-induced pain did not increase overall FRP in the erector spinae. Rather, it prompted a shift of

FRP toward cranial areas, while reducing its caudal presence. Yet, these findings are still preliminary and require further confirmation with the complete sample size (n=20).[1] C Murillo et al., Scientific reports 9 (1), 15938 (2019).

## P1.49-O: Evaluation of Muscle Electrical Activity in Patients with Myofascial Pain Syndrome Using Surface Electromyography

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Subject: Myofascial pain syndrome (MPS) is a common health problem characterized by the presence of myofascial trigger points (MTrP). However, the changes in neuromuscular functions incurred by MPS are still well-understood. The purpose of this study was to compare the differences in muscle electrical activity between the painful (P) and non-painful (NP) sides in patients with unilateral MPS and to verify the feasibility of surface electromyography (sEMG) for assisting in MPS assessment.Methods: Forty patients with unilateral lumbar MPS were recruited via the outpatient department of West China Hospital Sichuan University from October 2022 to October 2023. A sEMG system was used to record the sEMG signals of both sides of the erector spinae muscles. Then, the subjects conducted six trunk extension trials. Each trial was a 5-second maximal voluntary contraction with a 5-second rest period in between. Six time-domain features of sEMG were extracted, namely, root mean square (RMS), mean absolute value (MAV), integrated EMG (iEMG), and waveform length (WL). Additionally, the frequency domain features used are the median frequency (MDF) and mean power frequency (MPF).Results: The time-domain features on the painful side were significantly higher than those on the non-painful side (RMS, P: 75.4 ± 34.1, NP: 63.4 ± 24.9, p < 0.001; MAV, P: 59.3 ± 26.8, NP: 49.6 ± 19.5, p < 0.001; iEMG, P: 11854.6 ± 5352.0, NP: 9923.6 ± 3898.9, p < 0.001; WL, P: 8809.9 ± 4161.9, NP: 7613.6 ± 3421.0, p = 0.001). Additionally, there was no difference in the frequency-domain features between the painful side and the non-painful side (MPF, P: 111.4 ± 21.2, NP: 113.0 ± 22.7, p = 0.478; MDF, P: 91.8 ± 20.8, NP: 92.5 ± 22.3, p = 0.758).Conclusion: Our results indicated that MPS likely leads to abnormal time-domain features of sEMG, while not in frequency-domain features. These preliminary results demonstrated the potential feasibility of using sEMG as a tool for assessing the neuromuscular function of MPS.

## P1.50-P: Gait analysis for support in diagnostics in neuromuscular disorders

Nicole Voet, Radboudumc/ Klimmendaal

In rehabilitation medicine, instrumented gait analysis was developed to assist in clinical decision-making to optimise treatment to improve walking in patients with neuromuscular diseases (NMD) and complex gait problems. In instrumented gait analysis, quantitative data of the gait cycle is collected: kinematics, kinetics and electromyography.We recently applied gait analysis in two cases to assist the neurologist in the diagnostic process: a patient with nemaline myopathy and polyneuropathy, respectively. In both patients, an accurate diagnosis could not be found based on the symptoms they reported, despite a thorough analysis by the neurologist. Instead, the symptoms were caused by the compensations patients used to optimise walking and not directly by the health condition itself. Through instrumented gait analysis, the direct

impact of a health condition on the gait pattern can be distinguished from compensations. This can be an asset in finding the correct diagnosis, especially in NMD patients with complex gait problems or multiple health conditions.  In patients with abnormal gait patterns, the complaints are not always the direct result of the primary problem; they may also result from compensations, secondary problems or a yet undiagnosed underlying condition. When there are complaints during walking, it may be valuable to have the rehabilitation physician perform a gait image analysis in the diagnostic phase. This can identify the primary problem, shorten diagnostics and optimise treatment.

## P1.51-P: Exploring the Biomechanical Impact of Chronic Ankle Instability on Cutting Movements: a systemic review

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This review investigates lower limb biomechanics during side-cutting movements in individuals with chronic ankle instability (CAI). Studies from PubMed, Scopus, Web of Science, and SPORTDiscus up to 2023 were examined, focusing on case-control studies with subjects exhibiting CAI or recurrent ankle sprains. Inclusion criteria comprised chronic, functional, or mechanical instability, with primary outcomes including joint angle, ground reaction force (GRF), and muscle activation during cutting. Fourteen articles met the criteria, assessed for quality using a modified Downs and Black Checklist. CAI individuals exhibited distinct biomechanical alterations, including joint angle deficits, increased ankle inversion, abnormal sagittal motion, and altered kinetics and muscle activities during cutting tasks. These findings highlight the intricate biomechanical adaptations in CAI individuals, suggesting potential compensatory mechanisms and neuromuscular compromise.

## P1.52-P: Relationship between fibula motion characteristics and knee joint during walking.

Akihiro Yamashita, The University of Electro-Communications; Tsutomu  Fukui, Bunkyo Gakuin University; Kazuyuki Mito, The University of Electro-Communications

INTRODUCTIONDue to its position and structure in the body, the fibula has almost no role in compressive stress on the physiological axis and is said to be unrelated to load. But the lower leg transmits the impact of walking ground above the knee joint. Since a shock-absorbing effect occurs throughout the lower limb when grounded, it may have a similar function between the tibia and fibula. The position of the fibula relative to the tibia affects the knee joint and ankle joint, but its dynamics are still largely unknown. Therefore, in this study, by measuring the fibular dynamics during walking in relation to the tibia, we will elucidate a part of the fibula function by examining the movement of the fibula relative to the tibia during walking and examine whether intervention on the fibula is useful for knee joint treatment because of the influence of the fibula function on the joint movement of the knee joint.METHODSThe subjects were 16 healthy adult males aged 18 to 40 who had a history of lower limb surgery, orthopedic disease within the past 1 year, and no pain. The measurement operation was a stationary standing and walking, and the

subject was instructed to step on the floor reaction force meter on the fourth step on a 10 m straight road. The measurement instrument used a 3D motion capture system consisting of 12 MX cameras, and the measurement sampling frequency was 100 Hz. A total of 45 infrared reflective markers with a diameter of 14 mm were affixed to the subjects' bodies. Segments were created using the arithmetic processing software Body Builder, and the angles of the femur, tibia, and fibula in absolute space were calculated. Correlation analysis was performed using the amount of angular change of the fibula with respect to the tibia and the amount of angular change of the tibia relative to the femur as output variables.RESULTS AND DISCUSSIONThe fibula changed position relative to the tibia when walking. We also found that the phenomenon during the loading response correlated with the knee joint of the coronal plane and the horizontal plane at the same time. Since the time when the fibula moves during walking is like the time when the ankle joint moves, it is expected to be affected by talus pulleys. Previous studies have shown that when the lower leg muscle was resected and then dorsiflexed from the median position with a load applied, the malleolus was displaced backwards. The movement of the fibula is thought to change its position due to joint structure and muscle contraction because the anterior displacement of the outer malleolus was also observed in this experiment. CONCLUSIONSIt was predicted that the fibula moves independently of the tibia to absorb the impact applied to the knee joint by performing a combination of coronal, sagittal, and horizontal planes. These results suggest that the observation of peroneal dynamics can be used as an index to predict knee joint rotation during walking.

## P1.53-P: **High-density surface electromyography feedback improves the recruitment of the peroneus longus muscle in individuals with chronic ankle instability**

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Context: People with chronic ankle instability (CAI) have inhibition of the posterior compartment of the peroneus longus. However, it is unknown if any intervention can restore regional activation of this muscle. One possible solution is high-density surface electromyography (HD-sEMG) feedback.Purpose: This study aimed to determine whether individuals with CAI can activate the peroneus longus compartments with HD-sEMG feedback to the same extent as those without CAI and HD-sEMG feedback use. Methods: Sixteen volunteers were involved in the CAI group, and another 16 volunteers were part of the healthy group (No-CAI). All Participants were given 20 minutes to learn HD-sEMG feedback (familiarization protocol) and instructed to shift the center of gravity in the peroneus longus muscle. They performed ankle eversion at 30% and 70% maximum voluntary isometric contraction (MVIC), with adjustments to activate specific muscle compartments (Figure 1). After 5 minutes of rest, the HD-sEMG feedback training protocol was executed. The center of mass (COM) and the sEMG amplitude at each compartment (anterior and posterior) of the peroneus longus were recorded during ankle eversion at 30 and 70% of their MVIC, both with and without visual feedback on the spatial distribution of peroneus longus (Figure 1). Each participant completed 8 randomly eversion movements to mitigate learning bias. A thwo-way ANOVA (group x feedback condition) with repeated measures was applied.Results: A significant interaction effect between group and feedback condition was observed ($F_{1, 31} = 12.54$; $P = 0.0013$) during ankle eversion only at 70% MVIC. The posterior compartment sEMG amplitude in the CAI group trained with HD-sEMG feedback was significantly higher than without HD-sEMG feedback ($P = 0.0010$) and was similar

to the No-CAI group without HD-sEMG feedback (P = 0.9935). The COMx in the CAI group trained with HD-sEMG feedback was significantly shifted in the anteroposterior direction compared to the group without HD-sEMG feedback (P = 0.0012).Conclusion: The use of HD-sEMG feedback during ankle eversion allows activation of the posterior compartment of the peroneus longus to the same extent as healthy people not using feedback devices. HD-sEMG-based topographic maps can be used as a feedback training tool to restore motor control, although their long-term effectiveness needs to be investigated through longitudinal and prospective studies.LeyendFigure 1: Representation of high-density surface electromyography electrode (13 x 5 electrodes; 1 mm diameter electrode; 8 mm interelectrode distance) placement over participants' peroneus longus muscle. Surface electrodes arranged in 5 columns which represented the anterior (columns 1/2) and posterior (columns 4/5) compartments. Representation of the testing setup. Participants were instructed to shift the position of the center of gravity of the HD-sEMG map towards the posterior compartment of peroneus longus. For this, a researcher palpated the posterior region of the electrode mesh to induce an artifact in the sEMG signal –represented by hot colors in the activation map– that would allow the participant to recognize the activation of posterior compartment of the peroneus longus.

## P1.54-P: The intervention combining motor imagery of knee extension and transcranial magnetic stimulation facilitates corticospinal excitability of the tibialis anterior muscle, but not the rectus femoris muscle.

Keiichi Ishikawa, The University of Tokyo; Naotsugu Kaneko, University of Tokyo; Kimitaka Nakazawa, The University of Tokyo

Introduction Motor imagery (MI) is the mental simulation of movement and can modulate corticospinal excitability (CSE). MI is used in rehabilitation, but its effects have been suggested to vary depending on the MI task and target muscle. Our recent study found that MI of knee extension facilitates CSE of the rectus femoris muscle (RF), which is the agonist muscle, and tibialis anterior muscle (TA), which is not recruited in the knee extension. As a continuation of the study, we propose the intervention combining MI with transcranial magnetic stimulation (TMS) to induce neuroplastic changes. This study aimed to investigate the effects of the intervention (MI+TMS) on CSE of the lower limb muscles. Method Twenty healthy individuals participated in this study. Participants were seated on a chair and electromyographic (EMG) activity was recorded from the right side of the RF, biceps femoris (BF), TA, and soleus (SOL) muscles. CSE was evaluated by motor evoked potential (MEP) amplitudes obtained by TMS to the primary motor cortex. The stimulation position was the hotspot of RF, and the intensity of TMS was set at 1.2 times the resting motor threshold of RF for both intervention and evaluation. In MI+TMS, participants were instructed to avoid any muscle contraction and to repeat the resting and MI states every 4 seconds. In the resting state, they were asked to relax without internal imagery. In the MI state, they performed MI of maximal effort knee extension, and TMS was applied during MI. MI and TMS were repeated 120 times, and the duration of MI+TMS was 16 minutes. Evaluations of CSE at rest were performed before the intervention (Pre), immediately after the intervention (Post 0), 15 minutes later (Post 15), and 30 minutes later (Post 30). The average peak-to-peak amplitude of 12 MEPs at each time point was calculated. The Friedman test and Steel post hoc test were used to compare MEP amplitudes between Pre and Post MI+TMS.Results MEP amplitudes of RF, BF, and SOL after MI+TMS were not significantly different from those at Pre at any time point (p > 0.05). On the other hand, MEP amplitude for TA was significantly larger at Post 0 and Post 15 than at Pre (p < 0.05).  Discussion    The MI task in this study was a knee extension movement and expected to facilitate CSE of RF, which mainly acts for knee extension movement. However, there was no significant change in CSE of RF after MI+TMS. On the other hand, the intervention enhanced CSE of TA at Post 0 and Post 15. Although our previous study indicated that MI of knee extension facilitated CSE of RF and TA, in this study, the effect of MI+TMS was apparent only in the TA muscle. These results suggest that CSE of TA is more susceptible to neuroplastic changes than that of RF. Our findings may contribute to the development of neuro-rehabilitation methods to restore motor function by inducing plastic changes in the central nervous system.

## P1.55-P: Motor Imagery then Action Observation as a Treatment for Stroke Patients with Distal Upper Limb Flaccidity- Preliminary Results in Normal Adults

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Introduction: Poor motor recovery in the upper extremity (UE) following a cerebral stroke significantly compromises the independence of the patient's life and places a substantial burden on both the patient and their caregivers. Recent scientific evidence indicates that action observation (AO), motor imagery (MI), and mirror therapy (MT) can effectively enhance UE motor function in stroke patients. These interventions can be applied even when patients have limited or no ability to move their limbs, making them suitable for individuals with flaccid hands post-stroke. However, these treatments have not been classified as essential; rather, they are often regarded as adjuvant therapies for improving hand flaccidity following a stroke. One key reason for this might be their limited bidirectional influences on both the central and peripheral components of the motor system (Figure 1 illustrates the distinctions among these training modes concerning the direction of influences over the peripheral and central components of the motor system).Aim& Methods: To address this gap, we have developed an integrated treatment platform capable of delivering AO, MI, and a novel training mode (MI then AO) that establishes a connection between central motivation and peripheral visual stimulation. These modes can also be adjusted to tune the velocity and range of movement videos, making them adaptable to the specific training needs in clinical settings. In the preliminary study, we recruited 20 healthy participants to record EEG signals from the sensorimotor cortex (C3, Cz, and C4). We analyzed the event-related desynchronization (ERD) of the mu rhythm under a carefully designed paradigm to evaluate the effects of these three distinct training modes. Results: The initial findings revealed a noticeable increase in the overall ERD area in the C4 channel compared to C3 and Cz channels across all three modes (all P < 0.001). During the P3 phase (2-4 seconds), we identified a significantly higher activation in the C4 ERD area during the MI then AO mode (P<0.01), which suggests that the novel training mode induces a greater level of brain activity. Conclusion: Our findings demonstrate that the novel training mode enhances cortical activation in specific brain areas in normal participants. Moving forward, we aim to extend the implementation of our treatment strategy to clinics, with the hope that our innovative approach will prove beneficial for patients experiencing distal UE flaccidity.

## P1.56-P: Development of an Integrated Digital Movement Therapy Platform for Mirror Therapy, Action Observation and Motor Imagery

Stroke can have a profound impact on an individual's motor function, often leading to muscle weakness and limited mobility. However, a cognitive treatment approach, which includes motor imagery, action observation, and mirror therapy, has shown promising results in improving the motor function of stroke patients. Motor imagery involves mentally visualizing movements and actions, activating neural pathways associated with physical tasks. Stroke survivors can mentally rehearse movements they struggle to perform, effectively retraining their brains to regain motor skills. Action observation complements this by having patients observe others performing tasks, enhancing their understanding and motivation to relearn movements. Mirror therapy uses a reflective surface to create the illusion of a functional limb, encouraging the affected limb to mimic the movements of the unaffected one. This visual feedback stimulates brain activity and promotes the recovery of motor function.Together, these cognitive techniques harness the brain's neuroplasticity, fostering the rewiring and strengthening of damaged neural connections. Stroke patients can regain muscle strength, coordination, and mobility, ultimately regaining independence and enhancing their quality of life. This holistic approach to rehabilitation offers hope and tangible progress for those on the journey to recovery.

## P1.57-P: Relationship between rotational movement patterns of the pelvis and each thoracic vertebral level during gait in healthy adults

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Background and aimsDuring gait, the thorax exhibits a coordinated movement pattern with pelvic rotation, resulting in rotation in the opposite direction of the pelvis to maintain equilibrium. However, we speculate that not all thoracic vertebrae rotate identically in the opposite direction to the pelvis during gait; instead, the direction of rotation differs at each thoracic vertebral level. Therefore, we aimed to examine the relationship between pelvic rotation during gait and the rotational movement patterns at each thoracic vertebral level. Clarifying these relationships will improve the current understanding of trunk motor control necessary for efficient gait and will serve as an indicator for gait evaluation. MethodsThe participants were 17 healthy adult males (age 23.0 ± 1.5 years, height 1.72 ± 0.05 m, weight 65.2 ± 8.7 kg). The measurement device used was a VICON system, a three-dimensional motion analyzer, and the Visual 3D software was used for analyses. A total of 46 markers were attached to the participants by modifying an IOR gait model. The trunk was divided into four segments: T2, T4, T7, and T10; a marker was attached to each thoracic spinous process (T2, T4, T7, and T10), along with two other markers that formed a triangle under the spinous processes. The measurements were averaged over five runs of barefoot gait at the optimal speed, and the measurement interval was 100% normalized to a total of three steps from the right heel contact to the second left heel contact. Time series data of the pelvic and thorax segments, T2, T4, T7, and T10 rotation angles (+; left rotation) during the normalized gait cycle were calculated, and the relationship between the pelvic and thorax segments and T2, T4, T7, and T10 was examined using cross-correlation coefficients. The significance level was set at <5%.ResultsThe time series waveform of the rotation angle (Fig.1) showed a different waveform trend at each thoracic vertebral level. The correlations between the pelvic segment and each segment were as follows:

thorax segment (r = -0.507), T2 (r = -0.345), T4 (r = 0.290), T7 (r = 0.931), and T10 (r = 0.813). The correlations between the thorax segments and each thoracic spine were as follows: T2 (r = 0.976), T4 (r = 0.657), T7 (r = -0176), and T10 (r = 0.053).ConclusionThe lower thoracic vertebral levels (T7 and T10) had ipsilateral and similar rotation patterns to the pelvis, whereas the upper thoracic vertebral level (T2) had contralateral and different rotation patterns; however, T4 showed no consistent relationship to the pelvis. The thorax and upper thoracic vertebrae levels (T2 and T4) exhibited similar rotation patterns. These findings suggest that the lower thoracic vertebral level rotates ipsilaterally in coordination with the pelvis and that counter-rotational motion to the pelvis may occur at the upper thoracic vertebral level. The upper and lower thoracic vertebral levels may have different motor controls during gait in healthy adults.

## P1.58-P: The effect of Scapulothoracic Motion Restriction on Glenohumeral Muscle Activation: Implications to Injury

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Background and Aim: The shoulder joint is highly complex, requiring coordinated motion at the glenohumeral (GH), scapulothoracic (ST), acromioclavicular (AC), and sternoclavicular (SC) joints. Prior research has proposed that scapular dyskinesia can lead to injury by disrupting the scapulohumeral rhythm (SHR). The scapula can be restricted by endogenous pathology, through nerve injuries or muscle dysfunction, or by exogenous factors, such as body positioning, PPE, tight or restrictive clothing, and the use of some tools (e.g., backpacks, harnesses, hosing). These restrictive scenarios are commonly encountered in the workplace or during activities of daily living. The aim of this project was to investigate the effect of scapular dyskinesia, imposed by applying antero-inferior compression to the scapula, on both task-specific and overall muscle activation profiles.Methods: Fifteen right-handed adult males without history of shoulder pathology performed activities of daily living (ADLs) using their dominant arm, with and without a custom-made scapula restriction device. The selected ADLs performed by each subject were: straight-arm scaption, flexion, and abduction (simple), and combing hair front-to-back, pouring water from a pitcher, and removing and replacing an object from a shelf using an anterior and a cross-body reach (complex). Surface electromyography (sEMG) data was recorded on 11 muscles; anterior, middle, and posterior deltoid (ADel, MDel, PDel), upper and lower pectorals (UPec, LPec), upper and lower trapezius (UTrap, LTrap), latissimus dorsi (LDor), infraspinatus (InSp), biceps brachii (BiBr), and triceps long head (TrLh). Infrared motion-capture technology was simultaneously used to track 3-D movement of the subject's trunk, scapula, and dominant arm. Muscle activation patterns were demeaned, band-pass filtered (10-450 Hz), and RMS processed using MATLAB and normalized to percent maximum voluntary contraction (%MVC) produced during isometric/isokinetic tasks on a Cybex dynamometer. MANOVAs were used to assess differences in level of sEMG activation between restriction conditions, followed with post-hoc univariate F tests. Results and Discussion: There was significantly higher sEMG muscle activation in the restricted condition across tasks (simple p<0.003, η2>0.83; complex p<0.024, η2>0.68). The post-hoc univariate test indicated higher sEMG activation: for MDel, PDel, and LDor during abduction (p<0.009; partial η2>0.39); for UPec and LDor during flexion (p<0.009; partial η2>0.21); for MDel and LDor during scaption (p<0.019; partial η2>0.33); for ADel, MDel, UPec and ADel, UPec during

anterior (p<0.017; partial η2>0.35) and cross-body (p<0.002; partial η2>0.50) object removal and replacement, respectively; for MDel, LDor, and BiBr for hair combing (p<0.025; partial η2>0.50); and for Adel and UPec for water pouring (p<0.005; partial η2>0.34). Interestingly the InSp showed a statistically significant decrease in activation during cross-body object placement and water pouring (p<0.01).Conclusions: Restriction of ST motion causes a compensatory increase in activation of several muscles crossing the GH joint, which may predispose individuals to increased rates of shoulder pathology when performing tasks in the upper extremity workspace. These findings can provide a predictive foundation for injury risk determination and medical management in individuals with scapular dyskinesia or exogenous ST motion restriction.

## P1.59-P: Relationship between fibula motion characteristics and knee joint during walking.

Akihiro Yamashita, The University of Electro-Communications

INTRODUCTIONDue to its position and structure in the body, the fibula has almost no role in compressive stress on the physiological axis and is said to be unrelated to load. It constitutes a joint with the tibia and displaces its position in the distal tibial joint for continuous adaptation of the distance between the inner and outer malleolus in the ankle joint. As mentioned above, the fibula does not have a load function, but the lower leg transmits the impact of ground reaction above the knee joint. Since the shock-absorbing role occurs throughout the lower limb when grounded, part of them may contain same function between the tibia and fibula. The position of the fibula relative to the tibia affects the knee joint and ankle joint, which I have strongly felt from my clinical experience, but its dynamics are still largely unknown. Therefore, in this study, by measuring the fibular dynamics during walking in relation to the tibia, we will elucidate a part of the fibula function by examining the movement of the fibula relative to the tibia during walking and examine whether intervention on the fibula is useful for knee joint treatment because of the influence of the fibula function on the joint movement for the knee joint.METHODSThe subjects were 16 healthy adult males aged 18 to 40 who had a history of lower limb surgery, orthopedic problems within the past one year, and no pain. The measurement operation was a stationary standing and walking, and the subject was instructed to step on the force platform on the fourth step on a 10 m walking way. The measurement instrument used a 3D motion capture system consisting of 12 MX cameras, and the measurement sampling frequency was 100 Hz. A total of 45 infrared reflective markers with a diameter of 14 mm were affixed to the subjects' bodies. Three segments were created using the Body Builder, the femur, the tibia and the fibula. The relative angles to others e were calculated. Correlation analysis was performed using the amount of angular change of the fibula with respect to the tibia and the amount of angular change of the tibia relative to the femur as output variables.RESULTS AND DISCUSSIONThe fibula changed position relative to the tibia when walking. We also found that the phenomenon during the Lording Response correlated with the knee joint at the same time. Since the fibula movement is coincident the ankle sagittal behaviors, it is expected to be affected by the morphology of the pulley of talus. Previous studies have shown that when the peroneus brevis muscle was resected and then dorsiflexed from the neutral position with a load applied, the malleolus was displaced backwards. The movement of the fibula is thought to change its position due to joint structure and muscle contraction because the anterior displacement of the outer malleolus was observed in this experiment.CONCLUSIONSIt was predicted that the fibula moves independently of the tibia to absorb the impact applied to the knee joint by performing a combination of coronal, sagittal, and horizontal planes. These results suggest that the observation of peroneal dynamics can be used as an index to predict knee joint rotation during walking.

## P1.60-Q: Decoding Prime Mover Motor Units Enables the Intuitive Control of the Paralyzed Hand after Spinal Cord Injury

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The intricate movements of the human hand are governed by a neural network involving large number of neurons in the brain and spinal cord. Surface electromyography (sEMG) records electrical currents generated by muscle fiber contractions. Recent advancements in high-density sEMG (HD-sEMG) analysis allow precise identification of motor unit firing activities. Individuals with motor complete spinal cord injuries (SCI, AIS A & B) exhibit residual motor units responsible for finger movements. Our research aims to decode prime mover motor unit ensembles using online decomposition and connect these ensembles to mechatronic systems to assist individuals living with motor complete SCI in their daily lives in real-time.  This study aimed to investigate the performance of our approach in achieving precise and intuitive control over rehabilitative systems with the goal of restoring grasp functionality.In our study, we have applied 128 channels of HD-sEMG on the forearms of individuals with motor complete SCI (n=4, injury level C5-C6). Using our software NeurOne, we performed real-time digitalization of motor unit activity. The HD-sEMG signals were decomposed into individual motor units using convolutive blind source separation. The decoded motor units were classified into the prime mover motor unit ensembles afterwards. NeurOne converted the decoded spiking activity of the prime mover motor units into smooth activation signals by utilizing a physiologically driven motor unit twitch. The resulting smoothed activation signals for each prime mover ensemble were then used to control different mechatronic and virtual systems. The first experiment was to enable paralyzed individuals to track the movements of a virtual hand with a second virtual hand under their control. In addition, in a second experiment, the NeurOne output enabled control of an artificial sixth finger attached to the paralyzed user's wrist and facing the palm for simple grasping movements. In addition, the NeurOne system was connected to a neuroorthosis covering the thumb and index finger in a third experiment, which was attached to the paralyzed hand equipped with HD sEMG electrodes. Task-specific protocols were created for both mechatronic systems, in which the test subjects had to perform various tasks with different objects. The performance assessments were carried out with and without the support of the respective systems to enable a comparative analysis.Paralyzed individuals were able to use the control signal provided by NeurOne to follow a virtual hand intuitively and accurately. In combination with mechatronic systems, NeurOne enabled people with complete motor SCI to grasp and lift objects. Some of these tasks were impossible without mechatronic support, such as removing the lid from a bottle, demonstrating NeurOne's potential as an intuitive assistive device control to enhance the independence of the paralyzed.

## P1.61-Q: The Effects of Combined Use of Robotic Control on the Ankle Joint and Electrical Stimulation Therapy

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One of the causes of abnormal gait in patients with cerebrovascular disorders is dorsiflexion impairment of the ankle joint. Electrical stimulation therapy (ES) is often used for the treatment of gait impairment. On the other hand, the use of robots has been advanced (i.e., an ankle assisted walking robot, RE-Gait®). It was hypothesized that combining ES and robotic control on the ankle joint may enhance the treatment effectiveness compared to each intervention alone. Therefore, this study investigated the combined effects from the perspectives of ankle joint angle, minimum toe clearance (MTC), and electromyogram (EMG) of TA muscles.Ten healthy adults participated in this study. They performed gait training (GT) under 4 conditions with wearing RE-Gait® on the right lower limb as follows; RE-Gait® and ES both inactive (OFF), ES only active (ES), RE-Gait® only active (RG), and both RE-Gait® and ES active (RG+ES). Measurements were taken following a protocol; barefoot walking (PREBF), RE-Gait® wearing only (PREGT), gait training under each condition (15 minutes after intervention, DURINGGT), and barefoot walking again (POSTBF). Kinematic data were measured at all time points, and EMG data were measured at PREBF and POSTBF. Each intervention time was 20 minutes, and the measurements were taken on four separate days with an interval of at least one day between each measurement. Short-term intervention effects before and after intervention were verified by comparing PREBF and POSTBF. The effects during intervention were examined by comparing PREGT and DURINGGT.Comparing PREGT and DURINGGT, RE-Gait® intervention (RG and RG+ES conditions) showed a significant increase in dorsiflexion angle and MTC. Comparing PREBF and POSTBF, no changes were observed in ankle joint angle under all conditions. However, in the three conditions except of the OFF condition, there was a significant increase in MTC. In the ES condition, peak amplitude of TA activity was significantly decreased, and peak latency was significantly decreased. In the RG+ES condition, there was a trend of decreased peak latency.Significant increases in kinematic data were observed during intervention in the RG condition, and EMG changes were observed in the ES condition. These results may suggest distinctive changes with each intervention alone, indicating different therapeutic effects. Additionally, in the RG+ES condition, the significant increase in kinematic data suggests a treatment effect similar to the RG condition, and the changes in TA activity indicate a therapeutic effect similar to the ES condition. These findings may suggest that combining ankle joint dynamic control and ES may exhibit the respective effects and potentially achieve a higher therapeutic effect.

## P1.62-Q: Intramuscular coherence of the lower flexor muscles during robotic ankle-assisted gait training

Kei Nakagawa, Hiroshima University; Akari Ikeda, Hiroshima University; Eiichiro Tanaka, Waseda University; Louis Yuge, Hiroshima University; Makoto Takahashi, Hiroshima University

From the terminal stance to the pre-swing phase of the gait, the forefoot rocker function plays a crucial role in smooth energy utilization by generating plantar flexion torque. Subsequent dorsiflexion torque occurs in the swing phase to prevent toe dragging. These movements are essential for efficient walking; however, it is difficult to provide enough assistance using manual support or static orthoses alone. To address this issue, robotic walking rehabilitation devices have been developed. A robotic-controlled ankle-foot orthosis (rAFO) designed to support ankle dorsiflexion and plantarflexion movements has the potential to be effective in acquiring a proper gait pattern throughout the entire gait cycle. However, there is currently insufficient neurophysiological evidence to support its therapeutic effect. When assessing the function of the sensory-motor loop during gait, intramuscular coherence (IMC) in each frequency band from two parts of the tibialis anterior muscles is often used to determine if a common synaptic drive is present. Therefore, this study investigated whether the functioning of the sensorimotor loop was enhanced during the utilization of the rAFO from the pre-swing to the initial swing phase.Seventeen healthy volunteers participated in this study. They engaged in a 15-minute session of robotic-assisted gait training using the rAFO on a treadmill at their comfortable speed. Robotic assistance was administered to facilitate rapid plantar-flexion during the pre-swing phase (after the heel offset) to generate push-off movement. Additionally, dorsiflexion assistance was provided during the initial swing phase to enhance toe clearance. Gait parameters and IMC of proximal and distal parts of the tibialis anterior muscles were measured before (pre), during, and immediately after (post) a 15-minute intervention.As a result, the trailing limb angle and step length were significantly enhanced during and post the session compared to the pre-session. In addition, the values of IMC in the beta frequency band were significantly different in the initial swing phase (F(2,32)=3.40, p<0.05, η2=0.18), and post-hoc tests revealed that the rAFO session significantly enhanced the IMC in the beta band compared with the pre-session (p<0.05). Comparing the behavioral and neurophysiological data, a significant correlation was found between IMCs in the beta and low-gamma frequency bands and the enhancement ratio of step length.These findings suggest that implementing robotic ankle assistance, incorporating both plantar flexion and dorsiflexion from the pre-swing to initial swing phase, may improve gait function with an enhancement of the functioning of the sensorimotor loop.

## **P1.63-R:** Strength training and magnetomyography – a controlled study using optically pumped magnetometer [Poster Award]

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Muscle strength training induces neuromuscular adaptations, typically assessed through electromyography (EMG). Magnetomyography (MMG) captures these signals by quantifying the circular and concentric magnetic fields generated by the muscle's electrical currents, adhering to the Biot-Savart law. This study investigates the potential of MMG as a new contactless modality for recording neuromuscular signals, utilizing miniaturized quantum sensors, more specifically optically pumped magnetometers (OPM). The employed zero-field-OPM are based on a zero-field resonance caused by the Zeemann-effect and utilize laser light absorption of vaporized and spin-polarized alkali metal atoms to measure the magnetic field. The primary objective of this study is to test whether MMG can detect neuromuscular adaptations comparable to those, which are measurable using EMG.This study investigates the potential of MMG as a new contactless modality for recording neuromuscular signals, utilizing miniaturized quantum sensors known as optically pumped magnetometers (OPM). OPM are based on the Zeemann-effect and utilize laser spectroscopy to measure the wavelength changes of vaporized and spin-polarized alkali metals induced by the changing magnetic field. Simultaneous EMG and OPM-MMG recordings were conducted on the right biceps brachii muscle in 12 healthy, untrained subjects during maximal voluntary contraction (MVC) and a 40% MVC muscle fatigue paradigm, lasting three minutes. Data collection encompassed three time points: pre-training, mid-training, and post-training over a 30-day strength training program, with six subjects undergoing training and an equivalent control group.Results revealed anthropometric enlargements of the biceps muscle of the trained, but not the non-trained control cohort. Both EMG and MMG revealed increasing signal amplitude (here, root-mean-square (RMS)) over the training period during the MVC- and fatigue-paradigms, with no concurrent alteration in frequency (here, Center of gravity, COG). A strong correlation could be determined between the RMS and COG of EMG and the three axes OPM-MMG-signals (Bx, By, Bz). Furthermore, three-dimensional visualization of time-series data was possible using a single OPM, a capability that is impossible using a single bipolar EMG.This study pioneers the first-ever performed longitudinal MMG, providing insights into the potentials and hurdles of OPM-MMG. The robust correlation between EMG and MMG suggests the capability of MMG in measuring the increasing neural drive resulting from training-induced neuromuscular adaptations. Our study paves the way for future longitudinal MMG studies, potentially enabling monitoring of physiological and pathological changes in sport science or neuromuscular diseases. The integration of OPM introduces a novel modality, showcasing their potential for three-dimensional visualization and potentially also enabling a complementary view of neuromuscular physiology.

## P1.64-R: The Effect of Sporting Expertise on Motor Strategies under the influence of muscle fatigue

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Background: Lately, the performance of athletes, both novice and expert, has garnered significant attention by researchers, especially to explore the boundaries of human performance and the risk of musculoskeletal injury. Sporting expertise leads to the development of motor strategies within an athlete's motor system, which either enhance performance and/or minimize functional costs. On the other hand, an increased injury risk has been consistently reported among novice athletes. Consequently, it is plausible that the motor

strategies used by experts may also have injury prevention potential. Motor strategies in sports performance is commonly assessed by the concept of motor variability (MV). MV refers to the fluctuations observed in motor performance across multiple repetitions of the same task. It can be assessed through muscle activity, motion, or forces generated during tasks. In sports, several investigations have assessed the impact of expertise on MV in different activities. Recently, we have conducted a scoping review about the effect of expertise on MV in sports gesture which included 53 studies (unpublished results). This review concluded that higher-skilled athletes tend to use less MV than lower-skilled ones while performing their sports without any constraint. Despite the recurring presence of muscle fatigue while practising multiple sports and the well-known alteration of fatigue on MV, to our knowledge, no studies have explored the effect of expertise in sport on VM in the presence this constraint. Objective: The aim of this study is to assess the impact of expertise on MV in the presence of muscle fatigue in cycling.Methods: To answer this objective, 40 cyclists, including novices and experimented, will be recruited to pedal on a smart stationary bike. The MV of their lower limbs will be assessed during submaximal pedalling in two different contexts: without constraint, and with lower limbs muscle fatigue. Two instruments will be used to quantify participants' motor strategies: a 3D motion analysis system (OptiTrack) and a bipolar wireless surface electromyography system (Delsys). To quantify MV, metrics such as the coefficient of variation and muscle synergy, will be calculated on different biomechanical variables. These variables include kinematic parameters (range of motion, linear velocity, linear acceleration, angular velocity, and angular acceleration) and muscular activity parameters (amplitude and median frequency of the signal). Repeated-measures ANOVAs will be used to compare the effect of levels of expertise (novice and expert) and muscle fatigue on the MV metrics. Special attention will be given to strive for gender-balanced athlete groups, as our literature review reveals a significant gap in the study of female athletes.Research implications: By integrating muscle fatigue into this research protocol, it enables a deeper comprehension of how experienced athletes adapt their motor strategies to surpass their novice counterparts, even when faced with sub-optimal performance conditions. Future studies should investigate the effect of other constraints in sports like pain.

## P1.65-R: Anaerobic power and kinematic characteristics during sliding are associated with performance in long-track speed skating.

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Background: Long-track speed skating requires significant mechanical output. Previous studies highlighted the importance of physical functions, including vertical jump height and anaerobic power. Studies also reported the significance of techniques like knee and hip joint angles. However, there has been no study that has comprehensively investigated the relationship between performance, physical function, and technical aspects. This study aimed to investigate factors influencing skating performance, considering both technical aspects and physical functions.Method: Participants were 23 high school and college speed skaters (13 males, average height 167.4±8.0 cm, weight 63.2±8.0 kg). Physical functions were evaluated with the vertical jump height, anaerobic power test using Power Max V III, and the Wingate test. Technical aspects were assessed during ice skating. Skaters started from a stationary position.

Short-distance skaters (n=11) covered 500 m, and middle- and long-distance skaters (n=12) skated 1500 m at maximum power. The first lap was used as the performance indicator. The Inertial Measurement Unit (myoMOTION, Noraxon) was used for technical analysis, measuring hip and knee joint angles, and pelvic orientation. Pearson's correlation coefficient determined the correlation between lap time and physical function/technique. In Model 1, a single regression equation was created with the physical function variable showing the highest correlation coefficient as the independent variable and lap time as the dependent variable. In Model 2, multiple regression equations were developed, with lap time as the dependent variable and the physical function and technique variables with the highest correlation coefficients entered one by one as independent variables. The statistical significance level was set at 5%.Results: The physical function exhibiting the highest significant negative correlation coefficient with lap time was anaerobic power (r=-0.835, p<0.01). The technical outcome exhibiting the highest negative correlation coefficient with lap time was hip abduction angle at push-on (r=-0.623, p<0.01). The regression equation of the Model 1 was “lap time = 36.584 - 0.006 * anaerobic power” (R2=0.697, F=30.946, p<0.01, Figure 1 A). The regression equation of the Model 2 was “Lap time = 36.292 - 0.005 * anaerobic power - 0.084 * hip abduction angle (R2=0.809, F=42.393, p<0.01, Figure 1 B), where the standard partial regression coefficients were -0.700 (p<0.01) for anaerobic power and -0.361 (p<0.01) for hip abduction angle.Discussion: Model 2, which integrated both physical function and skating technique, showed superior predictive ability (R2=0.809) compared to Model 1 (R2=0.697). These findings underscore the significance of technique in skating performance. The highest correlation coefficient for technique in this study indicates that the hip abduction angle might be a crucial factor influencing speed skating time, independently of anaerobic power.

## P1.66-R: **The relationship between shank angular acceleration, hamstring muscle activation, and maximum speed during treadmill sprinting**

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Purpose: Hamstring muscle strain injury (HSI) stands as the most prevalent non-contact muscle injury in sports involving sprinting. Previous research has suggested motion-dependent torque (MDT), arising from lower limb segment movements and their mechanical interactions, as a significant risk factor for HSI. MDT places increased demand on the hamstring muscles, particularly in the late swing phase of the running cycle. Notably, the shank angular acceleration (SAA), the largest component of MDT at both the hip and knee joints, has been suggested as a potential factor contributing to excessive strain and an overloading of the hamstring muscles during this phase.  Consequently, enhancing control over SAA during the late swing could be instrumental in reducing the risk of HSI. However, the relationship between SAA and hamstring muscle activation remains unclear, and improving control over SAA may pose a challenge to maximum running speed. Therefore, the aim of our study was to clarify the pattern of SAA and examine its relationship with both hamstring muscle activation and the maximum speed within the swing phase of the running cycle in sprinting.Methods: Eighteen recreational players of various sports were recruited and gave their written informed consent to participate in this study. Each participant was instructed to perform a minimum of three successful treadmill sprints with maximum speed. Hamstring muscle activation and SAA were collected by employing wireless electromyography and inertial measurement units (IMU). Spearman’s rank correlation coefficient (r) was employed to determine the relationship between SAA during the swing phase, hamstring muscle activation, and maximum speed, using a significant level of 0.05.Results: During the swing phase of the running cycle in maximum speed sprinting, SAA exhibited a pattern of alternating between flexion and extension. SAA reached its initial peak of flexion value shortly after toe off (at approximately 20% of the swing duration), before attaining maximum extension value (at approximately 60% of the swing duration). Towards the end of the swing phase, SAA again reached the peak flexion value at foot strike. Strong positive relationships between SAA and the peak activation of semitendinosus (ST) were identified, while no significant correlation between SAA and the peak activation of bicep femoris long head (BF) was found. In addition, significant positive relationships were also discovered between the activation of BF at toe off and SAA. Meanwhile, no significant relationship between SAA and maximum speed was observed, even when considering stride length and frequency.Conclusion: Based on these results, the mitigation of SAA during the swing phase may serve to reduce loading demand on the hamstring muscle in the late swing phase, without compromising maximum speed. Additionally, the effect of SAA varies among different muscles and clinically it may indicate the development of training methods focusing on individual muscles to prevent injury. These insights could be valuable in informing clinical decision making for coaches and players when developing training programs.

## P1.67-R: Muscle Activation During Ankle Machine and Thera-Band Training in The Individuals with Chronic Ankle Instability

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Background:Chronic ankle instability (CAI) is a long-term symptom that often occurs after an ankle sprain. The most common type of ankle sprain is inversion sprain that usually damage and weaken the peroneal longus and brevis. Strength training is an important part of the therapeutic approaches for athletes suffering from CAI. Traditionally, the training of ankle muscular strength practically utilizes elastic bands. A new type of ankle training machine was designed to provide multi-directional training and allow the subjects to be trained with stable trails in sitting position.Objective:The purpose of this study is to investigate the effectiveness of the ankle machine training by comparing the electromyographic (EMG) signals between Thera-band and ankle machine training in individuals with CAI.Methods: The study is expected to recruit 10 college students, who are regularly participated in sports at least three times a week. All participants should have not experienced severe lower-limb injuries or surgery in the past 3 months. They will be allocated into the CAI or control group by using Cumberland Ankle Instability Tool (CAIT). The participants in the CAI group should have a history of at least one severe ankle sprain that affect his sports participation. The experimental process begins with the use of the BIODEX System 3 to obtain the maximum voluntary isometric contraction (MVIC) and determine the intensity of the strength training. At the same time, EMG from tibialis anterior, peroneal longus, and medial gastrocnemius are also collected to establish the baseline data for normalization. Then, two training programs were implemented by a randomly assigned order for Thera-band and the ankle machine, while the EMG signals are measured during the exercises. The raw EMG data of four movements were collected at sampling rate of 2000Hz. Subsequently, a bandpass filter with a range of 20-450Hz is applied, followed by the use of the root mean

square (RMS) with 10-ms moving window to obtain the amplitudes of muscle recruitment data. The two-way ANOVA was used to examine differences in muscle recruitment levels between the two types of training and between two groups. Levels of significance was set at p<0.05.Results:Until now, six individuals have completed the experimental program in this study (CAI=3, control group = 3). There is no statistical difference between two training programs in EMG activation level during dorsiflexion, plantarflexion and inversion movement. However, during eversion movement, the EMG activation level showed significantly higher in the ankle machine group (109.83 vs. 46.80 %MVIC, p=0.011).Conclusion: This study confirmed that the training in eversion with the ankle machine is more effective than training with Thera-band. The well-trained peroneal longus muscle is able to prevent the ankle joint from recurrent inversion ankle sprain in athletes.

## P1.68-R: A comparison of neuromechanical latencies between karate practitioners and general population during gyaku tsuki executions

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Electromechanical delay (EMD) is defined as the latency between neuromuscular activation and exerted force during a muscle contraction. The evaluation of EMD is an important field of interest in sport science. However, only a few preliminary studies have dealt with how EMD behaves in karate practitioners. The main objective of this study is to analyze the EMD in a karate-specific movement of the upper limb, the gyaku tsuki. The gyaku tsuki is a movement consisting of a straight punch executed from a front stance when the advanced leg and fist are on opposite sides. Three karate athletes and three people with no experience in karate participated in the study. 10 gyaku tsuki executions were performed by each participant. During the movements, several recordings were performed: kinematics (with an inertial measurement unit); electromyographic activity (EMG) activity of the deltoid, pectoralis major, triceps and biceps muscles (1500 Hz sample frequency, Noraxon MiniDTS system); and the contact force of the punch (arm full extension) with a flat force sensor placed on a self-made makiwara (punching cushion). To compute the delays, the envelope of the EMG signal for every muscle has been obtained to extract muscle onsets. The onset of the first active muscle has been compared to the movement onset and the force onset.Results show that the biceps muscle is the one that activates first during the movement. A significant difference is present between karate practitioners and general population during gyaku tsuki execution in terms of EMG to Contact Force delay (402±18 ms for karate y 512±26 ms for the control group), EMG to Movement Onset delay (320±17 ms for karate y 349±35 ms for the control group) and Movement Onset to Contact Force delay (82±8 ms for karate y 163±25 ms for the control group). These results show that all delay components are significantly lower for the karate practitioners, meaning that a decrease in EMD components is present after specific training. This is coherent with the way karatekas are trained to increase punching velocity and precision and with a decrease of EMD with increased force, as previously proven in literature. Still remains to be estimated how the different EMD components are affecting these delays, so future studies should focus on evaluating if these changes are due to neural adaptations or improvements in the muscle and tendon properties due to specific training. In the future, this setup will also allow the analysis of different isometric and isotonic movements.This study has been developed

within project MYOREHAB (PCI2023-143405), funded by MCIN/AEI/10.13039/501100011033. This research has also been supported by the Valencian Graduate School and Research Network on Artificial Intelligence (ValgrAI), Generalitat Valenciana and the European Union.

## P1.69-S: Differences in sit-to-stand motion between older people with and without frailty using sensors embedded chair

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Background: Sit-to-stand (STS) motion is frequently used to evaluate physical function in older adults. Frail older people take a longer time to perform STS than healthy people. In addition, the trunk lean angle in older adults was smaller than that in younger adults. These parameters were measured using an optical motion capture (MoCap) system and stopwatches. Thus, operators of these devices were necessary for the evaluation. However, we believe that evaluations of the physical functions of older adults via STS motion should be performed in daily life. Our developed chair: We developed laser range finders-embedded chair to easily evaluate the STS motion. This chair has two laser range finders, which measure the distance between the seat and the right thigh, and the backrest and trunk. The sensors were controlled using microcontrollers. Trunk and thigh angles were calculated using the distances assumed in the two-link model. Purpose: This study aimed to examine differences in trunk kinematic parameters during STS motion between older people with and without frailty. Methods: Ninety-five community-dwelling older adults participated in this study. The participants were instructed to stand up at a comfortable speed with their hands folded in front of their chest. The STS motion was measured five times. The noise of the distance data was removed using a fourth-order low-pass Butterworth filter with a cut-off frequency of 6 Hz. We calculated trunk flexion angle, angular velocity, angular acceleration, and STS time. Angle-related parameters were extracted from the peak values during the flexion phase. We defined the start and end of the STS motion as a change of at least 1 °in the trunk angle and a change of at least 1 °in the thigh angle. Frailty was assessed using physical strength-related items from the Kihon Checklist. Participants with a score ≥ 3 on that item were considered frail. STS-related parameters were compared between participants with and without frailty using unpaired t-tests. Results: Older adults with frailty had significantly smaller trunk flexion angles, angular velocities, and angular accelerations, and longer STS times than healthy adults.Conclusion: Our developed sensor-embedded chair could measure the STS motion of frailty in older people. This chair can realize to assess the physical function of older adults in their daily lives.

## P1.70-S: Validation of a digital dynamometer for assessing the cranio-cervical flexion test in volunteers with neck pain

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Introduction: The Cranio-Cervical Flexion Test (CCFT) is a clinical test designed to evaluate the activation of the deep cervical flexor muscles, particularly the longus capitis and longus colli, pivotal for optimal motor control and postural function in the craniocervical region. The test involves incremental stages of cranio-cervical flexion, facilitated by a pressure biofeedback unit, gauging muscle activation as the patient progresses through the incremental levels of the test. The CCFT's primary objectives are to assess the activation and endurance of these muscles, to determine the need for training the cranio-cervical flexor muscles. Despite its established construct validity and widespread clinical recognition, the application of the CCFT with a customized digital dynamometers has not been investigated.The aim of this study is to validate the use of the Neuromuscular Cranio-cervical Device (NOD, OT Bioelettronica, Italy) during the execution of the CCFT by conducting a comparative analysis with the Stabilizer (Chattanooga, USA), the established reference standard.Methods: A strong positive correlation was hypothesized between CCFT scores obtained using the two devices: the NOD and the Stabilizer. Sixty-two volunteers with neck pain were recruited across five outpatient clinics. Each was scheduled for a CCFT session involving both devices during their treatment plan. To counteract order effects, the sequence of device use was randomized. A Mantel-Haenszel test of trend was run to determine whether a linear association existed between the CCFT scores obtained using Stabilizer and NOD; afterwards, a Pearson's product-moment correlation was run to estimate the strength and direction of the association. Video motion analysis assessed the upper cervical spine's range of motion during all completed CCFT stages, and results from both devices were compared via two-way ANOVA.Results: The distribution of CCFT scores revealed a pronounced skewness towards scores higher than the “normal response” threshold, limiting the definitive assessment of the NOD's validity, especially at lower scores. However, among the 62 volunteers enrolled, only four (6.45%) failed to achieve equivalent test scores across the devices. The Mantel-Haenszel test of trend showed a statistically significant linear association between the scores (X2(1) = 45.295, p < .001) and Pearson’s correlation procedures supported a strong positive relationship (p < .001, r = .862). The range of motion analysis showed no significant differences during the execution of the CCFT using the two devices. The observed mean difference of -0.77 degrees falls within the instruments' sensitivity threshold of 1 degree, indicating that the devices did not influence cranio-cervical flexion movement during the CCFT.Conclusion: The study findings endorse the NOD's validation for evaluating CCFT performance in patients experiencing neck pain. Additional research involving individuals with greater impairment of the deep cervical flexor muscles is recommended. The NOD emerges as a valuable tool for assessing the CCFT in clinical and research settings.

## P1.71-S: Temporary tattoo for high-density electromyography

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High-density surface electromyography (EMG) is used in a range of applications, including identification of motor unit discharge patterns and myoelectric control. Conventional technology relies on materials that are relatively stiff and therefore prone to lift-off, preventing long-term use. Soft electrodes that can conform with the curved skin surface are crucial for overall wearability.To this end, we have designed and manufactured flexible high-density tattoo electrodes that can be temporarily applied to the skin for EMG recordings.The electrodes feature 64 detection sites in gold (3 mm diameter) arranged in a rectangular configuration (13x5 electrodes with one missing at one of the corners) with 8 mm inter-electrode distance. Gold is sandwiched between two layers of parylene C. The total thickness is less than 2 microns. Electrodes were clean-room manufactured (Myfab Chalmers).Due to the constituent materials and their minimal thickness, the electrode grids are extremely flexible ensuring conformal adhesion to the skin and high-quality EMG signals.

## P1.72-S: Non-linear measures of postural control in the low back, mobile phone technology versus gold standard. BackMeUp project

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Low back pain (LBP) individuals are shown to have altered postural control compared to healthy individuals yet research in linear measures have not provided valuable indicators to distinguish between healthy and LBP populations. Nonlinear analyses have been able to identify those alterations and discriminate between pathological populations, for instance, risk of fall in elderly population or the degradation of motor skill in Parkinson disease. Force plates and motion capture systems are the gold standard to measure postural control but mobile phones could be a cheaper alternative in combination with non-linear methods such as multiscale entropy (MSE) to provide a greater insight into the complex nature of postural control.The aim of this study was to investigate the concurrent validity of nonlinear measures of postural sway derived from a smartphone against the gold standard 3D motion capture system.MethodsTwenty healthy adults (age: 21.1 ± 3.36) completed four static balance tasks in a random order. The data were simultaneously collected by the smartphone (Samsung Galaxy A3, Samsung, Seoul, South Korea) fixed on the sternum at 100 Hz and by an eight-camera SMART-D Motion Capture System (BTS S.p.A., Milan, Italy) at 250 Hz using twenty-five passive reflective markers. Concurrent validity was examined by comparison (Spearman's rank correlations) of nonlinear measures, quantified as complexity indexes of Multiscale entropy (MSE) of postural sway acceleration derived from the two systems. ResultsThere were significant correlations between MSE from the smartphone and the motion capture system during tandem stance (rho=0.535, p =0.018) and single leg stance (rho=0.698, p =0.001), but not during double leg stance with eyes open (rho=0.165, p =0.448) and closed (rho=0.142, p =0.481). Conclusions These preliminary results demonstrated that smartphones are valid to assess nonlinear measures of postural sway during challenging static stance with the small base of support. Smartphones have potential to provide accessible, objective postural sway measures, to identify people at risk of LBP, which may have an impact on clinical practice, the development of mobile digital health, accessible (self-)assessment, and implementation of LBP preventive strategies.

## P1.73-P: Analysis of Upper Limb Movement during Equine-Assisted Therapy for Super Low-Birthweight Children: Insights from EMG and 3D Motion Analysis

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Equine-assisted therapy stands out as a promising rehabilitation method for individuals with spinal injuries and/or brain damage. In recent years, a substantial number of studies have been conducted to investigate the effects of equine-assisted therapy. The results obtained in this present review demonstrate the potential benefits of equine-assisted therapy in enhancing gross motor function among children with cerebral palsy (CP). We investigated differences in the activity patterns of trunk and cervical muscles during equine-assisted therapy between super low-birthweight children with CP and healthy children using electromyogram (Trigno Wireless System, USA) and 3D motion analysis (Xsens MVN and MVN Animate, Netherlands). In children with CP, the muscle activity pattern in the lumbar region exhibited reduced activity during horseback riding compared to that of healthy children. In children with CP, EMG activity in the cervical region for the overall muscle activities of trunk muscles was observed to be greater than that in the lumbar children with CP exhibited improved trunk posture control during horseback riding, primarily in the engagement of cervical muscles. The EMG activities with the low-frequency band (62.5-20 Hz) was smaller than that for the healthy group within the muscles of the lumbar region. The chi-square test for independence revealed a statistically significant difference of 1% for the muscles of the lumbar region. In contrast, there was no statistical difference for the muscles of the cervical region. In addition, the trajectory of upper limb movement during horseback riding, analyzed through motion capture, was found to be larger in children with CP healthy children. The trajectory of chest movement during horseback riding was larger in individuals with CP than in healthy children as shown in the figure. These results suggest that the characteristics of trunk muscle activities and the strategy for controlling trunk posture during horseback riding differ between children with CP and their healthy counterparts. It is hypothesized that the spectral properties of surface EMG are influenced by the volume conductor effects of muscle fibers and the number of activated motor units (MUs). The recruitment strategies of the lumbar region in children with CP may involve higher MUs activities compared to healthy children during equine-assisted therapy. The lower-frequency EMG activity within the lumbar region may serve as a suitable physiological index for evaluating gross motor function and the effectiveness of equine-assisted therapy.

## P1.74-P: Asymmetry of intermuscular coherence during static and dynamic standing tasks in sub-acute patients after stroke

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Introduction: Sub-acute patients after stroke often experience balance disability during both static and dynamic standing tasks, significantly increasing their risk of falls. Previous studies have reported that asymmetrical neuromuscular control due to hemiparesis is an essential characteristic in observed balance deficits during static standing in patients after stroke. Dynamic standing activities are believed to demand more complex modulations of postural muscle control by the motor cortex compared to static standing activities, to cope with increasing task difficulty. However, neuromuscular control during dynamic balance tasks in stroke patients remains largely unclear. Therefore, the present study aimed to elucidate the neuromuscular control mechanisms of the motor cortex through intermuscular coherence analysis in dynamic standing tasks among sub-acute patients after stroke.  Methods: Twenty patients after stroke within their sub-acute phase (< 3 months) participated in the study. The participants performed the static and dynamic standing tasks without prosthetic devices or physical assistance. The dynamic standing tasks consisted of maintaining the maximum leaning posture for twenty seconds each in the forward and backward directions. Surface electromyography of the bilateral tibialis anterior (TA), soleus (SL), and medial gastrocnemius (MG) muscles was acquired during the tasks. Intermuscular coherence was calculated using the Fourier transform of surface electromyography in the pairs of unilateral synergistic (SL-MG), antagonistic (TA-SL and TA-MG) of paretic and non-paretic sides. The area under the z-transformed coherence curve of the 95% confidence interval in the beta bands (15-35 Hz), reflecting the descending common input from the motor cortex, was calculated. Two-way [task condition (static, dynamic forward, and dynamic backward) and muscle type (paretic or non-paretic)] repeated measures ANOVA was performed in each pair of the intermuscular coherence area to investigate the modulation of cortical muscle control and its asymmetry.Results: Two-way repeated measures ANOVA revealed a significant main effect of muscle type (paretic or non-paretic) on intermuscular coherence area across all pairs, indicating that intermuscular coherence area in non-paretic muscles was larger compared to the paretic ones during both static and dynamic standing tasks. On the other hand, two-way repeated measures ANOVA indicated that task condition did not significantly influence the intermuscular coherence area for any muscle pairs.Conclusions: The study shows the inherent asymmetry in cortical muscle control during static and dynamic standing tasks among sub-acute stroke patients. It also suggests that the adaptation of neuromuscular control in response to varying task difficulties is limited, indicating the mechanisms and potential areas for therapeutic intervention in the dynamic balance disability.

## P1.75-P: The Association Between Motor Unit Firing Rate and Deformity and Pain Severity in Patients with Knee Osteoarthritis

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IntroductionInterest in neural factors has grown due to their contribution to the decline of muscle function in patients with knee osteoarthritis (OA). Previous studies have demonstrated that patients with experimental knee pain or who have undergone anterior cruciate ligament reconstruction show a lower firing rate (FR) of motor units (MU) during muscle contraction. Because various factors can influence neural changes, the association between these changes and knee joint deformity or pain severity is not fully understood in knee OA. This study aims to investigate the relationship between MUFR and knee joint deformity and pain in patients with knee OA. MethodForty-six older women were evaluated for knee joint deformity severity using the Kellgren-Lawrence (KL) grading scale, which assesses the severity of OA based on radiographic findings, and for knee pain using the Knee Society Score (KSS) symptom score, which evaluates knee pain and function. High-density surface electromyography signals were recorded from the vastus lateralis (VL) during isometric knee extension at 20% of maximum voluntary contraction (MVC) and were decomposed into individual MU firings. The average FR of all detected MU was calculated for each participant. The normalized amplitude during 20% MVC (20%EMGamp) was calculated using the amplitude during MVC, and MVC torque was normalized to each participant's body weight. From B-mode ultrasound images, muscle echo intensity (EI) and muscle thickness (MT) in the VL in the supine position were assessed. Participants were categorized based on knee joint deformity severity into non-OA (KL grade 0,1), mild OA (KL grade 2), and severe OA (KL grade 3,4) groups, and based on knee pain severity into asymptomatic (KSS≥23), moderate symptom (KSS≥18), and severe symptom (KSS<18) groups. Indicators were compared using one-way analysis of variance with the Holm-Sidak post hoc test. The significance level was set at p<0.05. ResultAn average of 7.9 ± 4.9 of MU was detected per individual. When comparing groups based on knee joint deformity severity, only EI showed a significant difference, with the mild OA group having significantly higher EI values than the non-OA group (p<0.05). Analysis based on knee pain severity revealed significant main effects in MVC, EI, and average FR (p<0.05). FR was lower in the moderate symptom group compared to the asymptomatic group (p<0.05). Both moderate and severe symptom groups had lower MVC values than the asymptomatic group, and EI was higher in the severe symptom group compared to the asymptomatic group (p<0.05). No differences were observed in MT and 20%EMGamp. ConclusionAnalysis of knee pain severity showed no differences in 20%EMGamp between groups, but FR was lower in the moderate symptom group compared to the asymptomatic group. When comparing groups based on deformity severity, no differences in MUFR were found. These findings suggest that in patients with knee OA, the lower MUFR in the VL is more closely related to the severity of knee pain rather than to deformity severity.

## P2.1-A: Investigation of the association between swallowing problems and jaw kinematic movements in the elderly

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Background and Purpose: Videofluoroscopy (VF) and videoendoscopy (VE) are both widely used as the gold standard for diagnosis of swallowing disorders despite that the limitations related to their radiation exposure or invasive procedure. There is a growing emphasis and emerging trend on using non-invasive/non-radiation assessment tools for swallowing disorders. This study aimed to identify swallowing difficulties using the repetitive saliva swallowing test (RSST), and to determine if observation of jaw kinematic movements could be a non-invasive means of screening for swallowing problems. Methods: One hundred community dwelling elderly people (74 females and 26 males; 41 aged between 65-74 y/o, 40 aged between 75-84 y/o and 19 aged between 85-94 y/o) were recruited in this study. The criterion for swallowing problems was RSST<3. The Kinovea software was used to analyze jaw kinematics, maximum mouth opening distance, maximum mouth opening angle, opening velocity, closing velocity, opening angular velocity and closing angular velocity were calculated. In addition, the study designed diadochokinetic (DDK) tasks, participants must finish 10, 15 repetitions and in one breath to pronounce /pa/, /ta/, /ka/ sound respectively. Audacity audio software was used to calculate the pronunciation rate in Hz to represent the agility of tongue movement. Results: The results showed that swallowing problems with a notable increase in the 75-84 y/o (60%) and 85-94 y/o

(61%) groups compared with 65-74 y/o (36%). A moderate correlation (r=0.302-0.377, p<0.01) between maximum mouth opening distance/angle and DDK performance were found. There was significantly different for females in closing velocity (p<0.05) and closing angular velocity (p<0.05) between subjects with swallowing problems or not. Meanwhile, there was significantly different for males in mouth opening velocity (p<0.05) and opening angular velocity (p<0.05) between subjects with swallowing problems or not. Subjects with swallowing problem showed slower mouth opening or closing velocity as well as smaller mouth opening or closing angular velocity compared with those without swallowing problem. Conclusion: Image analysis of jaw kinematic movements shows considerable potential as a non-invasive and rapid screening tool for identifying swallowing problems. It is recommended that the focus on future community screening should be on individuals aged over 75 years old.

## P2.2-A: **Motor unit discharge characteristics in post-menopausal females and the effects of hormone replacement therapy**

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Oestrogen and progesterone are the predominant female sex hormones which potentially influence neuronal activity via excitatory and inhibitory effects (Ansdell et al., 2019; Piasecki et al., 2023). The menopausal transition marks the cessation of the female reproductive cycle and is characterised by a rapid decline in these sex hormones. This significant hormonal shift is not observed in males and may contribute to sex-based disparities in the development of frailty (Piasecki et al., 2024). Hormone Replacement Therapy (HRT) has been shown to have beneficial effects on physical function in post-menopausal females (Ronkainen et al., 2009), however, the effects of HRT on individual motor unit (MU) characteristics have not yet been fully investigated. Eight post-menopausal females aged 59.5 yrs (±7.4) were recruited according to NICE guidelines, and all participants reported ≥ 12 consecutive months without menstruation. HRT users (n=4) were taking combined hormone therapy for a minimum of 6 months, and control females (n=4) were not using any form of hormone therapy. Maximum isometric dorsiflexor force was recorded from the right leg. High-density surface electromyography (HD-sEMG) signals were recorded from the tibialis anterior (TA) during trapezoid contractions (3s ramp up, 12s hold, 3s ramp down) normalised to 25% of maximum force, and decomposed into individual MU spike trains. The mean number of TA MUs recorded from these older individuals was 15 ± 5. Non-HRT users had a maximum dorsiflexion strength of 94.8N, compared to 117.2N in the HRT group. Mean MU discharge rate (MUDR) at the point of recruitment was 9.23Hz in the non-HRT group, and 9.01Hz in the HRT. At de-recruitment, mean MUDR was 7.58Hz in the non-HRT, and 7.84Hz in the HRT. During the sustained phase held at 25% of maximum force, mean MUDR was 12.94Hz in the non-HRT and 13.41Hz in the HRT group. Although the current pilot data preclude definitive outcomes, there are indications muscle strength may differ across these hormonally distinct groups, with little difference between MU characteristics at this single contraction intensity. The current data and the accompanying ongoing study highlight the plausibility of exploring the effects of exogenous hormone administration in older humans and help alleviate the minimal MU data available in older females. This has the potential to identify clinically relevant interventional targets to help address sex-based differences in sarcopenia and frailty.
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## P2.3-B: Asymmetry in Children with Cerebral Palsy and Healthy Controls Performing Fine-Motor Tasks, as Measured by Machine Learning Models

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Introduction:Cerebral palsy can lead to impaired bimanual function and heightened preference for the dominant hand, hindering performance of activities of daily living (ADLs). We used 3D motion analysis, submovement decomposition, and machine learning models to assess dominance along the upper extremity in cerebral palsy patients and healthy controls during a block-stacking task. Methods:We recorded the movements of 25 healthy subjects and 3 with cerebral palsy while stacking six blocks using the Vicon Vero motion capture system. Participants performed the task with their dominant and non-dominant hand three times each. We then processed data to remove noise and segmented each trial into submovements using joint velocity zero-crossings, and extracted features from each submovement. We discarded highly correlated features, retaining between 30 and 60 features per joint marker. We then trained machine learning models to predict hand dominance at each joint. For the best performing models, we used SHAP feature importance to identify the most influential features. Results:Tree-based models, like RandomForest, were most accurate for estimating dominance, with a 95% score at the hand and 78% at the shoulder. Accuracy for cerebral palsy patients was 90% at the same markers. For healthy patients, proximity of a joint influenced predictability, with accuracy decreasing sequentially from the hand to shoulder. Cerebral palsy patients showed less of a proximal-distal pattern. The most important features also differed. In healthy patients, horizontal velocity, vertical change in acceleration (jerk), and late peak (i.e. accelerative) submovement velocity had strong relationships with dominance at proximal and distal markers. The relevant features for cerebral palsy patients varied with location. Proximal features such as skewness, entropy, and absolute maximum velocity fell in importance at distal locations, where top features more closely resemble those of healthy subjects. Conclusion:Our findings suggest that machine learning models can expose differences in features of dominance between healthy individuals and cerebral palsy patients during upper-limb motor tasks—particularly between distal and proximal joint movements. Significance:Cerebral palsy often presents with asymmetric hand motion and upper extremity dysfunction, leading to challenges in ADLs. These results present potential measures to assess improvement or deterioration.
Keywords: Cerebral palsy, handedness, machine learning, fine motor tasks

## P2.4-B: **Possibility of Measuring Skills by Operating Experience of a Surgical Simulator Using Multi-Channel Surface EMG**

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With the increase in the number of robot-assisted surgeries in recent years, many studies have been reported that are interested in skill evaluation in the training of surgeons. In our previous report, the authors showed the data suggesting that it is possible to quantitatively evaluate surgical skill relatively based on statistics of amplitude information from time-frequency analysis and a machine learning method. However, the authors have not been able to identify the reason why those statistics can reflect the degree of surgical skill. In this study, the authors record four channels of the radial and ulnar sides of the forearm EMGs during two trials of a specific procedure on a surgical simulator in non-skilled persons. This study aims to evaluate the difference in skill level between the first and second trials based on the statistics of EMG amplitude and to clarify the dependence of skill level on learning experience. All participants were young, healthy adults with no previous surgical simulator experience. They stood in front of the surgical training box and held forceps in both hands. Inside the box was monitored by a camera, and they could confirm their own operation on the monitor in front of them. Many rods stand in the box, and elastic rings are threaded through the rods. The participants are asked to pick up a ring with the left forceps, change to the right forceps, and pass the ring through a rod other than the original rod 20 times in one trial.The EMG amplitude in the time-frequency domain is calculated by applying CDM to the filtered EMG. The extracted amplitude distribution was divided into several analytic durations with frequencies ranging from 50-250 Hz, and the standard deviation, skewness, and kurtosis were calculated. Logistic regression was applied to the statistics as input to evaluate the degree of skill. Test data were selected from one of the participants, and data from the remaining participants were used as training data. The training was performed 12 times between two trials. Our results showed that there was no clear trend in the difference in proficiency between the first and second trials. It is clear that the second trial was more successful than the first trial, as evidenced by the significant reduction in operation time. Our previous study was an evaluation of skills among highly trained specialists in real surgical settings, whereas the present study is not easy to compare because of its short analytical duration. In other words, the analysis duration was shorter than before, which may have caused instability in the statistics. When the operation time was significantly different between the first and second trials, a trend toward a significantly higher skill level on the second trial was obtained. In conclusion, our results suggest that the analytic duration may contribute significantly to the statistics.

## P2.5-C: **Importance of weight bearing on the affected side in gait of hemiplegic stroke patients: A Cyclogram analysis of the unaffected Side**

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IntroductionGait disturbance is common in hemiplegic stroke patient due to weakness, spasticity and motor incoordination. Especially in hemiplegic stroke, muscle weakness could

limit the ability to transfer weight to the affected side. Previous studies have shown that weight bearing on the hemiplegic side plays a crucial role in stroke patients' locomotion. However, quantifying the amount of weight bearing on the hemiplegic side remains a challenge. While measuring ground reaction forces using force plates is the gold standard, its high cost and limited accessibility pose significant barriers. We propose utilizing cyclogram-based analysis of the unaffected side to estimate the ground reaction force on the affected side and identify potential correlations with gait quality and balance, as assessed by the Berg Balance Scale (BBS) score. MethodsWe retrospectively enrolled 208 hemiplegic stroke patients who were able to walk independently indoors (FAC 4,5) and conducted instrumented gait analysis. We derived the cyclogram parameters from the kinematic data of a single gait cycle using the result of gait analysis. Additionally, we collected spatio-temporal data and ground reaction force data during the gait analysis. We compared the peak vertical ground reaction force on the affected side with the cyclogram parameter on the unaffected side, spatio-temporal parameters, and the Berg Balance Scale (BBS) score. To assess the significance of these relationships, we computed Spearman rank correlation coefficients. ResultsWe found the correlation between ground reaction force on affected side and cyclogram's area of swing phase of unaffected side. (ρ = 0.62, p<0.01) Swing phase area of cyclogram of unaffected side was correlated with gait speed (ρ = 0.76, p<0.01) and BBS (ρ = 0.49, p<0.01). Ground reaction force on the affected side is also directly correlated with gait speed (ρ = 0.62, p<0.01) and BBS (ρ = 0.33, p<0.01). ConclusionOur study found that the swing phase area of the hip-knee cyclogram on the unaffected side correlated with amount of weight-bearing on the affected side measured by force plate during gait. The swing phase area of the cyclogram of the unaffected side correlated with gait speed and balance control ability as well.

## P2.6-C: Relationship between neural drive of the lower trapezius and serratus anterior and scapular motion

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BackgroundMuscle weakness of the lower trapezius and serratus anterior is associated with alterations in scapular motion. Morphological and neurological factors contribute to muscle weakness. The importance of neurological factors rather than morphological factors in scapular motor control has been suggested, but the details are unclear. The purpose of this study was to investigate the relationship between neural drive of the lower trapezius and scapular motion, and neural drive of the serratus anterior and scapular motion, respectively.MethodsThree scapular motions (upward (–) /downward (+) rotation, external (–) /internal (+) rotation, anterior (–) /posterior (+) tilt) during scapular plane upper limb elevation in 50 healthy young subjects (25 males/25 females) were recorded with an electromagnetic tracking device (Liberty, Polhemus, Colchester, VT, USA). From the data obtained, the scapular motion angle at 120° of upper limb elevation was extracted. Next, a trapezoidal contraction task at 70% maximum voluntary contraction of the lower trapezius and serratus anterior was performed, and surface electromyography (sEMG) waveforms (Delsys Inc., Natick, MA, USA) were collected during the task. The obtained sEMG waveforms were decomposed into motor unit action potential amplitude (MUAPAMP), mean firing rate (MFR), and recruitment threshold (RT). Motor units with a decomposition accuracy of ≥85% were used in the analysis, and the average MUAPAMP, average MFR, slope and y-intercept of the regression of MUAPAMP and MFR with RT were used as indicators of neural drive. Pearson product-moment correlation coefficient or Spearman rank correlations were used to examine the relationship between the three extracted scapular motion angles and indices of neural drive.ResultsSignificant correlations were found between scapular posterior tilt angle and average MUAPAMP of the lower trapezius (r = 0.466, p = 0.001), MUAPAMP-RT slope of the lower trapezius (ρ = 0.459, p = 0.001), MFR-RT y-intercept of the lower trapezius (r = 0.369, p = 0.009), and average MFR of the serratus anterior (r = 0.367, p = 0.009) (Figure 1a).Significant correlations were found between scapular upward rotation angle and average MFR of the serratus anterior (r = –0.309, p= 0.030) and MUAPAMP-RT slope of the serratus anterior (r = –0.330, p = 0.021) (Figure 1b).ConclusionNeural drive of the lower trapezius affects the angle of scapular posterior tilt and angle of upward rotation, and neural drive of the serratus anterior affects the angle of scapular upward rotation. In correcting abnormal scapular motion, it may be necessary to improve the neural drive (size and firing rate of the motor units) of the lower trapezius and serratus anterior.

## P2.7-C: **The effects of speeds on EMG profiles of Tibialis posterior detected by multiple fine wire electrodes**

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IntroductionThe tibialis posterior (TP) has important roles in controlling the subtalar joints and other joints within the foot. Fine-wire (FW) electrodes are the only method for detecting EMG in TP due to their location. There are two common approaches and positions for FW insertions in TP. The EMG profiles detected by them are similar at the normal self-selected speed, but the performance of these insertions is unknown at different speeds. This study aims to examine the differences in dislocation rate and detected EMG profiles between two common sites of FW in TP at different speeds.Participants and method11 healthy volunteers (age 35 ± 6 years, 7 males, height 1.67±0.10 m, weight 71±12 kg) who were self-reported to be free from any neurological or musculoskeletal disease gave consent to participate in the study. Using two methods under the guidance of ultrasonography, FW electrodes detected EMG at two locations in the TP that were each 2 cm apart from one another [1, 2]. The participants were instructed to walk at different speeds: self-selected speeds, 25% slower, 50% slower, 25% faster, and 50% faster. The processing of EMG data involved time normalization to 100% of the gait cycle, the removal of movement artifacts, full wave rectification, and envelope detection. Then they were normalized from peak amplitude at self-selected speed and averaged from six gait cycles for comparison between participants.ResultTheir average walking speed was 1.18 ± 0.15 m/s. The detected average speeds are slowest (0.64 ±0.15 m/s), slower (0.94 ±0.14 m/s), self-selected speed (1.18 ±0.15 m/s), faster (1.46 ±0.19 m/s), and fastest (1.86 ±0.24 m/s). The dislocation of the distal electrodes occurred at 'faster' speed in 1 case and at 'fastest speed' in 4 cases, whereas the dislocations of the proximal electrodes occurred at the 'fastest' speed in 3 participants. The amplitude of EMG increased, and the timing of the peak normalized EMG occurred earlier in the gait cycle during the active phases as the speed increased. The magnitude of the normalized EMG at the distal electrodes tended to be higher than that at the proximal electrodes.DiscussionThe dislocation rate of the distal electrode was higher than that of the proximal one. This may be due to closer contact with the other limb. The increase in muscle activity is not directly proportional to the increase in speed. There is a slight difference between the two EMG peak values at the faster speed, which may require further investigation.ConclusionEMG detected by two FW sensors at different speeds in TP tended to be similar: an increase in peak magnitude and a change in timing of peak. However, the distal electrodes had a higher dislocation rate than the proximal electrodes. The walking speed or task stated in the protocol for EMG data collection should be considered when selecting the appropriate location of the electrode in TP.

## P2.8-C: **Study of the floor pressing force with the hallux and metatarsals during walking for hallux valgus.**

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[Background and aim] We have 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. 2018,2022) How pressing on the floor in three axes force vector has not been studied, when hallux valgus people walking. The purpose of this research is to measure the floor pressing force with the hallux and metatarsals during walking for hallux valgus,  and use this as basic data for walking.[Participants and Methods] Two hallux valgus students that did not affect daily life participated. The participants walked on a flat straight road of about 20m. We measured the FPF vector for right toes (1st toe, 3rd toe) and right metatarsal head (1st metatarsal head, 5th metatarsal head), right heel. We used the sensors, attached the acrylic plates (100mm × 100mm × 20 mm) to 3-axis force sensor (Tec Gihan Co., Ltd.), for measuring the FPF vector 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%. In order to examine whether the waveforms are similar from the first step to the stop, we used a cross-correlation function to calculate the value (Rxy(0)) when there is no time lag (lag 0). The analysis was performed using SPSS (ver.28).[Results] A low correlation was observed in the waveforms of the first 2 to 3 steps. A similarly low correlation was seen for 2 to 3 steps before stopping. In other steady walking sections, the correlation coefficients for 1MP tended to be high, and the same was true for 5MP (r=0.6 to 0.9). In addition, the correlation between the vertical and anteroposterior components of the big toe in the steady walking section was high (r=0.6-0.99), and the correlation between the left and right components was low (r=0.28-0.4).[Conclusion] Based on the results of this study, it was thought that the correlation was high because even for hallux valgus, loads are applied in the vertical direction depending on the state of deformation. The above results are similar to those of healthy subjects, indicating that it is possible to evaluate the degree to which hallux valgus people press their toes against the floor when walking.

## P2.9-C: **Preferred direction of muscle activities in the hip adductors varies with hip flexion angles**

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INTRODUCTION: Hip adductors (adductor longus [AL], gracilis [Gra], and adductor magnus [AM]) have moment arms of hip flexion and extension as well as that of hip adduction (1). We can exert force in various directions around the hip joint (e.g., between the hip flexion and adduction). However, little is known about the direction in which the muscle activity of the hip adductors is highest in the transverse plane (preferred direction: PD). The electromyographic (EMG) activity of AL and AM during hip flexion significantly decreased as the hip flexion angle increased (2), suggesting that the PDs of muscle activities may also change with the hip flexion angle. This study aimed to investigate the effects of hip flexion angle on the PDs of muscle activities of the hip adductors in the transverse plane.METHODS: Eighteen males performed maximum voluntary isometric contractions (MVIC) in five directions (hip flexion, flexion + adduction, adduction, extension + adduction, and extension) at three hip flexion angles (at 0°, 45°, and 90°). The direction of the force was measured as the angle of a load cell with respect to the horizontal line. The electrode positions of AL, Gra, and AM were carefully determined using ultrasonography (3). Root mean square (RMS) of EMG and force direction during MVICs were plotted in a polar coordinate system. The angle of the vector connecting the centroid of the five MVICs and the pole with respect to the polar axis was defined as the PD of muscle activity. The Friedman test was used to analyze the differences in PDs between different hip flexion angles. Data were presented as median (interquartile range).RESULTS: The PDs of AL at 45°[15.3 (11.0 to 21.4)°] and 90° [8.8 (4.8 to 13.6)°] of hip flexion were significantly inclined to extension compared with that at 0° of hip flexion [19.2 (17.1 to 27.3)°]. The PD of Gra at 90° of hip flexion [13.0 (6.8 to 16.5)°] was significantly inclined to flexion compared with that at 0° of hip flexion [−2.0 (−9.0 to 4.3)°].The PD of AM at 90° of hip flexion [−20.7 (−36.4 to −7.8)°] was significantly inclined to flexion compared with that at 0° of hip flexion [−37.8 (−49.0 to −32.8)°].DISCUSSION: The PD of AL was significantly inclined to extension as the hip flexion angle increased. This result is in line with the previous findings that AL acts as a hip flexor in the hip extended position and acts as a hip extensor in the hip deeply flexed position. Meanwhile, the PDs of Gra and AM were significantly inclined to flexion as the hip flexion angle increased. These results is inconsistent withthe anatomical findings (1). These results suggest that the changes in the PD with the hip flexion angle are likely to be attributed to possible changes in the role within the synergistic muscles rather than changes in the moment armREFERENCES:Dostal et al., Phys Ther, 1986 Kato et al., Eur J Appl Physiol, 2019Watanabe et al., Eur J Appl Physiol, 2009

## P2.10-C: **Muscle activity required to turn patients in their bed: an assessment of four techniques**

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IntroductionPatient handling (PH) is a leading cause of musculoskeletal injury among health care providers. In New Brunswick (Canada) there are two competing PH programs developed to reduce the biomechanical and muscular strain associated with PH tasks. This research assessed the activity of eight muscles bilaterally when using the Back in Form (BiF) and All The Right Moves (ATRM) PH techniques developed to reposition the patient in their bed. Both programs are based on proper body mechanics and the concept of not lifting to reposition patients.MethodsTwenty-six university aged students were recruited. The exclusion criteria for this study were that participants must not suffer from low back pain or shoulder disorder during the study period (or 3 months prior) and they must be between 19 and 35 years old.   The BIF program has two techniques for turning a patient in their bed and are referred to as Turn-to-side 1-Caregiver andTurn-to-Side 2-Caregiver, respectively.  The ATRM program also has two techniques referred to as Turn-1 and Turn-2, where each technique is completed by one caregiver.  Participants performed each of the techniques twice while neuromuscular activity was monitored bilaterally on eight muscles using a Bortec Octopus AMT-8. The eight muscles of interest were: anterior deltoid [AD], trapezius descendens [TD], biceps brachii [BB], thoracic erector spinae [TES] located at the level of the T9 spinous process, lumbar erector spinae [LES] located at the level of the L3 spinous process, external oblique [EO], rectus femoris [RF], and biceps femoris [BF]. Results and ConclusionThe raw EMG signal was rectified, and Butterworth low passed filtered (RMS converted) using MATLAB. Peak activity was determined for each muscle during a maximum voluntary contraction protocol (MVC) and used to normalize all subsequent EMG data. The Peak muscle activity was determined for two phases: 1) the preparation for patient turning (PPT); and 2) the patient turning (PT).  A series of ANOVAs with corrections were used to determine the difference in peak muscle activity.  In the PPT phase, significant differences in peak muscle activity on the right were observed: TD, AD, BB exhibited higher activity for the Turn-2 technique, while the TES showed increased activity in Turn-to-side 1-Caregiver technique, and the LES showed higher activity for Turn-1 technique. On the left side, differences were found for BB during the Turn-2 technique and for the RF during the Turn-to-side 1-Caregiver technique. During the PT phase, significant differences on the right were found: AD showed higher activity in the Turn-to-side 1-Caregiver technique, and higher activity was found for TES and LES in the Turn-1 technique. On the left side, differences were found for the AD in the Turn-1 technique and for the RF in the Turn-to-side 1-Caregiver technique. Overall, it was observed that lower neuromuscular activity occurred when two caregivers performed the task, compared to only one, regardless of which program used.

## P2.11-D: Combining measures of central (functional MRI) and peripheral (surface electromyography) correlates of movement control

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Introduction:Whereas functional magnetic resonance imaging (fMRI) has been extensively used to describe the central correlates of real and imagined movement [2], surface electromyography (sEMG) provides complementary information about muscle engagement and synergies [1]. The combination of both will facilitate the exploration of quantitative relationships between brain and peripheral muscle activations during overt movement and motor imagery.Methods:This study involved 19 healthy subjects (31.1±7.3 years; 8 females, 11 males). MRI data were acquired on 3 Tesla scanners (Prisma, Siemens Medical, Germany). A multimodal whole-brain MRI protocol included a high-resolution T1-weighted anatomical scan and a 10-minute fMRI scan with multi-band T2*-weighted gradient echo (BOLD) EPI acquisition during a block paradigm consisting of two active (paced dorsi-/plantarflexion of the ankle and gait imagery) and two resting (with and without beeps) 30-second conditions, each repeated five times. sEMG and kinematic data were recorded (Brain Products GmbH, Germany) during BOLD scanning. The bipolar sensors for sEMG were located on the left lower limb at tibialis anterior (TA) and gastrocnemius medialis (GM). Accelerometric data were acquired from the dorsal side of the foot to verify the presence or absence of motion.Analysis of fMRI data was conducted in FSL software, and physiological data was analysed in MATLAB R2023b. Data processing began with a gradient artifact correction algorithm, followed by signal processing involving frequency filtering and RMS (root mean square) calculations.Results:The pilot study revealed activation in all relevant cortical areas (M1, S1, SMA) during execution of the movement task. During imagination, active cortical areas included SMA, pre-SMA, S1, SPL/IPS (superior parietal lobule / intraparietal sulcus), CMA (cingulate motor area) and the cerebellum. Active movement measurements revealed increased sEMG activity in the TA (48.9±5.5 μV) and GM (20.2±4.8 μV), gait imagery revealed sEMG activity in TA (4.7±1.3 μV) and GM (2.8±0.7 μV).Conclusions:The combination of sEMG-fMRI with accelerometer recordings offers a more precise understanding of the brain's motor system activation than using fMRI alone. Additionally, we have complementary information about muscle activation and their interplay, including tracking the kinematics of the movement performed.Acknowledgment:We acknowledge the core facility MAFIL supported by MEYS CR (LM2023050 Czech-BioImaging), part of the Euro-BioImaging (www.eurobioimaging.eu) ALM and Medical Imaging Node (Brno, CZ). AH was supported by Slovenian Research and Innovation Agency (P2-0041).References:1. Kolářová et al. Effect of Gait Imagery Tasks on Lower Limb Muscle Activity with Respect to Body Posture. Percept Mot Skills. 2016. 2. Boyne et al. Functional magnetic resonance brain imaging of imagined walking to study locomotor function after stroke. 2021.

## P2.12-E: Post-Activation Depression is Attenuated in Individuals following Spinal Cord Injury with and without Spasticity

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Post-activation depression (PAD) is thought to be one of the mechanisms altered after spinal cord injury (SCI) that might contribute to spasticity. However, limited information is available on how PAD differs between humans with SCI with and without spasticity. To address this question, we tested the soleus H-reflex at interstimulus intervals of 1, 2, 4, and 10 s using half of the maximal H-reflex (half H-max) and the maximal H-reflex (H-max) size in 34 individuals with chronic (≥6 month) SCI and 17 aged-matched control subjects. Spasticity in the soleus muscle was assessed by the stretch reflex (elicited by rapid >300°/s passive dorsiflexion of the ankle) and the Modified Ashworth Scale (MAS). The presence or absence of spasticity in individuals with SCI was classified based on the highest amplitude of stretch reflex obtained in control subjects. We found that the H-max was similar in individuals with SCI with and without spasticity and control subjects, whereas the M-max was smaller in both groups of individuals with SCI compared with control subjects. PAD was stronger at shorter interstimulus intervals at half H-max compared with H-max in individuals with SCI with and without spasticity and control subjects. Notably, PAD was attenuated to a lesser extent in individuals with SCI compared with control subjects but no differences were found in individuals with SCI with and without spasticity. In addition, the magnitude of PAD was not correlated with the stretch reflex and the

MAS. Our findings demonstrate that PAD is attenuated following SCI regardless of the presence of spasticity, suggesting that it is less likely that PAD plays a role in the pathophysiology of spasticity.

## P2.13-E: Central and peripheral somatosensory characteristics of the ankle joint: an exploratory study

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Background: Previous research in somatosensory dysfunction has predominantly focused on neurological disorders. Recently, some emerging evidence showed alterations in somatosensory regions in individuals with chronic musculoskeletal conditions, such as anterior cruciate ligament injury. However, little was known regarding the central somatosensory characteristics of the ankle joint. The purpose of this study aims to explore the central and peripheral somatosensory characteristics including the evoked potentials (SEP), corticomuscular coherence (CMC), joint position sense, and two-point discrimination (TPD) of the ankle joint. Methods: In this exploratory study,10 asymptomatic healthy adults between 20-30 y/o were recruited. SEP and CMC were collected using the 64-chanel electroencephalogram (EEG) and surface electromyography (EMG). The stimulus site was on the tibial nerve, and target muscles were the peroneal longus (PL), soleus, and tibilalis anterior (TA). Joint position sense of ankle joint was measured using the Active movement extent discrimination assessment (AMEDA) with a self-made device. TPD was measured using a caliper on the 1st and 5th metatarsal bone and heel. The within-day measurement reliability was assessed using the intra-class correlation coefficients (ICC) for CMC, TPD, and joint position sense. Results: The SEP testing showed a significant increase in amplitude between 30 to 100 milliseconds following a sensory level electrical stimulation on Cz and C1 electrodes. The range of CMC ranged from 0.074 to 0.259 for the PL, from 0.0743 to 0.2558 for the soleus, and from 0.074 to 0.2198 for the TA. The measurement reliability was moderate for the C3 electrode and PL muscle at the alpha band ($ICC_{3,2}$=0.428), for the C1 electrode and PL muscle at the beta band ($ICC_{3,2}$=0.601), and for the C1 electrode and soleus muscle at the gamma band ($ICC_{3,2}$=0.645). As for the remaining electrode-muscle pairs in the three frequency bands, their reliability is poor. The measurement of TPD had excellent reliability on the 1st and 5th metatarsal bone and moderate reliability on the heel (1st : TPD=12.77±2.4 mm, $ICC_{3,1}$=0.905, standard error of measurement (SEM)=0.743; 5th : TPD=14.51±2.3 mm, $ICC_{3,1}$=0.866, SEM=0.855; heel: TPD=14.09 mm, $ICC_{3,1}$=0.558, SEM=2.194). The AMEDA had moderate to excellent measuring reliability ($ICC_{3,1}$= 0.697 to 0.891) and the accuracy rate is between 47.5% to 82.5% in forty trials. Conclusions: This research established the measurement method for further investigations of central and peripheral somatosensory characteristics in musculoskeletal conditions related to the ankle joint. Our data indicated that with good practice and standardization, measurement of SEP, CMC, AMEDA, and TPD offers reasonable reliability for clinical investigation.

## P2.14-E: Changing the position of the stimulating electrode reduces the pain when recording the F-waves from the vastus lateralis muscle

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Introduction: F-waves are compound muscle action potentials produced by the reciprocal excitation of motor neuron axons and back-firing in anterior horn cells upon electrical stimulation. F-wave latency measures the nerve conduction velocity, and F-wave persistence is a measure of the excitability of the anterior horn cells. Conventional recording of F-waves from the vastus lateralis muscle (VL) causes severe pain in some subjects. We aimed to investigate the effects of stimulation position on pain when recording F-waves from the VL and to develop a method for recording F-waves from the VL that causes minimal pain.Methods: A total of 15 healthy subjects participated in the study. The active electrode was placed distal to the VL. The reference and ground electrodes were placed on the patella and the anterior surface of the lower leg, respectively. The anode of the stimulating electrode was placed at the lateral aspect of the thigh. In the conventional trial, the cathode of the stimulating electrode was located 80% of the distance along a line extending from the groin proximally to the patella. In the new trial, the cathode of the stimulating electrode was placed 80% along a line extending from the greater trochanter to the patella and at a point where a large M-wave could be recorded even with weak electrical stimulation. The stimulation intensity was at 1.2-fold the maximum M-wave amplitude obtained by gradually increasing the voltage. The stimulus duration was 0.2 milliseconds, the stimulus frequency was 0.2 Hz, and the number of stimuli was 30. The filters were set from 20 Hz to 3000 Hz. The examiners electrically stimulated each site of the distal thigh at random and recorded the F-waves from the VL. A visual analog scale was used to evaluate pain intensity. The participants were asked to indicate the pain intensity of the electrical stimulation immediately after the F-waves recording. The stimulation intensity, visual analog scale score, M-wave amplitude, F-wave latency, F-wave average amplitude, and F-wave persistence were analyzed at each trial.Results: In the new trial, the stimulation intensity, visual analog scale score, M-wave amplitude, and F-wave persistence decreased, and F-wave average amplitude increased compared with the conventional trial.Discussion: In the conventional trial, it is presumed that the cathode of the stimulating electrode was far from the motor branch of the VL, potentially resulting in stimulation of both the VL and non-VL muscles. Conversely, in the new trial, the cathode of the stimulating electrode was probably closer to the motor branch of the VL, thus selectively stimulating only the VL. Consequently, in the new trial, both stimulation intensity and pain were decreased. Furthermore, we inferred that the exclusive excitation of the VL contributed to the reduction in M-wave amplitude and F-wave persistence, alongside an increase in the F-wave average amplitude.

## P2.15-E: Exploring spinal reflex modulation in the pelvic floor muscles through tibial nerve stimulation

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Background: Urinary dysfunctions are often experienced in older adults and people with neurological injuries. The spinal segments mediating lower urinary tract function overlap with those controlling lower limb sensorimotor function at the lumbosacral region. Studies in animals indicate that activating one system affects the other. However, the interaction between the somatic nervous system and autonomic function is less studied in human participants.

Spinally-mediated reflexes, such as Hoffmann (H-) reflex and cutaneous reflexes, show task-dependent modulation in the leg muscles indicating sensory inputs from the muscles and skin regulate motoneuron excitability based on the functional goal of the tasks. The pelvic floor muscles (PFM) play critical roles in maintaining continence during different physical activities. Our recent studies in healthy adults show that PFM is activated during walking and jogging with greater activity seen during the stance phase. Emerging evidence also shows that gait training may be accompanied by improved bladder function in people with spinal cord injury. Furthermore, electrical stimulation of the posterior tibial nerve at the ankle is a target for treating overactive bladder. These lines of evidence indicate potential modulatory effects of peripheral sensory inputs from the leg on PFM activity. The purpose of this study is to explore: 1) the feasibility of measuring tibial nerved evoked spinal reflexes in PFM and 2) whether this reflex response is modulated by posture and task. Methods: Five healthy young adults have been recruited for this study so far. Soleus and pelvic floor muscle electromyography were measured using surface electrodes. Soleus H-reflex and M-wave were evoked through electrical stimulation of the tibial nerve at the popliteal fossa. Reflex responses in the pelvic floor muscle were concurrently measured when obtaining the recruitment curve of soleus H-reflex in sitting and standing positions, with the soleus muscle relaxed and contracted to different levels. Results: Tibial nerve stimulation evoked a reflex response in PFM at a latency around 15ms. The amplitude of this response is modulated task-dependently and enhanced during soleus muscle contraction. Conclusion: Peripheral sensory input from the tibial nerve has a modulatory effect on the activity in PFM. This study indicates that the neural circuits that control the sensorimotor function of the leg muscles interact with those that control urinary function. It shows the potential of using exercise-based rehabilitation approaches such as walking exercises and transcutaneous stimulation to manage neurogenic dysfunction.

## P2.16-F: Exercise combined with electrical stimulation for the treatment of chronic ankle instability – a randomized controlled trial

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Purpose: Chronic ankle instability (CAI) is a common condition that can lead to significant functional impairment and reduced quality of life. One of the factors contributing to CAI is arthrogenic muscle inhibition (AMI), which is characterized by decreased activation of the muscles surrounding the ankle joint. Both Transcutaneous Electrical Nerve Stimulation (TENS) and Neuro-Muscular Electrical stimulation (NMES) have been shown to improve muscle activation in conditions involving AMI. This study aimed to compare the short, medium, and long-term effects of balance exercises combined with either peroneal NMES or peroneal TENS on dynamic postural control and patient-reported outcomes (PROMs) in subjects with CAI.Methods: Thirty-four participants with CAI were randomly assigned to a 12-session home-based exercise program combined with NMES (Ex-NMES) or TENS (Ex- TENS). Both the participants and the investigator were blinded to group assignment. Postural control was tested with the modified Star Excursion Balance Test (mSEBT) and time to stabilization (TTS) after a single-leg drop-jump. Self-reported function was measured using the Cumberland Ankle Instability Tool (CAIT), the Identification of Functional Ankle Instability (IdFAI), and the Sports subscale of the Foot and Ankle Ability Measure (FAAMSport). Subjects were assessed at baseline, before and after treatment, and PROMs were also measured at 6 and 12

months.Results: Both groups showed significant improvements in all self-reported outcome measures at 12-month follow-up. Subjects in the Ex-NMES group had significantly better IdFAI (-4.2 [95% CI -8.1, -0.2]) and FAAMSport (13.7 [95% CI 2.2, 25.2]) scores than those in the ex-TENS group at 6- and 12-month follow-up, respectively. Medium to large between-group effect sizes were observed for self-reported functional outcomes and mSEBT. Yet, there were no improvements in mSEBT and TTS immediately after training with either TENS or NMES.Conclusions: The consistent trend for long-term improvement in self-reported functional outcomes when training is combined with NMES compared to training with TENS may indicate a potential benefit that should prompt clinicians to consider the use of NMES when prescribing balance training for individuals with CAI.

## P2.17-F: **Effect of electrolyte amount and concentration on Neuromuscular Electrical Stimulation (NMES) stimulation – Towards near-dry textile electrodes**

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BackgroundIn recent years, textile electrodes have gained recognition for medical applications pertaining to both sensorics and stimulation, particularly in a home-based setting. Some of these applications, such as Neuromuscular Electrical Stimulation (NMES), involve current intensities that can be high enough to be perceived as painful, and therefore require the addition of an electrolyte in the form of a conductive gel or saline solution. However, little is known about the minimum requirements in terms of electrolyte volume and concentration. AimThis exploratory study investigates the lower limit of electrolyte volume and the effect of saline concentration in an NMES modality using two motor points on the calf. In doing so, it aims to deepen the understanding of the painfulness of electrostimulation with near-dry textile electrodes, to improve the safety of home-based electrostimulation.MethodsDifferent pairs of 3×3cm textile electrodes, knitted with silver-coated yarns, were wetted with different combinations of electrolyte volume (ranging from 0µL to 320µL) and saline concentration (0%, 0.9%, 5%). These pairs of electrodes were then tested on 21 volunteers for their propensity to evoke pain (rated on a 101-item Numerical Rating Scale) at increasing stimulation intensity levels, following the first clear observation of plantar flexion. Participants were also asked to fill in a short survey about factors thought to have an impact on the quality of electrostimulation (use of moisturizer, frequency of physical activities, etc.). Results were analyzed using nonparametric statistics and ordinal regression.ResultsPlantar flexion could be obtained in an NMES modality with textile electrodes and very low electrolyte volumes (<1mL). Unsurprisingly, higher electrolyte volumes were associated with lower pain ratings. Pain ratings were more strongly correlated with electrolyte volume than with saline concentration. Moreover, sigmoid curve fitting, and comparisons based on Wilcoxon-Mann-Whitney Odds seem to suggest the existence of “painfulness thresholds”, in current intensity and electrolyte volume.ConclusionThe findings indicate that NMES can be effectively performed using very small electrolyte volumes (<1mL), with reasonable levels of evoked pain or discomfort. Short-term applications of these results could include the creation of safety guidelines for home-based products. In the more distant future, textile-based electrostimulation devices could be designed to store and/or transport enough electrolyte, to allow for safe electrostimulation with less complexity for the end-user. These considerations are especially important in a home-based setting, where ease of use and minimal need for supervision are key factors of treatment adherence.

## P2.18-G: Effects of Prolonged Mouse Aiming on Forearm Muscle Fatigue and Motor Performance in Gamers and Non-Gamers

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Introduction: Esports are becoming increasingly popular; however, little research exists on the physical demands of the sport. Many individuals become injured (McGee and Ho, 2021) or experience pain and discomfort in their upper limbs while gaming (Forman and Holmes, 2023). Investigating changes in forearm muscle activity and fatigue while gaming could provide critical insight into how muscular demands change during extended periods of gaming and how those changes may impact the performance and health of gamers. Therefore, the purpose of this study was to evaluate muscle fatigue and performance impairments during an extended mouse aiming fatigue protocol.Methodology: Twenty participants were recruited for this study (8F, 12M), separated into gaming and non-gaming groups. Surface electromyography was measured from eight muscles of the right upper limb. Participants performed a 30-second aiming task using aim training software (AimLab, State Space Labs, Inc., New York, New York, USA). The fatiguing protocol involved six, 5-minute bouts of clicking targets in AimLab. To assess muscle fatigue, reference contractions of radial and ulnar deviation (30% of maximum) were performed throughout the experiment. Participants also provided ratings of perceived fatigue (RPF) throughout the experiment. Performance and fatigue assessments were performed after each bout of AimLab fatigue. Mean power frequency (MnPF) and RMS amplitude were calculated and spike shape analysis was performed during reference contractions to quantify muscle fatigue. Performance measures were calculated in AimLab and included total targets hit, accuracy, and error size. Results: While gamers outperformed non-gamers, no changes in performance measures were observed throughout the experiment. Extensor digitorum (ED) and extensor carpi ulnaris (ECU) produced the greatest levels of muscle activity at 9.3% and 8.2% of MVC, respectively. RPF increased in a linear fashion during the fatiguing protocol, reaching a maximum rating of 4.2/10 after 30-minutes. MnPF of the wrist extensors significantly decreased due to the fatiguing protocol, with a maximum decrease of 25.7%. Spike shape characteristics of the wrist extensors showed a decrease in spike frequency, peaks per spike, spike slope, and zero crossings following the fatigue protocol.Discussion: Changes in performance metrics indicate no impairments caused by the fatigue protocol. RPF ratings reached 4.2/10 after 30-minutes, indicating participants experienced muscle fatigue. Changes in fatigue metrics indicate that ED and ECU were fatigued following prolonged mouse aiming, which could suggest that the wrist extensors are prone to gaming related fatigue and injury.References:[1] McGee and Ho. (2021). Tendinopathies in Video Gaming and Esports. Front. Sports Act. Living.[2] Forman and Holmes. (2023). Upper-Body Pain in Gamers: An Analysis of Demographics and Gaming Habits on Gaming-Related Pain and Discomfort. Journal of Electronic Gaming and Esports.

## P2.19-G: The Impact of Joint Angle on Muscle Fatigue in Concentric Contractions using sEMG: Assessing Muscle Fiber Conduction Velocity-Amplitude Relationship

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IntroductionSurface electromyogram (sEMG) stands as a non-invasive and objective method for evaluating muscle function, showing potential applications in sports training and rehabilitation. This study aimed to assess muscle fatigue based on the relationship between MFCV (Muscle Fiber Conduction Velocity) and sEMG amplitude differences at varying elbow joint angles.MethodTwenties males were participated, and they performed repetitive elbow flexion and extension exercise from 40 to 140 degrees of elbow joint angle at a speed of 10 degree/s in a seated position until reaching a state of fatigue. sEMG signals of the right biceps brachii muscle were recorded using array electrodes (with an electrode distance of 5mm). the signals were derived bipolarly from adjacent wires, filtered by a band-pass from 5 Hz to 1 kHz, and digitized with sampling frequency of 10 kHz. In the data, the signals were sampled 1 second at 50, 90, 130 degrees during each cycle. MFCV and the root mean square (RMS) of the amplitude were calculated every 20 ms. The distributions of RMS and MFCV were analyzed to examine the relationship between RMS and MFCV with muscle fatigue.Results and discussionsIn some subjects, there was a tendency for the average MFCV and RMS to increase with an increasing elbow joint angle during each cycle. Additionally, MFCV decreased and RMS increased during muscle fatigue. However, the variabilities of the average value were significant, and the trends were not clearly observed in other subjects. The figure shows a heatmap illustrating the relationship between MFCV and RMS during muscle fatigue across various elbow joint angles in subject A. Regarding the muscle fatigue, there tended to be a shift in the mode positions of MFCV and RMS towards higher values with increasing elbow joint angle, and the distribution variability increased. In addition, there was a larger variance in distribution at 130 degrees compared to 50 degrees. During muscle fatigue, the position of RMS mode consistently shifted towards higher across all elbow joint angles, and the distribution variability increased with the muscle fatigue. From the relationship between MFCV and RMS, it was suggested that the size of motor units participating in activity varies with elbow joint angles and fatigue.ConclusionThis study investigated muscle fatigue assessment based on the relationship between MFCV and sEMG amplitude differences across varied elbow joint angles. As the result, MFCV and the amplitude increased with increasing elbow joint angle. Additionally, motor units of various sizes were involved in the activity at 130 degrees compared to 50 degrees, regardless of the muscle fatigue.

## P2.73-G: Can task-specific training mitigate the effects of fatigue?

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Introduction: Fatigue has the potential to impact both physical and cognitive functions, causing disruptions in muscle function and hindering the central nervous system's capacity to coordinate voluntary movements. Ultimately, fatigue heightens the risk of injuries by altering the mechanical stress on musculoskeletal structures. Considering the detrimental effects of fatigue, it is imperative to develop prevention strategies to mitigate its negative consequences. Optimizing motor control through practice holds promise as a preventive measure. This could be achieved through targeted motor training interventions that promote motor learning, involving the repeated practice of context-specific motor tasks. Such practice is thought to enhance movement planning, strengthen internal representation, and reinforce feedforward control. The objective of this study was to examine the effects of task-specific training on upper limb motor performance and kinematics during a reaching task performed in a fatigued state.Methods: Thirty young and healthy participants, free from self-reported pain or disabilities, were recruited and assigned to either the Training group (n=15) or the Control group (n=15). Both groups participated in two evaluation sessions (Day 1 and Day 5), performing an upper limb reaching task under two conditions: rested and fatigued. Motor performance (accuracy and speed) and joint kinematics were assessed during the reaching task. The Training group participated in three task-specific training sessions on Day 2, 3, and 4, practicing the same task as in the evaluation sessions (five times each training day, totaling 375 reaching movements). The Control group did not undergo any training. Non-parametric ANOVA for repeated measures (Nonparametric Analysis of Longitudinal Data) was used to assess the impact of the condition (rested vs fatigued) and the training (Training vs Control group) on motor performance and joint kinematics.Results: There was no statistically significant between-group difference (p>.05) in participants' characteristics. There was a significant condition effect (p<.01) on both motor performance and kinematics. Fatigue led to a reduction of accuracy and speed, coupled with an increase in sternoclavicular elevation, trunk contralateral trunk rotation and trunk extension during reaching. Following the training period, the Training group demonstrated a significant increase in reaching speed compared to the Control group (Group x Day interaction effect; p<.01). No significant between-group difference was observed in terms of accuracy (p>.44). The Training group exhibited a reduction in contralateral trunk rotation and lateral trunk flexion on Day 5 under the fatigue condition (Group x Day interaction effect, p<.04). Discussion: Task-specific training mitigated certain compensations linked to upper-limb reaching in a fatigued state. After the 3-day training, participants exhibited improved performance and demonstrated reduced reliance on trunk compensations to complete the task under fatigue. Engaging in task-specific training may prove beneficial in alleviating some of the negative effects of fatigue.

## P2.20-H: Highly configurable model for the simulation of muscle superficial electromyography

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The objective of this study is to propose a versatile framework for simulating muscle activity, with a primary focus on the muscle fiber as a fundamental unit of activation. Our methodology treats the muscle fiber as an autonomous programmable entity, complete with defined characteristics, enabling a broad spectrum of potential configurations. Parameters like fiber radius, length, intracellular conductivity, conduction velocity, spatial distribution, force generation properties, etc., can be tailored to suit the precise demands of the task or the muscle under simulation. Additionally, the proposed muscle fibers can be dynamically organized into motor units and muscles. Furthermore, higher-level control strategies, such as the selection of motor units to engage and the timing of impulses received by each unit, are also subject to customization.Recent strides in artificial intelligence and machine learning introduce thrilling possibilities for exploring and optimizing our model's extensive parameter range. By harnessing these technologies, this approach holds promise for shedding fresh insight on the intricate interplay among muscle fibers, motor neurons, and higher-level motor control systems. It has the potential to unlock new revelations in the realm of human movement.

## P2.21-H: **Consensus for experimental design in electromyography (CEDE) project: Checklist for reporting and critically appraising studies using EMG (CEDE-Check)**

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Background: The diversity in electromyography (EMG) techniques and their reporting present significant challenges across multiple disciplines, including neurology, neuroscience, electrodiagnostic medicine, physiology, sleep medicine, sports science, ergonomics and rehabilitation, biofeedback, and control of artificial limbs, where EMG is commonly needed. To address these challenges and enhance the consistency and replicability of studies using EMG, the Consensus for Experimental Design in Electromyography (CEDE) project has developed a checklist (CEDE-Check) through a multi-stage Delphi process. Methods: The method used for the development of this checklist followed a similar process employed in previous CEDE matrices. We followed a three-step process: 1) initial listing and rating of potential items via an online survey; 2) development of the checklist draft; 3) Delphi process for consensus. Consensus was defined as 70% or more of the respondents indicating that an item should be reported ‘most of the time’ or ‘always’; fewer than 15% scoring it as ‘unsure’ or ‘never’; and an interquartile range <2 points.Results: From the 17 CEDE experts who agreed to participate in the Delphi process, 16 (94%) replied to the first- and second-round questionnaires, and consensus was achieved afterwards. A few additional amendments were made to the checklist after a pilot test assessment. The final CEDE-Check consists of 40 selected items covering four critical areas in EMG recording and reporting – the task investigated (10 items), electrode placement (6 items), characteristics of recording electrodes (13 items), acquisition and pre-processing of EMG signals (11 items). Conclusion: The CEDE-Check aims to guide researchers in accurately reporting and critically appraising EMG studies, thereby promoting a standardised critical evaluation, and ensuring scientific rigor in EMG-based research. This approach not only aims to facilitate comparisons between studies but will also contribute to the advancement of research quality and its clinical application. We encourage researchers to adopt and adhere to the checklist in their future EMG studies and advocate for journal editors to endorse the checklist as a reporting guideline.

## P2.22-H: **Evaluation of Accuracy and Precision for Low-Frequency Oculometers: A Preliminary Study Prior to Cervical Torsion Testing**

Min Hsu, Kaohsiung Medical University; Lan-Yuen Guo, Kaohsiung Medical University

Introduction: Cervicogenic dizziness is a condition that impairs postural control. It is associated with sensitization of the neck muscles. It is caused by abnormal proprioceptive signals or sympathetic control due to cervical pathology. The cervical torsion test and cervical joint

localization test are frequently used in clinical evaluation. An effective diagnostic model for cervicogenic dizziness has not yet been developed due to the high cost of the evaluation system and failing to consider the sensorimotor and oculomotor characteristics of the head planes. The aim of this study is to improve the accuracy of the instruments that are required for the development of a measurement system.Method: Ten study participants collected data using the instruments to determine the accuracy of the rating system instruments. Data were collected using the Stuart platform and two low-frequency eye trackers: the Tobii 5 and the Gazepoint GP3. The study was carried out in a two-phase design. In Phase 1, seven participants conducted repeated reliability tests on the Tobii 5 and made correction of translations on the Stuart platform. The participants received instructions to focus on the target displayed on the monitor. Eye movements recorded from five different screen positions while the participants were securely attached to a chair for safety. The study examined seven head positions, including a neutral position, 20 degrees of rotation to each side, 5 degrees of forward and backward tilt, and 5 degrees of lateral flexion to each side. In the second stage, data were gathered from three participants with different visual fitness, comparing the accuracy and precision of the Tobii 5 and the GP3. The accuracy and precision of the oculometers used for the task were analyzed by calibration and processing of physiological parameters of eye movements.Results: In the early stage of the study, Tobii 5 reliability with the Stewart platform was tested in various positions, but performance was unsatisfactory due to data errors from head movement and high blink frequency (mean of ICC: 0.07±1.19, range: -6.01~0.98). Reliability test performance can be improved to a medium level by controlling environmental variables and processing data signals (mean of ICC: 0.50±0.26, range: 0.01~0.86). The second phase of the study was a comparison of the accuracy and precision of the Tobii 5 and the GP3. The results indicated that the Tobii 5 performed better in the center position with better accuracy (mean: 0.71±0.28°) and precision (0.22±0.18°) after data filtering, but accuracy decreased as visual fitness declined. In contrast, the GP3 showed a less accuracy (mean: 1.36±0.82°) and precision (0.73±0.15°) but a similar performance across visual fitness level, with a smaller change in angle after filtering. Conclusion: Confirmed by precise head rotation control and low-sampling rate dynamometer-recorded eye tracking parameters, output data accuracy and precision revealed gaze points within the 0.5-1.5° range. This study lays the foundation for cervicogenic dizziness diagnostic system development, emphasizing the need for controlling head movement, addressing blinking factors, and implementing post-processing to enhance low-cost eye-tracking device data quality.

## P2.23-I: Neural mechanisms underlying task dependency of inter-limb reflexes during bimanual postural maintenance task

Hirotaka Sugino, Keio University; Daichi Nozaki, The University of Tokyo; Junichi Ushiyama, Keio University

Our daily activities demand versatile control of our upper limbs, ranging from independent movements like using knife and fork to coordinated movements such as carrying a tray. Remarkably, this adaptability extends to reflexive response. For instance, during tasks like carrying a tray, stretch reflexes emerge in both limbs even when one side limb is perturbed. This phenomenon is known as inter-limb reflexes. However, the neural mechanisms underlying this task dependent reflex modulation remain unclear. To clarify this point, we have conducted two experiments.In Experiment 1, we initially examined the presence of reflexive interaction

between limbs during a task requiring independent control of each limb. Twenty-two participants performed a bimanual postural maintenance task. They tried to control two cursors representing their left and right fingertip positions under background load and align them within the target . Elbow flexion torque was randomly applied to either the right or left limb, while they were required to maintain the unperturbed limb within its target. Electromyograms (EMGs) from both biceps brachii and triceps brachii muscles (TB) were recorded. Stretch reflexes were divided into three segments (R1, 20-50 ms; R2, 51-75 ms; R3, 76-105 ms) aligned with perturbation timing . Results from Experiment 1 demonstrated that stretch reflex was elicited in the TB of perturbed limb in all tasks, while TB activity in the unperturbed side decreased in the R2 compared to the baseline, even though they did not need to change its activity to maintain its target (fig. 1a ). To investigate the mechanism behind the inhibited activity in the unperturbed limb, transcranial magnetic stimulation (TMS) was applied to the primary motor cortex corresponding to the hotspot of TB in unperturbed limb during the inhibited activity phase. The active motor threshold intensity was set for stimulation. As a result, motor evoked potentials (MEPs) of the unperturbed limb TB were smaller than linear prediction. This prediction value was derived from the summation of MEPs when TMS given alone and EMG activity of the unperturbed side during perturbation alone (fig. 1b). This indicates that corticospinal excitability of the unperturbed limb was inhibited in R2 by perturbation.In Experiment 2, we examined the presence of reflexive interaction between limbs during a task requiring coordinated control of upper limbs. Twenty-two participants performed a task similar to Experiment 1 by controlling a bar at the midpoint between both fingertips, necessitating bimanual coordination. As a result, the inhibitory activity in R2 seen in Experiment 1 was not observed, while reflexive response of unperturbed limb appeared in R3 (fig. 1c). Furthermore, in contrast to Experiment 1, even by adding TMS to the hotspot of TB in unperturbed limb, MEPs showed no difference from linear prediction (fig. 1d). These findings suggested the adaptation of inter-limb reflexes depending on task demands by modulating the corticospinal excitability of the unperturbed limb. This modulation is probably caused by interhemispheric inhibition . In independent control tasks, a hemisphere controlling unperturbed limb was inhibited by signals from the opposite hemisphere, while in coordinated tasks, it may be disinhibited to generate simultaneous bimanual reflexes.

## P2.24-I: **The force steadiness of the middle finger and variability of motor unit discharge frequency are affected by the position of the ring finger.**

Momoka Nakamura, Graduate School of Science and Technology, Shinshu University; Moeka Samoto, Graduate School of Science and Technology, Shinshu University; Yasuhide Yoshitake, Shinshu University

[Introduction]Humans have an extremely ability to flex digits of the hand independently, compared with other non-human primates, but this independence is not perfect. Notably, voluntary flexion of the metacarpophalangeal joint in the middle finger can lead to involuntary flexion in the ring finger, suggesting potential mechanical linkages between the compartments of the extrinsic muscle controlling each finger. Since a shortening of the muscle compartment controlling one finger in the extrinsic muscle would be forced to cause a change in muscle length in the muscle compartment of the other finger, mechanical linkages would thus interfere with the shortening of the muscle compartment to achieve the required force. In other words, additional neural input to motor units (MUs) in the muscle compartment should be required to produce the desired force output. Hence, it is possible that the mechanical linkages between the muscle compartment of one finger and the adjacent muscle compartment of another finger may reduce the ability to perform steady force output due to alterations in MU activity. The current study aimed to examine whether the position of the ring finger (metacarpophalangeal joint angle), which may determine the stiffness of mechanical linkages between muscle compartments, influences the force steadiness and MU activity during steady isometric finger flexion with the middle finger. Mechanical linkages can be stiffer when the muscle length is longer. Therefore, the length of the ring finger muscle compartment was varied by flexion and extension of the ring finger metacarpophalangeal joint. [Methods]Eleven healthy young male adults were sheated in a chair with their right elbow joint and wrist fixed at 150° (full extension = 180°) and 60° dorsiflexion (natural position = 0°), respectively. The metacarpophalangeal joint of the middle finger was flexed at 90° and a force transducer was attached to the skin surface of the metacarpophalangeal joint to measure the isometric flexion force. The ring finger was placed in two conditions: full extension (EXT) and 90° flexion (FLX) of the metacarpophalangeal joint. A target force was 20% of maximal voluntary contraction (MVC) that was obtained during isometric flexion with the middle finger with maximum effort while the ring finger was at FLX. The target force and the actual middle finger flexion force were displayed as lines on a monitor in real time. The participants attempted to match the lines as steady as possible for approximately 10 s. A 64-channel high-density surface EMG from the flexor digitorum superficialis muscle was measured to detect MU discharge timing using the CKC method. The analysis interval was 8 s, during which the force was stable. Force steadiness was assessed by the standard deviation (SD) of the force. After extracting MU that can be assessed as the same across two conditions, MU activity was evaluated as the mean discharge frequency and the coefficient of variation (CV) of the discharge frequency. All calculated parameters were compared between EXT and FLX conditions using a paired t-test. If there were no statistical differences between conditions, the intraclass correlation coefficient (ICC) was calculated to check whether the values were similar between conditions. [Results]The SD of the middle finger force was 58% greater in EXT than in FLX (P < 0.05). The mean discharge frequency of a total of 34 MUs did not differ between conditions (P > 0.05, ICC = 0.83, mean 13.9 ± 2.4 Hz in both conditions), but the CV of discharge frequency was greater in EXT (20.1 ± 2.5%) than in FLX (17.9 ± 2.5%, P < 0.05). [Conclusion]These results suggest that when the ring finger is passively extended, which may increase the stiffness of the mechanical linkages between muscle compartments, force fluctuations are increased, accompanied by an increase in variability of MU discharge frequency during steady isometric finger flexion with the middle finger. This sheds light on the intricate interplay between muscle compartments during finger movements, highlighting the importance of considering mechanical linkages in understanding precise force control.

### P2.25-I: The force steadiness of the middle finger and variability of motor unit discharge frequency are affected by the position of the ring finger

Yasuhide Yoshitake, Shinshu University; Momoka Nakamura, Graduate School of Science and Technology, Shinshu University; Moeka Samoto, Graduate School of Science and Technology, Shinshu University

[Introduction] Humans have an extremely ability to flex digits of the hand independently, compared with other non-human primates, but this independence is not perfect. Notably, voluntary flexion of the metacarpophalangeal joint in the middle finger can lead to involuntary flexion in the ring finger, suggesting potential mechanical linkages between the compartments of the extrinsic muscle controlling each finger. Since a shortening of the muscle compartment controlling one finger in the extrinsic muscle would be forced to cause a change in muscle length in the muscle compartment of the other finger, mechanical linkages would thus interfere with the shortening of the muscle compartment to achieve the required force. In other words, additional neural input to motor units (MUs) in the muscle compartment should be required to produce the desired force output. Hence, it is possible that the mechanical linkages between the muscle compartment of one finger and the adjacent muscle compartment of another finger may reduce the ability to perform steady force output due to alterations in MU activity. The current study aimed to examine whether the position of the ring finger (metacarpophalangeal joint angle), which may determine the stiffness of mechanical linkages between muscle compartments, influences the force steadiness and MU activity during steady isometric finger flexion with the middle finger. Mechanical linkages can be stiffer when the muscle length is longer. Therefore, the length of the ring finger muscle compartment was varied by flexion and extension of the ring finger metacarpophalangeal joint.[Methods] Eleven healthy young male adults were seated in a chair with their right elbow joint and wrist fixed at 150° (full extension = 180°) and 60° dorsiflexion (natural position = 0°), respectively. The metacarpophalangeal joint of the middle finger was flexed at 90° and a force transducer was attached to the skin surface of the metacarpophalangeal joint to measure the isometric flexion force. The ring finger was placed in two conditions: full extension (EXT) and 90° flexion (FLX) of the metacarpophalangeal joint. A target force was 20% of maximal voluntary contraction (MVC) that was obtained during isometric flexion with the middle finger with maximum effort while the ring finger was at FLX. The target force and the actual middle finger flexion force were displayed as lines on a monitor in real time. The participants attempted to match the lines as steady as possible for approximately 10 s. A 64-channel high-density surface EMG from the flexor digitorum superficialis muscle was measured to detect MU discharge timing using the CKC method. The analysis interval was 8 s, during which the force was stable. Force steadiness was assessed by the standard deviation (SD) of the force. After extracting MU that can be assessed as the same across two conditions, MU activity was evaluated as the mean discharge frequency and the coefficient of variation (CV) of the discharge frequency. All calculated parameters were compared between EXT and FLX conditions using a paired t-test. If there were no statistical differences between conditions, the intraclass correlation coefficient (ICC) was calculated to check whether the values were similar between conditions.[Results] The SD of the middle finger force was 58% greater in EXT than in FLX (P < 0.05). The mean discharge frequency of a total of 34 MUs did not differ between conditions (P > 0.05, ICC = 0.83, mean 13.9 ± 2.4 Hz in both conditions), but the CV of discharge frequency was greater in EXT (20.1 ± 2.5%) than in FLX (17.9 ± 2.5%, P < 0.05). [Conclusion] These results suggest that when the ring finger is passively extended, which may increase the stiffness of the mechanical linkages between muscle compartments, force fluctuations are increased, accompanied by an increase in variability of MU discharge frequency during steady isometric finger flexion with the middle finger. This sheds light on the intricate interplay between muscle compartments during finger movements, highlighting the importance of considering mechanical linkages in understanding precise force control.

## **P2.26-I: Antagonism of 5-HT2 receptors effects the excitability of intracortical motor circuits in humans**

Liana Laughton, Griffith University; Tyler Henderson, Griffith University; Justin Kavanagh, Griffith University

Introduction: In recent times the monoamine serotonin (5-HT) has been heavily studied as a key neuromodulator of human movement. Serotonergic pathways from the raphe-nuclei of the brainstem project to the spinal cord to regulate motoneuron firing via 5-HT2 receptors located on the soma and dendrites. However, the raphe-nuclei also ascend to cortical areas associated with motor activity. Although 5-HT2 receptors have been suggested to affect cortical inhibition associated with γ–amino butyric acid (GABA) activity within motor cortical areas (Henderson et al., 2023; Thorstensen et al., 2021), the mechanisms by which 5-HT2 receptors regulate corticospinal excitability remain unknown. Thus, the purpose of this study was to investigate the effects of 5-HT2 receptor antagonism on the excitability of motor cortical circuits.Method: This project was a human double-blind, placebo-controlled crossover design with 10 healthy participants (23 ± 4 years, 7 female). Participants attended two testing sessions where neurophysiological measurements were obtained pre- and post-administration of either a 5-HT2 antagonist (cyproheptadine, 8 mg) or a placebo. During each session, Transcranial Magnetic Stimulation (TMS) was applied to the motor cortex to produce motor evoked potentials (MEP) in the resting first dorsal interosseus muscle of the right hand. Single- and paired-pulse TMS paradigms were used to produce unconditioned and conditioned MEPs as a measure of corticospinal excitability and intracortical excitability. Paired-pulse TMS was used at interstimulus intervals of 3 ms to measure short-interval intracortical inhibition (SICI), 100 ms to measure long-interval intracortical inhibition (LICI), and 10 ms to measure intracortical facilitation (ICF). Results: Change scores were calculated as the difference in the outcome measure from pre- pill to post-pill. There was no difference in the change in MEP amplitude between the drug condition and the placebo condition ($p = 0.250$). However, the amplitude of SICI ($p = 0.043$) and ICF ($p = 0.024$) increased following the administration of cyproheptadine compared to the administration of placebo. There were no drug differences identified for LICI ($p = 0.089$) responses. Conclusion: While 5-HT2 receptors are involved in the modulation of intracortical motor circuits, the same receptors do not affect the overall excitability of the corticospinal pathway. Drug-related changes to SICI and ICF suggest that the serotonergic system can regulate GABA and glutamate activity within cortical circuits. Overall, this study provides evidence that 5-HT2 receptors modulate motor cortical circuits even without voluntary drive to the muscle, since all measurements were made at rest.

## **P2.27-I: Modulation of corticomuscular coherence by changes in the visuomotor environment**

Mariko Ichikawa, Keio University; Junichi Ushiyama, Keio University

When using surgery robots and computers, we can deal with the changes in visuomotor environments (i.e., the correspondence relationship between actual movements and how they are reflected visually in the system) and control their movements at the time. Such flexible control of our bodily movements can be accomplished through the neural interaction between the brain and the body. Corticomuscular coherence (CMC) is known as a physiological indicator that evaluates synchrony between activities of the motor cortex and the contracting muscles

(Conway et al. 1995). Recently, our laboratory reported CMC is modulated depending on the motor context, which is a combination of some parameters about motor tasks, such as muscle contraction type (sustained or intermittent contraction), contraction intensity, trial randomization, and how to output force initially (Suzuki & Ushiyama 2020). However, no CMC studies have examined whether visual information could become a crucial motor context that affects CMC.Here, the present study investigated whether and how CMC was modulated in the change of visual feedback gain (i.e., how visual information of contracting force was provided to participants through a monitor) within a task in 31 healthy young adults. Within experiments, when visual feedback gain was changed, the relation between a cursor movement on the monitor and the contraction intensity was changed.We conducted 2 experiments with the intermittent contraction task using two types of visual feedback gain (i.e., High- and Low-gain conditions). Specifically, when a certain force output, the movement of a cursor was larger in the High-gain trials, and smaller in the Low-gain trials. Therefore, participants received more detailed feedback of their movement in the High-gain trials than Low-gain trials. We recorded the ankle dorsiflexion force, electroencephalogram (EEG) over the motor cortex of the lower limb, and electromyogram (EMG) from the tibialis anterior muscle during visuomotor tasks (Fig. 1a). In Experiment 1 (Fig. 1b), we provided two visual feedback gains randomly within a set, where the visually needed intensity was the same, but the required intensity was different (10% and 25% of maximal force). In Experiment 2 (Fig. 1c), we also provided two visual feedback gains randomly within a set, where the visually needed intensity was different, but the required intensity was the same (10% of maximal force).The results showed that the magnitude of CMC was significantly greater in the High-gain trials than in Low-gain trials in only Experiment 1. On the other hand, Experiment 2 didn’t show a significant difference in CMC between visual feedback gains.These results suggested even in the visuomotor environment where visual feedback gain changed within the task, our nervous system deals with it online by modulating neural interaction between the motor cortex and muscle depending on a difference in the motor output exhibited, rather than how it is visual feedback.

## P2.28-I: Modulation of triceps surae cutaneous reflexes to non-noxious stimuli during walking and running in humans

Alan Phipps, Medical University of South Carolina; Aiko Thompson, Medical University of South Carolina

Background: Cutaneous reflexes (CRs) to non-noxious stimuli are task-dependently modulated between standing and running (Brain Res. 1993:613:230-238), and the modulation pattern is nerve-specific during walking (J. Neurophysiol 1997:6:3311-3325). Because different modes of locomotion are typically associated with different speed (i.e., speed of locomotion is faster during running than during walking), whether CRs are speed or mode (task) dependently modulated during locomotion is currently not known. Are cutaneous reflexes modulated between different modes of locomotion and/or between different speeds of locomotion? To address this question, this study examined the triceps surae CRs during two modes (i.e., walking and running) of locomotion at two different speeds each, with the speed of faster walking matching the speed of slower running speed.Methods: 18 individuals with no known neurological conditions participated in this study. CRs were elicited by stimulating the sural (SRn), superficial peroneal (SPn), and distal tibial nerve (DTn) near the left ankle. For each stimulation, a 5 x 1-ms pulse train (200 Hz) at ~1.9 x radiating threshold was delivered while the participant walked at 3 or 4 km/h (WalkSlow) and 6 or 7 km/h (WalkFast) and ran at 6 or 7 km/h (RunSlow) and 9 or 10 km/h (RunFast). EMG was recorded from the soleus, medial (MG), and lateral gastrocnemius (LG) ipsilateral to the stimulation site. For three distinctive phases (early stance, mid-late stance, end swing) of each locomotion condition, short (50-80ms post-stimulus onset, SLR) and medium (80-120ms, MLR) latency CRs were quantified as the difference between stimulated and non-stimulated EMG in early stance, mid-to-late stance, and end swing phase, and expressed in % maximum M-wave (%Mmax).Results and Discussion: Soleus, MG, and LG SLRs showed mode- (i.e., WalkFast vs. RunSlow) and speed- (i.e., different speeds within the mode of walking or running) dependent modulation during early and mid-to-late stance phases but only speed-dependent modulation during end swing. For instance, in the soleus, early stance SLR was inhibitory and greater during RunSlow than WalkFast with all three nerve stimulation conditions: SPn (-3.4%Mmax vs. -1.7%, p=0.002), SRn (-3.8% vs. -1.3%, p=0.002), and DTn (-3.7% vs. -0.8%, p=0.004) while inhibitory SLRs were greater during WalkFast than WalkSlow (-1.3% vs. -0.6%, p=0.036) to SRn stimulation; during end swing, SLRs to SPn stimulation was less excitatory during WalkFast than Walkslow (0.01% vs. 0.4%, p=0.046). MLRs were modulated similarly to SLRs but appeared less robust in all three phases studied. The facts that triceps CRs are mode- and speed-dependently modulated in early stance but only speed-dependently modulated in end swing may suggest phase-dependent roles of cutaneous afferent input in human locomotion. Spinal processing of cutaneous afferent activity appears to be complex and dynamically modulation across the locomotion cycle in humans.

## P2.29-I: Co-modulation of the stress response and motor activation during adaptation to split-belt walking

Beier Lin, University of British Columbia; Kaya Yoshida, Rehabilitation Research Program; Jayne Garland, Western University; Tanya Ivanova, Western University; Janice J. Eng, University of British Columbia; Lara Boyd, University of British Columbia; Amy Schneeberg, University of British Columbia; Courtney Pollock, University of British Columbia

Introduction: When individuals encounter unexpected perturbations to gait, the central nervous system actively recognizes error and rapidly recalibrates sensorimotor control to accommodate the altered walking conditions. Neurophysiological changes associated with the autonomic nervous system (ANS) and its stress response to perturbations may contribute to adaptation of motor control strategies when standing balance is challenged. However, the interaction between motor adaptation and the stress response associated with challenge to gait remains unknown. The purpose of this study was to investigate the co-modulation of the physiological stress response as measured by electrodermal activation (EDA) and the motor activation of muscles about the ankle during a repeated block split-belt treadmill walking protocol. Methods: Twelve healthy young adults (28.5 ± 5.5 years, 8 males) participated in a single session of split-belt treadmill walking. The belt speeds were individualized. The fast belt speed was set at 90% of a person's fast walking speed measured during a 10m over ground walking test and, the slow belt speed was set at 50% of the fast speed to achieve a 2:1 ratio between belts. Participants were familiarized with the fast and slow speed of tied-belt treadmill walking, then were exposed to 3 blocks of split-belt walking (3.5 mins, 2:1 belt-speed) alternated with 3 blocks of tied-belt walking (3.5 mins, slow speed). EDA measured the ANS stress response and electromyography (EMG) recorded bilateral tibialis anterior (TA) and gastrocnemius medialis (MG) muscle activation. Step length symmetry (SLS) was measured with embedded force plates. Linear mixed models were conducted to test changes in EMG amplitude, EDA and SLS across blocks, and within blocks during the initial 10s (early) and final 10s (late) phases. Results: Both EDA and bilateral ankle muscle activation showed similar patterns of adaptation during the first exposure (block 1) to split-belt treadmill walking only. There was a decrease in muscle activation in the late phase compared to the early phase of block 1 in bilateral TA and MG muscles (p<0.05). EDA was also decreased in the late phase compared to the early phase of block 1 (p<0.05). SLS was increased in the late phase compared to the early phase of block 1 (p<0.05). There were no significant differences found between the late and early phases of blocks 2 and 3 in any variables. Conclusions: Our results are consistent with an established pattern of adaptation to split-belt treadmill walking whereby participants demonstrate the greatest amount of improvement in SLS early in a practice session. Importantly, these results extend our understanding of the co-modulation of the stress response and motor activation of muscles during adaptation of motor performance of walking when gait is challenged.

## P2.30-I: Differential Changes in Short-latency SEP Peaks and Motor Performance Following a Visuomotor Tracing Task in Healthy Adults

Alexandre Kalogerakis, Ontario Tech Univeristy; Hailey Tabbert, Ontario Tech Univeristy; Ushani Ambalavanar, Ontario Tech Univeristy; Bernadette Murphy, Ontario Tech Univeristy; Paul Yielder, Ontario Tech Univeristy

Neck muscle vibration has been shown to alter neural processing and upper limb proprioception in healthy adults. Previous research has demonstrated significant differential changes in the N18 and N24 SEP peaks coupled with altered motor learning following acquisition of force matching task, reliant on proprioceptive inputs while under the influence of vibration. The current research aims at discovering if neck muscle vibration impacts motor learning of a visuomotor tracking task in addition to force matching.14 right-handed, healthy participants (aged: 21.4 ± 2.3) were divided into vibration (V, n=8) and no vibration control (NV, n=6) groups. All had the vibration device affixed over the right sternocleidomastoid and left cervical extensor muscles. Participants underwent right median nerve stimulation at 2.47Hz and 4.98Hz to elicit short and middle latency somatosensory evoked potentials (SEPs). 1000 sweeps were recorded and averaged using a 64 lead EEG cap pre- and post-acquisition of a novel visuomotor tracing task (MTT). After the pre-acquisition trials, the NV group was given 10 minutes rest, and the V group received 10 minutes of vibration at 60Hz before performing the motor acquisition task. Task performance was assessed immediately post-acquisition and at retention 24 hours after. Motor Tracing Results: Trends from the motor tracing data indicate that accuracy in the NV group improved by 30% from pre to post and by 6% from post to retention. Accuracy in the V group improved by 28% from pre to post and by 3% from post to retention. SEPs Results: The N18 SEP peak amplitude increased by 13% in the V group and decreased by 33% in the NV group. Similarly, the N20 amplitude increased by 13% in the V group and decreased by 33% in NV group. The N24 SEP peak increased by 20% in the V group while decreasing by 8% in the NV group. Discussion: The preliminary data suggests that neck muscle vibration resulted in differential SEP changes induced by motor learning as compared to no vibration for the N18, N20 and N24 SEP peaks. Both groups appeared to learn the task, with the V group showing a trend towards less retention than NV. When compared to previously published work which used a proprioceptive-based force matching task (FMT), the V group had opposite effects on the N18 which increased in this study but decreased in the previous FMT study. The N24 had similar findings with increases after both tasks. Interestingly, the N20 which reflects processing in primary somatosensory cortex, showed differential changes in this study, while showing no significant differences in the previous FMT study. Conclusion: Preliminary trends in the neurophysiological and motor performance data indicate that vibration may have differential effects on processing of olivo-cerebellar and primary somatosensory cortex SEPs for a visuomotor tracking task as compared to a proprioceptive-based force matching task. Additional data is being collected to confirm these findings.

## P2.31-J: **Possibility of early Parkinson's disease detection by support vector machine classifier**

Yuichi Nishikawa, Kanazawa University

Parkinson's disease (PD) is one of the most common neurodegenerative diseases. Early treatment relies on early diagnosis of PD. This study was to investigate characteristics of motor unit firing behavior of first dorsal interosseous (FDI) muscle between people with PD and healthy control subjects using high-density surface electromyography (HD-sEMG), and to distinguish PD patients from healthy control subjects according to the HD-sEMG information using a support vector machine (SVM) classifier. Twelve people with PD and 14 healthy control subjects were enrolled in this study. Healthy control subjects were targeted on the dominant hand and people with PD were targeted on the less-affected side. The participants performed ramp-up and sustained contractions at 30% of their maximal voluntary contraction. HD-sEMG signals were recorded in the FDI muscle and decomposed into individual motor unit firing behavior using a convolution blind source separation method. Discharge rate, coefficient of variation (CV) of the inter-spike interval, and persistent inward currents (PIC) were used in the analysis. The $\Delta F$ obtained from the paired-motor unit analysis was used to estimate PIC. CV of ISI and $\Delta F$ were found to be significantly different between the people with PD and healthy control subjects. This information was subsequently used to distinguish people with PD from healthy control subjects using the SVM classifier to obtain a mean accuracy of 93.79%. Although it targeted the less-affected side, which has fewer or no symptoms, this study was able to distinguish PD with a high degree of accuracy. Identification of people with PD by SVM classifier is useful for early detection of people with PD.

## P2.32-J: **Motor unit properties in human movement disorders**

Vishal Rawji, Imperial College London; Dario Farina, Imperial College London

Movement disorders encompass a wide range of neurological conditions that affect the normal execution of voluntary movements as well as producing additional involuntary movements. These disorders, which include parkinsonian disorders, dystonia, ataxias, myoclonus, and tremors, have a profound impact on the quality of life for millions of individuals worldwide. Despite extensive research efforts, the underlying pathophysiology of these disorders remains elusive, making it challenging to develop targeted and effective treatments. We believe that understanding the behaviour of motor units, the basic functional units of motor control, is crucial for elucidating the mechanisms underlying movement disorders. Motor units, composed of motor neurons from the spinal cord and the corresponding muscle fibres, play a crucial role in muscle contraction and movement execution. As the final common output for generating movement, studying motor units provides valuable insights into the motor system's functioning. High-density electromyography (HD-EMG) systems, allow simultaneous recording of electrical signals from multiple motor units non-invasively. HD-EMG, coupled with advanced signal processing techniques, enables the extraction and analysis of individual motor unit action potentials. Through HD-EMG decomposition, spinal cord motor neuron activity can be inferred, offering a non-invasive method to study human motor unit behaviour. This approach provides insights into firing patterns, recruitment properties, and synchronisation of motor units, contributing to our understanding of human motor control. Combining HD-EMG with neurophysiological techniques like electroencephalography (EEG), transcranial magnetic stimulation (TMS) and peripheral nerve stimulation reveals the causal drivers of motor unit activity. We present work that showcases how motor unit estimation can be used to inform about the pathophysiology of several human movement disorders. Simply, we show that patterns of motor unit activity will be different in muscles affected by movement disorders versus those muscles that are not (i.e., motor units in a dystonic muscle behave differently to motor units in a non-dystonic muscle). We also show that the patterns of activity are specific to the movement disorder in question (i.e., the motor unit patterns during dystonia are different to those during tremor, ataxia, myoclonus, and bradykinesia). By combining HD-EMG with TMS, EEG and peripheral nerve stimulation, we reveal the causal drivers behind changes that we find in these movement disorders.

## P2.34-K: Towards the Identification of Neural and Biomechanical Constraints on Motor Unit Control

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The repertoire of human movement is made possible by control of the elementary actuators of our neuromuscular system – the ‘motor units’. A motor unit comprises an alpha motor neuron and the muscle fibres it innervates. Motor unit behaviour is thought to be subject to neural constraint by 1) common synaptic inputs that prevent their selective recruitment, and 2) Henneman’s size principle. Whilst these descriptions have helped conceptualise the coordination of motor units for control, ultimately, our understanding has been hindered by difficulties disambiguating neural and biomechanical constraints. Depending on the task demands, functional correlations are imposed on motor unit activity. This may in part justify differences between canonical motor unit descriptions, and recent works hinting at more flexible motor unit control. For instance, Bräcklein et.al (eLife 2020)demonstrated some volitional decorrelation of two motor units during de-recruitment, whilst Marshall et.al (Nature Neurosci 2022) showed selective modulation of motor unit activity during targeted electrical stimulation of motor cortex. Accordingly, the field is yet to clearly identify the fundamental principles of motor unit control. An abridging perspective that would remain consistent with all observations is the notion of ‘motor unit modules’. Here, motor units are grouped by their synaptic inputs, leading to an anatomically unrestricted definition in which modules span parts of a muscle, or even multiple muscles.  To disentangle the contributions of neural and biomechanical constraints on motor unit control and explore the existence of motor unit modules, our first study will focus on muscles partitioned by compartments. Compartments are relevant candidates for possessing motor unit modules, given earlier reports on less common synaptic inputs to motor units across muscle compartments, compared to within. With such partitioning in synaptic input, the functions of different compartments may be effectively decoupled, as observed previously for compartments controlling different effectors or actions. However, not all compartmentalised muscles appear to be structured under the same incentive. One example may be the human Flexor Carpi Ulnaris (FCU), a forearm flexor with two distinct compartments. Unlike muscles of prior studies, each compartment is not associated with a unique function; rather ,they work cooperatively in achieving wrist flexion and adduction. With intramuscular and high-density surface EMG recordings, we will study the activity of motor unit populations in each FCU compartment, comparing motor unit co-modulation metrics within and across compartments. Concurrently, we will detect the motor unit activity of neighbouring synergistic and antagonist muscles that harbour either a similar neural (innervation), or mechanical (muscle origin) constraint. Combined with the study of several contraction types and forearm configurations, we will begin to decouple the influences of task-related (biomechanical) and neural constraints on motor unit control. In turn, this will help us to establish whether motor unit modules exist at the most coarse, compartmental level within muscle, and their stability across behaviours. Overall, our experiment will aid in defining what constitutes the smallest functional unit of the motor system, shedding light into a fundamental question in systems neuroscience whilst also informing the design of muscle-machine interfaces.

## P2.36-K: Considerations for determining 'gold standard' methods for analyzing motor unit firing behavior

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Presently, there are no ‘gold standard’ methods to analyze estimated motor unit firing behavior (MUFB) due to theoretical and practical limitations of varying decomposition-based technologies. This barrier increases the difficulty to objectively assess the accuracy of MUFB. Current methods to assay MUFB vary from collapsing data for an individual or a group of individuals at a particular contraction intensity, collapsing data across multiple intensities, or analyzing data on a subject-by-subject or group-by-group basis before collapsing the data. Additionally, there are a variety of methods to report MUFB data, ranging from listing the traditional absolute values to listing values in a relative way, such as normalizing data by ‘recruitment, frequency, or time bins’, or by averaging data across certain phases of a contraction. Moreover, the time at which data is extracted for analysis also influences the information that is gleaned. For instance, data has been reported via extraction rates of a few milliseconds to rates that exceed a few minutes. Finally, it’s important to highlight that visual real-time feedback provided to the subject, whether it be force or an EMG-derived index such as root mean square, dictates the underlying motor control scheme for the MUs used during that contraction. For example, a 60% maximum voluntary contraction (MVC) force matching task doesn’t imply each synergistic muscle uses 60% of its MUs, but rather the combined effort of all MUs recruited across the synergistic muscles equates to a 60% force output. Thus, individual percent contributions for MUs from synergistic muscles remain unknown. While each approach has advantages and limitations, the clinical significance of that data lies in the data’s interpretation. To illustrate this point, when estimating motoneuron intrinsic excitability (delta F) the identification of when a MU is recruited and decruited is paramount to determining whether a pool of MNs is considered hyper or hypo-excitable. Taken together, these points underscore the need to develop universal analysis standards for accurate clinically meaningful interpretations of MUFB.

## P2.37-K: Assessment of motor unit activity in patients with post-COVID-19 syndrome

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A significant number of individuals infected by SARS-CoV-2 report persistent symptoms lasting weeks or months after the acute phase of COVID-19. This condition, not yet fully understood, characterizes the post-COVID-19 syndrome (PCS), whose prevalent symptom is fatigue. Fatigue encompasses a wide range of physiological manifestations, including cognitive, neuromuscular, and psychological, precluding a precise definition and assessment. In the present study, we design an experimental protocol to assess the fatigability in individuals affected by PCS by measuring muscle force and motor unit activities. Participants were divided into two groups: COVID and Control. The COVID group consisted of 18 volunteers (16 women, 40.6 ± 7.5 yr.), while the Control group comprised 17 participants (14 women, 41.6 ± 9.5 yr.). Participants performed isometric abduction of the index finger of the dominant hand in four different motor tasks. The experimental protocol consisted of three blocks: pre-fatigue, post-fatigue, and post-rest, with a 30-minute interval between the last two blocks. Maximum voluntary contraction (MVC), reaction time, trapezoidal force, and time to task failure motor tasks were performed. Throughout the tasks, surface electromyography signals were collected and subsequently decomposed using the software NeuroMap (Delsys) to analyze motor unit activities. The main results of this study highlighted notable differences between COVID and Control groups in both motor unit activity and force metrics. MVC was significantly lower in COVID when compared to Control participants (13.79 ± 1.81 N vs. 20.03 ± 2.42 N, p = 0.02). In the reaction time task, significant differences were observed in the maximum discharge rate (COVID: 15.41 ± 1.33 Hz vs. Control: 18.42 ± 1.43 Hz, p = 0.037) and in the rate of force development (COVID: 182.92 ± 18.84 %MVC/s vs. Control: 236.74 ± 29.92 %MVC/s, p = 0.007). In the trapezoidal force task, there were significant differences in the force variability, quantified by the coefficient of variation (COVID: 4.25 ± 0.49 % vs. Control: 2.86 ± 0.32 %, p = 0.001), as well as in the coefficient of variation of smoothed cumulative spike train (sCST) (COVID: 17.58 ± 1.82 % vs. Control: 13.48 ± 1.10 %, p = 0.005) and the relative power spectral density of sCST in the 5-10 Hz frequency band (COVID: 8.76 ± 1.42 % vs. Control: 5.96 ± 0.86 %, p = 0.012). Furthermore, significant differences were observed in motor unit action potential (MUAP) amplitude (COVID: 177.18 ± 10.96 mV vs. Control 212.37 ± 11.57 mV, p < 0.001) and duration (COVID: 20.28 ± 0.49 ms vs. Control: 18.96 ± 0.42 ms, p < 0.001), assessed in the plateau phase of trapezoidal force task. These findings show that infection by SARS-CoV-2 modifies both discharge (central) and MUAP (peripheral) properties of motor units with a detrimental influence on performance of the neuromuscular system of patients with PCS. The specific causes of these changes should be further investigated.

### **P2.38-K: Acute changes in motor unit recruitment threshold following resistance exercise with various exercise intensities [Poster Award]**

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Purpose: The number and/or types of motor units recruited during exercise is primarily determined by exercise intensity. Also, repeated contraction-induced neuromuscular fatigue can change motor unit recruitment pattern due to a decrease in the recruitment threshold. In the actual scenes of resistance exercise session, the number of repetitions is determined by exercise intensity, so motor unit recruitment pattern could be determined by exercise intensity and number of repetitions. The purpose of this study was to clarify acute changes in motor unit recruitment threshold (MURT) following single session resistance exercise with various combinations of exercise intensity and number of repetitions. Methods: Eleven healthy men were recruited for the study. Isometric knee extension exercises were performed at 40%, 60%, and 80% of maximal voluntary contraction (MVC). In order to match the total work among different exercise intensities, three sets of 14, 9, and 7 repetitions were conducted for 40%, 60%, and 80% of exercise intensity. The participants completed three exercise sessions with different exercise intensities on separate days and the order of the given exercise intensities were randomized. Before and after the exercise sessions, MVC of isometric knee extension and high-density surface electromyography (EMG) of the vastus lateralis was recorded during submaximal ramp-up isometric knee extension. MURTs of motor units that could be tracked before and after the exercise session was then calculated. Results: MVCs were decreased 16.8±6.1%, 16.5±5.0%, and 19.0±6.1% for 40%, 60%, and 80% of exercise intensities (p < 0.05). Degrees of decrease in MVC were not significantly different among three exercise intensities (p > 0.05). Numbers of detected and tracked motor units for 40%, 60%, and 80% of exercise intensities were 91, 79, and 85. MURTs were significantly decreased following single resistance exercise sessions with 40% and 60% of exercise intensities, i.e. -1.3±4.3%MVC and -2.4±3.9%MVC (p < 0.05), but not with 80% of exercise intensity (-0.3±4.8%MVC, p > 0.05). Conclusion: The present study suggests that additional recruitment of motor units can be induced during a single session of resistance exercise with middle exercise intensities (≤ 60%), but not with higher exercise intensities (≥ 80%) when total work are matched.
Acknowledgement: The authors appreciate Prof. Aleš Holobar of the University of Maribor, Slovenia, for supporting the analyses of motor unit firing properties using the DEMUSE tool.

### **P2.39-K: Short-term strength training does not affect motor unit recruitment threshold and discharge frequency during isometric dorsiflexion at a submaximal level in the tibialis anterior muscle [Poster Award]**

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A classical study conducted by Moritani and deVries (1979) revealed that, following several weeks of strength training, the amplitude of surface EMG remained unaltered during submaximal contractions at a given level while maximal voluntary contraction (MVC) force and the corresponding amplitude of surface EMG increased without muscle hypertrophy. The intricate nature of surface EMG signals, composed of a summation of motor unit (MU) action potentials presents a significant challenge in identifying adaptations in MU recruitment and discharge patterns induced by strength training during submaximal contractions. Using recent advances in high-density EMG (HDEMG), Del Vecchio and colleagues (2019) showed that a 4-week of strength training decreased MU recruitment threshold and increased MU discharge frequency during isometric contractions at a given submaximal level. Assuming identical twitch force characteristics such as contraction time, relaxation time and peak force, an increase in discharge frequency and the number of recruited MU may lead to a greater exerted force. Based on this notion, the finding by Del Vecchio et al. (2019) implies that a 4-week of strength training may reduce electro-mechanical efficiency concerning force exertion at a submaximal identical level. This study aims to re-investigate whether a 4-week strength training intervention induces changes in MU recruitment threshold and discharge frequency concerning isometric force exertion at a submaximal level.[Methods]Thirteen healthy young males participated in a 4-week training session, with the same content as that conducted by Del Vecchio et al. (2019). Before and after the training intervention, participants were seated in a chair with their right ankle angle at 10° of plantarflexion. Participants performed trapezoidal isometric dorsiflexion contractions while following visual guidance that involved a linear-increase in force to a 35% MVC (obtained before training) at a rate of 5% MVC per sec and 10 s of constant force at 35% MVC. A 64-channel HDEMG from the tibialis anterior muscle was recorded to identify MU discharge timing using the CKC method (Holobar & Zazula 2007). MUs were tracked across the training intervention based on the cross-correlation analysis of the MU action potential, which was extracted by spike-triggered averaging from HDEMG. MU activity was evaluated in terms of MU recruitment threshold during the ascending phase and mean discharge frequency during the steady phase.[Results]Following four weeks of strength training, a 14.2% increase in maximal strength was observed (P < 0.05), which was a very similar increase (13.8%) to the results of Del Vecchio et al. (2019). In 74 trackable MUs before and after training, there was no change (P > 0.05) in the MU recruitment threshold between before (20.7 %MVC) and after (22.5 %MVC) strength training. Similarly, there was no change (P > 0.05) in mean MU discharge frequency between before (17.0 Hz) and after (16.7 Hz) strength training.[Conclusion]These results suggest that four weeks of strength training do not alter the recruitment threshold and discharge frequency of MUs during isometric submaximal dorsiflexion. It is implied that the number of recruited MUs and their discharge frequency during submaximal isometric contractions at a given level may remain unchanged after training intervention. The inconsistency with the findings by Del Vecchio et al. (2019) remains unclear.

## P2.40-K: **Motor Unit Activity and Active Area Changes in the Gastrocnemius Muscle During Single Joint Movement**

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Movement is achieved through an intricate motor control system regulated by the central nervous. Despite the potential of motor unit: MU analysis in understanding movement control, MU measurements during dynamic tasks are scarce because of hampering their application. This study aimed to elucidate the relationship between MU activity and biomechanics in dynamic tasks, using gastrocnemius muscle MU activity and joint torque data during single-joint movements while tracking MU spatial position coordinates.  Five healthy adult male subjects were used as subjects, and the target muscle was the medial head of the gastrocnemius muscle: MGAS. The multi-mode dynamometer, BIODEX, and High-density surface EMG: HDEMG were used. The target torque was set at 10 and 25% MVC. The task was isokinetic contraction at each target torque. The joint motion was controlled using BIODEX so that the joint angular velocity was 5 and 10 degrees per second. MUs decomposed were analyzed using DEMUSE, and only MUs with a PNR of 28 dB or higher were included. In the analysis, the activity position coordinations were calculated from the increase/decrease rate of MU discharge rate: DR and MUAP of grid electrodes, and the changes in MU activity during the dynamic task were followed. The rate of increase in MUDR during concentric contraction was significantly higher than the rate of decrease in DR during eccentric contraction during the task. The rate of increase in MU activity during concentric contraction at the target torque of 10% MVC increased significantly with increasing joint angular velocity. The MU activity position during the task varied greatly at each MU spike timing, and the activity position distribution was wide, with no differences depending on the muscle contraction style. The rate of increase or decrease in MU activity has been reported to vary with contraction mode and rate of contraction. The rate of change in MUDR was smaller in centrifugal contractions than in concentric contractions. This may be due to the involvement of non-contractile tissues with high tension, such as tendon tissue, in force generation. Because of the shortening of muscle length in concentric contractions, it is difficult to utilize tension outside the muscle. Therefore, neuromuscular activity may flexibly adjust the contractile force and velocity changes. These results suggest that MU activity can be efficiently regulated by considering the tension caused by non-contractile tissues and that the amount of activity is regulated according to the velocity and force. In addition, the change in spatial position coordinates of MU activity during a task may be greatly affected by the anatomical structure of the muscle and waveform propagation during contraction. Therefore, it is difficult to extract the same MUAP waveform from EMG, and it is difficult to calculate and track the MU position coordinates for each activity.

## P2.41-L: Muscle synergy from changes in subjective effort in table tennis service.

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In competitive sports, the ability to subjectively control the exertion of force is considered crucial. The focus of this study is on the service action in table tennis, where players often vary their force to confuse their opponents – sometimes applying a strong spin with considerable force, and at other times hitting the ball with less force. This variability highlights the essential nature of being able to control force exertion subjectively. However, the impact of this subjective force exertion ability on muscle synergy in the table tennis service action is not yet clearly understood. This study aims to investigate the relationship between subjective effort levels in the forehand backspin serve in table tennis and muscle synergy, using muscle synergy analysis.For the experimental trials, the forehand backspin serve was selected. This was chosen because it is one of the most common services used in table tennis matches by a wide range of players. The subjective effort levels were divided into five stages (60%, 70%, 80%, 90%, and 100%), with each level performed consecutively five times. The order of these trials was randomized. During these trials, surface electromyography (sEMG) was recorded for ten upper limb muscles involved in the forehand backspin serve. The movement was captured using five motion capture cameras, which facilitated the extraction of analysis segments. The sEMG data were then filtered and used to calculate the Average Rectified Value (ARV). Subsequently, the data from the five trials were averaged, and non-negative matrix factorization was applied to derive muscle synergy vectors and synergy activation coefficients.The results revealed that several muscle synergies were identified in the forehand backspin serve across the five levels of force exertion. This indicates that muscle synergies in table tennis backspin serves change in response to variations in subjective effort levels. This study thus sheds light on how subjective control of force influences muscle coordination and synergy, particularly in the context of table tennis serving techniques. The findings contribute to a broader understanding of the role of subjective force control in sports performance, with potential implications for training and technique optimization in table tennis and other sports.

## P2.42-L: Center of pressure change and lower limb muscles activities during single leg stance

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INTRODUCTIONPostural stability is an important ability to maneuver many daily life movements. Especially good balance helps kids and the senior people from falling or getting injured. It is an important to measure the stability ability of a person, especially children and old adults, with proper tools. In this study, we used a plate equipped with the load cells as well as multi-electromygraphy electrodes (n= 14 places) during single leg stance (SLS). METHODSMultiple surface electromyography (sEMG) electrodes (Ultium, Noraxon, USA) were used for both legs: tibialis anterior, soleus, rectus femoris, rectus abdominus, peroneus, lumbar erector spinae, and biceps femoris. Participants were 15 children (age = 8.9 +/- 1.5 years, 10 females), 14 young adults (age = 22.2 +/- 1.9 years, 14 females), and the old adults (age = 71.6 +/- 3.7 years, 5 females) during SLS. Tests were made after taking signed consent forms from all participants before participation (IRB no. KRISS-IRB-2023-01 and DHCIRB-2022-06-0008). The measurement device (Bertec force plate) was used to measure the center of gravity (COP). Authors finished the calibration and calculation of the uncertainty of the device. We employed Brain Motor Control Analysis (BMCA) protocol for sEMG analysis composing of an amplitude and a similarity index for the analysis. We built prototype vector using young adults and then compared with the other groups. <Performance time>, <95% confidence ellipse area>, <COP path length>, and <COP average velocity> were evaluated using COP data. RESULTS AND DISCUSSIONAll three groups were showing significant difference in <Performance time> and <COP average velocity> (p<0.05). <95% confidence ellipse area> showed significant difference between Children and young adults groups (p<0.05). <COP path length> showed significant difference between children and old adults, and between young adults and old adults (p<0.05). BMCA analysis showed similarity index from 0.34 to 0.99. Average similarity index of children were 0.91, 0.93 for young adults, and 0.82 for old adults. Total magnitude of EMG from all muscles was 902, 950, and 831 (uV) for each groups during SLS. EMG patterns showed similar patterns in children and young adults. Abnormal EMG patterns were observed from one young adult and one old adults. BMCA protocol showed the strong point that it may pick one abnormal behavior out of ten muscle activities involved during the SLS. <COP path length> and <COP average velocity> could be a good index for evaluate aging effect on stability (Fig. 1). Fig. 1. COP path length, average velocity, and BMCA analysis results CONCLUSIONS Inthisstudy, we evaluated the center of pressure and muscle activities during single leg stance. It may be a reliable quantitative index to evaluate the stability ability of children and old adults.

ACKNOWLEDGEMENTSThis study was financially supported by the Ministry of Trade, Industry, and Energy (MOTIE), Korea, under the Korean Reference Data Center ProgramsupervisedbytheKoreaResearchInstituteofStandardsandScience(KRISS).
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## P2.44-M: Modelling surface EMG signals during voluntary movements with neuromechanical and deep network models

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BACKGROUND AND AIM Neuromechanical studies investigate how the nervous system interacts with the musculoskeletal (MSK) system to generate volitional movements. Such studies require an integrated understanding of the dynamic systems, which are complicated to understand from experimental measurements alone. Simulations play a complementary role by providing insights into the variables that cannot be directly measured and a test platform for iterating if-then scenarios before experimental implementations. However, current simulation methods of surface electromyogram (EMG), a core physiological signal in neuromechanical studies, are mainly limited to static conditions. Here, we address this limitation by proposing NeuroMotion, an integrated open-source simulator that can be used to simulate surface EMG signals during hand, wrist, and forearm dynamic movements. METHODS NeuroMotion is comprised of three modules. The first is a neuro-biomechanical module that uses an upper-limb MSK model and OpenSim API to estimate the muscle activations and fibre lengths during movement. We used the ARMs Wrist and Hand Model, which includes 23 degrees-of freedoms (DoFs) that cover the finger movement and the flexion/extension and the radial/ulnar deviation of the wrist. The estimated muscle fibre lengths are then utilised by the second module, BioMime, which is a deep generative model that takes in the physiological parameters and outputs the dynamic motor unit action potentials (MUAPs) during the movement. The third module is a motoneuron pool model that simulates motor unit spike trains given the muscle activations. Lastly, surface EMG signals during the movement are generated by convolving the dynamic MUAPs and the motor unit spike trains with some additive noise. The three modules are implemented in Python and integrated into a single package available here https://github.com/shihan-ma/NeuroMotion. RESULTS We first show how simulated MUAPs change during different levels of physiological parameter changes and different movements. Then, we show that the synthetic data during two-DoF hand and wrist movement can be used to augment the experimental dataset for improving joint angle regression. Ridge regressors trained on the synthetic data can be directly applied to predict the joint angles from two subjects’ experimental data with Pearson correlation coefficient > 0.5. The regression accuracy can be further improved for two subjects when the experimental data are combined with the synthetic data. CONCLUSIONS With NeuroMotion, users can generate plausible surface EMG signals given the kinematics during a voluntary human hand, wrist, and forearm movement. The synthetic dataset is useful to fast iterate regression algorithms and validate information extraction algorithms.

## P2.45-M: Quantum sensor-based magnetomyography for contactless measurement of muscle fiber conduction velocity [Poster Award]

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Abstract:Muscle fiber conduction velocity (MFCV) is the speed at which electrical activity propagates along muscle fibers and can be measured using high-density electromyography (HD-EMG). With the development of miniaturised quantum sensors (so-called optical pumped magnetometers, OPM), contactless MFCV can now also be measured using the magnetic counterpart of EMG, magnetomyography (MMG). However, this claim remains to be proven experimentally in-vivo.Therefore, the right abductor digiti minimi muscle of 12 healthy volunteers was measured using simultaneous non-magnetic high-density(HD)-EMG (64 channels) and -MMG (15 OPM sensors) after electrical stimulation of the ulnar nerve at the cubital tunnel. Post-hoc synchronisation of the two data sets was used to compare the peak-to-peak latencies of evoked muscle activity per electrode pair with the spatially matched OPM.The electrically evoked muscle activity was measurable In all 12 healthy subjects, both in HD-EMG and MMG. After preprocessing (30-120Hz, 50Hz notch filter), and the application of a peak detection algorithm, it became evident that in both modalities the delay of the respective evoked peak-to-peak muscular activity was already visually apparent. Both modalities showed comparable results of 3-4 m/s of MFCV. Of note, measuring simultaneous HD-EMG and -MMG was not straight-forward, since MMG requires magnetic shielding and is clearly susceptible to artefacts whose origin can be traced back to movements, electromagnetic signals or vulnerabilities of the measuring system. Therefore, all used materials must be tested aforehead for magnetism, i.e. if the materials inherit ferromagnetic metals like iron, nickel or cobalt.Despite the practical difficulties and considering the explorative, partly pioneering nature of measuring MMG using OPM, we firstly were able to prove that MCFV is measurable contactless. This study paves the way towards the further employment and development of quantum sensors for clinical neurophysiology.

## P2.46-M: Muscle activation between individuals with anterior cruciate ligament reconstruction and matched healthy controls during 30-min running

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Background: Since neuromuscular alterations during dynamic tasks (e.g., running) vary, monitoring electromyographic (EMG) activity during a bout of exercise would yield insights into neuromuscular activation profiles in response to sports activities.Objectives: To compare muscle activation in the lower extremity between individuals with anterior cruciate ligament

reconstruction (ACLR) and matched healthy controls during 30-min self-paced running.Methods: Twenty physically active individuals with ACLR (25.2 years; 171.4 cm; 73.1 kg; 24.7 kg/m2; month after surgery: 50.0 months; exercise duration: 320.6-min per week) and twenty matched healthy controls (24.7 years; 169.6 cm; 67.0 kg; 23.2 kg/m2; exercise duration: 310.5-min per week) were volunteered. A total of three surface EMG (sampled at 2,000 Hz) electrodes were attached to the rectus femoris (RF), semitendinosus (ST), and medial gastrocnemius (MG) on their involved limb (defined as the limb that had undergone ACLR or dominant limb in healthy control). Participants were asked to run at a self-paced speed for 30-min on a force plate instrumented treadmill (sampled at 1,000 Hz). The average speed was recorded as 8.3 km/h. The EMG signals were recorded for a minute at the 5th and 25th minute during running. Recorded signals during the five successful stance phases (0% being heel strike and 100% being toe off, distinguished by the heel marker) were filtered and smoothed through a 4th order Butterworth filter (cutoff frequency: 10 to 500 Hz and 20 Hz). Afterward, smoothed data were normalised by the peak amplitude value recorded during the knee extension phase of countermovement jumps. The amplitude-normalised EMG data were analysed using 2 (group: ACLR vs. control) × 2 (time: 5th-min vs. 25th-min) functional data analysis ($\alpha$=0.05). Cohen's d effect sizes (d) were calculated where the statistical differences exist.Results: Regardless of time, activation of the RF (1% to 12%; 39% to 50% of the stance phase), ST (83% to 100% of the stance phase), and MG (84% to 90% of the stance phase) were greater (RF: < 61%, d=0.45; ST: < 68%, d=0.65; MG: < 16%, d=0.36) while activation of the ST (2% to 7% of the stance phase) and MG (1% to 70% of the stance phase; Figure 1) were less (ST: < 5%, d=0.39; MG: < 64 %, d=0.64) in individuals with ACLR than those with the control. Regardless of group, activation of the RF (13% to 24% and 38% to 91% of the stance phase) was greater (< 114%, d=0.41) at the 25th-min time point than the 5th-min.Conclusion: Individuals with ACLR showed different neuromuscular patterns during 30-min running compared to healthy controls. Except for the RF, these altered neuromuscular activation patterns were consistent during running in individuals with ACLR. For the RF, neuromuscular activation increased at 25th-min regardless of the group.

## P2.47-M: Neuromuscular activity of the lower extremities during walking in ACL reconstructed individuals and healthy controls

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Background: Anterior cruciate ligament reconstruction (ACLR) may lead to alterations in muscular activation of the lower extremities during walking, yet the neuromuscular activity after a bout of exercise (e.g., 30-min running) is unclear.Purpose: We asked two research questions: (1) Will neuromuscular activation patterns in the lower extremity be different between individuals with ACLR and healthy individuals during walking? (2) Will lower extremity neuromuscular activation during walking be altered after 30-min running in both groups? Methods: Twenty individuals with ACLR (25.2 years; 171.4 cm; 73.1 kg; 24.7 kg/m2; 50.0 months from surgery) and twenty matched healthy controls (24.7 years; 169.6 cm; 67.0 kg; 23.2 kg/m2) who self-reported exercising at least 150-min per week were recruited. Three surface electromyography (EMG; sampled at 2,000 Hz) electrodes were attached to medial gastrocnemius (MG), rectus femoris (RF), semitendinosus (ST) on their involved limb (defined as

the limb that had ACLR or the matched limb in healthy control). Subjects walked for 1-min with a habitual walking speed (an average of 4.6 km/h) before and after 30-min of self-paced running (an average of 8.3 km/h). The EMG signals during the consecutive three stance phase (SP; from heel strike to toe off; 1%=heel strike, 100%=toe off) were cropped and filtered through a 4th order Butterworth band-pass filter (cutoff frequency: 20 to 350 Hz), full-wave rectified, and smoothed through low-pass filter (cutoff frequency: 20 Hz). Afterwards, smoothed EMG data was normalised with the peak amplitude value recorded during the knee extension phase of countermovement jumps. Amplitude-normalised EMG data was analysed using two factor (group by time) functional linear models (p<0.05). Cohen's d effect sizes (ES) were calculated to determine practical significances.Results: Regardless of time, RF activation was greater (1 to 7% of the SP, ES=0.44; 18 to 27% of the SP, ES=0.36; 62 to 66% of the SP, ES=0.33; 84 to 86% of the SP, ES=0.33) and ST activation was less (1 to 16% of the SP, ES=0.39; 21 to 27% of the SP, ES=0.34); Decreased (59 to 80% of the SP, ES=0.57; Fig. 1) and increased (91 to 100% of the SP, ES=0.53; Fig. 1) MG activation were observed in individuals with ACLR relative to healthy controls. Regardless of group, MG (26% of the SP, ES=0.32; 37 to 38% of the SP, ES=0.32; 50 to 54% of the SP, ES=0.35; 68 to 73% of the SP, ES=0.37) and ST (44 to 48% of the SP, ES=0.34; 71 to 73% of The SP, ES=0.32) activation were decreased while RF was increased (23 to 26% of the SP, ES=0.32) after 30-min running.Conclusion: We answered the research questions: (1) Individuals with ACLR have different MG, RF and ST neuromuscular activation pattern compared to healthy controls during walking. (2) 30-min running changed MG, RF and ST neuromuscular activation patterns during walking individuals with ACLR.

## P2.48-M: Differences in gait electromyographic activity in stroke and healthy subjects using Discrete Wavelet Transform

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Hemiplegic gait is a common outcome of stroke. Hence, to assess asymmetric control of poststroke gait, this work analyzed time-frequency domain (TFD) of surface electromyography (sEMG). Methodology: 9 chronic stroke patients (SP) and 10 healthy controls (HC) were compared using Discrete Wavelet Transform (DWT) to study the electrophysiology underlying tibialis anterior (TA) activity. DWT was applied to filtered sEMG signals during 10 walking trials. Percent of energy within frequency bands (25Hz bandwidth, 25 to 300Hz) was compared in stance (ST) and swing (SW) phases using Wilcoxon's test (dominant vs. nondominant in HC, paretic vs. nonparetic in SP) and Mann-Whitney U-test (paretic, nonparetic vs. HC). Results: The energy at each frequency band may reflect the number and type of recruited motor units (MUs). For dominant vs. nondominant HC, a marked distribution along gait was found: low-frequency MUs prevailed in ST (25-50Hz), while slow (50-75Hz) and fast (200-225Hz) did in SW for effective foot clearance. Yet, differences in HC were observed, probably due to subjects' variability or other effects (i.e., nondominant required more energy for the same task in ST). This physiological distribution was altered in SP. For paretic vs. HC, paretic ST had lower energy. In SW, it increased at 25-50Hz, but decreased at 75-100 and 150-300Hz. This overall reduction explains the typical TA weakness in stroke. Energy changes in bands suggest alterations in MUs recruitment: 50-75Hz MUs that sustain HC ST were replaced by slower MUs in paretic (25-50Hz). Also, faster MUs were reduced in paretic ST (75-125, 175-275Hz) and SW (75-100, 150-300Hz). For nonparetic vs. HC, energy was lower in 25-50Hz, but it increased in 75-99, 125-150 and 175-200Hz, likely because of nonparetic mechanisms that compensate the inability to activate the affected TA. During SW, nonparetic showed a rise in low frequencies (25-50, 50-75Hz) and a reduction in 175-250Hz, contrary to the HC pattern of MUs during SW. For paretic vs. nonparetic, energy in paretic was lower in all bands. In SW, energy in paretic increased in 25-50 and 225-300Hz bands and was reduced in 50-75 and 150-200Hz. Thus, paretic relies on the slowest (25-50Hz) and fastest (225-300Hz) MUs, rather than the 50-75Hz (HC and nonparetic) or 200-225Hz (HC) and 150-174Hz (nonparetic) ones. Conclusion: DWT of TA showed altered spectral attributes in stroke gait. The energy distribution in HC was modified in paretic and nonparetic, which may indicate a pathological alteration in the ratio of recruited MUs of each class during gait. In paretic SW this change is pronounced, possibly due to the occurrence of foot drop. Energy distribution characterized poststroke gait and asymmetries of dominant vs. nondominant and paretic vs. nonparetic. In the future, these findings will be compared with Continuous Wavelet Transform and new features will be extracted from TFD to provide a deeper description of neuromuscular altered mechanisms.

## P2.49-M: **Force Fluctuations (Steadiness) in patients undergoing Anterior Cruciate Ligament Reconstruction.**

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Introduction: Anterior Cruciate Ligament (ACL) rupture is one of the most common knee injuries in physically active individuals. After the injury patients undergo surgery which has a very deleterious effect on the quadriceps muscle. It has been reported that approximately 30% of the patients who undergo surgery will develop persistent muscle atrophy, and consequently won't be able to regain muscle strength. Steadiness has been described as a variable that results from the variability in motor unit discharge, providing insight into altered muscle control mechanisms.  Methods: This study was approved by the ethics committee of Clínica MEDS. 13 controls and 13 patients were assessed before surgery and 1, 2, and 3 months after ACLR. Clinical and demographic data was assessed before surgery, maximal voluntary force (MVC), and a trapezoidal force profile at 30% of the MVC was captured in each period to calculate steadiness as the Coefficient of Variation expressed as a percentage (CoV %) as previously described in the literature. The Shapiro-Wilk test was used to assess the data's normality, and then descriptive statistics and data inference using ANOVA were described.Preliminary Results: Nine males and four women with ages 34 ±9 years, weight 75 ± 11 Kg, height 1.72 ± 0.084 m and Body Mass Index 25.23 ± 2.67Kg/m2. There are significant differences in the force variable between the first month after surgery (F1=286 ± 117.4 N) and all the other periods of assessment (F0=467 ± 243 N, F2=387.87 ± 167.83 N and F3=420 ± 157.15 N). The steadiness (CoV, %) at 30% of the MVC didn't show significant differences between periods of assessment.Conclusion: As previously reported in the literature, MVC exhibits a major decrease immediately after surgery but after 2-3 months it returns to pre-surgery levels. Steadiness at 30% of the MVC didn´t show significant differences as we expected.

## P2.50-O: **Associations between impaired dynamic trunk muscle control in people with chronic low back pain and altered spatial EMG-torque correlations**

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Background: Torque fluctuations depend mainly on the amplitude of the low-frequency component of the neural command. Surface electromyographic (sEMG)/torque relationships provide insights into the association between muscle activity and the generated force, which is useful for muscles/muscle groups such as the lumbar erector spinae (ES), where sEMG signal decomposition is challenging. Applying principal component analysis (PCA) further refines these estimations. People with chronic low back pain (CLBP) show reduced isometric torque steadiness and altered HDsEMG-torque relationships compared to controls, likely due to regional adjustments in ES sEMG oscillatory activity, as assessed by topographical δ band coherence maps. However, the neuromuscular control during dynamic contractions, particularly eccentric and flexion movements, and the mechanisms of force control impairments in people with CLBP are yet to be fully understood.Purpose: To quantify the relationship between HDsEMG-torque oscillations in both time and frequency domains during concentric/eccentric trunk extension/flexion contractions in individuals with and without CLBP and evaluate and compare regional variations in HDsEMG amplitude and HDsEMG-torque cross-correlation and coherence for the ES, rectus abdominis (RA), and external oblique (EO) muscles.Methods: Twenty people with CLBP and 20 asymptomatic controls participated. HDsEMG signals were recorded unilaterally from the thoracolumbar ES using two grids, each containing 64 electrodes and from the RA and EO muscles using a single 64-electrode grid for each muscle. Torque was recorded using an isokinetic dynamometer during submaximal trunk flexion/extension contractions. The relationship between HDsEMG signals and torque was investigated using coherence (δ-band, 0–5 Hz) and cross-correlation analysis. Topographical maps of HDsEMG amplitude and HDsEMG-torque cross-correlation and coherence maps were also generated for each muscle to assess regional between-group differences in muscle activation. PCA was used to reduce HDsEMG data dimensionality. Results: People with CLBP had reduced torque steadiness during trunk flexion/extension concentric/eccentric contractions. For trunk extension, they showed greater HDsEMG-torque coherence in the upper region of the thoracolumbar ES and a higher HDsEMG cross-correlation than asymptomatic participants. For trunk flexion, they demonstrated increased HDsEMG amplitude in their abdominal muscles, with a higher cranial centre of activation and a higher contribution of these muscles, particularly of the EO, to the resultant torque.Conclusions: This study revealed notable differences in muscle activation patterns in the thoracolumbar ES and EO between people with and without CLBP during trunk flexion/extension contractions and poorer trunk muscle force control in people with CLBP, highlighting the importance of assessing torque steadiness in this patient group.Keywords: chronic low back pain, torque steadiness, coherence, cross-correlation, PCA

## P2.51-O: Concurrent validity and reliability of a novel algometer for measuring pressure pain thresholds in healthy volunteers.

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Background: Assessment of the response of the body to an applied load is a fundamental component of a clinical examination. Obtaining pain responses to such loads is particularly useful for diagnosis, management and monitoring recovery of musculoskeletal conditions. The Pressure Pain Threshold (PPT) is defined as the minimum pressure applied to body tissues required to evoke pain. Renowned for its simplicity, speed of application, and objectivity, lower PPT values are typically recorded in those with pain conditions, indicating altered pain sensitivity and possible central sensitization. Traditional commercial algometers, such as the Somedic, are validated tools but are limited by their cost and lack of visual feedback. The eAlgo algometer, with its lower cost and user-friendly interface, offers a viable alternative for PPT assessment in clinical settings. The objective of this study was to evaluate the concurrent validity and reliability of PPT measurements performed using eAlgo across multiple testing sites, compared with a commonly used commercial digital algometer (Somedic).Methods: Two novice raters received training to perform PPT measurements. Twenty-two healthy volunteers from the University of Birmingham were invited to participate in three experimental sessions (two with the same rater, and one with the second rater). Two digital algometers (eAlgo and Somedic) were used to record bilateral repeated PPT measurements, in a controlled environment, at the upper trapezius, tibialis anterior, dorsal first interosseous, and erector spinae (C5, T5, and L3 spinal levels). Participants reported their PPT in response to a gradual increase in pressure (30 kPa/s). A minimum of 30-seconds interval between PPT measurements was used to prevent sensory adaptation. Each site was initially assessed using eAlgo, followed by the Somedic device. Real-time visual feedback was used to control load in both devices. Customized software installed on a 7” tablet was used to wirelessly monitor pressure applied using the eAlgo, via a Bluetooth connection. The LCD screen of the Somedic algometer provided visual feedback. For statistical analysis, Pearson’s correlation coefficient r was determined to measure the linear relationship between PPT measured with the two algometers. The means of the two measurements per site were calculated and a Bland-Altman plot was used to visualize the mean differences and limits of agreement between eAlgo and Somedic measurements. Intraclass correlation (ICC) and respective 95% confidence intervals were calculated to evaluate the intra- and inter-rater reliability of eAlgo. Results: The analysis demonstrated strong concurrent validity between the eAlgo and Somedic algometers (r=0.883, p<0.001). The Bland-Altman plot indicated minimal bias with an average PPT difference of +82.9 kPa, underscoring the validity of eAlgo. Excellent to good intra-rater reliability (ICC: 0.81-0.96) and excellent to moderate inter-rater reliability (ICC: 0.62-0.91) were established for PPT measurements with eAlgo. Conclusion: The eAlgo algometer exhibits robust concurrent validity in comparison with the Somedic for PPT assessment within a healthy population. Moreover, eAlgo demonstrated excellent to good intra-rater reliability and excellent to moderate inter-rater reliability. Its cost-effectiveness, clear real-time feedback and user-friendliness support its potential adoption in broader research and clinical practice.

## P2.52-P: Pronounced limb size asymmetries after post-anterior cruciate ligament reconstruction rehabilitation clearance

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Current recovery from anterior cruciate ligament (ACL) reconstruction or repair can take six to nine months and results in severely decreased strength and muscle mass (atrophy) of the quadriceps muscles in the effected leg.The primary aim of this study is to determine the extent of the muscle asymmetry after an athlete incurs any knee-related injury.Fourteen athletes (female=3) aged 18.6 +/- 5.6 years that had experienced ACL reconstruction consented to participate in this study. The participants’ operative (OP) and non-operative (NOP) limbs were assessed for differences in muscle size (muscle cross-sectional area: mCSA; cm2) by ultrasound image analysis and thigh circumference (Tcirc). Additional segmental body composition was collected for OP and NOP leg lean mass (LLM). Maximal isometric extension and flexion were also recorded for each limb using a handheld dynamometer. Analyses included paired t-tests with a predetermined level of significance at p<0.05 and were completed using IBM SPSS Statistics version 28.0.1.1. The results of the OP vs NOP comparisons revealed significant differences in quadriceps mCSA (OP>NOP; mean difference = 9.32 cm2; p<0.001; d=1.368) and total thigh circumference (OP>NOP; mean difference = 1.64 cm; p=0.005; d=0.898). There were no differences indicated for hamstrings mCSA (p=0.223), LLM (p=0.326), isometric maximal extension strength (p=0.053), nor isometric maximal flexion strength (p=0.217).The primary indicators practitioners use to clear an athlete to safely return to sport are performance metrics of the OP being within (or greater than) 90% of the function of NOP. In many cases muscular size is overlooked or it is measured indirectly using circumference and not used as an indicator of potential performance. The present results demonstrate that despite the muscular size difference in the quadriceps, no differences existed between the limbs at return to sport clearance testing.

## P2.53-P: Comparison of gait asymmetry between groups with longer and shorter time since amputation in unilateral transfemoral amputees

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【Background/Aim】Time since amputation (TSAmp) is one of the non-modifiable predisposing parameters and influences social reintegration or mobility. For example, clinical outcome and mobility score were reported to improve with longer TSAmp (Puhalski et al., 2008; Seth et al., 2022). Hence, the TSAmp is one of the factors that can predict mobility in individuals with lower limb amputation. However, little is known about how the TSAmp affects gait mechanics in transfemoral amputees from a long-term perspective. Therefore, the aim of this study was to investigate the effect of TSAmp on gait asymmetry in individuals with unilateral transfemoral amputation over a wide range of walking speeds. 【Method】Thirty individuals with transfemoral amputation (7 females and 23 males, K-3 or K-4 levels, average TSAmp 11.5 ± 8.6 years) were recruited. All participants were asked to walk on an instrumented treadmill (FTMH-1244WA, Tec Gihan, Kyoto, Japan) at 8 speeds from 2.0 to 5.5 km/h in 0.5 km/h increments.

Based on previous studies (Puhalski et al., 2008; Gailey et al, 2002), the participants were allocated into two TSAmp groups (shorter and longer than 11 years). From the ground reaction forces (GRFs), the spatiotemporal parameters (stance time, swing time, double limb stance time, cadence, step time, and step length) and GRF peaks (anteroposterior, mediolateral, and vertical GRFs) were determined. The asymmetry ratio for each parameter was calculated by prosthetic value/intact value (Patterson et al., 2008). When the data were normally distributed, a two-way mixed analysis of variance (ANOVA) was performed (within-subject; speeds, between-subject; groups). If the asymmetry ratios were not normally distributed, the Friedman tests and Mann-Whitney U test were used to investigate the main effects of groups and speeds, respectively. Statistical significance was set to P < 0.05. 【Results】There were no significant main effects of group on the asymmetry of all parameters. On the other hand, significant main effects of speeds were found on the asymmetry ratio of all parameters, except for 2nd peak of anteroposterior GRF. As walking speed increased, the asymmetry ratio of contact time, step time, and step length increased. However, the asymmetry ratio decreased in other gait parameters. Further, there were no significant interaction effects of the groups and speeds on the asymmetry ratio of all parameters. 【Conclusion】The results of the present study suggest that gait asymmetry in individuals with unilateral transfemoral amputation is not solely determined by the TSAmp. And social reintegration and/or higher levels of mobility are likely influenced by other factors as well.【References】Gailey et al. The Amputee Mobility Predictor: A instrument to access determinants of the lower-limb amputee's ability to ambulate, Arch Phys Med Rehabil. 83 (2002) 613-627Puhalski et al., How are transfemoral amputees using their prosthesis in northwestern Ontario? J prosthet Orthot. 20 (2008) 53-60Seth et al. Time since lower-limb amputation an important consideration in mobility outcomes, Am J Phys Med Rehabil. 101 (2022) 32-39

## P2.54-P: **Effects of Diagonal Exercise with Resistance Training in Traumatic Brachial Plexus Injury Patients after Nerve Reconstruction**

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Background Traumatic brachial plexus injuries (BPI) would cause severe damage and affect the functional activities. Recovery of shoulder stability and elbow movements are primary goals of surgical treatments and post-surgical rehabilitation. Diagonal exercise with resistance training might increase the stability of shoulder and trunk, and it is worth to investigate the training effects in BPI patients after reconstruction. Methods Eight (1 female and 7 males, age=35.9±8.3) upper arm type BPI patients (C5-C6 / C5-C7 = 7/1) received nerve transfer were recruited in our study. Subjects were required to perform the diagonal movement in sitting position with isokinetic dynamometer (Biodex system 4, Biodex Medical System Inc., New York) as fast as possible. They needed to perform 5 repetitions per set and 3 sets at the speeds at 60°/sec and 120°/sec. Muscle activities of biceps, serratus anterior, and latissimus dorsi were collected synchronously by surface EMG system (Noraxon, USA Inc.) at sampling rate of 1200 Hz. After 1st evaluation, subjects had 12-week training program of diagonal exercise with resistance by the theraband. They needed to perform 30 reps / day and 5 days/week. The normalized peak torque of shoulder flexion/extension and muscle activities level were conducted for further analysis. The differences between pre-training and post-training were examined by paired-t test with SPSS software. Significant level was set at p<0.05. Results At the first evaluation, the normalized peak torque of shoulder flexion and extension at 60°/sec were 51.2±22.4 Nm/BW and 30.3±19.4 Nm/BW, respectively. At the speed of 120°/sec, the peak shoulder flexion torque was 54.1±17.6 Nm/BW and the peak extension torque was 38.1±24.0 Nm/BW. After training, subjects showed trends of increased torque in shoulder extension at 60°/sec (34.2±20.0 Nm/BW) and significant improvement shoulder flexion torque at 120°/sec (62.9±17.7 Nm/BW, p=0.02). In muscle activities, subjects showed trends of higher activation in serratus anterior and latissimus dorsi muscles after training. However, no significant differences of muscle activation level were found (p=0.09 for serratus anterior, p=0.8 for latissimus dorsi). Discussion & Conclusions Based on our results, resistance training in diagonal direction could improve the shoulder stability and muscle strength. Shoulder movement in diagonal plane is a functional activity in our daily life. Though the small sample size and large variation between subjects might cause non-significance after training, diagonal exercise still could be the rehabilitation protocol in BPI patients after surgery.

## P2.55-P: Comparison of electromyographic activity of the gluteal muscles and tensor fascia lata between persons with and without patellofemoral pain during a step-down activity, using indwelling fine-wire electrodes

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Introduction: Persons with patellofemoral pain (PFP) have been shown to activate the tensor fascia lata (TFL) muscle greater than, and the gluteus medius (GMED) and superior gluteus maximus (SUP-GMAX) muscles less than, uninjured persons in selected, hip-focused therapeutic exercises. In addition, it has been shown that persons with PFP activate the TFL greater than the GMED and SUP-GMAX in numerous exercises, with the clam exercise as a notable exception. However, this has not been assessed in the step-down task, which is commonly used in both examination and intervention in persons with PFP. Excessive hip internal rotation and adduction have been associated with PFP, hence, the interest in studying electromyographic (EMG) activity in hip muscles contributing to and/or opposing these motions. Thus, the purpose of our study was to compare activation of the TFL (hip abductor and internal rotator), SUP-GMAX (hip abductor and external rotator) and GMED (hip abductor) between persons with and without PFP, during the step-down task.Methods: Participants comprised 12 persons with PFP and 19 persons without PFP between the ages of 18-50. EMG signals were collected from the TFL, SUP-GMAX, and GMED using indwelling fine-wire electrodes during performance of the step-down task. EMG activity (mean root-mean-square) for each muscle during the step-down was normalized to maximum voluntary isometric contraction. Independent t-tests were used to compare EMG activity between groups for each muscle.Results: There was significantly lower activation of the GMED in persons with PFP compared to those without PFP (p=.025). There were no significant differences between groups for the TFL (p=.555) and SUP-GMAX (p=.555). Conclusions: Based on the lower EMG activity of the GMED in persons with PFP, it appears that the step-down task can differentiate between persons with and without PFP. We recommend that the step-down not be used as an intervention without prior facilitation exercises to enhance activation of the GMED.

## P2.56-P: WEIGHT BEARING ASYMMETRY DURING STANDING IN INDIVIDUALS WITH UNILATERAL TRANSFEMORAL AMPUTATION

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・IntroductionSince excessive loading on one leg could increase the risk of knee degenerative disorder [1], weight bearing is important parameter in gait rehabilitation and clinical settings [2]. Despite that the patients with hemiparesis showed asymmetric weight bearing during standing, little is known about the weight bearing individuals with unilateral transfemoral amputation. The aim of this study was to investigate the relationship between weight bearing and demographic data in individuals with unilateral transfemoral amputation. ・MethodsWe recruited active 34 individuals with unilateral transfemoral amputation (K2-K4). All patients walked independently without a walking aid at the time of testing. They were asked to stand comfortably for five seconds using their conventional transfemoral prosthesis on the two force platforms (FTMH-1244WA, Tec Gihan, Kyoto, Japan). As shown in Figure 1, we collected the vertical grand reaction force (vGRF), and then determined the weight-bearing over one second during the stable time-course vGRF. We also calculated the weight-bearing ratio (WBR), which was calculated as the prosthetic limb divided by the intact limb. Correlation analysis was performed to investigate the relationships between the WBR and demographic data, such as age, height, body mass and time since amputation, respectively. Further, we compared the WBR between sexes and prosthetic knee units (microprocessor vs. non-microprocessor knee) by allocating whole population into the two groups. WBR was also compared among different residual limb length levels (short, middle, long and knee disarticulation). Finally, we compared the WBR between exercise histories (Athletes vs. Non-Athletes). IBM SPSS statistics (Ver. 28.0.1.1(15)) was used for statistical analysis. ・ResultsOverall, the WBR of the current population was 1.36. There were no linear correlations between the WBR and all demographic data. Further, we also found no significant differences in the WBR between sexes and prosthetic knee units. Furthermore, despite there was a significant main effect of residual limb length on the WBR, no significant differences were found for the post-hoc comparisons among the groups. On the other hand, the WBR was significantly smaller in Athletes group than Non-Athletes group (p<0.05). ・DiscussionThe aim of this study was to investigate the relationship between weight bearing and demographic data. The WBR was 1.36, which was smaller than that of hemiparesis (1.46) [3], indicating that weight bearing may be symmetric in active individuals with transfemoral amputation than patients with hemiparesis. Further, we found that the WBR of Athletes group was significantly smaller than that of Non-athletes group. Therefore, the result of the present study suggests that training history and functionality could affect the weight bearing asymmetry during standing. ・References[1] Highsmith et al., Gait & Posture, 34: 86-91, 2011[2] Eng and Chu, Arch Phys Med Rehab, 83: 1138-1144, 2002[3] Bohannon and Larkin, Phys Ther, 65: 1323-1325,1985

## P2.57-P: Unstable Subject's Characteristics of Center of Pressure Changes During the Transition from Bilateral to Unilateral

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In the initial phase of gait, there is a critical transition from a bilateral to a unilateral stance, a juncture notoriously susceptible to falls. Consequently, accurate fall prediction and specialized training in this specific postural transition from a bilateral to a unilateral stance are imperative in the context of fall prevention strategies. The disparity in balance strategies between subjects who are unstable during the transition from bilateral to unilateral stance and those who are not, aids in forecasting falls at the onset of walking and in developing specific training to reduce fall risk for individuals. The objective of this study is to define the characteristics of the center of pressure (CoP) changes during the postural transition from bilateral to unilateral stance in both unstable and stable subjects as quantitative indicators, thereby enhancing fall predictability and formulating training protocols aimed at reducing fall risk. The subjects were informed about the purpose and methods of the study, and their consent was obtained. Subjects performed the task under instruction to transition from a bilateral to a unilateral left leg stance. We simultaneously collected the 2 types of data during the task; the medial-lateral center of pressure (CoP) and the position of the right lateral malleolus. Also, we determined the starting point of the change in the medial-lateral CoP position (C1) and the vertical position of the right lateral malleolus (M1) and defined C1M1 as the value obtained by subtracting C1 from M1. Our study found that unstable subjects in the transition to a unilateral stance had a shorter C1M1 compared to stable ones. This implies that subjects with instability during the bilateral to unilateral postural transition are prone to delayed weight shift. For subjects who are unstable and at a higher risk of falling during the transition to a one-legged stance, a key training component could be conscious weight shift training to the stance leg before lifting the other leg. Further research is needed to define more precise quantitative indicators and to verify the effectiveness of training.

## P2.58-P: Scapular muscle activity including rhomboid major during arm raising and lowering without loading in healthy participants —Examination using fine-wire and surface electrodes—

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Background and Aims: Coordinated activity of muscles attached to the scapula play an important role in scapular motor control. Rhomboid major (RM) and Serratus anterior (SA) share an attachment site at the medial border of the scapula and are thought to contribute to scapular motor control. Inman et al. reported that RM and middle trapezius (MT) are functionally similar. (Inman et al., 1944) However, no studies have quantitatively compared their muscle activity and clarified functional differences between RM and MT during arm raising and lowering. The purpose of this study was to clarify the scapular muscle activity including RM during arm raising and lowering without loading in healthy participants using fine-wire and surface electrodes.Method: Thirteen healthy men (age: 21⍰2 years) participated in this study. RM activity was measured using bipolar intramuscular fine-wire electrodes, upper trapezius (UT), MT, lower trapezius (LT), and SA activity was measured using surface electrodes. Participants performed raising and lowering of dominant arm without loading five times each in two directions of shoulder flexion and abduction in random order. The speed of motion in trials was controlled with a metronome set at 60 beats per minute for 3 s of raising (from the starting limb position to the maximum raising position) and 3 s of lowering (from maximum raising position to the starting limb position). The raising and lowering phases in 3 s were subdivided into 1 s early, middle, and late phases, respectively. The muscle activity was represented as percent MVIC (%MVIC). Two-way analysis of variance (ANOVA) on two factors (directions, phases) was used to compare the %MVIC of each muscle between each trial. Additionally, two-way ANOVA on two factor (muscles, phases) was used to compare the %MVIC of each phase between RM and MT. The significance level was set at 0.05.Results: All muscles measured in this study had a significant main effect in the phases, with a unimodal activity pattern with the highest activity in the late raising phase for both flexion and abduction trials. RM (flexion; 23.7±16.5%MVIC, abduction; 23.1±14.7%MVIC) and SA (flexion; 45.8±32.2%MVIC, abduction; 45.8±28.1%MVIC) activity in the late raising phase was significantly higher than all other phases. MT also had a significant main effect in the directions, with abduction (7.9±6.6%MVIC) showing a higher activity pattern throughout the entire phase than flexion (2.9±4.3%MVIC). In comparing activity of RM and MT, significant main effects were found in the muscles and phases, and RM (flexion: 13.4±11.5%MVIC, abduction: 11.9±10.2%MVIC) was greater throughout the entire phase than MT (flexion: 2.9±4.3%MVIC, abduction: 7.9±6.6%MVIC).Conclusion: In arm raising and lowering without loading, RM showed coordinated activity with SA, suggesting a contribution to scapular motor control. RM and MT showed different muscle activity patterns, suggesting that they have functional differences.

## P2.59-P: Isometric co-contraction training effects on muscle torque and muscle thickness in patients undergoing chemotherapy for colorectal cancer (The CoConTract Study) – Preliminary results

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BACKGROUND AND AIM: Chemotherapy induces fatigue and muscle strength reduction in 80% of patients living with cancer, which negatively impacts quality of life. While traditional strength training has positive outcomes on muscle strength and self-reported fatigue, adherence to supervised programs during chemotherapy is typically low (<60%). Co-contraction training, which involves the simultaneous activation of agonist and antagonist muscles without the need for external equipment, emerges as a potential alternative. We aim to analyze the effects of co-contraction training of elbow and knee flexors and extensors muscles on strength (muscle torque) and morphology (muscle thickness) in patients living with and beyond colorectal cancer undergoing chemotherapy. METHODS: The CoConTract study (Trial Registration: RBR-7hh489b) is an ongoing randomized-controlled double-arm study. To be able to participate, individuals must have completed surgery, be enrolled in chemotherapy treatment, be at I-III colorectal cancer stage, and have access to an electronic device as well as reliable internet connection. The exercise program runs for 8-weeks, with participants attending virtual supervised exercise sessions twice weekly. The virtual supervised exercise sessions are composed by 10 sets of 10 voluntary co-contractions (five sets for elbow and five sets for knee flexor and extensor muscles). Each co-contraction is composed by four second effort followed by four second rest. Between each set there is a 90-second interval. Data collection occurs pre and post-exercise program. Muscle torque is assessed by isokinetic dynamometer (Biodex, System 4 Pro) and muscle thickness is assessed by ultrasound B-mode (Saevo FP 102) for the elbow and knee flexors and extensors muscles. RESULTS: To date, one participant (59 years old, 173.0cm, 58.0kg, body mass index 19.4 kg/m$^2$) completed the supervised exercise program with 100% attendance. The elbow peak torque increased for both extension (+9%, pre: 28.6 vs. post: 31.2 N·m) and flexion (+11%, pre: 48.8 vs. post: 54.0 N·m) after intervention. Regarding knee peak torque, there was an increase for extension (+1%, pre: 134.1 vs. post: 135.4 N·m) but a decrease for flexion (–4 %, pre: 65.7 vs. post: 63.3 N·m). Regarding muscle thickness, all muscles presented increases after intervention: rectus femoris (+40.0%, pre: 7.5 vs. post: 10.5mm); vastus intermedius (+7.5% pre: 10.6 vs. post: 11.4mm); vastus lateralis (+3.9%, pre: 18.0 vs. post: 18.7mm); elbow flexors (+43.6%, pre: 14.0 vs. post: 20.1mm); elbow extensors (+102.1%, pre: 9.4 vs. post: 19.0mm). CONCLUSIONS: Co-contraction training appears to be a promising alternative for preventing muscle impairments in patients undergoing chemotherapy for colorectal cancer, as evidenced by the increased muscle mass and torque observed in the majority of analyzed muscles.

## **P2.60-P:** Analysis of Injury Incidences and Risk Factors in Korean Female Professional Soccer Players

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Background: The purpose of this study is to monitor injuries that occur during the 2020 WK (Korea Women's Football) League season in Korean female professional soccer players to identify the epidemiological characteristics of injuries and to identify risk factors for observed injuries. The assumed internal risk factors are hip joint flexibility, ankle joint flexibility, hamstring flexibility and past injury history, and external risk factors are soccer position, climate and playing surface. Methods: This survey was conducted on 138 players from six Korean women's professional soccer teams. All players are officially registered with the KFA (Korea Football Association). And the 2020 WK League injury surveillance system included injury date, location, type, mechanism, severity, recurrence, activity, ground condition, and climate. We calculated injury rates per 1000 hours of exposure and rate ratio. The logistic regression was used to analyze the risk factors of injury. It examined how flexibility in the hip joint and ankle joint affects injury of the lower extremity, how the flexibility of the hamstring affects the injury, and how previous injuries in the sprained ankle and knee affect the recurrence of injury.Results: In 2020 WKLeague injury surveillance, lower extremity injuries accounted for more than 80% of all injuries, and most of them were joint, ligament, and muscle injuries. And the overall injury incidence rate in the 2020 WK League was 5.86, and the injury rate was about 11.5 times higher in the competition (35.70) based on practice (3.10). As a risk factors for injury, the lower the internal rotation flexibility of the hip joint and the eversion flexibility of the ankle joint, the lower extremity injury increased. And the players who had suffered grade 1 and 3 previous knee sprain injury were more likely to appear again as new knee sprain injury. In addition, it was confirmed that the characteristics of injuries vary depending on the soccer position, and severe and moderate injuries occurred in artificial turf compared to natural grass.Conclusion: With regard to injury risk, the results of this study suggest that it is desirable to identify injury-prone players with respect to playing surfaces, playing positions, flexibility, previous injuries and so on. A continuous injury surveillance system can inform the development of interventions to help

reduce the severity and frequency of injuries suffered by players, and it may be appropriate to provide injury prevention programs tailored to individual characteristics.

## P2.61-Q: A novel methodology utilizing nonnormalized surface EMG with a minimal number of sensors in the development of powered ankle prosthesis control algorithm.

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Lower limb amputation is partial or complete removal of the limb due to disease, accident or trauma. Advancements in motion assistive device technologies and robotic rehabilitation instrumentation support improved powered ankle prostheses hardware development for amputees. However, control algorithms have limitations regarding number and type of sensors utilized and achieving autonomous adaptation, which is key to a natural ambulation. Surface electromyogram (sEMG) sensors are promising for this purpose. Previously, sEMG of a large number of muscles and force sensors have been used to develop control algorithms for lower limb powered prostheses. Therefore, minimizing the use of solely sEMG muscle inputs will make the powered prosthesis control algorithm economic. On the other hand, unlike ankle disarticulation, transtranstibial amputation yields less intact lower leg muscle mass in the lower leg. Taking this into account, limiting the use of specifically the lower leg muscles will make the control algorithm flexible. With those definitions in place, in order to determine appropriate sensor combinations, a systematic assessment of the predictive success of variations of multiple sEMG inputs in estimating ankle position and moment has to be conducted. More importantly, tackling the use of nonnormalized sEMG data in such algorithm development to overcome processing complexities in real-time is essential, but lacking. We used healthy population level walking data to (1) develop sagittal ankle position and moment predicting algorithms using nonnormalized sEMG, and (2) rank all muscle combinations based on success to determine economic and practical algorithms. Eight lower extremity muscles were studied as sEMG inputs to a long-short-term memory (LSTM) neural network architecture: tibialis anterior (TA), soleus (SO), medial gastrocnemius (MG), peroneus longus (PL), rectus femoris (RF), vastus medialis (VM), biceps femoris (BF) and gluteus maximus (GMax). Five features extracted from nonnormalized sEMG amplitudes were used: integrated EMG (IEMG), mean absolute value (MAV), Willison amplitude (WAMP), root mean square (RMS) and waveform length (WL). Muscle and feature combination variations were ranked using Pearson's correlation coefficient (r > 0.90 indicates successful correlations), the root-mean-square error and one-dimensional statistical parametric mapping between the original data and LSTM response. The results showed that IEMG+WL yields the best feature combination performance. The best performing variation was MG + RF + VM (rposition = 0.9099 and rmoment = 0.9707) whereas, PL (rposition = 0.9001, rmoment = 0.9703) and GMax+VM (rposition = 0.9010, rmoment = 0.9718) were distinguished as the economic and practical variations, respectively. The study showed for the first time the plausibility of the use of nonnormalized sEMG signals in control algorithm development for powered ankle prostheses in level walking.

## P2.62-Q: Effects of an ankle-assist robot on spinal reciprocal inhibition and voluntary ankle dorsiflexion movements.

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Post-stroke hemiplegic patients often have difficulties in walking due to their ankle dorsiflexion limitation. One of the possible reasons for this issue is the modulation of spinal reciprocal inhibition (RI), which includes reciprocal Ia inhibition and presynaptic short (D1) and long (D2) inhibition. These RI pathways can control coordinated movements of the antagonist muscle. RE-Gait® is a robotic-controlled ankle foot orthosis that can repeatedly induce appropriate plantar and dorsiflexion of the ankle joint. A previous study reported that the RE-Gait® intervention resulted in an immediate improvement in reciprocal Ia inhibition in post-stroke hemiplegic patients. However, the changes of D1 inhibition and dynamic muscle tone after the intervention have not been evaluated. Therefore, this study assessed the effectiveness of RE-Gait® in detail by examining these parameters. Twelve healthy adults and one post-stroke hemiplegic patient (male, age: 40s, BRS V) participated in this study. They engaged in a 20-minute session of robotic-assisted gait training (RAGT) using the RE-Gait® at their comfortable speed. RI was assessed before and after RAGT. The test stimulus was administered to the tibial nerve and conditioning stimulus to the common peroneal nerve, and EMG potentials were recorded from the soleus (SOL) and tibialis anterior (TA) muscles. The intensity of the conditioning stimulus was set to 0.1 μV, and that of the test stimulus was set to induce an H-reflex of 20% of the maximum amplitude value of the M-wave. The conditioning-test stimulation interval (CTI) was set at 0-4 ms in the measurements of reciprocal Ia inhibition, and at 0 and 20 ms in the measurements of D1 inhibition. The number of stimuli administered was randomly set to 12 stimuli in each CTIs. Moreover, the subjects performed 10 repetitions of the ankle voluntary dorsiflexion task from 20°of ankle plantar flexion to maximum dorsiflexion at the fastest speed. The task was recorded with slow motion video (120 fps). As a result, in healthy adults, the reciprocal Ia inhibition ratio with 1ms-CTI was significantly enhanced after the intervention (p < 0.05), while the D1 inhibition ratio with 20ms-CTI was not significantly changed after the intervention (p = 0.14). The duration of ankle dorsiflexion voluntary movement was significantly reduced after the intervention (p < 0.05). In post-stroke hemiplegic patients, both the reciprocal Ia and D1 inhibition ratio were increased after the intervention. In addition, the duration of the ankle voluntary dorsiflexion task was reduced. These findings suggest that ankle joint assistance by a robotic-controlled ankle foot orthosis may influence the RI and the improvement of ankle voluntary dorsiflexion movements.

## P2.63-Q: Effects of Robotic Ankle Joint Control on the Hip Joint during the Stance Phase

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RE-Gait® is one of the robots used for rehabilitation of walking impairments in Post-stroke hemiplegic patients. RE-Gait® is an ankle-foot orthosis exoskeleton-type walking assistive robot designed to assist ankle joint movements during gait specifically dorsal flexion and planter flexion. Just as RE-Gait® controls the ankle joint and acts on the ascending kinetic chain of gait, robot-assisted control of the ankle joint also affects the knee joint, suggesting that it is effective not only for ankle disorders but also for problems occurring in the knee joint. However, the specific changes in the hip joint refusing from ankle joint control remain unclear. Therefore, this study investigated the detailed examination of the influence of ankle joint control on the hip joint and aims to contribute to the intervention of robot-assisted rehabilitation for hemiplegic patients.  The study recruited 15 healthy young adults. The task involved attaching RE-Gait® to the right lower limb and performing level ground walking at a comfortable speed. The settings of RE-Gait® were determined based on the measurement of the subject's gait cycles, specifically from heel contact (HC) to 30% of the stance phase, corresponding to the midstance (MSt). Three conditions were established: no setting from HC to MSt (FLAT condition), dorsiflexion setting (DF condition), and plantarflexion assistance setting (PF condition). After MSt, the settings were same for each condition, and no control was applied from MSt to heel off (HO). From HO, plantarflexion assistance was provided during the pre-swing phase, and dorsiflexion assistance was provided during initial swing phase. Kinematic and kinetic data ware obtained using a three-dimensional motion analysis system and force plates. Joint angles and moments at the hip and knee joints were calculated. Additionally, hip joint angles were separated into three stance phases based on the vertical ground reaction force, and changes in hip joint angles during each phase were computed.  In the PF condition, the knee joint angle exhibited a significantly larger extension angle during the stance phase compared to the other conditions (p<0.01). While no significant difference was observed in the maximum hip joint extension angle during stance phase, the PF condition demonstrated a larger extension angle from the loading response (LR) to MSt (p<0.05) and a smaller from MSt to the terminal stance (TSt) compared to the FLAT condition (P<0.05). In terms of hip joint moments, the maximum flexion moment in the PF condition was significantly smaller than that in the FLAT condition (p<0.01). The robotic control of ankle dorsiflexion during the stance phase significantly influenced the angular changes and peak moments at the hip joint. The ankle joint control by RE-Gait® not only affects the ankle and knee joint but also has an impact on the hip joint, suggesting the potential for adaptability to various walking impairments.

## P2.64-R: Comparison of knee strengthening combined with hip or ankle joint exercises on clinical symptoms and muscle strength in women with patellofemoral pain syndrome

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Patellofemoral pain syndrome(PFPS) reduces exercise performance and quality of life. Currently, the inconclusive strategy of the rehabilitation process remains challenging. Although PFPS leads to anterior knee pain, the cause of pain does not only originate from the knee. The pain may also come from other surrounding joints, such as the hip and ankle joints. Therefore, the treatment appears to be complicated. Among them, is used to describe the combined kinetic movement of the ankle, knee, and hip joints during weight-bearing. When the dynamic knee valgus (DKV) angle becomes excessive, it is one of the risk factors for lower limb injuries. However, most researches focus on the knee joint intervention alone while there is still a lack of further high-level evidence to compare the comprehensive benefits of knee joint strength training combined with hip or ankle joint exercises in women with PFPS. PURPOSE: To compare the effects of knee strengthening combined with hip or ankle joint exercise on intensity of pain, muscle strength, and DKV angle in women with PFPS. METHODS: This study was a randomized controlled trial. Eligible 9 female recreational players (age: 24.9 ± 5.7 years, height: 160.4 ± 5.7 cm, weight: 55.0 ± 5.4 Kg) diagnosed by the physicians with PFPS were recruited. The participants had symptoms for 3 months at least. participants were randomized to hip and knee combined exercise group (n = 3), knee and ankle combined exercise group (n = 3), or non-intervention control group (n = 3). A physical therapist instructed the exercise. Each exercise consists of 30 minutes, once a day, 3 times a week, for periods of 8 weeks. The primary outcome was Visual Analogue Scale (VAS) for the intensity of pain during activity. Secondary outcomes were single leg landing test to assess DKV angle and maximal isometric strength. RESULTS: After an 8-week intervention, significant improvements in VAS scores during activities were observed after the intervention in both the hip + knee group (3.0 ± 0.58; p = 0.04) and ankle + knee group (4.33 ± 0.67; p=0.02), but not in the control group. No significant differences between interventional groups were found in all outcomes. CONCLUSION: Both the hip + knee group and the ankle + knee group showed a significant clinical effect in reducing pain during activities. A larger sample size warrants verifying the clinical effectiveness of the combined exercise treatment for this population.

## P2.65-R: **Effect of tasks on intramuscular regional differences in rectus femoris elasticity during isometric contraction: an ultrasound shear wave elastography study**

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Background: Based on various research, regional differences exist within the rectus femoris (RF) muscle. In particular, RF muscle strains are known to occur more frequently in the proximal region during hip flexion motions. However, intramuscular regional differences and task specificity of mechanical stress associated with contraction related to injury development remain unknown. Ultrasound shear wave elastography (SWE) can quantify the elasticity of specific muscular regions. The elasticity measured by SWE has been shown to reflect the change in force associated with contraction. This study aimed to investigate intramuscular regional differences and task specificity of RF elasticity during isometric contraction.Methods: Sixteen healthy males (aged 24.3 ± 4.1 years) participated in this study. Subjects were seated at 50° hip flexion and 90° knee flexion, with the distal leg and distal thigh fixed to the force sensors. The tasks included isometric hip flexion (HF) and knee extension (KE), and the contractions were maintained at 0%, 30%, and 60% of their respective maximum voluntary isometric contraction (MVC) forces for 5 seconds each. RF elasticity was measured in two regions, proximal (33%) and distal (66%). The shear modulus (kPa) measured by SWE was used for RF elasticity. A three-way ANOVA with repeated measures was used to compare the changes in shear modulus with increasing contraction intensity among regions and tasks.Results: A significant interaction was observed (intensity × region × task) (P = 0.01). In the KE task, the RF shear modulus increased with increasing contraction intensity in each region, while in the HF task, the RF shear modulus in the proximal region was higher than that in the distal region at 0% MVC (Mean ± SD, proximal: 12.18 ± 3.02, distal: 6.21 ± 1.35) and 60% MVC (proximal: 70.63 ±

14.36, distal: 51.66 ± 21.62). In the proximal region, the RF shear modulus of the KE task was higher than that of the HF task only in the 30% MVC (30% MVC KE: 55.05 ± 18.24, HF: 38.45 ± 21.72; 60% MVC KE: 74.87 ± 19.05, HF: 70.63 ± 14.36). In the distal region, the RF shear modulus of the KE task was higher than that of the HF task at 30% MVC (KE: 52.83 ± 18.52, HF: 30.98 ± 19.67) and 60% MVC (KE: 77.75 ± 17.98, HF: 51.66 ± 21.62).Discussion: The present results indicate that the trends of intramuscular regional differences in RF elasticity differ depending on the exercise task. No interregional differences were observed in the KE task. However, in the HF task, the proximal region had higher elasticity at 60% MVC. Since muscle elasticity during contraction as measured by SWE reflects mechanical force, there will be proximal-specific heterogeneity in mechanical stress during contraction of moderate to high intensity in the HF in RF. In addition, the KE may generate more mechanical stress in the distal region than the HF since the distal region showed higher RF elasticity in the KE than in the HF at contraction.

## P2.66-R: The effects of EMG waveforms on the availability of EMG threshold detection

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<Introduction> It has been reported that the rapid increase of the EMG amplitude in the lower limb, especially the anterior thigh muscles is observed during incremental pedaling exercise. The exercise intensity where it occurs is equivalent to the lactate threshold (LT), which is one of the anaerobic threshold (AT) estimation indices. In the previous studies, this point is called EMG threshold (EMGT), and its usefulness of EMGT as an index estimating AT noninvasively and relatively inexpensively is claimed. On the other hand, some previous studies reported that, during incremental exercise, EMGT is not observed, the detection rate is not stable depending on subjects or tested muscle, and EMGT is inconsistent with other AT estimation indices and is not practical. As above, there is no unanimous view on EMGT. In the previous studies on EMGT, the average amplitude of EMG is calculated using EMG data extracted from relatively long intervals, such as several seconds or one crank cycle, so it is not clear which factor of the EMG waveform changes during one single crank cycle to cause the rapid increase in EMG average amplitude. Therefore, in this study, we investigate the differences in EMG waveform changes during one crank cycle between subjects whose EMGT is detected and those whose EMGT is not detected and try to obtain that will contribute to the practical use of EMGT. <Methods> Male cyclists performed incremental pedaling exercise (90rpm, start at 110W, add 10W every 30 seconds) and EMG measured from lower limb muscles which are considered suitable for EMGT detection in previous studies. At the same time, the acceleration and angular velocity of the crank arm were measured to synchronize the EMG and crank motion. The ARV was calculated from lowpass-filtered EMG and divided into each workload. Then, averaged ARV during one crank cycle was calculated using stable EMG data in each workload, and they are normalized to the maximum value in the muscle overall workloads. We calculated the EMG activation interval and peak value and compared their changes between EMGT detectable group and EMGT undetectable group. <Results> The EMG activation interval length gradually increased from the start of incremental exercise in the EMGT detectable group and the final increase in the EMG activation interval length with increasing workload tended to be larger than in the EMGT undetectable group. Referring to the peak value in each workload, continuous increases during exercise are observed in both groups.

## P2.67-R: **Biomechanical characteristics of trunk muscles and sagittal alignment of basic posture in ballet**

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Purpose In ballet, teachers often encourage their students to keep good posture by the words "pull-up". Sueyoshi et al.(2016) reported that the curvature of the spine decreased by changing from a relaxed posture to a ballet posture in people with ballet experience the cross-sectional area of their core muscles was significantly larger than those of the non-dance group. It was also found that there was a significant negative correlation between changes in the spinal alignment angle, the amount of change in the lumbar kyphosis angle, and the cross-sectional area of the psoas major and transversus abdominis muscles. McMeeken et al. (2004) investigated the relationship between changes in the thickness of the transversus abdominis muscle and electromyogram and reported that electromyogram activity increased in proportion to the increase in muscle thickness, and there was a high correlation. However, few studies have examined the biomechanical difference between basic posture in ballet and natural standing posture. Therefore, the purpose of this study was to examine the basic posture of ballet in terms of the trunk muscles' structure and sagittal skeletal alignment.Methods17 Japanese female students with more than 10 years of ballet experience participated in this study. From the ultrasound images, the thickness of rectus abdominis, right and left external oblique abdominal muscles, internal oblique abdominal muscles, and transversus abdominis muscles were measured in both supine and standing position at rest, during maximal inhalation, maximal exhalation, and basic posture in ballet. For skeletal alignment, six markers were fixed to the subcostal, 10th and 12th thoracic vertebrae, left ASIS, PSIS, and greater trochanter for evaluating sagittal skeletal alignment. The video images were recorded 2.5 m away from the side of the subject. The lumbar spine angle, pelvic angle, the angle between the PSIS and the greater trochanter on the axis of ASIS, and the angle between the lower ribs and the PSIS were measured by the images using ImageJ.Results and DiscussionNo significant difference in the rectus abdominis muscle in the supine position among four different posture conditions. In basic ballet posture, the muscle thickness of the left and right external oblique muscles, transversus abdominis muscles, and the left internal oblique muscle were significantly greater compared to the other three conditions. No significant differences were observed in sagittal skeleton alignment. Conclusion From the results of this study, greater muscle thickness during basic ballet posture compared to at rest or during maximal inhalation/exhalation would indicate that structural changes would occur especially in deeper trunk muscles. In addition, no significant changes in skeletal alignment were observed among four different conditions related to sagittal alignment of the posture.

## P2.68-R: **Neural and morphologic changes in calf muscles during five-week of session-adjusted calf-raise training in untrained males: a preliminary study**

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Purpose: The study aimed to test how a session-adjusted resistance exercise protocol is effective in gaining strength and to observe neural and morphologic changes in the medial gastrocnemius (MG) and tibialis anterior (TA) during and after five-week calf-raise training in untrained males. Methods: Five healthy untrained males (21 years; 177.2 cm; 67.5 kg) performed five weeks of resistance exercises (two sessions per week). Participants who had been engaged in aerobic or resistance exercises for the last six months or a history of musculoskeletal surgery in their lives were excluded. In each session, participants performed three sets of calf-raise exercises on a Smith machine with a workload of 10-repetition maximum and a rest period of 2-min between sets. The workload of each set was controlled by the session-adjusted protocol with the cut-off range (e.g., from 9 to 11 repetitions). Specifically, if the number of repetitions were > 12 or < 8, the workload was increased or decreased by 2.5 kg. Dependent measurements were the workload, neuromuscular activity, and muscle morphology at week 1, 3 (1st session), and 5 (2nd session). The average workloads at each time point (week 1, 3, and 5) were recorded. Two surface electromyography (EMG) electrodes (2,000 Hz) on the MG and TA on the dominant leg were used to record neural changes in the 2nd set. The EMG signals during the concentric (raise up) and eccentric (raise down) phases were separately cropped and filtered through a 4th order Butterworth band-pass filter (cutoff frequency: 20 to 450 Hz). Filtered data was wavelet-transformed in the time-frequency domain with 11 morlet wavelets to get intensities. After that, principal component analysis was used to extract the principal components (PCs) and PC scores. Before the first set, three ultrasonographic images (frequency: 12 MHz; depth: 6 cm) of MG and TA were obtained and averaged to test morphologic changes. One-way analysis of variances with Tukey's tests were performed to test a time effect on workload and muscle morphology (p<0.05). A two-way analysis of variances was performed to test differences in PC scores between the contraction type over time. Results: The workload was different (F4,16=11.33, p<0.0001) that there was a 23% increase at week 3 (81.2 kg to 99.8 kg, p=0.009) but there was no further increase at week 5 (110.2 kg, p=0.24). Although PCs captured amplitude shift and frequency shift, respectively, there was no interaction and main effect on PC scores were observed between contraction type over time (p>0.05). The muscle morphology was not different in the MG (F2,8=0.78, p=0.49) and the TA (F2,8=0.15, p=0.86). Conclusion: Our study resulted in a 36% increase in workloads after five-weeks of training. Despite the strength gain, neither neural nor morphologic change was observed. A larger sample size would be needed to detect the relative contribution of each factor.

## P2.69-S: Development of a self-adhesive, reusable sEMG electrode designed for independent application by the patient

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BACKGROUND: Information about muscular coordination during everyday activities is becoming increasingly important in rehabilitation. From a clinical perspective, it is desirable to monitor muscle activation preferably in the patient's home environment and over longer periods. This approach presupposes that the recording surface electrode (sEMG electrode) can be placed autonomously by the patient and remain in this position all day. The quality of the derived signals should neither be impaired by inaccurate positioning nor by time. METHOD:

Silicone rubber was chosen as the carrier material. To achieve the adhesive properties of the carrier material, the mixed silicone components were poured into a rectangular mold with the underside coated with a porous material. In this way, the silicone adheres to the small pores, enabling the carrier material to adapt to irregularities of the human skin. This results in an adhesion effect. Additionally, a curved shape of the silicone carrier leads to a better adaptation to the shape of the human body and, thus, to even better adhesion. A total of 7 gold contacts were integrated into the carrier material to form regions with high conductivity. The gold contacts used have a hemi spherically curved surface, a diameter of 8 mm, and a spacing of 10 mm. By differential amplification close to the electrodes, two sEMG leads were created from 3 gold contacts (lead electrodes) arranged in line. The individual components of the amplifier circuit were adapted to the high contact impedances between the gold contact and the skin. The required ground electrode was formed from the remaining 4 gold contacts, arranged symmetrically around the center lead electrode and short-circuited to each other. This results in an active sEMG electrode that provides 2 sEMG channels and adheres to the skin surface on its own. RESULTS: The newly developed sEMG electrode was tested for adhesion strength, adhesion duration, and reusability on 7 subjects. The adhesive sEMG electrode could be reused up to 5 times without any problems and was worn by the test subjects for an average of 14 hours daily. In terms of wearing comfort, all test subjects found the electrode acceptable and comfortable to wear. Skin irritation did not occur. In addition, the signal quality was analysed in terms of the signal-to-noise ratio, long-term stability, and interference from movement artifacts. The signal quality achieved was comparable to conventional wet electrodes and stable over several hours. Only minor movement artifacts occurred even with strong movements. CONCLUSION: The carrier material with integrated gold contacts represents an adhesive electrode material with which an sEMG electrode can be realised that adheres to the skin surface like a plaster and is reusable. The sEMG electrode can be attached autonomously by the patient. Its signal quality is sufficient to use it for long-term recording of muscular activation.

## P2.70-S: Development of a Surface EMG E-Textile

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Background: In recent years, the incorporation of electronics into clothing has become more common, particularly in the healthcare sector. These wearable systems allow researchers and clinicians to monitor patients outside of a laboratory setting. This advancement addresses the dissatisfaction with current market systems and offers features such as comfort, washing resistance, and flexibility in usage. Surface electromyography (sEMG) is commonly used to measure the muscular activity of athletes and patients, aiding in diagnosis and rehabilitation. Although wireless systems capable of transmitting signals to computers currently exist and have become standard, implementing them outside the laboratory remains challenging. Purpose: The purpose of this study was to design and test a custom-built 8-channel e-textile sEMG system to analyze signals obtained from two materials: conductive thread and dry electrodes, to achieve an e-textile grid that is easily replaceable, low-cost, reusable, and can be used outside of a laboratory setting. Methods: Four male subjects (mean age 21 ± 0.43 years) participated in the study. Participants completed isometric and isotonic contractions while

wearing the two different EMG e-textile grids. In the isometric protocol, participants were given a handheld dynamometer and asked to reach 25 kg of force for a period of 4 seconds twice within ten second period. The signals were obtained from the participant's dominant forearm. In the isotonic protocol, a 2.5-pound weight was positioned in the subject's hand. They rested their elbow on a flat platform and fully extended their forearm, forming a 110° angle at the elbow joint. The subject was asked to flex their arm within a 4-second period twice within a ten second window. During the isotonic contractions, sEMG signals were collected from the biceps brachii muscle. The signals were acquired using a Sessantaquattro+ (OTBioelettronica, Turin, Italy) and power spectrum densities, signal-to-noise ratios, coefficient of variations, and root mean squares were compared between the conductive thread and dry electrodes. Results: Both materials met the expectations of an electrode for (sEMG) data collection. The frequency distribution is as expected for an sEMG signal, as shown in Figure 1. Both materials are sensitive to electromyographic activity, and the signal-to-noise ratio is significant, indicating that the signal stands out and is detectable in relation to the noise. When comparing individual values between material groups, the differences between the dry electrodes and the conductive thread are evident. The conductive thread shows better performance in the power spectral density (PSD) as it exhibits fewer artifacts, resulting in a lower amount of noise. Additionally, the conductive thread obtains a higher signal-to-noise ratio (SNR) in the isotonic contraction (+10 dB). Conclusion: In summary, the conductive thread material displayed clear advantages in metrics such as PSD and SNR. Successfully embedding electrodes into fabric is the first step in creating a robust and practical e-textile system which presents possibilities in the fields of wearable technology and biomedical monitoring. While preliminary, these results are promising, and future work will include a greater sample size as well as different contractions to test the robustness of the materials.

## P2.71-S: Exploring the impact of including activity when walking when quantifying daily upper limb use in people with sub-acute stroke

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Introduction: Incorporating the use of the arm and hand in daily life is the ultimate goal of upper extremity rehabilitation. Objectively measuring UE activity during free-living can provide clinicians with essential information regarding performance and functional use of the paretic UE. Inertial measurement units (IMUs) have been used post-stroke to objectively measure UE activity during free living. Bilateral magnitude (BM) and magnitude ratio (MR) are metrics used to quantify intensity of activity across both arms and symmetry of arm use, respectively. Use of these metrics to quantify UE activity during free-living have been studied in stroke; however, how arm swing during walking compared to non-walking UE use (i.e., activities of daily living) contributes to measurement of UE use is not known. Aim: This study aims to evaluate the impact of removing UE activity that occurs during walking on the measurement of UE use during free-living. BM and MR were used as measures of UE activity and were compared when including UE activity during walking vs. UE activity without walking. Methods: Participants (< 6 months post-stroke) wore bilateral wrist and ankle Axivity AX6 IMUs for 24 hours/day for 7 days. Data was collected at 50 Hz. A 20 Hz low pass 4th order Butterworth filter was applied to the raw data and average vector magnitude was calculated using 1-second epochs. The mean BM and MR were calculated for UE activity with walking included and without walking included for each participant. Statistical Analysis: We used Lin's Concordance Correlation Coefficient (CCC) to 1) explore agreement between BM with and without walking and 2) explore agreement between MR with walking and without walking. Bland Altman analysis was conducted between 1) BM with and without walking and 2) MR with and without walking.Results: Eight (2 females) participants (66.25± 11.65 years) were included in the preliminary analysis. Participants ranged from severe to marked impairment for the hemi-paretic side (Fugl Meyer Assessment: 56.75± 22.89). There was moderate agreement (CCC= 0.93, 95% CI 0.74– 0.98) between BM with walking and without walking. Bland Altman plots showed that inclusion of walking activity tended to increase BM reported (95% Limit of Agreement -5.6 – 14.9) compared to without walking. Substantial agreement (CCC=0.994, 95% CI 0.971– 0.998) was found between MR with walking and without walking. Bland Atlman plots showed no systematic bias between MR with walking and without walking (95% Limit of Agreement -0.09– 0.06)Conclusion: Results suggest that inclusion of arm swing during walking in free-living data may increase the reported BM as a reflection of the intensity of UE activity. However, it may not impact MR to a similar extent. Agreement between measurements of MR suggest that symmetry of arm swing in walking reflects symmetry of UE use in non-walking tasks such as activities of daily living.

## P2.72-S: Extended reality for physical performance enhancement

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BACKGROUND AND AIM: Physical performances are of utmost importance in sports and at work to obtain optimal efficiency without increasing the risk of musculoskeletal injuries. The development of modern electronics and computer enables to feed the users with metrics that inform about their current level of physical performance. Sensory information using audio, tactile or visual feedback can be added to the input an athlete, or a worker receive while performing sports or while working. This places the athlete or the worker in a setup called augmented or extended reality. The aim of this abstract is to showcase a few applications impacting the future of sports and work.METHODS: Augmented or extended reality is defined as the combination of real environment complemented by additional sensory information. Augmented reality covers a large spectrum that e.g., mix real and virtual environment being depicted as either augmented or mixed reality where the athlete or the worker is provided with additional feedback using visual, auditive or tactile sense. The additional feedback is based on data collected using inertial measurement units and/or optic sensors. Inertial measurement units combine accelerometer, inclinometer, and gyroscope data and are getting more and more integrated in equipment like watches and goggles feeding the user with information concerning e.g., running or swimming style, heart rate, and effort level. Further these sensors also open a new era for gamification that can also been used in real-life settings to improve e.g., head pitch angle in swimming.RESULTS: The current approaches offer a vast number of possibilities found to (i) be reliable and possible, (ii) improve physical performance during for example penalty kicks in soccer. Still feeding the sportsmen or the worker with additional sensory information can also have negative effect especially if the added information increases the cognitive load or changes the focus of attention that could have a negative effect and increase the risk of injuries.CONCLUSIONS: Augmented or extended reality is and will be become an integral part of

our life during sports and at work. This opens a large number of possibilities to improve physical capacity even if longitudinal studies are needed to clearly demonstrate the real benefit of extended reality.

### P3.1-B: Exploring Lower Body Action Recognition Through Distance-Based Time Series Analysis and Template Matching

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Human motion recognition technology has significant applications in various fields, such as rehabilitation, long-term care, monitoring, entertainment, and human-computer interaction. These technologies primarily process data in the form of time series and are categorized based on the data source into two main types: image-based and wearable sensor-based. This is a widely researched topic in the realms of big data and artificial intelligence. Our study aims to analyze human motion in an intuitive manner that does not rely on traditional neural networks or machine learning techniques. We understand the mechanics of motion by analyzing the changes in human joint angles, focusing on similarity measurement and time series alignment, employing various time series distance metrics such as Euclidean distance, Dynamic Time Warping, Move-Split-Merge, and Fisher-Rao Metric.The research is divided into three main parts: First, we collect motion data using the Vicon motion capture system to obtain movement data and build a human model in OpenSim software to calculate the rotational angles of the lower limb joints. This time series data of angles is used to describe lower limb motions. Second, we create and analyze motion templates, covering ten common lower limb movements, adjusting the motion samples through time series alignment techniques and various distance metrics to align the main features in the samples. We then use these aligned samples to establish motion templates and analyze the distance distribution among different sample categories. Lastly, we conduct template matching experiments, proposing a similarity scoring method based on time series distance measurement, integrating the softmax and bell-shaped functions for motion classification, effectively eliminating outliers. We designed three motion scenarios for testing, including artificially generated scenarios. The results show that our similarity scoring method is effective, particularly when using the Dynamic Time Warping method, maintaining good performance even in data with noise.

### P3.2-B: Decoding the patterns of motion: a comparative analysis of AI algorithms for hand movement prediction using HD-sEMG

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Artificial Intelligence (AI) algorithms are frequently employed to decode neural inputs for controlling hand movements originating from the spinal cord, which are detected via surface Electromyogram (sEMG) signals in the arm muscles. This non-invasive approach is beneficial for understanding the neurophysiological aspects of movement in healthy individuals, as well as enabling people suffering from paraplegia due to spinal cord injury (SCI) to control an assistive device through their movement intent. The aim of this work is to identify the most

effective AI models and feature extraction methods for translating complex sEMG signals into consistent hand movements. Key questions include whether Machine Learning (ML) or Deep Learning (DL) architectures are more optimal for decoding movement intentions and what the required model complexity is for decoding hand movements relevant to daily activities.A comparative analysis of state-of-the-art ML and DL models for myoelectric applications was conducted to assess their decoding capabilities and efficacy. Using a preexisting dataset from 13 healthy subjects, comprising sEMG signals and 3D joint hand kinematics from synchronized camera recordings, six AI models were employed: Linear Regressor, Ridge Regressor, Random Forest, Gradient Boosted Regression Tree, 2D Convolutional Neural Network (CNN), and 3D CNN. The sEMG signals were recorded using 3 8x8 electrode grids, spatially filtered to reduce crosstalk and input dimensions for AI models. Finger joint angles were derived from the 3D hand kinematic models. EMG features, including Root Mean Square, Mean Absolute Value, Variance, Histogram, and Random Fourier Features, were extracted for the ML models. The dataset encompassed eight dynamic hand movements, including power grasping, two-finger pinching movements, and flexion-extension movements of each individual finger following a sinusoidal pattern. Model performance was evaluated using R2 score, Mean Absolute Error (MAE), and Pearson's Correlation Coefficient (PCC) as models were trained and tested on an increasing number of movements or Degrees of Freedom (DoF). Two-sided paired t-tests were conducted to identify significant differences between algorithms. To assess the statistical significance of the observed differences between the evaluated models, a one-way analysis of variance (ANOVA) was performed for the results of each AI model, followed by post-hoc t-tests with Bonferroni correction to identify specific differences between each pair of models. Additionally, a Shapley Additive Explanations (SHAP) analysis was performed on the model which consistently displayed highly accurate predictions for all evaluated tasks, to determine both the most impactful EMG features used for its input and the most relevant grid channels.The Gradient Boosted Regression Tree and the 3D CNN achieved an overall R2 score above 0.8 for all eight movements, maintaining an error below 6 degrees and a correlation coefficient above 0.8, alongside the Random Forest. These models demonstrate superior performance, indicating that non-linear approaches excel in interpreting the complex relationship between sEMG and hand movement, especially in clinical settings. Conversely, Linear and Ridge Regressors show a steeper performance decrease with increasing Degrees of Freedom (DoFs), yet remain viable for assistive devices with lower computational complexity requirements, provided the number of identifiable movement patterns is limited. The SHAP analysis highlights Mean Absolute Value and Variance as the most impactful features for the Gradient Boosted Regression Tree, which reflect signal amplitude and power akin to the Root Mean Square. Only 14 out of 192 grid channels were identified as most relevant, suggesting ML models can predict hand gestures effectively using amplitude-based features from a limited number of channels. However, detecting these channels via myoelectric bracelets or large electrodes could prove challenging due to their non-circular distribution around the forearm. High-density grids with small-diameter channels offer better support for AI models to identify neural activity relevant to movements.To the best knowledge of the author, this study represents a pioneering comparative analysis of myoelectric AI algorithms. It uniquely compares various state-of-the-art ML and DL models employing different signal features by directly testing their performance on a range of dynamic finger movements and hand gestures. The author hopes this work will serve as a valuable guide in selecting the most suitable AI model for appropriate rehabilitation therapy or myoelectric applications. Future work is still necessary to fully validate the long-term usability of these models and their robustness to time-dependent neurophysiological changes occuring in the input EMG signal, such as from muscle fiber fatigue and from change of fiber length during movement.

### **P3.3-C:** Visually induced vection leads to sensory reweighting in postural control- A preliminary study-

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【Introduction】Vection, a form of whole-body kinesthetic illusion induced by visual stimulation, is a phenomenon where subjects perceive motion despite their stationary position due to the presented visual input. Vection results in an augmented vestibular and somatosensory influence during postural control in conjunction with visual stimulation. Thus, vection-inducing video is possible to be effective as balance training for subjects such as elderly individuals who are considered to have higher vision weighting. However, sensory reweighting in postural control when subjects are asked to watch a video for a relatively long period (i.e. period of balance training) have not been shown. The purpose of this study was to demonstrate the effect of sensory reweighting in postural control after visually induced vection in healthy subjects as a preliminary study.【Methods】Eight healthy adults (four males and four females, age: 21.5±0.5 years) participated in this study. Subjects were applied to the intervention to watch the vection-inducing video using by Head-Mounted Display (HMD: Meta Quest pro, Meta Inc.). This intervention was roll circular vection in which random dots rotates around anti-clockwise. Video rotated random dots was presented for 10 seconds, and static dots image was presented for 20 seconds, and the videos were repeated for 10 minutes. Subjects were asked to stand in side-by-side stance during this intervention. Outcomes were center of pressure (COP) of side-by-side stance in 30 sec using a force plate. COP data were acquired before and after the intervention. COP parameters were total trajectory length, rectangular area, and power spectrum density (PSD) in the lateral direction of COP using the fast fourier transform. PSD was then divided into three frequency intervals: the low-frequency (LF: 0–0.3 Hz), the medium-frequency (MF: 0.3–1 Hz), and the high-frequency (HF: 1–3 Hz) band. The PSD of each band was thereafter normalized by the sum of three bands and is presented as percentages.【Results】There were no significant different in total trajectory length and rectangular area. After intervention, LF band was significantly decreased and MF band was significantly increased compared to before intervention. 【Discussion】Our results indicated that the sensory reweighting in postural control was led by visually induced vection. Previous studies have reported that the LF band reflects visual weighting, and the MF band reflects vestibular and somatosensory weighting in postural control. Increasing the MF band after the intervention in this study might contribute to lead reweighting of vestibular and somatosensory in postural control by vection. Vection may be effective as the intervention methods of balance training for the elderly who are considered to have higher vision weighting.

### **P3.4-C:** Temporal muscle activation during gait post-Achilles surgery: A longitudinal analysis using surface electromyography.

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Introduction. Advancements in Achilles tendon reconstruction have led to significant improvements for patients, expediting the return to routine activities. Minimally invasive techniques, such as PARS-Dresden, have notably reduced recovery times, enabling patients to walk without crutches by postoperative week five. However, it remains unclear whether alterations in the triceps surae muscle activation patterns occur during recovery. This study aims to compare the onset-offset activation intervals in the triceps surae during gait following Achilles reconstruction.Material and methods. Eight patients (age:35.37±4.74 years; height:172.12±6.37cm; weight:70.50±13.90kg, eight males) were recruited after Achilles surgery (PARS-Dresden) and followed for one year. Three-dimensional motion capture was used to identify the different gait cycles while each person walked on the treadmill (evaluated at 8, 12, 24, and 48 weeks). Each volunteer walked at a self-selected speed, determined in the first session (8 weeks) and maintained during the follow-up sessions. Surface electromyography (sEMG) was utilised to measure muscle activation of the triceps surae (soleus [SOL], medial [MG], lateral [LG] gastrocnemius). Each sEMG signal was processed with the Teager-Kaiser energy operator and filtered with a low pass of 50Hz. The onset, offset, and duration of each burst of muscle activation in the operated limb were determined on ten gait cycles and then averaged. The results were represented in milliseconds (ms). Activation outcomes were compared between sessions using a one-way ANOVA and Bonferroni's post-hoc test. All statistical analyses were calculated with a p-value<0.05.Results. There was a main effect of session for each outcome. Post-hoc analysis showed changes for the onset and burst duration of the MG between 8 weeks (onset=475±185ms, burst duration=280±203ms) versus 24 weeks (onset=208±99ms, p=0.001; burst duration=538±147ms, p<0.01) and 48 weeks (onset=139±35ms, p<0.01; burst duration=625±86ms, p<0.01). LG onset and burst duration changed similarly over time from 8 weeks (onset=399±121ms, burst duration=349±176ms) versus 24 weeks (onset=191±167ms, p=0.01; burst duration=562±211ms, p=0.04) and 48 weeks (onset=160±74ms, p<0.01; burst duration=603±137, p=0.01). For SOL onset and burst duration also differed from 8 weeks (onset=445±100ms; burst duration=222±109ms) versus 24 weeks (onset=211±150ms, p<0.01; burst duration=554±197ms, p<0.01) and 48 weeks (onset=142±50ms, p<0.01; burst duration=639±127ms, p<0.01). The SOL offset also differed between 8 weeks (668±103ms) versus 48 weeks (781±97ms, p=0.02),Conclusions. The activation timing of the triceps surae muscles differed over time from 8 to 24 weeks post-Achilles tendon reconstruction. Notably, there was an earlier onset and a marked increase in the duration of activation at both 24 and 48 weeks. These findings advance our understanding of alterations in neuromuscular control during post-surgery recovery.

## P3.5-C: Neurophysiological factors associated with performance parameters in elementary school students

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Background: It is known that both neural and muscular adaptations develop with growth; however, their contribution to performance parameters in children remains unclear. The present study aimed to clarify: 1) the association of muscular and neural factors with performance parameters (maximal voluntary isometric contraction (MVC) and vertical jump (VJ)), and 2) the effects of growth on them in elementary school-age children.Methods: 68 (52 boys and 16 girls) elementary school students (chronological age (CA): 8.71 ± 1.63 years) participated in this cross-sectional study. We measured MVC, VJ, muscle thickness (MT) and the motor unit firing rate (MUFR) of knee extensor muscles. MT and MUFR were measured using an ultrasound device and high-density surface electromyography, respectively. Age of peak height velocity (PHVA) was calculated to consider individual maturity level by using the BTT model. A non-parametric partial correlation analysis was performed to investigate the association of muscular/neural factors (MT, MUFR) with performance parameters (MVC, VJ), controlling for maturation level assessed by subtracting PHVA from CA. In addition, Kruskal-Wallis test and Mann-Whiteney test were used to compare all data (MVC, VJ, MT, MUFR) among the three groups classified by the following maturity levels: young (CA-PHVA < -5 years), middle (-5 years ≤ CA-PHVA < -3 years), old (CA-PHVA ≥ -3 years).Results: Average of PHVA and CA-PHVA were 12.41 ± 1.05 years and -3.70 ± 2.12 years, respectively. 60 motor units detected from 27 participants were used in analysis for MUFR. A partial correlation analysis showed that there were no significant correlations with MVC for MT (r = .33, p = .09) and MUFR (r = .21, p = .30). No significant correlations with VJ for MT (r = -.11, p = .57) and MUFR (r = .13, p = .50) were also found. In comparison among groups, MVC and VJ values were significantly higher with increasing maturity levels (MVC: young vs middle, p < .01; young vs old, p < .01; middle vs old, p < .05; VJ: young vs middle, p < .01; young vs old, p < .01; middle vs old, p < .05). Moreover, the MT value in old group was significantly higher than that in young group (p < .05) although no significant difference in MUFR values among groups was found.Conclusion: The findings of the present study suggested that performance parameters such as MVC and VJ of elementary school-age children are influenced by both of muscular and neural parameters. On the other hand, it was suggested that MUFR is not affect by maturation level although MVC, VJ, and MT improve with maturation.

## P3.6-C: Relationship between forelimbs and head/neck movements and muscle activity during cantering on the treadmill in Thoroughbreds

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(Background and Purpose)When thoroughbreds in their high-speed locomotion such as canter and gallop, they move with asymmetry gait patterns. The limbs on the side that contact first in time between left and right is called the trail limb, and those on the side that contact last is called the lead limb in horses. When the forelimb is in protraction, the brachiocephalic muscles, which has its origin and insertion at the cranial surface of the humerus and dorsal surface of the neck, contracts, causing the neck to rotate downward theoretically. The head and neck parts which have almost 10% weight show up and down oscillation during one single complete stride. However, it is an interesting question whether the head and neck parts, whose downward rotation is initiated and controlled by trail or lead front limb. The purpose of this study was to clarify the relationship between the protraction/retraction motion of the forelimbs and the head/neck rotating motion and the muscle activities controlling them. (Methods)Four thoroughbreds cantered on the treadmill at the speed of 12m/s with 0% slope condition. Two of subject horses were left leading limbs and others were right leading limbs. Their sEMG was obtained from left and right brachiocephalic, infraspinatus and deltoid muscles with 1000Hz sampling rate. For the kinematical analysis, 14 optical motion capture cameras were settled to capture 32 reflective markers on the anatomical landmarks of horses. The obtained marker trajectories were smoothed by IIR Butterworth low pass digital filter at the cut off frequency of 15Hz. The sEMGs were also smoothed by the band pass filter with between 15 to 500Hz, then rectified and calculated iEMG. The activation period was identified with 30% threshold level of each muscle's maximum amplitude of iEMG. (Results)The infraspinatus muscle, which is thought to support the forelimb, activated immediately before the forelimb landed, a trend similar to that observed in previous studies. We observed that changes in the angular velocity of forelimb swinging were synchronized with the timing of activation of the brachiocephalic muscle. However, there was no synchronization between the activation of the brachiocephalic muscle and the movement of the head and neck. In addition, the activation of trailing front limb's brachiocephalic muscles initiated, then leading side followed, i.e., asymmetrical motion on the left and right sides muscular activity was observed. It suggested that the head/neck motion was controlled by not only the brachiocephalic muscle, but also the cervical ligaments and the splenius muscles, which might anchor their neck part from the dorsal side. Also, it suggested that an alternating left-right bending moment always acts in the rotating neck motion during the single complete stride.

## P3.7-C: Changes in pregnancy-related hormones, neuromechanical adaptations and clinical pain status throughout pregnancy: a prospective cohort study

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BACKGROUND AND AIM: More than half of pregnant women will experience lumbopelvic pain during their pregnancy. During this period, women undergo hormonal, neuromechanical and clinical adaptations, which may contribute to the development of lumbopelvic pain. For instance, increased relaxin, estrogen and progesterone levels contribute to ligament laxity in the pelvic girdle, potentially leading to joint instability and predisposing pregnant women to lumbopelvic pain. Various changes observed in a woman's posture can also lead to neuromuscular adaptations, such as increased muscle activation of the lumbar muscles. The flexion-relaxation phenomenon has been used to evaluate neuromuscular adaptations since silencing of myoelectric activity during a full trunk flexion is lacking in individuals with low back pain. Although hormonal changes might be involved in lumbopelvic joint instability causing pain in pregnant women, their influence is not yet clearly determined.The main objective of this study was to assess changes in pregnancy-related hormones, neuromechanical adaptations and clinical pain status throughout pregnancy. An exploratory objective was to examine the possible association between those variables.METHODS: Twenty-eight pregnant women completed, at each trimester, clinical questionnaires to assess functional disability, risk of poor prognosis, avoidance behaviors, catastrophizing and pain, and realized a flexion-relaxation task. Blood samples were taken to assess the levels of relaxin, estrogen and progesterone. During the flexion-relaxation task, surface electromyography over the right and left lumbar paraspinal muscles was assessed. Also, lumbar and pelvic angles during the task were collected using a motion capture system (flexion-relaxation phenomenon onset and cessation).RESULTS: Results showed that nocturnal and diurnal pain intensity, disability, risk of poor pain prognosis and avoidance behaviors increased, while pain catastrophizing decreased throughout pregnancy. Neuromechanical characteristics of the flexion-relaxation phenomenon, including EMG and kinematics, were similar throughout the three trimesters.Positive associations were found between estrogen levels and disability (changes between first and second trimester, r=0.46), and between estrogen levels and diurnal lumbo-pelvic pain intensity (change between second and third trimester, r=0.53).CONCLUSIONS: Our result showed moderate correlations between pregnancy hormone levels and clinical pain status. In pregnant women with and without lumbopelvic pain, estrogen was the only hormone associated with clinical features such as physical disability and the diurnal intensity of lumbopelvic pain. If the woman develops this type of pain during pregnancy, another physical test could be more appropriated to provide associations between the variables.

## P3.8-C: Thoracic spine and shoulder kinematics and muscle activation of rock climbers with shoulder pain

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Background: Rock climbing has been a popular sport in recent years, involving a variety of arm movements, such as overhead reaching and pull-up. Overhead reaching and pull-up during climbing may be accompanied by trunk movement due to various wall inclinations. Among rock climbing injuries, shoulder injuries are about 17%, the second most common. Individuals with shoulder impingement syndrome have shown decreased upward and externally rotation during arm elevation and have limited thoracic extension range of motion and greater kyphotic posture. However, a previous study found no difference in the scapular kinematics and scapular muscle activation during pull-up between rock climbers with shoulder pain and healthy climbers, possibly due to no inclination during the pull-up task. Therefore, this study aimed to investigate kinematics and muscle activation of the shoulder and thoracic spine in rock climbers with shoulder pain during tasks designed to mimic climbing tasks.Methods: Thirteen rock climbers with shoulder pain and 13 healthy climbers matched with gender, age, and dominant hand have been recruited. Testing tasks included arm elevation in the scapular plane and climbing tasks. The climbing task was pull-up in backward inclination with overhead reaching upward and backward. Thoracic and shoulder kinematics were collected using an electromagnetic tracking system. The upper trapezius, lower trapezius, serratus anterior and latissimus dorsi were collected with surface electromyography (EMG). Results: Compared to healthy climbers, climbers with shoulder pain exhibited more serratus anterior muscle activation during arm elevation from 90 to 120 degrees ($p=0.03$) with no other difference in scapular and thoracic kinematics between groups. Additionally, climbers with shoulder pain demonstrated greater scapular posterior tilt during pull-up with overhead reaching upward ($p=0.027$) and backward ($p=0.023$), and less activation of the latissimus dorsi at 90 degrees of pull-up with reaching upward ($p=0.032$), as compared to controls. Furthermore, climbers with shoulder pain exhibited less thoracic extension range of motion compared to controls ($p=0.03$), with no differences in thoracic posture between groups. Conclusion: During arm elevation, climbers with shoulder

pain may increase the serratus anterior activation to maintain normal scapular kinematics. Greater scapular posterior tilt during pull-up shown in climbers with shoulder pain may be a compensatory movement to increase subacromial space. Furthermore, lower activation of the latissimus dorsi in climbers with shoulder pain suggests potential muscle imbalance issues that hinder the latissimus dorsi muscle from serving as the primary mover to provide the necessary force during pull-up. Additionally, assessing thoracic extension range of motion may be more important than assessing posture in climbers with shoulder pain.

## P3.9-C: Validation of Using Markerless Motion Capture System to Measure Functional Test in Patients with Degenerative Lumbar Disease: A Pilot Study

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Introduction:Degenerative lumbar disease (DLD) is a common geriatric condition that leads to lumbar degeneration and lower extremity dysfunction. Previous studies have shown that these patients exhibit significant abnormalities in lower extremity kinematics when performing functional tests, such as the five times sit-to-stand test, clinically. In the past, these kinematic changes were mainly detected using marker-based motion capture systems, which are not readily adaptable to clinical settings. With advances in technology, markerless motion capture systems have become popular.The purpose of this study was to investigate the validation of MediaPipe, a markerless motion capture system, compared to that of a gold standard motion capture system for the functional test in DLD. We hypothesized that there is a strong correlation for the five times sit-to-stand test in DLD between the markerless motion capture system and the marker-based motion capture system. Materials and Methods:DLD patients aged 50 to 80 with no surgical history were recruited. Data was captured using: 1) 11-camera VICON system (ver. 2.5, Oxford Metrics Ltd., Oxford, UK) with 45 reflective markers, 2) Markerless system with two iPhone 14 cameras - 2D poses estimated via MediaPipe (ver. 0.10.3, Google, California, USA), then lifted to 3D using 2D-to-3D approach. The pipeline is illustrated in Figure 1. To enhance the feasibility of rapid 3D human pose reconstruction, two calibrated cameras were placed in front of the participant with 40 cm apart, which is illustrated in Figure 2.The joint positions of the lower extremities in the anterior-posterior (A-P), medio-lateral (M-L), and vertical axes while performing the five times sit-to-stand test were analyzed using the Pearson correlation coefficient and 95% confidence intervals (95% CIs) and a p-value < 0.05 was considered statistically significant. Statistical analysis for this study was conducted using PASW Statistics 25. Results:Three DLD patients were recruited (age: 61.00 ± 8.19 years; height: 157.33 ± 55.51 cm; weight: 56.33 ± 1.53 kg). Validity data of the MediaPipe compared to the VICON were presented in Table 1. Discussions:The results supported our hypothesis of a strong correlation between the MediaPipe and VICON systems for the five times sit-to-stand test in DLD. Markerless systems can aid in assessing lower limb kinematics, providing objective data for DLD clinical intervention and facilitating telemedicine evaluation. Acknowledgement:This work was supported by National Science and Technology Council (MOST 111-2223-E-002-004-MY3) and National Taiwan University (NTU-113L7854) awarded to Dr. Wei-Li Hsu.

## P3.10-E: Oscillatory transcranial direct current stimulation targeting corticoreticular pathway increases common neural drives to thigh muscles during gait

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BACKGROUND AND AIM: Human gait depends on the integrated neural action of supraspinal and spinal levels, within which the corticospinal tract has important contribution. Recently, corticoreticular pathway (CRP), which is derived from the secondary motor areas such as pre-supplementary motor area (pre-SMA) to reticulospinal tract, has also been proposed to have an important role in human gait because CRP has a crucial role for bilateral activation of axial and proximal muscles during postural control. However, there is little evidence that non-invasive brain stimulation targeting CRP during gait can modulate the neural control of human gait. Therefore, we investigated the effects of oscillatory transcranial direct current stimulation (otDCS), which can modulate the potential and oscillation activity of brain neuronal membranes, targeting CRP on common neural drives to lower limb muscles during gait using coherence analysis of paired surface electromyography (EMG). METHODS: Sixteen healthy young adults were subjected to following treadmill gait measurements: pre-stimulation gait for 5 min, gait with otDCS over the pre-SMA for 11 min, and post-stimulation gait for 5 min. Subjects randomly experienced following 3 stimulation conditions on 3 different days apart from about 1 week: 10 Hz otDCS, 30 Hz otDCS, and sham stimulation. otDCS with a current intensity of 1.5 mA (ranging from 0 to 1.5 mA) was applied for 10 min with each 30 s fade in/out stimulation, and sham stimulation was applied only for 30 s. EMG-EMG coherence was calculated from following muscle pairs: the proximal and distal parts of the tibialis anterior muscle (TA-TA), medialis and lateralis gastrocnemius muscles (MG-LG), vastus medialis and lateralis muscles (VM-VL), and semitendinosus and biceps femoris muscles (ST-BF). The average coherence values in the 7.5 to 12.5 Hz (alpha) and 20 to 40 Hz (beta to low-gamma) frequency bands were calculated during the pre- and post-stimulation gait using each 200 gait cycles. RESULTS: Only one subject was excluded from statistical analyses because this subject had high coherence over 0.3–0.4 across a broad range of frequency bands, which might have been attributable to crosstalk, volume conduction, and/or current noise. In the 30 Hz otDCS condition, the average VM-VL coherence in the beta to low-gamma bands was significantly increased during the post-stimulation gait compared to the pre-stimulation gait. There were no significant differences between the pre- and post-stimulation gait in all paired EMG-EMG coherence in the alpha and beta to low-gamma bands in the 10 Hz otDCS and sham stimulation conditions. CONCLUSIONS: Since 30 Hz otDCS over the pre-SMA targeting the CRP increased the common neural drives to quadriceps muscles around stimulation frequency, otDCS targeting CRP during gait may be an effective rehabilitation tool in patients after stroke, who have low motor function in the proximal lower limb muscles.

## P3.11-E: Larnygeal magnetomyography using an array of optically pumped magnetometer

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Objective: This feasibility study investigated whether and to what extent laryngeal muscle activity can be recorded and functionally mapped contactless using magnetomyography (MMG)

with optically pumped magnetometers (OPM).Methods: Five healthy subjects vocalized a high-, normal- and low-pitched A-schwa ("Aaa...") several times for 5 seconds each in a total duration of 90 seconds with a loud and a soft voice while a 3x5 array of OPM recorded the magnetic muscle activity of the larynx and the neighboring cervical muscles. The root-mean-square (RMS) average of each pitch per individual subject was calculated, color-scaled, and mapped to a general cervical anatomy. In addition, the individual amplitude per pitch was calculated.Results: Although little consideration could be given to individual anatomical differences in the placement of the OPM and the subjects had not been trained beforehand, it was possible to identify an individual activity pattern for each subject that made it possible to distinguish between low and high pitches. The amplitude per pitch varied considerably between subjects (Min.: 0.4, Max.: 2.5 pT) and also the baseline noise between 0.2-0.5pT, which had to be taken into account for the analysis.Conclusions: Laryngeal MMG using an array of OPM is possible, but sensor positioning is crucial. In comparison to other skeletal muscles, the signal amplitude of laryngeal and neighboring muscles during vocalization is low.Significance: Functional, contactless muscle mapping of vocalization is feasible and might pose a new application of miniaturized quantum sensors for linguistic studies and speech rehabilitation.

## P3.12-E: Facial magnetomyography

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Objective: This feasibility study investigated whether and to what extent facial muscle activity can be recorded and imaged using non-invasive magnetomyography (MMG) with optically pumped magnetometers (OPM).Methods: Five healthy subjects performed 12 different standardized facial expressions (repetitive 2-second expression-trials during 90 seconds recording), while an array of 11 OPM of the right side of the face was utilized to measure the MMG of the respective facial muscles. The root-mean-square (RMS) average of each facial expression-trial per OPM and individual subject was calculated, color-scaled, and mapped to the individual face per facial expression to prove that an array of OPM can image facial muscle activity across facial expressions. In addition, the maximum average muscle activity and signal-to-noise ratio (SNR) per facial expression were calculated.Results: Facial muscle activity could be mapped individually per facial expression, but the positioning of the OPM revealed to be a crucial factor for mapping accurately muscle activity. The SNR ranged from 1 to 8, the maximal observed average muscle activity reached almost 25pT in one subject and was on average 1±0.57pT.Conclusions: Imaging facial MMG with an array of OPM is possible, but sensor positioning is crucial. In comparison to other skeletal muscles, the signal amplitude of facial muscles is low.Significance: As imaging of facial MMG is feasible, this study paves the way for future studies for using quantum sensors diagnostics, monitoring and rehabilitation of facial muscles.

## P3.13-F: Spatial-temporal transcutaneous spinal cord stimulation improves walking in humans with SCI

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The goal of this study was to determine whether the application of spatial-temporal transcutaneous spinal cord electrical stimulation will facilitate walking in humans with SCI. Ten subjects with chronic (>1 year) SCI were recruited in this study. They were tested in 3 different spinal stimulation conditions: swing phase, stance phase, and combined stance and swing phases. For the swing phase condition, two self-adhesive round electrodes (5cm diameter) were placed at ~2 cm laterally from the midline over L1 and L4 spinous processes of the weaker leg as active electrodes. The stimulation waveform used was monophasic, rectangular, 100 us pulses at a frequency of 80 Hz filled with a carrier frequency of 9.5 kHz. Each participant was tested in 4 sessions, i.e., L1, L4 phasic, and L1, L4 continuous. Participants walked on a treadmill with the stimulation was applied to L1 or L4 segment and each session was lasted for ~2 minutes. For the stance phase condition, a protocol that was comparable to the swing phase condition was used except that the active electrodes were placed at 2cm laterally from the midline over L3 and S1 spinous process and the stimulation frequency was 30 Hz. Each participant was tested in 4 sessions, S1, L3 phasic, and S1, L3 continuous. For the phasic stimulation sessions, the stimulation was delivered only during the swing or stance phases of the weaker leg for the swing and stance phase sessions, respectively. For the combined condition, a protocol that was comparable to the swing phase condition was used except that the stimulation was applied to S1 during stance phase with frequency of 30 Hz, and to L4 during swing phase with frequency of 80 Hz. For the control condition, no electrical stimulation was applied. Kinematics of pelvis and ankle, and muscle activity of the weaker legs were recorded.Results: For the swing phase stimulation condition, the step height of the weaker leg was significantly greater for the phasic stimulation at L4 (p = 0.02) and L1 (p = 0.045) compared to the control. The step height of the weaker leg tended to be greater for the phasic stimulation at L4 (p = 0.058) and L1 (p = 0.05) than that of the continuous stimulation. For the stance phase stimulation condition, step height of the weaker leg was significantly greater for the phasic stimulation at S1 than the control (p = 0.0498), and than that of the continuous stimulation (p = 0.038). The application of stimulation at L3 had no significant impact on the step height of the weaker leg (p = 0.16). For the combined condition, the step height of the weaker leg was significantly greater for the combined condition that the control (p = 0.04). Conclusion: The application of spatial-temporal spinal cord stimulation through non-invasive transcutaneous electrodes may facilitate walking in people with SCI. Results from this study may be used to develop a new intervention approaches for improving locomotor function in people with SCI through targeted non-invasive spinal cord neuro-modulation.

## **P3.14-F:** Does acute electrical muscle stimulation induce stress responses?

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Introduction: Recent studies suggest that electrical muscle stimulation (EMS) applied to lower limb muscles can be used as an alternative modality to voluntary exercise. Despite this, EMS often induces pain sensation, which may induce stress responses. However, it remains unclear whether EMS induces stress responses. The purpose of this study was to identify stress responses in response to a single bout of EMS in healthy participants.Method: Eleven male participants (age: 23.1 ± 0.9 yr., height: 172.2 ± 4.6 cm, weight: 65.2 ± 5.0 kg) were recruited for the experiment. Subjective pain was assessed using visual analogue scale (VAS) score at the end of EMS. Electroencephalogram (EEG), heart rate (HR), and salivary cortisol concentration were measured before and after acute EMS. EMS was applied bilaterally to the abdomen, glutes, thighs, and lower legs with an electrical stimulator while lying supine (Auto Tens Pro; Homerion laboratory Co., Ltd, Tokyo, Japan). The stimulator current waveform was set at a frequency of 4 Hz with a pulse width of 0.25 ms. Stimulus intensity was set at the maximal tolerable level. A power spectrum was calculated from the EEG signal using a fast Fourier transformation, and percentage of relative power of theta (4-8 Hz), alpha (8-13 Hz), and beta (13-30 Hz) bands was calculated. Inter-beat (R-R) interval data was used to assess autonomic modulation of HR, and LF to HF ratio (LF/HF) was calculated as an index of autonomic balance. Results:  Percentage of relative power of theta, alpha, and beta bands did not change after EMS at Fz, Cz, and Pz (all p > 0.05), whereas LF/HF ratio decreased after EMS (p = 0.008). EMS did not affect salivary cortisol level (p = 0.489).  However, there was a negative correlation between VAS score and changes in relative percentage of theta band (Spearman’s rho = -0.691, p = 0.023), suggesting that relative percentage of theta band was reduced with individuals who experienced stronger pain sensation.Conclusion: The present results suggest that EMS does not induce stress responses. However, stimulus intensity should be carefully set for each individual to minimize stress responses.

## P3.15-G: **Effects of blood flow restriction on muscle fatigue during isometric contractions**

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Blood Flow Restriction (BFR) is a training method that partially restricts arterial blood flow and completely restricts venous return by applying a cuff proximally on the target limb, exerting pressure (Scott et al., 2015). This acute reduction of blood flow, decreases oxygen supply, leading to muscle hypoxia, and blood pooling in occluded capillaries (Patterson et al., 2019). Originating from Japan's KAATSU (meaning ”training with added pressure”) proposed by Yoshiaki Sato in 1966, BFR was inspired by Sato's observation of muscle discomfort during prolonged kneeling. BFR induces muscle hypoxia during voluntary muscle contraction, affecting ATP rephosphorylation, reactive oxygen species production, and energy processes (Manini & Clark, 2009). Muscle tissue under BFR experiences greater oxygen depletion, switching to anaerobic metabolism, increasing blood lactate, and reducing pH. The higher AMP-activated protein kinase (AMPK) production in regular BFR training may explain increased muscle glycogen content (Manini & Clark, 2009).The aim of the present study is to observe the acute effects of blood flow restriction on muscle fatigue during isometric contraction in healthy subjects. The hypothesis is that higher percentages of blood occlusion lead to higher muscle fatigue, thus higher slope values for EMG variables such as mean power spectral frequency (MNF).The experiment was conducted on quadriceps muscles of five healthy volunteers.

Participants were sitting with the knee joint of the dominant leg at 90° and were asked to exert knee extension againss a strap fixed to the ankle with a constant torque of 50 Nm (provided by a visual feedback) until failure. Tests were administered in three different conditions: at 0%, 40%, and 80% of arterial occlusion pressure (AOP). For the restriction of blood flow, we used AirBands (AirBandsBFR, Newstead, Queensland), while EMG measurements were performed with bipolar electrodes positioned over vastus medialis and lateralis muscles using a wireless amplifier (Due, OT-Bioelettronica). ARV and MNF were computed using epochs of 1s to evaluate changes of amplitude and frequency during the endurance contraction. Perceived exertion was asked to the subject using the Borg CR10 scale, and individual discomfort was assessed through a modified VAS every 30s. A higher restriction percentage showed higher slopes of heart rate, as well as higher slope values for MNF. Higher percentages of BFR were also associatede with slighly higher ARV slopes during the contractions suggesting higher neuromuscular recruitment. Additionally, we observed that in 4 out of 5 participants, BFR resulted in higher values of perceived fatigue (Borg CR10). Given the limitations of the study and the nature of the sample, further in-depth research is necessary to determine which among the available percentage options may be most suitable for achieving greater neuromuscular fatigue and, therefore, establishing a more effective dosage for rehabilitative purposes.The preliminary findings underscore BFR's capacity to amplify muscular fatigue, hinting at its utility for endurance training. However, robust empirical support is necessary to confirm its clinical value.

## P3.16-H: Detection volume simulation of diaphragm bilateral sEMG electrodes using an MRI-based finite element model

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Surface electromyography (sEMG) of respiratory muscles is applied in assisted mechanical ventilation to analyze both respiratory effort and patient-ventilator-interactions. A variety of research projects used a differential electrode pair positioned bilaterally on the midclavicular lines on the costal margin for recording the diaphragm as the main respiratory muscle. However, no widely accepted standard has been established yet. Due to the diaphragm’s shape, the area of the costal part detected by these electrodes and contributing to the signal is non-obvious. The objective of this research project is to develop a numerical electrophysiological simulation of the diaphragm enabling the investigation of the detection volume. To implement an anatomical model, an MRI T1w sequence (Dixon) of the torso in the end-expiratory phase for one subject was acquired. Data were segmented into the lung, heart, rib cage, and diaphragm with Materialise Mimics 24.0 (Materialise NV, Leuven, Belgium). A size-principle motor unit (MU) pool was implemented. To reproduce the physiological fiber pathways, a curvilinear vector field in both hemidiaphragms was simulated using the curvilinear coordinates system simulation in COMSOL Multiphysics® v. 6.1 (COMSOL AB, Stockholm, Sweden). The homogeneously distributed fibers follow the vector field, and motor end plates as well as fiber ends were uniformly placed. MUs were assigned to fibers using a probability function depending on the MU size and proximity. To calculate single fiber action potentials (SFAPs), a reciprocal approach was used, which determines the fiber's transfer behavior by solving the Poisson equation in

COMSOL Multiphysics® v. 6.1. The obtained transfer function per fiber was convolved with the propagating signal component and static signal components were added. To visualize the detection volume the SFAP peak-to-peak amplitude is calculated. The MU pool was simulated for five stochastic seeds to account for the unknown physiological parameters. The MU pool resulted in approximately 16000 simulated muscle fibers. Due to the electrode positions bilaterally on the midclavicular line above the costal margin, the end-of-fiber effect is dominant in most SFAPs. The different stochastic seeds provide comparable peak-to-peak amplitudes of SFAPs. The visualization of the mean detection volume clearly shows the contribution of fibers in both diaphragm domes. However, only a limited area of the costal diaphragm on the ventral torso will make a substantial impact on the resulting sEMG signal. The anatomically and physiologically based simulation of the diaphragm provides useful information to enhance the understanding of respiratory sEMG. It enables the visualization of SFAPs and the resulting detection volume in the diaphragm. By considering further electrode positions and extension to the end-inspiratory breathing phase, the work has the potential to contribute to the standardization of electrode positions.

## P3.17-H: **A biophysical model of the motoneuron pool to understand the role of neuromodulation in motor control**

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Supraspinal regions control motoneuron activity by modulating their firing patterns to produce the desired muscle force. A substantial portion of these descending synaptic inputs project to multiple motoneurons within a pool, imposing a rigid constraint on their behaviour. Common synaptic input thus leads to the orderly recruitment — from smallest to largest — of motoneurons, and mediates force control through the modulation of motoneuron firing rate. Recent studies, however, have challenged this longstanding view of motoneuron control, suggesting that it may be more flexible. For example, Marshall et al. (Nature Neurosci, 2022), reported that the responses of motoneuron pairs evoked by intracortical microstimulation changed in relatively latency and magnitude depending on the stimulation site. Besides, Bräcklein et al. observed patterns of inversion of derecruitment, consistent with activity-dependent changes in motoneuron excitability (eLife, 2022). These observations conflict with the most rigid view of motoneuron control, and can be potentially explained by neuromodulatory processes.Neuromodulation refers to the alteration of motoneuron excitability that occurs due to neurotransmitter release — primarily, serotonin — from descending brainstem axons. The most significant neuromodulatory effects in the spinal cord are persistent inward currents (PICs). PICs impact motoneuron function via amplification, which accelerates the initial phase of motoneuron firing, and hysteresis, which sustains motoneuron firing activity even after the cessation of synaptic input. In this work, we aim to understand how neuromodulation leads to a more flexible control of motoneurons. Our first objective is to characterise the mechanisms that facilitate the inversion of motoneuron derecruitment. To better understand the distribution and interplay of PICs and inhibitory mechanisms with synaptic input, we are developing a biophysical model of a motoneuron pool that builds upon the Hodgkin-Huxley model. In our model, all motoneurons receive the same common synaptic input as well as different combinations of neuromodulatory and inhibitory signals; together, they drive the firing activity of single motoneurons. The parameters of the biophysical model will be optimised based on recordings from large populations (n~130 per participant) of motoneurons from the Tibialis Anterior and Vastus Lateralis muscles from 16 participants performing trapezoidal contractions during. Our model will also implement a feedback controller, to simulate motor control tasks. First, we will model the experiments by Bräcklein et al., in which participants had to control the movement of a cursor in two dimensions to acquire different targets by modulating the activity of two motoneurons from the same muscle. We will compare the results from simulations with different combinations of neuromodulatory and synaptic input to establish potential biophysical mechanisms underlying the reversion in motoneuron derecruitment order reported there.By replicating these and other experimental results, we expect our model to clarify the contributions of neuromodulatory inputs to motoneuron control, in particular in enabling a degree of flexibility that was unsuspected until very recently. Besides, by comparing across alternative implementations, we will be able to define potential mechanisms by which neuromodulation may achieve this additional flexibility.

## P3.18-H: A neuromorphic approach to decoding motor intentions from intraneural recordings of a trans-radial amputee

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Advanced prosthetic devices hold the promise of restoring dexterity for upper-limb amputees by decoding the user's motor intentions and delivering tactile sensory feedback during object manipulation. These bidirectional interfaces operate by recording and processing neural signals from multiple electrodes while concurrently stimulating the afferent pathway to elicit sensations. Crucially, both the decoding and encoding systems must unfold in real-time within a closed-loop framework, and continuously adapt to a changing neural signal. Furthermore, considering the wearability constraint of prostheses, processing of neural signals and stimulation modules should be implemented on low-power, low-latency, compact hardware placed in close proximity to the recording site. Consequently, careful consideration of algorithms and processing techniques alongside their hardware implementation is essential for the system realization.In this poster, we depart from conventional machine learning-based approach and adopt a neuromorphic, event-based computing paradigm for the processing of the recorded neural signals. Our primary focus is on the decoding pathway of the bidirectional prosthesis. We present the stages within a neuromorphic pipeline and demonstrate their advantages, in terms of pre-processing computation requirements, accuracy, and linearity on gesture decoding from nerve recordings, electroneurography (ENG), of a trans-radial amputee acquired using Transverse Intrafascicular Multichannel Electrodes (TIMEs). Neuromorphic computing is a computational paradigm that stands in stark contrast to conventional processing. By emulating the biophysical properties of biological neurons and synapses, neuromorphic systems adopts key biological features such as fault-tolerance, robust computation and event-driven, low-power processing. A neuromorphic pipeline starts with the encoding of recorded signals into a stream of events. The encoding stage should be carefully crafted to extract key features from the signal. Our findings demonstrate that using leaky-integrate-and-fire neuron model effectively converts the power of each ENG channel into a

sequence of spike trains and further increases the linear separability of the gestures. Next, a spiking neural network is trained to predict the intended motor task based on the firing rates of output neurons.We show that this event-based approach can decode 4 gestures of a trans-radial amputee. Furthermore, it enhances the overall robustness of the system, achieving an accuracy improvement from 62 % +/- 8 % to 67 % +/- 1.8 % compared to a traditional machine learning pipeline. These results suggest that neuromorphic processing holds significant value for the field of neuroprosthesis, particularly in addressing key constraints such as accuracy, latency, and power efficiency.

## P3.19-I: Modulation of bilateral motor learning by the order and timing of right and left upper limb movements

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When learning upper limbs movement in our daily life, it is common to start practicing with each limb individually, and then combine both limbs together. It is known that acquired skills through unimanual motor learning can only be partially transferred to bimanual movement (Nozaki el al., Nature Neuroscience 2006), which means that a specific practice is required to master a bimanual movement. In the bimanual task used in the previous study, participants only moved both limbs at the same time. However, in our daily life, we move both limbs in the certain order depending on the task (i.e., one-two punch in boxing). To expand the understanding of bimanual motor learning, therefore, the present study compared bimanual motor learnings where both limbs move in different order and timing. We used exoskeleton robot manipulandum to replicate a protocol from the previous study. Participants performed bimanual reaching task with forcefield perturbation on right limb. We altered the order and timing of limbs' movements as follows: 1) Perturbed limb and non-perturbed limb moved at the same timing (PTB-sync); 2) Non-perturbed limb moved first then perturbed limb followed after 0.1s (PTB-later-0.1s) or 1s (PTB-later-1s); 3) Perturbed limb moved first then non-perturbed limb followed after 0.1s (PTB-first-0.1s) or 1s (PTB-first-1s). By repeating the trials with forcefield perturbation, they gradually learned to reach straight to the target with the opposing force to the perturbation. Subsequently, we prepared two washout phases. First, in unimanual washout, they performed unimanual reaching with their right limb without the forcefield to forget the motor memory. Next, in bimanual washout, they performed bimanual reaching without the forcefield to confirm how much memory is remained. We evaluated the aftereffect by measuring lateral deviation of right limb's trajectory, with the first trial of unimanual and bimanual washouts. In PTB-sync condition, unimanual aftereffect was observed and bimanual aftereffect was also observed even after the unimanual washout (fig1. a). In PTB-later-0.1s condition, bimanual aftereffect was significantly larger than unimanual aftereffect (fig1. b). In contrast, in PTB-first-0.1s condition, unimanual aftereffect was significantly larger than bimanual aftereffect (fig1. c). In PTB-later-1s and PTB-first-1s conditions, unimanual aftereffect were larger, and bimanual aftereffect were smaller compared to 0.1s conditions (fig1. d, e). These results suggest the exhibition of two discrete nature of bimanual motor learning, such as "a single bimanual movement" or "two separate unimanual movements." PTB-later-0.1s condition with significantly greater bimanual aftereffect would mean that motor learning proceeded as a single bimanual movement. On the other hand, PTB-first-0.1s and PTB-first-1s conditions with significantly greater unimanual aftereffect would mean that motor learning proceeded as two separate unimanual movements.

## P3.20-I: Rhythmic Galvanic Vestibular Stimulation Modulates Sensorimotor Synchronization to Auditory Syncopation

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## P3.21-I: Temporal Relation Between Corticomuscular Coherence and Event-related Desynchronization is Associated with Force Output Strategies

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"Corticomuscular coherence (CMC)" is a synchronized phenomenon between the electroencephalogram (EEG) activity over the sensorimotor cortex and the electromyogram (EMG) activity of voluntary contracted muscle within the β-band (15-35Hz). However, there is a desynchronization in the β-band EEG activity known as "event-related desynchronization (ERD)", starting from motor preparation and leading to reduced EEG β-power. Our purpose is to clarify the temporal relation between the synchronized (CMC) and the desynchronized phenomena within the β-band during voluntary muscle contraction.In Experiment 1, 30 healthy young adults performed intermittent ballistic-and-hold contractions of the tibialis anterior muscle at 10% of maximal voluntary contraction (MVC). EEG β-power decreased before EMG activity onset and rebounded during force maintenance. The magnitude of β-rebound following ERD varied among individuals (Figure 1). Moreover, the CMC occurred after the muscle contraction onset and increased coincided with the dynamic β-rebound following the ERD (Figure 1A-C). Notably, participants with continuous ERD during force maintenance showed no significant CMC, whereas participants with clear β-rebound showed significant CMC (Figure 1D). Linear regression analysis revealed a positive correlation between β-rebound magnitude and CMC ($r = 0.54$, $p=0.0021$). Based on Experiment 1, we hypothesized that participants with continuous ERD and less CMC might make a greater effort to actively adjust their force even during the force-maintenance period, while those with clear β-rebound and greater CMC performed force maintenance with lower energy cost by using efficient sensorimotor integration. To test this hypothesis and investigate the individual differences in β-power rebound after ERD, we conducted experiment 2. In experiment 2, we compared the difference in temporal relation between ERD and CMC across tasks with different difficulties in controlling force output.In experiment 2, 9 participants with significant CMC from experiment 1 were involved in three tasks: 10% MVC straight-line task (identical to experiment 1), sin task (target line consisted of a sine wave with 10% MVC average and 2% MVC amplitude), and 3sin task (target line consisted of 3 sine waves with 10% MVC average and 2% MVC amplitude). Results aligned with our predictions with the highest β-rebound and CMC in the 10% MVC straight-line task and the lowest in the 3sin task (Figure 2).In summary, our studies clarified the temporal relation between ERD and CMC and demonstrated that the individual CMC difference was positively correlated with the extent of β-rebound. Furthermore, increased task difficulty in force adjustment resulted in lower β-rebound and CMC. Therefore, β-rebound variations suggested different strategies of force output: ongoing active adjustment of motor output in those with continuous ERD versus efficient adjustment after initially reaching the target in those with β-rebound. This distinction also correlated with CMC variations, indicating various extents of sensorimotor integration.

## **P3.22-I:** Discovering the occupational profiles and occupational performance of children with handwriting difficulties: A parent's perspective

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Background and aimHandwriting is a complex perceptual-motor skill that involves visual-motor coordination, motor planning, cognitive and perceptual skills, and tactile and kinesthetic sensitivity to effectively complete a writing task. The occupational profile and occupational performance analysis are combined in the evaluation to inform the occupational therapy intervention plan. The occupational therapist considers all aspects of the domain and assesses their impact on the others, both individually and collectively. The purpose of this research is to identify and analyze factors that support and hinder children's handwriting improvement.MethodsThis study conducted semi-structured individual interviews through purposive sampling with parents who have children with handwriting difficulties in Indonesia. In order to recruit participants, the researcher will ask teachers at the school where the study will take place to select parents who meet the criteria. Parents were asked about their perspectives on handwriting difficulties, the child's learning environment, and the child's learning process at home. This study was ethically approved by the ethics committee of the university where the authors are affiliated and conducted from September to November 2023. All participants gave informed consent before their participation.ResultsFive parents participated in the study. The interview lasted 45 to 60 minutes. A qualitative study with inductive content analysis was used to analyze the data, and two themes emerged: supportive factors and inhibiting factors. Details of the results are shown in result table. From the parents' perspective, they realized that their child has a difficulty with handwriting and they need to seek advice from professionals. At home, they provide a special place for practicing and also accompany their child while practicing. Even though they already set up an environment to study, the child often gets easily tired and have short attention span during practice. In addition, sometimes their siblings also distract while the child is practicing.ConclusionHandwriting is a complex skill that is not only related to the child's personal factors, but also related to the child's environmental factors. Most of the child's time during a day is spent at home. With a better understanding of the supporting and hindering factors of handwriting difficulties, OTs can provide appropriate practice to improve children's handwriting skills at home. From this study, it clearly stated that supportive family members, supportive environment and parent-child attachment could be considered while designing handwriting practice in child's natural environment.

## **P3.23-I:** Evaluation of neck force control and neck muscle activation in Astronauts post-spaceflight

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Background: Astronauts have an increased risk of cervical intervertebral disc herniation (IVD) post-spaceflight, yet the cause of this heightened risk remains elusive. People with neck pain commonly exhibit changes in neck muscle strength and altered neck muscle activity, which can contribute to the persistence of their symptoms. Whether astronauts experience similar

alterations post-flight and if these are linked to the higher prevalence of IVD in this population is yet to be determined. Purpose: This project aimed to explore potential alterations in the behaviour of the neck flexor and extensor muscles in astronauts after extended time (>120 days) at the International Space Station by utilising high-density surface electromyography (HDsEMG) and hand-held dynamometry.Methods: This study is ongoing, and to date, three astronauts have been measured at two measurement sessions (pre-flight and five days post-spaceflight). Neck flexor and extensor muscle isometric strength was recorded with a handheld dynamometer. Then, submaximal isometric neck flexor/extensor force steadiness was measured during force target-tracking contractions at 25% and 50% of their maximal voluntary contraction. Visual trapezoidal feedback of their force trace was provided on a monitor. HDsEMG signals were acquired bilaterally from the sternocleidomastoid (SCM) and splenius capitis (SCap) muscles in monopolar mode, using four grids of 64 equally spaced (4mm) electrodes. The monopolar signals were differentiated longitudinally in the direction of the muscle fibres for each muscle to form adjacent bipolar channels. Topographical HDsEMG amplitude maps were created to investigate regional changes in muscle activation across all electrode pairs, and modified entropy was calculated based on the root mean square values. Force steadiness was characterised by the force signal's standard deviation (SD) and coefficient of variation (CoV).Results: A consistent trend of reduced neck flexor and extensor muscle strength (19.37%), in addition to a decline in neck flexor and extensor muscle force steadiness (CoV: 61.39%; SD: 59.65%), was observed for all astronauts, five days after returning to Earth. Additionally, alterations were observed in the distribution and uniformity (modified entropy) of neck flexor and extensor muscle activation during the submaximal contractions.  Conclusions: This study offers preliminary insights into changes in neck flexor and extensor muscle behaviour immediately after spaceflight. The reduction in muscle strength and force control, together with changes in neck muscle activation, could be relevant factors in understanding the increased risk of IVD in astronauts. Given the preliminary nature of this work, these findings should be interpreted with caution. All additional data collected by the time of the presentation will be incorporated to strengthen these findings.Keywords: Neck muscles, Force steadiness, High-density EMG, Regional Activation This study is funded by the UK Space Agency (ST/X002233/1).

## P3.24-I: Effects of Stochastic Resonance-Based Mechanical Stimulation Intervention in the Abdominal Core Muscle on Static Balance: A Pilot Study

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Background: Young people have been exercising less due to lifestyle changes. This has resulted in poor muscle endurance and postural stability, increasing the risk of exercise injury or falls in exercise. Poor core stability has been identified as a risk factor for athletes' lower back and extremity injuries. Sensory Augmentation (SA) has proposed a potential positive intervention on postural control in people during standing. A novel design of vibrotactile mechanical stimulation system over the torso still not be confirmed experimentally.   Aim: This study aimed to discuss whether the stochastic resonance-based mechanical stimulation intervention in the abdominal core muscle can improve changes in postural stability during static balance. Method: Ten volunteers (2 men and eight women) participated in this study. All participants had no injuries in their lower limbs, did not experience any balance impairment, and were without any surgical history of lower limbs. Our outcome measures were the forefoot force, the midfoot force, the rear foot force, the total force in lateral and medial, and overall COP. Statistical analysis was performed using the Wilcoxon rank sum test, with a significance level defined at P <0.05. Result: After the intervention, significant differences in the decrease in pressure in medial total foot pressure (p=0.022) and lateral total foot pressure (p=0.022) were found during standing on the dominant side, significant differences in the subject's center of pressure (COP) the medial-lateral direction demonstrated the Sharped Romberg test with an open eye(p=0.022). However, the Romberg test with closed eyes condition reduced sway from the medial-lateral(MD=7.06) and anterior-posterior direction(MD=11.97) but no significant difference (p>0.05). Conclusion: The stochastic resonance-based mechanical stimulation intervention may improve our stability during single-leg standing.

## P3.25-I: Dynamic Taping Improves Scapular Neuromuscular Control in Individuals with Impingement Syndrome

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IntroductionSubacromial Impingement Syndrome (SIS) is the commonest disorder of the shoulder, accounting for 44%–65% of all complaints of shoulder pain [1]. Previous studies have found changes in scapular kinematics and muscle activation patterns [2,3]. To restore altered scapular kinematics and muscle activation in individuals with SIS, treatments for SIS commonly include scapula-focused exercises or/and taping. Recently, a newly developed biomechanical taping technique, dynamic tape, has been used in clinical practice to provide load absorption, force contribution and modify movement. However, only few studies have investigated the effect of dynamic tape in individuals with musculoskeletal injuries and no research has investigated the effect of dynamic tape in combination with exercises, in individuals with SIS. The purpose of this study was to investigate the immediate effects of dynamic taping in combination with scapula-focused exercise, compared to exercise alone on scapular kinematic and muscle activity in individuals with subacromial impingement syndrome.MethodsThis was a randomized control trial. We plan to recruit 30 individuals with SIS and randomly assign them into either an exercise group (Control group) or a dynamic taping with exercise group (Taping group). Both groups received one 30-minute treatment protocol of scapula-focused exercise. The taping group performed exercise with dynamic taping, which was applied to increase scapular upward rotation, posterior tilt and external rotation (Figure1). Outcome measures were collected at baseline and right after the treatment protocol. Outcome measures included scapular kinematics and scapular muscle activation (upper trapezius, lower trapezius and serratus anterior) during arm elevation with an electromagnetic device (ViperTM, Polhemus, Colchester, VT, USA) and surface electromyography (myoMotionTM, Noraxon, Scottdale, Ariz , USA). Scapular kinematics and muscle activation were calculated at 30° 60° 90° and 120° of the humerothoracic elevation. Changes from baseline to post-treatment were calculated to compare between groups.ResultsThis is an ongoing study. Ten individuals have been recruited (four individuals (4M/0F) in the taping group with average age of 28y, height of 1.8m, and weight of 79kg and six (5M/1F) in the control group individuals with average age of 29y, height of 1.7m, and weight of 75kg). The individuals in the taping group demonstrated significant increases in scapular external rotation at all elevation angles (p = 0.01 – 0.02), compared to control group (Figure 2).DiscussionCompared to those receiving only scapular motor control exercise, subjects having scapular motor control exercise with dynamic taping demonstrated increased scapular external rotation. These findings suggest that scapular exercise protocols for patients with SIS could include dynamic tape to improve scapular kinematics.References1. Bhattacharyya, Rahul et al. “Does arthroscopic sub- acromial decompression really work for sub-acromial impingement syndrome: a cohort study.” BMC musculoskeletal disorders vol. 15 324. 29, 20142. Ludewig, Paula M, and Jonathan P Braman. “Shoulder impingement: biomechanical considerations in rehabilitation.” Manual therapy vol. 16,1, 20113. Phadke, V et al. “Scapular and rotator cuff muscle activity during arm elevation: A review of normal function and alterations with shoulder impingement.” Revista brasileira de fisioterapia vol. 13,1, 2009

## P3.26-I: What is optimally updated in split-belt treadmill adaptation?

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The human motion involves redundancy, where movements to achieve a goal are not uniquely determined. In particular, it is unclear how to modify the redundant motion features in minimizing objective functions, e.g., movement error. A possible solution is to decompose motion features into task-relevant and task-irrelevant features and modify only the task-relevant features.However, there are few frameworks to evaluate how we modify redundant motion features when objective function is not evident. Split-belt treadmill adaptation is an example where objective function is not yet clearly defined. Although several studies assumed the asymmetry of step length as a modified motion feature (Vasudevan+, 2010, Jnp), recent studies reported a contradictory result against the assumption (Sanchez+, 2021, Jnp).Here, we propose a novel objective function in split-belt adaptation based on optimality of learning direction in redundant motion features. We assume that asymmetries of some kind of step parameters can be candidates of objective functions in split-belt adaptation. Under this assumption, the equilibrium state is “x_fast–x_slow=const”. The optimal learning direction, in the two-dimensional plane consisting of “x_fast“ and “x_slow”, is a vector “v” parallel to “v=(-1,1)”. By utilizing goal-equivalent manifold, we quantified variability along with the direction of “v”, optimality-relevant dimension, and that along with the orthogonal vector of “v”, optimality-irrelevant dimension. If some motion features are modified in an optimal manner, the variability in optimality-relevant dimension is larger than the variability in optimality-irrelevant dimension.In adaptation, assuming the objective function to be the minimization of step length asymmetry did not lead to optimal learning directions. Conversely, assuming the objective function to be the minimization of step velocity asymmetry resulted in learning towards the optimal direction. Within the framework of minimization of step velocity asymmetry, we can explain the change of sign in step length asymmetry in some cases.Furthermore, upon investigating the adaptive muscle activity, it became evident that muscles such as peroneus longus and medial gastrocnemius exhibited adaptive patterns in the fast leg. This is associated with the acceleration component of the Ground Reaction Force (GRF), indicating acceleration of gait due to left ankle plantarflexion. Conversely, in the slow leg, muscles like rectus femoris and vastus lateralis depicted adaptive patterns. This is linked to the deceleration component of GRF, signifying deceleration of gait due to right knee extension. These muscle activity components are implicated in the correction of walking speed asymmetry between both sides, suggesting a potential role in resolving asymmetry in step velocity.

## P3.27-I: Impact of perturbation type on muscle activation: insights from medial gastrocnemius responses to split-belt treadmill perturbations

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High Density surface Electromyography (HDs-EMG) has allowed the investigation of regionally-specific muscle activation during functional tasks. This study examined the impact of standing balance perturbation type on spatial muscle activity in the right medial gastrocnemius (MG). Eleven participants (22±3 yrs; 5 female, 6 male) experienced three perturbation types whilst standing on a split-belt treadmill: unilateral (left belt) and bilateral (both belts) backward translations and unilateral (left belt) forward translations. Each translation was 300 ms in duration and delivered at the maximal perturbation intensity without needing to take a step. HDs-EMG, using a 64-channel grid with 8 mm interelectrode distance, was employed to record spatial muscle activity within the MG of the right (stance) leg. Spatial activity analysis utilized the barycenter of the HDs-EMG, characterized as the weighted mean of maximal average rectified values across columns and rows, and assessed the medio-lateral and proximo-distal shifts in MG muscle activity. Perturbation type exerted a discernible influence on the barycenter location. Specifically, unilateral forward translations elicited a proximal shift (F=7.87, p<0.0001), while unilateral (F=6.91, p<0.0001) and bilateral backward translations (F=2.72, p= 0.008) resulted in a distal shift of the MG barycenter. Additionally, a medial shift of the barycenter was observed (F=1.91, p<0.04) in the unilateral forward translations. Analysis further revealed an association between perturbation type and muscle burst amplitude, with unilateral (F=5.33, p<0.001) and bilateral (F=8.54, p<0.001) backward translations eliciting larger HDs-EMG bursts compared to unilateral forward translations. There was no statistically significant difference in barycenter location or burst amplitude between the unilateral and bilateral backward translation perturbation types. Collectively, these findings revealed that the stance leg experiencing maximal standing perturbations activated different regions of medial gastrocnemius muscle, highlighting unique adaptive strategies contingent upon the direction of the perturbation.

## P3.28-K: Proximo-distal modulation of biceps femoris long head motor units during knee flexion and hip extension isometric tasks

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BACKGROUND AND AIM: Regionalized neuromuscular responses have consistently been reported for the rectus femoris and gastrocnemius [1,2], suggesting task-dependent activation in biarticular muscles. However, evidence regarding the biceps femoris long head (BFlh) is controversial, showing both homogeneous [3] and non-uniform patterns [4] when comparing knee flexion and hip extension movements. These discrepancies may be attributed to methodological issues in surface electromyography (EMG), especially amplitude cancellation [5]. To overcome these issues, in this study we decomposed high-density surface EMGs from the BFlh muscle to investigate whether the discharge rate of motor units located in distinct proximo-distal regions could be modulated differently during knee flexion and hip extension tasks.METHODS: Seventeen healthy men performed isometric knee flexions and hip extensions with trapezoidal ramp feedback set at 20% and 40% of maximal voluntary isometric contraction (MVC). Tasks were performed with the knee and hip in a neutral position. High-density surface EMGs (2 grids of 32 channels) were acquired from the proximal and distal regions of the BFlh. EMGs were decomposed into motor unit spike trains using a convolutive blind-source separation algorithm [6], and the mean discharge rate (MDR) was calculated during the plateau (30s), separately for each region. Linear mixed models (LMM) were applied to compare the effect of the two contractions intensities and the two BFlh regions on the MDR. Bonferroni's post-hoc test was used for paired comparisons.RESULTS: For both tasks, a significant main effect was observed (LMM; F > 6.021; P < 0.001 for both). In the knee flexion task, pairwise comparisons revealed a significant increase in MDR between 20% and 40% MVC in the distal region, but not in the proximal region (panel A). In the hip extension task, significant increases in MDR across contraction intensities were found for both proximal and distal regions (panel B). Conversely, for both tasks, no differences were observed in the MDR between proximal and distal regions, regardless of the contraction intensity.CONCLUSIONS: Our results revealed that proximal and distal regions of the BFlh exhibit a similar motor unit discharge rate pattern, regardless of the joint involved in the task. Moreover, this homogeneous pattern remained unchanged across different contraction intensities. These findings suggest that the motor units located in different proximo-distal regions of the BFlh are modulated similarly during isolated knee flexion or hip extension isometric tasks.REFERENCES: [1] Miyamoto et al. 2012; PLoS ONE 7(3)[2] Cohen et al. 2020; Experimental Brain Research, 238(1)[3] Watanabe et al. 2016; Journal of Applied Biomechanics, 32(1)[4] Hegyi et al. 2019; Scandinavian Journal of Medicine and Science in Sports, 29(1) [5] Keenan et al. 2005; Journal of Applied Physiology, 98(1)[6] Negro et al. 2016; Journal of neural engineering, 13(2)

## P3.29-K: **Underlying Changes in Motor Units Properties in Presence of Epidural Spinal Cord Stimulation in Individuals Affected by Spinal Muscular Atrophy**

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Spinal Muscular Atrophy (SMA) is the most common genetic disease of the spinal motor neurons (MN) and the most common cause of death in infants [1]. The disease causes motor neurons death and consequently muscle atrophy and motor impairment [2] as well as pulmonary and gastrointestinal complications [1]. Lefebvre et al. [3] identified the homozygous deletion of the SMN1 gene as the cause of SMA already in 1995, however, as of today, there are no effective disease-modifying treatments for SMA [1]. Moreover, Fletcher et al. [4], hypothesized that the effects of SMA on motor neurons may progressively expand to proprioceptive synaptic inputs, intensifying disease progression. Specifically, they have shown how the blockade of proprioceptive synaptic drive led to decreased MN firing rate and consequently motor behavior impairments.Here we hypothesized that epidural Spinal Cord Stimulation (SCS) could increase the MNs firing rate resulting in greater muscle strength and potentially reverse maladaptive changes in the spinal motor neurons. Over the past 20+ years, SCS has been applied to treat motor recovery after SCI, Stroke and Parkinson disease revealing striking motor improvements both at the lower and upper limb level. SCS preferentially recruit large diameter sensory afferents in the dorsal column and dorsal roots which in turn deliver synchronous volleys of excitatory inputs to α-motor neurons innervating the muscles. We hypothesized that the increased synaptic input mediated by SCS would increase the firing rate of MNs during active movements.In this study, two 8-contact SCS leads were implanted percutaneously in the dorsal epidural space of the lumbar spinal cord targeting bilateral lower extremity muscles in three participants affected by SMA. Participants kept the SCS leads implanted for 29 days to test immediate and long-term effects of SCS. To assess changes in the motor units' properties, we recorded HDsEMG signals from both knee extensor (i.e., rectus femoris) and flexor (i.e., hamstring) muscles. Participants were asked to perform two sets of three Maximum Voluntary Contractions (MVC) of knee extension and flexion in isometric condition using Humac Norm Isokinetic Machine. One 8x8 channel flexible HDsEMG grid was placed over the Rectus Femoris and Bicep Femoris muscles and signals were acquired using the TMSi SAGA 64 high density amplifier. HDsEMG recordings were then decomposed using the convolution kernel compensation (CKC) method.The MN spiking data show immediate increases in the firing rate in presence of SCS targeting lower limb muscles. Similarly, long-term effects on MNs population reveal increased firing rate after 4 weeks of testing with respect to the pre-implant even in absence of SCS. These results therefore support the hypothesis that SCS can compensate for MNs deficits such as decreased firing rate in people affected by SMA, potentially reversing maladaptive changes in spinal motor neurons. [1] Arnold, W. David, "Spinal muscular atrophy: diagnosis and management in a new therapeutic era." Muscle & nerve 51.2 (2015)[2] Montes, Jacqueline, et al. "Clinical outcome measures in spinal muscular atrophy." Journal of child neurology . Cell(1995)[3] Lefebvre, Suzie, et al. "Identification and characterization of a spinal muscular atrophy-determining gene." [4] Fletcher, Emily V., et al. "Reduced sensory synaptic excitation impairs motor neuron function via Kv2. 1 in spinal muscular atrophy." Nature neuroscience 20.7 (2017)

## P3.30-K: The influence of maturation on muscle strength, muscle size, and motor unit firing rate in soccer players.

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[Introduction and Purpose] It is believed that rapid muscle hypertrophy occurs during puberty with the increase in sex hormone secretion, while the development of the neural system is accelerated before puberty. However, the changes in muscle size and neural function associated with the development of muscle strength before and after pubescent are still unclear. Based on the peak height velocity (PHV), a key reference marker of maturation, this study aimed to clarify the developmental process of maximal strength, muscle size, and motor unit (MU) activity in children aged from pre- to post-PHV. [Methods] Ninety-eight soccer players aged 6 to 18 years participated in this study. They performed maximal voluntary isometric contraction with knee extensor (MVC, Nm). Muscle thickness of the quadriceps muscles (MT, cm) was measured. High-density surface electromyography (HDsEMG) was collected from the vastus lateralis during a submaximal ramp-up contraction to 70 %MVC. All HDsEMG signals were decomposed into individual MU activity. MU firing rate (FR) was calculated during the plateau phase of the 70%MVC ramp-up contraction. Input-output gain (pps/%MVC) was calculated from the relationship between the change in FR (ΔFR) and the change in exerted force (Δ%MVC) from recruitment to the plateau phase. All MUs were categorized into two groups based on their recruitment threshold: low-threshold MU (LT MU, MUs recruited at <30%MVC) and high-threshold MU (HT MU, MUs recruited at 30%MVC to <60%MVC). Estimated PHV age was calculated from body height history with AUXAL software. Participants ranging from three years before PHV to three years after PHV were included for further analysis. They were classified into three maturity groups according to their maturity status: pre-PHV (-3 years to > -1 years from PHV), circa-PHV (-1 to +1 years from PHV), and post-PHV (>1 to +3 years from PHV), respectively (n=18, 15, 13).[Results and Discussion] Circa-PHV and post-PHV showed significantly greater MVC and MT than pre-PHV (p < 0.05), and no significant difference was observed between circa-PHV and post-PHV. No significant group differences were observed in MU FR and input-output gain both in LT MU and HT MU. These findings suggested that developmental change in MU FR and the input-output gain were limited around PHV age. The gap in maximal strength between pre-PHV, circa-PHV, and post-PHV would be explained by the difference in muscle size.[Conclusion] Circa-PHV and post-PHV showed greater MVC and MT but not MU FR and input-output gain compared to pre-PHV. Maturation affects maximal strength and muscle size but does not neural function.

### P3.31-K: A multi-site analysis of female motor unit discharge behavior across the menstrual cycle [Poster Award]

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Biological studies have historically excluded females, resulting in a strong understanding of the neural control of movement in males, but a poor understanding in females. Furthermore, studies across the female menstrual cycle are often underpowered. There is a great need to study female motor physiology because many aspects of neurological disease and human performance differ between the sexes. Sex-related differences in neuromuscular fatigue and motor unit discharge patterns have been observed in recent work, including variations across the female menstrual cycle, but the underlying mechanisms remain unknown. One possible mechanism is the magnitude of motoneuronal persistent inward currents (PICs), which are facilitated by descending monoaminergic inputs. PICs modulate motor unit discharge patterns and estimates of their magnitude are greater in females. Endogenous levels of estradiol and progesterone fluctuate across the menstrual cycle in females not using hormonal contraception, and these hormones have known effects on monoaminergic signaling throughout the central nervous system. Therefore, fluctuations in female sex hormones are likely to influence PICs and, subsequently, motor unit discharge. The purpose of this collaborative, multi-site research effort is to explore the mechanisms behind sex-related differences in motor unit discharge by quantifying discharge properties across the female menstrual cycle.At four different universities, motor unit discharge properties and hormone levels were examined across the menstrual cycle. At each session, venous blood samples were taken, and high-density surface electromyograms were sampled from the tibialis anterior during isometric dorsiflexion contractions. Plasma levels of estradiol and progesterone were subsequently quantified, and blind source separation algorithms were used to identify motor unit spike times. PIC magnitudes were estimated using the paired motor unit analysis technique, which quantifies discharge rate hysteresis ($\Delta F$) by obtaining the discharge rate of a lower-threshold motor unit (reporter unit) at the onset and offset of a higher-threshold motor unit (test unit).Preliminary data revealed during the late follicular phase, when estradiol levels were elevated, estimates of PIC magnitude were lower (4.36 ± 0.60 pps) compared to the early follicular (5.15 ± 0.59 pps) and mid luteal (5.21 ± 0.60 pps; χ2 = 6.19, p = 0.045) phases. These findings suggest that fluctuating sex hormones have a substantial impact on motor unit discharge behavior, and that elevated estradiol levels might either reduce descending monoaminergic drive to motor units, alter patterns of inhibition, and/or have direct effects on intrinsic motoneuron excitability. These novel findings underscore the necessity of studies focusing on female participants both to ensure a comprehensive understanding of motor physiology and to strive towards scientific equity.

## P3.32-K: Effects of vibrotactile stimulation on motor unit recruitment and firing behavior

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BACKGROUND AND AIM: The effect of cutaneous afferents on motor unit recruitment remains inconclusive, with some evidence of inhibitory and excitatory effects on low and high threshold motor units, respectively. However, previous studies primarily utilized electrical stimulation, therefore bypassing the skin’s mechanoreceptors. This study aims at evaluating the effect of vibrotactile stimulation on motor unit recruitment and firing behavior during low-force contractions. METHODS: Eleven healthy young adults (7 men) participated in a trapezoidal force task involving the dominant first dorsal interosseus muscle. The task consisted of a 2.5-s ramp-up, a 5-s plateau sustained at 10 % of the maximal voluntary contraction (MVC) and a 2.5-s ramp-down. Participants executed three repetitions without cutaneous stimulation (CTR) and three with vibrotactile stimulation (VIB) in a randomized order. Vibrotactile stimuli, delivered by a linear resonant actuator (1.5 G) at a center frequency of 175 Hz, targeted the Paccini cutaneous receptors on the radial surface of the first metacarpophalangeal joint. In the VIB tasks, the stimulus was delivered 2 seconds before force onset and persisted throughout the trial. High-density surface electromyography recorded muscle activity, and a decomposition algorithm extracted motor unit (MU) spike trains. MUs were tracked for all VIB and CTR trials, and the recruitment threshold (RecTh), discharge rates at recruitment (RecDR), plateau (PlateauDR), and derecruitment (DerecDR), and discharge rate variability (PlateauDRCoV) were compared. Statistical analysis included dependent t-test for parametric distributions and Wilcoxon signed-rank tests for non-parametric distributions. Linear regression assessed the potential differential effects of VIB based on MU RecTh (during CTR). RESULTS: Vibrotactile stimulation significantly reduced RecTh (Z = -3.447, p = 0.001), particularly affecting the later recruited MUs (Fig. 1A). The linear regression between RecTh at VIB and CTR revealed a slope smaller than one (slope = 0.827, confidence interval [0.733, 0.922], p < 0.001). VIB also increased PlateauDR (t(81) = -2.47, p = 0.016), with a slightly stronger effect on the later recruited MUs (Fig. 1B). Linear regression between RecTh at CTR and the difference between PlateauDR at CTR and VIB demonstrated a slope smaller than zero (slope = -0.188, [-0.318, -0.058], p = 0.005). However, no statistically significant differences were observed between CTR and VIB for RecDR (Z = -0.423, p = 0.672), DerecDR (Z = -0.996, p = 0.319) and PlateauDRCoV (Z = -1.167, p = 0.243). CONCLUSIONS: Vibrotactile stimulation increased the excitability of motor units with recruitment thresholds up to 10% MVC, exhibiting a more pronounced effect on the later recruited units.

## P3.34-K: The Neuromuscular Functions in Stroke Patients Were Changing Depending on the Post-Onset Phases

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Stroke impaired voluntary motor function in patients. Paralysis post-stroke is a complex neuro-muscular condition because patients have primary neurological impairment and secondary disused dependent dysfunction. The aim of this study was to clarify the neuromuscular features, such as motor unit (MU) recruitment patterns in stroke patients at different phases.Eight subacute stroke patients and eight chronic stroke patients were recruited. We attached wireless surface EMG (Trigno Galileo; 2,222Hz) sensors on each biceps brachii muscle on the affected side and the less affected side to record muscle activity. Subjects performed a maximum voluntary contraction (MVC) followed by a force control task. The acquired muscle activity was decomposed into motor unit action potential (MUAP). From the obtained MUAP spike trains, the timing at each MU started firing (First firing timing) was detected. The quartile range and median of the First firing timing for all MUs recruited were then calculated and used as the Recruitment range and Recruitment threshold, respectively. We performed a two-way ANOVA on the phases factor and test side factor for MVC Force, Recruitment range, and Recruitment threshold. We also performed an unpaired t-test on the clinical score of the affected side in each group.MVC Force was a significant difference in the test side factor (p < 0.00), while there were no significant differences in the phases factor (p = 0.05). There was no significant difference in the recruitment range in the test side factor (p = 0.59) while there was a significant difference in the phases factor (p = 0.03). The recruitment threshold showed no significant difference in the test side factor (p = 0.99) while there was a significant difference in the phases factor (p = 0.02). The clinical score of the subacute stroke group showed no significant difference between the groups (p = 0.29).There were no significant differences in clinical scores and no significant difference in the phases factor in MVC Force. This indicates that the subacute stroke group and chronic stroke group had similar levels of paralysis. Nevertheless, neuromuscular functions such as the recruitment range and the recruitment threshold had a significant difference chronologically. Thus, the neuromuscular functions in stroke patients change depending on the phases. We should not only evaluate post-stroke paralysis with existing clinical scores but also investigate the neuromuscular functions of each phase in detail.

## P3.35-K: Selection of Optimal Multidimensional Feature Sets for Tracking Motor Unit Action Potentials

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Surface EMG decomposition enables the non-invasive detection of a relatively large number of concurrently active motor units. Reliably track the activity of the same motor unit across different trials, however, can be challenging when compared with traditional intramuscular recordings. The most commonly used methods of tracking motor units recorded using high-density arrays are based on the two-dimensional cross-correlation (Martinez-Valdes et al., 2017). Cross-correlation based methods, however, are highly sensitive to changes in motor unit action potential (MUAP) shape, which can occur with fatigue or MUAP superposition. An alternative approach proposed utilizes multidimensional representation of MUAP trajectories to characterize the waveform representation across multiple channels . Features extracted from the MUAP trajectories can be clustered, enabling MUAPs corresponding to the same motor unit to be identified and those with different spatial representations, originating from different motor units, to be distinguished. A number of different features are available to characterize the multidimensional motor unit trajectories , however, it is not clear which subset of features is optimal for representing the unique features of each motor unit, or whether this varies with muscle type. To address this, in this study we systematically examine the efficacy of different features in quantifying the similarity between pairs of MUAP trajectories using simulated and experimentally obtained MUAPs from the first dorsal interosseous muscle. The robustness of the feature set to perturbations in waveform shape, typical of those that can occur experimentally, was examined by distorting MUAPs waveforms through alterations in MUAP amplitude, the introduction of noise, and changes in muscle fiber conduction velocity. A total of 11 features were identified and tested. To measure the robustness of the features, the accuracy, sensitivity, specificity and clustering metrics including the Dunn index were used. Every possible combination of features was computed and given a score based on the metrics, the set of features that performed best among all the tested data sets was deemed to be the most robust for tracking MUAPs from the same motor unit. The original set of features was thus reduced to 4 final features: the standard Euclidian distance, the minimum projected distance and the Procrustes distance between trajectories as well as the instantaneous angle between velocity vectors. In conclusion, novel tracking methods using multi-dimensional representations of MUAP trajectories were used and the most robust features to consistently track motor units across trials were identified. Future work will investigate the optimal features in other muscles with different muscle fiber architecture and surrounding tissue properties to investigate the sensitivity of the optimal feature set to factors such as spatial filtering, fiber pinnation and muscle size.

## P3.37-L: Characteristics of muscle synergy in upper limb for reaching movement to different body locations

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Introduction: The upper limb muscles have intermuscular coordination during upper limb movements. It has been reported that intermuscular coordination is also exhibited during reaching movements and can be represented by a small number of muscle synergies. The muscle synergies are shared between subjects or between movements, and a shared muscle synergy may be the basis of intermuscular coordination. The shared muscle synergy during reaching movements has not been widely examined; thus, its characteristics still need clarification. This study examined the characteristics of muscle synergy during reaching movements to a body segment, focusing on shared muscle synergy.Methods: Muscle activities of upper limb muscles were measured while seven healthy adults performed reaching movements to the body location (head, lower back, contralateral shoulder, and ipsilateral ankle joint) with their dominant hand. Surface electromyographic signals were recorded from 17 muscles (4 shoulder girdle muscles, six shoulder joint muscles, three elbow/forearm muscles, and four wrist muscles). Root mean square waveforms were calculated from the electromyographic signals and were extracted during reaching movement as the muscle activity waveforms. Global muscle synergies were extracted from the non-negative matrix factorization for the muscle activity waveforms of all subjects during all movements, and task-specific muscle synergies were extracted from the non-negative matrix factorization for the muscle activity waveforms of all subjects during each reaching movement. For examining shared muscle synergies, muscle synergies were classified based on the cosine similarity between global and task-specific synergies.Results: Six global muscle synergies were extracted, which consisted of the coordinated pattern between the shoulder girdle and shoulder joint muscles and between the shoulder joint muscles and between shoulder girdle muscles. The coordinated pattern between the shoulder girdle and shoulder joint muscles was shared in all reaching movements. The shoulder girdle muscle pattern was similar in the three locations of reaching movement. The coordinated pattern between shoulder joint muscles was similar in the two locations of reaching movement.Conclusions: The coordination pattern between the shoulder girdle and shoulder joint muscles results in motor coordination between the scapula and humerus, which may provide the basis of body part reach. In addition, the coordination pattern between shoulder joint muscles, depending on the direction of reaching movement, is considered an activity specific to the direction of reach. These results suggest that upper limb muscles during reaching movements may be controlled by both intermuscular coordination underlying reaching movements and direction-specific intermuscular coordination.

## P3.38-L: Variations of lower limb muscle synergies during single leg squat depending on dynamic knee valgus.

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Background and aim Dynamic knee valgus (DKV) is a dynamic alignment that can be assessed through movements such as single leg squat (SLS). The ideal movement pattern is one in which the knee is not displaced medially, and a larger valgus is a risk factor for musculoskeletal disease of lower limb. Characteristics of people with larger DKV include larger trunk tilt and smaller dorsiflexion angle of the ankle joint. In addition, it has been reported that muscles such as the gluteus muscles and quadriceps are less active than in people with good dynamic alignment. However, coordinated muscle activity is still unclear. Therefore, this study focused on the relationship between kinematic differences that can be observed from outside the body and the coordination of muscle activity created inside the body. The purpose of this study was to investigate whether specificity is expressed in muscle synergy during single leg squat depending on the amount of DKV.MethodsTwenty-four healthy young adults (12 males, 12 females, age: 21.8 ± 0.7 years) participated in this study. The task was SLS with 60° of knee flexion at a comfortable speed on the dominant leg. DKV was calculated using frontal plane projection angle (FPPA) and subjects were divided into two groups (Large group and Small group) according to the median of the FPPA value. Muscle synergies were extracted from surface electromyography data of 12 dominant lower limb muscles using non-negative matrix factorization. The extracted muscle synergies were classified using the k-mean method based on synergy vectors to ensure that all data fell into one of the clusters. Statistical analysis for the

FPPA and synergy number was performed by applying the Shapiro-Wilk test, followed by the t-test or Mann-Whitney U test. The significance level was set at 0.05.ResultsThe median of the FPPA was 8.26°, used as a grouping criterion. The mean values for each group were Large group:15.9 ± 4.6° and the Small group: 4.5 ± 2.3° (p < 0.05). There were no significant differences in the number of muscle synergies between groups. Considering the average number, three muscle synergies were extracted from each subject and clustered using the k-mean method and divided into five groups. Each subject displayed distinct combinations, with the most frequent combination was Synergy1, 2, and 4. (Large group: 8/12 subjects, Small group: 5/12 subjects).ConclusionsThe percentage of subjects showing the most combinations differed between the groups. While similarity existed within the Large group, the Small group showcased diverse muscle synergy combinations. This implies that kinematic characteristics influence extracted muscle synergy patterns, even during the same task movement. It highlights the importance of flexibility in exercise performance rather than adhering rigidly to specific patterns for optimal outcomes.

## P3.39-L: Functional coordination of multiple muscles depends on time-frequency characteristics of target tracking movements

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When riding bicycles, one must steer the handlebars along the road while occasionally making swift adjustments in response to unexpected obstacles or pedestrians. This process involves generating movements towards a goal across different frequencies over time. Previous research on target tracking tasks, where movements were produced to follow a continuously moving visual target, demonstrated that the movements were flexibly controlled based on changes in goals and environmental conditions, as observed through various frequencies in the time-frequency domain (Yang et al., 2021, eLife). However, it remains unclear how the activity of multiple muscles is coordinated to produce movements with diverse time-frequency characteristics. This study aimed to elucidate the control of muscle activity for generating movements with a variety of time-frequency characteristics.Participants performed a task where they exerted force on a fixed handle in front of them while seated, gripping the handle with one hand. The force exerted in the horizontal plane was measured by a force sensor embedded in the handle, and a cursor corresponding to the measured force was displayed in real-time on a monitor. Additionally, the monitor showed a tracking target, synthesized from 14 different sine waves, with frequencies ranging from 0.1 to 2.15Hz, varied amplitudes, and phase shifts. The participants aimed to align the cursor with the moving target as accurately as possible. The required force for tracking was set below 5% of the participant’s maximum exerted force. The tracking task consisted of 48 trials, each lasting approximately 50 seconds. Surface electromyography (EMG) was recorded from 8 upper limb muscles. Coherence among activities of individual muscle pairs was initially calculated for 28 different combinations. Subsequently, non-negative matrix factorization was applied to these coherence functions to identify groups of muscles exhibiting shared time-frequency characteristics (Boonstra et al., 2015, Sci Rep).The study demonstrated several muscle control modules responsible for generating target-tracking movements across a broad range of time frequencies. The module activating distal arm muscles was associated with movements at relatively high time frequencies, whereas the module involving muscles closer to the trunk was linked to lower frequency movements. These results indicate that different muscle groups are recruited according to the frequency of movements. Furthermore, the other module was identified that involved muscle activity across a mixture of various frequency bands. These findings suggest the functional coordination of muscle activity to accommodate movements over a range of time frequencies. The modular control system, dependent on time-frequency, would allow for flexible adaptation and precise control over a diverse array of movements, from those requiring rapid adjustments to those demanding slower, more sustained changes.

## P3.40-L: Mechanomyography of Biceps Brachii Using the Microphones Array

Pilkee Min, student

According to the evaluation of muscle function during static exercise using an accelerometer and microphone, the accelerometer was reported to be less likely to introduce motion artifacts than the microphone [1], and muscle function was also evaluated using an accelerometer and a microphone during dynamic exercise in the biceps brachii muscle, and the microphone was reported to be less likely to introduce motion artifacts than the accelerometer [2]. It was reported that motion artifacts were less likely to be introduced by the microphone than by the accelerometer [2].However, this was due to the fact that muscle function was evaluated using Microphones Array at a single location on the muscle fiber,In this study, muscle function is evaluated in the biceps brachii muscle by Mechanomyography using an array of microphones to evaluate muscle function at different locations on the muscle fibers.Concentric and isometric contractions were performed on five healthy male subjects with three microphones attached over the right biceps brachii muscle at elbow joint angles ranging from 40° to 140°. Concentric contractions were performed at speeds of 10°/sec and 20°/sec, while isometric contractions were performed at 0°/sec. The contractile forces used were 20% and 40% of the maximum voluntary contraction (MVC) measured at 90° elbow angle during isometric contractions. The central frequency was used for analysis. The results showed that separate signals were obtained from the microphones at each position, so the Mechanomyography had different signals when the same muscle was applied in different positions.

## P3.41-M: Deltoid muscle and cortical complexity: a task-based analysis

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Introduction: How the M1 provides neural drive(ND) to specific motoneuron pools (MN) or if this is rigidly or flexibly wired depending on task constraints remains unclear. Classic M1 mapping methods enable the exploration of motor evoked potentials(MEP) with limited spatial resolution. High-density electromyography(HDsEMG) might gain extensive insights into muscle activity patterns and their organization over M1, especially in muscles with complex functions[e.g., deltoid muscle(DM)]. We hypothesized that certain M1 regions may steadily trigger MEPs irrespective of tasks, suggesting shared functions. Conversely, distinct areas might evoke task-specific responses, reflecting specialized roles of M1. Methods: Anterior(AD), Middle(MD) and Posterior(PD) DM regions were mapped with transcranial magnetic stimulation(TMS) in 4 right-handed healthy adults. They performed isometric shoulder abduction(ABD) in 90° at 5% of MVC. In separate trials, they were provided with feedback from each DM regions. Hotspot, Active and Resting motor threshold(aMT/rMT) for each region were identified. Three rounds x 42 stimuli were delivered over a 7x6cm grid at 120% aMT/rMT of the target portion. We generated a HDsEMG muscle map for each grid site. After normalisation to MVC, we explored 1)the difference between Rest and Active HDsEMG muscle maps(as % of sites with increased, decreased, and unchanged values in respect of the total sites) and 2)the differences between trials with feedback from each DM region(as % of the overlapped and non-overlapped area, in respect the total area). Results: Initial analysis shows how HDsEMG MEP distribution is M1-sites and task-dependent(Figure 1). Collectively, in ~63% of the map, the MEPs amplitude rises during Active from Rest[AD: 61(21)%; MD: 65(22)%; PD: 64(25)%], in ~33% MEPs amplitude doesn't change [AD: 33(18)%; MD: 29(16)%; PD: 29(20)%] and in ~4% MEPs amplitude falls[AD: 3(5)%; MD: 4(6)%; PD: 5(5)%]. When compared across feedback, 67(18)% of the maps overlap between AD and MD, 76(11)% overlap between AD and PD and 67(20)% overlap between PD and MD. Discussions: Initial findings suggest that MEP in the Active state differ between M1 sites of TMS. Changes in MEP amplitude from Rest to Active states are uneven across the HDsEMG grid. Although the proportion of HDEMG grid sites with amplitude changes is fairly consistent across the 3 feedback tasks, the distributions for AD, MD and PD don't fully overlap – some HDEMG grids sites are consistent between pairs of feedback tasks, but other change in a feedback-specific way. This suggests some independence of connections between M1 and MN for the 3 regions of the DM. Greater common responses between AD and PD suggest a greater common ND between the two, than MD. MD has the greatest mechanical advantage for pure ABD. The shared role of AD and PD to generate ABD, but with antagonistic functions (i.e., sagittal/transversal plane), might highlight coordinate action to prevent these motions.

## P3.42-M: Neuromuscular Mechanisms during Squatting Movement by Electroencephalogram and Electromyogram Coherence Changes in Healthy Young People

Kana Mori, Juntendo University; Reona Arai, Juntendo University; Shinji Onuki, Juntendo University; Hitoshi Makabe, Juntendo University; Eizaburou Suzuki, Yamagata Prefectural University of Health Sciences; Kenichi Kaneko, Fuji University

Background and aim: Squatting movements have been shown to improve balance function and prevent falls in older adults, but the neuromuscular mechanism still needs to be elucidated. Therefore, this study aimed to investigate the neuromuscular mechanisms during the squatting movement by examining Electroencephalogram and Electromyogram (EEG-EMG) coherence, and Electroencephalogram and Electroencephalogram (EEG-EEG) coherence changes. METHODS: Thirty healthy young people (male15, female15, age: 21.9 ± 0.7) participated in this study. The squatting movement was performed from standing position to a squatting posture with hip and knee joints at 90 degrees for 5 seconds and then to a standing position for 5 seconds after holding the squatting posture for 5 seconds. The squatting movement was divided into four phases according to the contraction pattern of the quadriceps muscle: (1) static phase, (2) eccentric phase, (3) isometric phase, and (4) concentric phase. A wireless biometric device (MP208, Miyuki Giken) measured electroencephalogram (EEG) and electromyogram (EMG) at 1000 Hz sampling frequency during squatting. EEG activity was recorded through unipolar silver electrodes placed at Fp1, Cz, and P3 by the international 10-20 system. Ag/AgCl surface EMG electrodes (Kendal H124SG, 30mm×24mm, interelectrode

distance between electrodes 2 cm) were placed in the vastus medialis of quadriceps femoris muscle (Quad) and medial head of gastrocnemius (Gas) of the right leg. The impedances of the EEG and EMG electrodes were kept below 10k Ohm. The Welch algorithm calculated EEG-EMG coherence (Fp1-Quad, Fp1-Gas, Cz-Quad, Cz-Gas, P3-Quad, P3-Gas) and EEG-EEG coherence (Fp1-Cz, Fp1-P3, Cz-P3) in beta (13-30Hz) bands (window width: 1024 points, overlap 512 points, resolution 1Hz). Differences in EEG-EMG coherence and EEG-EEG coherence in the four phases of the squat movement were examined using ANOVA. RESULTS: The EEG-EMG coherence between P3 and Quad in the beta band was significantly higher in the concentric phase than in the static phase. The EEG-EEG coherence between P3 and Cz was significantly higher than the coherence of EEG-EMG between P3 and Quad in all phases. Discussion: The brain-muscle network function was more facilitated in the concentric phase of squatting movement because the EEG-EMG coherence between P3 and Quad was significantly higher in the concentric phase. In addition to that, the network function between brain regions, especially between the frontal and parietal lobes, was promoted during the squatting movement. These results suggest that squatting movement may promote the network function between the brain and muscle and between brain regions.

### P3.43-M: **Neuromuscular Mechanisms during Squatting Movement by Electroencephalogram and Electromyogram Coherence Changes in Healthy Young People**

Kana Mori, Juntendo University; Reona Arai, Juntendo University; Shinji Onuki, Juntendo University; Hitoshi Makabe, Juntendo University; Eizaburou Suzuki, Yamagata Prefectural University of Health Sciences; Kenichi Kaneko, Fuji University

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phase than in the static phase. The EEG-EEG coherence between P3 and Cz was significantly higher than the coherence of EEG-EMG between P3 and Quad in all phases. Discussion: The brain-muscle network function was more facilitated in the concentric phase of squatting movement because the EEG-EMG coherence between P3 and Quad was significantly higher in the concentric phase. In addition to that, the network function between brain regions, especially between the frontal and parietal lobes, was promoted during the squatting movement. These results suggest that squatting movement may promote the network function between the brain and muscle and between brain regions.

## P3.44-M: **Distinguishing the neural origins of the anticipatory postural adjustment**

Cassandra Russell, University of Wollongong; Jonathan Shemmell, University of Wollongong

Background: Anticipatory Postural Adjustments (APAs) are crucial for postural stabilisation during voluntary perturbations[1]. The location of generation and execution of APAs in the brain is speculated to be cortical[1], however startreact (SR) studies using startling acoustic stimuli (SAS), a brainstem probe[2], released APAs at shorter latencies than voluntary APAs[3], suggesting the brainstem may release the APA. However, studies using Transcranial Magnetic Stimulation (TMS) and SAS simultaneously, and found the silent period induced by TMS delays SAS-induced movement onsets in a wrist extension task[4], suggesting cortical involvement. It remains unclear whether posturally-related APAs are dependent upon cortical or subcortical motor pathways.Objectives: We investigate APAs in the postural lower limb muscles, using SAS and TMS-induced cortical inhibition to assess the impact of cortical state on APA latency. Design: The onset of the APA from a stepping task was recorded with electromyography (EMG) from right tibialis anterior and soleus muscles. An auditory warning and Go cue initiated the APA. TMS was applied 200 ms prior to the Go cue and SAS were placed 30ms prior to, simultaneous with and 30ms after TMS firing, and alone.Results/Discussion: The average APA latency following a 'Go' cue was 90 ms in the tibialis anterior (TA) (N=3), and 126ms in the soleus, due to its initial inhibition in the APA. A SAS applied 200 ms prior to the Go cue, changed the onset latency to 50 ms (p<0.001, t-test). This was also significant in the soleus (p <0.001). In the TA activation was then significantly delayed (p= 0.002) when SAS and TMS stimuli were applied synchronously relative to SAS alone. TMS applied alone 200 ms prior to the Go cue increased TA latency by a further 40 ms, suggesting that APA expression can occur during cortical inhibition. In the soleus synchronous TMS+SAS resulted in a significantly shorter response than with SAS alone (p= 0.049), possibly due to the different role of the soleus in the APA, or the small sample. The APA delay then was significantly longer when TMS was applied at 200 ms prior to the Go cue alone (p= 0.040).Conclusion: TMS contributes to delayed APA onset when paired with SAS akin to previous work[7], alluding to cortical control, but the brainstem cannot be ruled out due to the advancement of APA onset when TMS is paired with SAS vs alone.1.Gahéry, Y. and J. Massion,Co-ordination between posture and movement. Trends in Neurosciences,1981.4(C):p.199-2022.Brown, P, et al, New observations on the normal auditory startle reflex in man. Brain, 1991.114(4):p.1891-19023.MacKinnon,CD, et al,Preparation of anticipatory postural adjustments prior to stepping. Journal of Neurophysiology, 2007.97(6):p.4368-43794.Alibiglou,L. and CD.Mackinnon,The early release of planned movement by acoustic startle can be delayed by transcranial magnetic stimulation over the motor cortex. Journal of Physiology,2012.590(4):p.919-936

## P3.45-M: Comparing objective and subjective thresholding methods for subthreshold galvanic vestibular stimulation

Nathan Difford, University of Wollongong; Paul Stapley, University of Wollongong; Cassandra Russell, University of Wollongong; Jonathan Shemmell, University of Wollongong

BackgroundSubthreshold electrical vestibular stimulation has been shown to improve the control of balance and posture in both healthy individuals and those with balance deficits due to age or pathologies (1,2). However, inconsistencies exist in the methods used to determine a participant's stimulation threshold, with a range of both physiological and perceptive thresholds employed in the literature (2). While some measures of threshold are objective, such as centre of pressure and body sway, they reflect the response of the balance system as a whole. This could potentially result in an overestimation of the threshold at which the vestibular system responds to stimulation. Vestibular evoked myogenic potentials (VEMPs) offer a direct, objective measure of the state of the vestibular system (3). Our aim was to compare commonly used physiological and perceptive thresholds with VEMP thresholds by ascertaining the relative stimulation levels at which responses to galvanic vestibular stimulation are observed in measures of balance perception, center of pressure and VEMPs. MethodContinuous cathodal galvanic vestibular stimulation (GVS) was applied to the mastoid processes of young participants (n = 9; mean age = 28.3), while VEMPs were unilaterally elicited using a 118 dB air-conducted tone burst. VEMPs were recorded via a surface EMG electrode placed on the sternocleidomastoid muscle ipsilateral to the stimulus. Baseline VEMP amplitude (without GVS) was measured. Subsequently, participants stood on a force plate while GVS was incrementally increased in 0.1 mA steps until they reported both a tingling sensation behind the ears (cutaneous threshold) and a sensation of swaying (perceived threshold). The centre of pressure sway threshold was determined on a force plate as the point at which the Ax deviation from quiet stance exceeded four standard deviations. VEMPs were then elicited with GVS starting at 0.1 mA and gradually increased until reaching 120% of the highest recorded threshold. Two-minute rest periods were provided to participants between blocks of trials to prevent fatigue.ResultsA one-way repeated measures ANOVA showed a significant difference between the physiological and perceptive threshold measures reported ($F = 7.66$, $p = 0.006$). Post hoc analysis was performed using two-tailed t-tests on three variables (Cutaneous, perceived sway, and change in CoP). The analysis revealed that Cutaneous threshold was significantly lower than perceived threshold (t-stat = -5.12, $p = 0.0014$). Additionally, CoP threshold was initially found to be significantly lower than perceived threshold (t-stat = 2.86, $p = 0.024$). However, after Bonferroni correction for multiple comparisons (adjusted $p = 0.017$), the difference in CoP was no longer statistically significant.ConclusionThe preliminary results of this study show a significant difference between perceptive and physiological thresholding techniques used to determine subthreshold levels of GVS to improve the responsiveness of the vestibular system. This highlights the need for a standardized thresholding technique for more accurate and reliable research and clinical outcomes. References1. Lajoie, K., Marigold, D.S., Valdés, B.A. and Menon, C., 2021. The potential of noisy galvanic vestibular stimulation for optimizing and assisting human performance. Neuropsychologia, 152, p.107751.2. Goel, R., Kofman, I., Jeevarajan, J., De Dios, Y., Cohen, H.S., Bloomberg, J.J. and Mulavara, A.P., 2015. Using low levels of stochastic vestibular stimulation to improve balance function. PloS one, 10(8), p.e0136335.3. Rosengren, S.M., Colebatch, J.G., Young, A.S., Govender, S. and Welgampola, M.S., 2019. Vestibular evoked myogenic potentials in practice: Methods, pitfalls and clinical applications. Clinical neurophysiology practice, 4, pp.47-68.`

### P3.46-M: Neuromuscular adaptations after isometric knee extension training performed at the knee flexed (muscle lengthened) versus at the optimal joint angle

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Introduction:Growing evidence suggests that training at long muscle lengths produces greater hypertrophy than training at short muscle lengths. However, it is unknown whether this superiority holds true when compared to training at the optimal joint angle for maximum torque production. We therefore compared the effects of isometric knee extension training performed at the knee flexed (muscle lengthened) versus at the optimal joint angle on the changes in quadriceps muscle size and strength.Methods:Nineteen healthy males performed isometric knee extension training in a seated position unilaterally with each leg (randomly allocated to the following conditions): one leg at the knee flexed angle (FLEX: 135° of knee flexion) where the knee extensors are at long muscle lengths, and the other leg at the individually assessed optimal knee joint angle for knee extension torque (OPT: 75 ± 7°). Both legs completed 5 sets of 10 repetitions (5-s isometric contraction and 5-s relaxation per rep) at the same relative torque (70% of maximum voluntary torque) during each training session, and 2 sessions/week for 12 weeks. Another 11 healthy males served as controls (CON). Isometric maximum knee extensor torque and electromyogram (TQ and EMG: at 20, 50, 65, 75, 85, 105, 135° of knee flexion) as well as MRI-derived muscle volume of the individual and whole quadriceps were assessed before and after the intervention for each leg in all participants. Additionally, hypoxic state (tissue oxygen saturation, StO2) of the quadriceps during exercise was measured at the first training session.Results:Throughout the intervention period, absolute torque output was always greater for the OPT than FLEX (+73% on average, P < 0.001) as expected. On the other hand, StO2 during exercise was lower for FLEX than OPT (45 ± 8% vs 53 ± 7% on average across muscles/sets, P < 0.001). There were significant increases in individual and whole quadriceps muscle volumes after FLEX (+13.6 – 17.1%, all P < 0.001), but no changes after OPT (+1.1 – 2.1%, P = 0.141 – 0.339) or CON (-0.4 – +0.4%, P = 0.622 – 0.981). Changes in TQ and EMG demonstrated joint-angle specificity in both training conditions (i.e. pronounced increases of TQ and EMG around the training angle, P ≤ 0.001), with no such changes found in CON (P = 0.058 – 0.956).Conclusions:Training at a long muscle length produced greater hypertrophy than training at the optimal joint angle. This suggests that muscle length (joint angle) rather than absolute torque output is a more influential factor, and even the necessary stimulus, for inducing quadriceps muscle hypertrophy during resistance exercise.

### P3.47-N: Morphologic characteristics in femoral cartilage in collegiate athletes for 11 sports and non-athletic males: a cross-sectional study

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BACKGROUND: Long-term high-intensity exercises with insufficient recovery can lead to deterioration of the structural integrity in articular cartilage. Comparisons of the femoral cartilage morphology across athletes for various sports and non-athletic individuals would be an early detection and a surrogate assessment of knee joint and cartilage health. PURPOSE: To cross-sectionally compare the femoral cartilage cross-sectional area (CSA) in collegiate athletes for 11 sports and non-athletic males. METHODS: A total of 589 males (34 Archery, 46 Badminton, 69 Baseball, 56 Basketball, 65 Judo, 54 SsiReum, 47 Taekwondo, 20 Tennis, 40 Track and Field, 48 Volleyball, and 66 Wrestling athletes, and 44 non-athletic individuals) volunteered. After a 20-min unloading period (seated with their knees fully extended), ultrasonographic images (frequency: 10 MHz, gain: 20 dB, frame rate: 30 fps, and depth: 3.0 cm) of the femoral cartilage on each side were obtained and manually segmented to calculate the CSA using ImageJ software. Femoral cartilage CSA values (mm2) were normalised by body mass index (BMI; kg/m2). Age, sex, height, weight, BMI, career, knee injury and osteoarthritis score (KOOS), a history of knee injury (none, left, right, and both sides) and a history of knee surgery (history or non-history), and pain perception were collected via questionnaire. After performing a variable selection using Multivariate Regression, ‘group’, ‘a history of injury’, and ‘a history of surgery’ were selected as the independent variables. Therefore, two-way analysis of variance with Tukey tests as post-hoc comparisons (α = 0.05) were performed to assess group (group by side; 12 × 2), a history of injury (injury history by side; 4 × 2), and a history of surgery effects (surgical history by side; 2 × 2). Cohen’s d effect size (ES) with 95% confidence intervals was calculated. RESULTS: There was no group by side interaction (F11,1177=0.50, p=0.91). There was a group effect (F11,1177=36.24, p<0.0001; Table 1) that Volleyball and Archery showed the largest and smallest femoral cartilage CSA (left: p<0.0001, ES=1.80; right: p<0.0001, ES=2.31). There was no injury history by side (F3,1177=0.20, p=0.90). There was an injury history effect (F3,1177=6.82, p<0.0001) that subjects who had a history of injury on both sides had a larger femoral cartilage CSA compared with subjects who had a history of injury on the left side (p=0.01, ES=0.29) and did not have an injury history (p=0.0002, ES=0.41). In addition, subjects who had a history of injury on the right side had a larger femoral cartilage CSA than the subjects who did not have experience of an injury (p=0.03, ES=0.23). There was no surgical history and side effect (F1,1177=0.07, p=0.93). CONCLUSIONS: Joint loading patterns from sports-specific movements and a history of lower-extremity injuries appear to be responsible for a long-term adaptation of the femoral cartilage morphology. Volleyball athletes showed the largest femoral cartilage CSA and Archery was the smallest. Subjects who had a history of injury to both sides had a larger femoral cartilage CSA than those who did not have an injury history.

## P3.48-N: The effect of measurement conditions on thigh muscles' size in vivo

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Background: Postural conditions during measurements of muscle size using magnetic resonance imaging (MRI) have not been well standardized across studies, and in the case of the thigh musculature there are studies employing supine or prone positions with the thigh compressed on an examination table, or suspended between the hip and knee secured high above the table. In each case, the thigh under compression or being sagged with gravity, can result in deformation of muscles which can change muscles' shape thereby affecting anatomical cross-sectional area (ACSA). Moreover, thigh compression can increase the external and intramuscular pressure in the thigh which may pump the existing water out of muscles and decrease muscle volume (MV). This study aimed to investigate the effect of postural conditions on muscle ACSA and MV.Methods: Twenty male participants (10 Olympic-style weightlifters and 10 untrained controls) underwent 3-T MRI scans in the supine and prone positions with the thigh compressed and suspended conditions, respectively, in a randomized and counterbalanced order. From the obtained axial images, the maximal ACSA (ACSAmax) and MV of 11 individual thigh muscles/muscle groups were assessed. As it was difficult to identify the boundaries between the adductor magnus, brevis, and longus, the sum of these muscles was assessed as the adductors. Four postural conditions were compared using a one-way repeated measures analysis of variance followed by multiple comparisons with a Bonferroni correction.Results: Upon the thigh compression, ACSAmax of vastus medialis (-3.3±1.6%, p < 0.001, d = 2.910) and vastus intermedius (-4.3±3.8%, p < 0.001, d = 1.307) and MV of semitendinosus (-2.9±1.9%, p < 0.001, d = 1.624) and semimembranosus (-3.7±2.9%, p < 0.001, d = 1.617) were significantly smaller in prone than in the supine position. In the supine position, ACSAmax of rectus femoris (-5.5±4.3%, p < 0.001, d = 1.337) and adductors (-4.3±2.9%, p < 0.001, d = 0.753) and MV of rectus femoris (-3.6±3.7%, p < 0.001, d = 0.889), vastus medialis (-2.5±2.9%, p < 0.001, d = 0.951), and adductors (-2.8±3.0%, p < 0.001, d = 0.991) were significantly smaller in compressed than in the suspended condition.Conclusion: In this study, we found significant, inhomogeneous, and large-sized effects of the measurement positions (supine versus prone) and conditions (compressed versus suspended) on the thigh muscles' ACSAmax and MV. These results may reflect the effects of deformations due to muscle compression/suspension and fluid shifts due to changes in external and intramuscular pressure. Our findings suggest the need to standardize the postural conditions for thigh muscle MRI and to take into account differences in postural conditions when summarizing results between studies (e.g., examining muscle-specific hypertrophy/atrophy and intervention effects).

## P3.49-P: **Effects of an augmented neuromechanical rehabilitation program on an acute phase after Achilles tenorrhaphy.**

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Introduction: Achilles tendon rupture is one of the most common tendinous injuries of the lower extremity. To date, little is known about the effects of neuromechanical rehabilitation protocols that begin during the first week after surgery. This study aims to assess mechanical and electrophysiological variables before and after an augmented neuromechanical rehabilitation protocol during the acute phase of an Achilles tenorrhaphy.Methods: This study was approved by the ethics committee of Clínica MEDS. 5 participants who meet the eligibility criteria were selected for this study. All patients were assessed during the first week after surgery and a second evaluation was performed 5 weeks after surgery. Variables assessed were, medial gastrocnemius stiffness using a Myoton PRO device, plantar flexor steadiness (% CoV) on the injured leg was quantified at 10% of the maximal voluntary contraction (MVC) and 20% of the MVC on the non-injured leg using a feedback trace as previously described in the literature, Achilles tendon length was assessed through ultrasonography. The rehabilitation protocol included 2 to 3 days a week of training for 5 weeks, during which EMGs feedback of the gastrocnemius medialis activity was provided to patients, also through ultrasonography feedback of the Posterior Tibialis, Flexor Hallucis Longus and Flexor Digitorum Longus muscle

contraction was provided. The Shapiro Wilk test was used to assess the data's normality, then the Mann–Whitney U test was used to compare medians.Results: There were significant differences (p < 0.05) in the plantar flexor steadiness of the operated limb between the before-protocol (17.00% CoV) and after-protocol (13.40% CoV) periods. Also, there were significant differences (p < 0.05) in the Gastrocnemius Medialis EMG signal amplitude of the operated limb between the before-protocol (0.50 mV) and after-protocol (0.89 mV) periods. There weren´t significant differences in the other variables measured. Conclusion: Augmented Neuromechanical Rehabilitation programs during an acute phase after Achilles tenorrhaphy have positive effects on plantar flexor steadiness and gastrocnemius medialis EMG amplitude of the operated limb. Steadiness improvement and an increase in EMG amplitude have been associated with better functional performance and an increase in intermuscle coordination respectively, providing evidence that miofeedback through EMG or ultrasonography feedback are promising tools to implement in rehabilitation programs.

## P3.50-P: **Design, development, and experimental validation of an Augmented Reality Biofeedback system providing information about muscle activation through HD-sEMG**

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BACKGROUND AND AIM. The use of electromyography-based biofeedback (BF) in sport and rehabilitation contexts has been widely investigated to improve voluntary muscle activation; BF has been demonstrated to have a remarkable potential in the treatment of a broad range of musculoskeletal conditions[1]. Augmented Reality (AR) allows to superimpose virtual contents over real-world scenes. Although AR has been proven to be effective in several biomedical applications[2], in rehabilitation settings it is mainly used to show virtual objects that patients have to interact with overlayed in the real world. The use of AR to provide biofeedback of electrophysiological signals is largely unexplored. This work aims to describe the design, development, and experimental validation of an AR-based BF framework for the monitoring of muscle activity from high-density surface electromyography (HD-sEMG).METHODS. Figure 1a shows the System Architecture. A wireless Body Sensor Network of HD-sEMG acquisition systems (Sensor Unit-SU) transmits EMG signals detected with one or more electrode grids to a PC or Mobile Device (Signal Processing Unit-SPU). The SPU calculates a muscle activation index for each grid (e.g. EMG RMS) and transmits this to one or more Feedback Units (FUs, e.g., tablet or Microsoft HoloLens). A monochromatic marker is attached over each electrode grid. The FUs recognize the markers and provide the augmented BF by coloring the electrode detection area according to the muscle activation level. The system was tested in an experimental study. Twenty-three healthy individuals and nine diagnosed with Patellofemoral Pain Syndrome were recruited. Both groups underwent two randomized measurement sessions performing isometric sub-maximal and fatiguing knee extensions with and without the AR BF. HD-sEMG signals were collected from Vastus Medialis (VM) and Lateralis (VL) muscles using two 8x4 electrodes grids (10mm inter-electrode distance). During the fatiguing contraction with the AR BF, the participants were required to modify their muscle activity, alternating the activation between VM and VL (Figure 1b). Endurance time, root mean square, and mean frequency normalized slopes were computed from the single-differential EMG signals and compared between the two conditions. Ongoing experiments on the symptomatic group are underway to increase the sample size.RESULTS AND CONCLUSIONS. The asymptomatic group exhibited a notably higher mean endurance time compared to the symptomatic group in both sessions, increasing when the AR BF was used. Further analyses on myoelectric manifestations of muscle fatigue and differences between the tested groups are in progress. The developed system was successfully tested in a rehabilitation scenario from a technological point of view. The demonstration of its effectiveness and advantage with respect to standard BF requires further research.REFERENCES[1] O. M. Giggins et al., JNER, 2013.[2] D. J. Im et al., Ann. Rehabil. Med., 2015. This collaborative work is partly funded by a Royal Society International Exchange Award (ES\R3\223137).

## P3.51-P: The immediate effects of Vibrotexture insoles on quiet standing balance and lower limb neuromuscular responses in healthy young adults

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Sensory-stimulating footwear devices are an emerging rehabilitation tool, which are designed to optimize balance control by providing enhanced sensory input to the plantar surface of the feet. Prior work has shown that insoles delivering a single source of sensory stimulus (vibration or texture) can improve clinical and laboratory measures of balance in young and old, healthy and disease populations. We propose that a hybrid insole design, delivering vibration and texture stimuli (‘Vibrotexture’) will offer greater benefits to balance control than insoles with a single stimulus. This study aimed to investigate the immediate effects of wearing Vibrotexture insoles (compared to vibrating, textured, and control [no stimulation] insoles) on standing balance and lower limb neuromuscular responses in healthy young adults.  Thirteen participants (9 females; 26.1±7.1 years; 65.6±8.8kg; 166.3±7.9cm) stood on a force plate with standardised foot and body position. Participants performed tests of quiet standing balance over 30 seconds with eyes open and closed, on a firm and foam surface, whilst wearing each of the four insoles (2 trials/condition) within standard shoes. Balance measures were centre of pressure (COP) velocity and COP anteroposterior (AP) and mediolateral (ML) excursion. Amplitude of lower limb muscle activity was examined using surface electromyography at the medial gastrocnemius, soleus, peroneus longus (PL), rectus femoris, biceps femoris, and gluteus medius (dominant leg only). Data were analyzed using a two-way (surface and eye condition vs insole) repeated measures analysis of variance. Post-hoc tests were performed using pairwise comparisons with a Bonferroni adjustment.Analysis of COP velocity revealed main effects for insoles (p=0.01) and conditions (p<0.001). Pairwise comparisons showed greater COP velocity when wearing vibrating insoles compared to textured insoles (p=0.02). For COP AP excursion, there were main effects for insoles (p=0.01) and conditions (p<0.001). COP AP excursion was greater when wearing vibrating insoles versus Vibrotexture (p=0.01) and textured (p=0.02) insoles. For COP ML excursion, there were main effects for insoles (p=0.04) and conditions (p<0.001), with no post-hoc differences between insoles (p>0.09). Greater PL amplitude was observed when wearing Vibrotexture insoles compared to vibrating insoles (p=0.02). Wearing Vibrotexture insoles for the first time does not appear to have a superior benefit on standing balance, over and above vibrating or textured insoles. However, our results suggest Vibrotexture insoles may have the capacity to alter underlying neuromuscular responses, specifically the amplitude of lower limb muscle activity, for balance control. The effects of Vibrotexture insoles may become apparent during more challenging balance tasks or on other measures of neuromuscular control (e.g., timing of muscle activity) in healthy and patient groups; this requires further investigation.

## P3.52-P: **Closed-loop transcutaneous vagus nerve stimulation (tVNS) approach for facilitating motor learning and rehabilitation with neuromodulation** [Poster Award]

Joshua Posen, Georgia Institute of Technology; Milka Trajkova, Georgia Institute of Technology; Nathaniel Green, Georgia Institute of Technology; Koki Asahina, Georgia Institute of Technology; Chanyeong Choi, Georgia Institute of Technology; Woon-Hong Yeo, Georgia Institute of Technology; Minoru Shinohara, Georgia Institute of Technology

Applying afferent vagus nerve stimulation via implanted electrodes during motor training can either enhance or impair motor recovery after stroke and motor learning in rodents, depending on the timing of stimulation. The stimulation modulates neurotransmitters in the cortex, such as acetylcholine and norepinephrine, due to the resultant activation of the brainstem. In a translational study employing noninvasive stimulation of the auricular branch of the vagus nerve in humans, random application of transcutaneous vagus nerve stimulation (tVNS) during training slowed motor adaptation in healthy adults (St. Pierre & Shinohara, J Neurophysiol, 2023), as reported in healthy mice. Rodent studies also suggest that motor learning or recovery enhancement can be expected if brief (500 ms) vagus nerve stimulation is applied immediately after only successful motor trials. No commercially available system can replicate such a closed-loop operation of brief tVNS and movement quality. Moreover, the effectiveness of brief tVNS on acutely inducing neuromodulation is unknown. Additionally, the available surface electrodes for tVNS on the outer ear are bulky and unsuitable for training involving whole-body or head movement. Our objective was to develop a closed-loop tVNS system for human motor training and explore the improvement of associated electrodes and procedures. A commercially available tVNS device was customized to be preprogrammed for an appropriate set of stimulation parameters and triggered by an external voltage input. By creating an Android app and a relay unit between the phone and the tVNS device, we enabled the tVNS device to be triggered wirelessly via Bluetooth. It allowed assessors to wirelessly send and record a tVNS trigger cue by tapping on the phone when they recognized a successful movement trial. We also developed a software toolkit for automated movement classification from markerless videos using machine learning, which identified successful backward walking steps with 88% accuracy in 28 older adults (73-93 years old) with and without Parkinson's disease. To improve tVNS electrodes, we developed thin film-like electrodes, which reduced the mass by 75% (from 0.29 g to 0.07 g) and the uncomfortableness of wearing electrodes while maintaining acceptable impedance (44k ohm vs. acceptable 500k ohm). To assess the effectiveness of brief tVNS in acutely inducing neuromodulation, we used a screen-based eye-tracker to analyze the pupil size, which is known to be increased with activation of the locus coeruleus in the brainstem. In our preliminary assessment, brief (500 ms) tVNS caused a transient increase in pupil size by 6.5% (4.8% - 8.3%), on average, in four young adults. Collectively, the study successfully created a closed-loop tVNS system and an acute neuromodulation assessment procedure and demonstrated their proof of concept and feasibility.Funding: McCamish Parkinson's Disease Innovation Program at Georgia Tech and Emory University

## P3.53-P: Prosthesis Users Demonstrate Similar HD-EMG Spatial Parameters of the Upper Limb during Slow, Moderate and Fast Isokinetic Contractions Compared to Controls

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Introduction: Upper limb function is critical for efficient movement during activities of daily living (ADLs) and can be impacted by injury, disease and disuse. Surface electromyography (sEMG) has been used to examine upper limb musculature to aid in muscle assessment, in particular for upper limb prosthetics. High density sEMG (HDsEMG) uses two-dimensional electrode grids to estimate spatial muscle activity and can provide insight regarding muscle function during common upper limb tasks. Aim: The purpose of this study was to examine HDsEMG activity of the biceps and triceps during slow, moderate, and fast isokinetic flexion and extension contractions in those with intact upper limbs and upper limb prosthesis users. Spatial features of the HDsEMG were compared to determine the effect of speed on muscle activity. Methods: Thirty-one males (n=16) and females (n=15) (mean age= 24.33 +/- 10.43) completed three maximal isometric ramped elbow flexion and extension contractions followed by three isokinetic dynamometer (HUMAC Norm) elbow flexion and extension contractions at 60, 90 and 120 degrees/second. Two prosthesis users (1 male, 1 female) also completed the testing protocol. High density sEMG signals were collected (OT Bioeelettronica, Turin, Italy) with a 32-channel electrode grid placed over the short head of the biceps brachii and the lateral head of the triceps brachii (HD10MM0804). Spatial distribution was estimated using the Root Mean Square (RMS) EMG signals for each of the electrode grid locations from which 2D maps were developed (Figure 1). Amplitude and frequency features of the HDsEMG signal were compared across speeds for all contractions (flexion and extension) and each arm. Entropy was used to represent the increased variety of signals (heterogeneity) of the HDsEMG distribution. Significant differences were determined using an analysis of variance (ANOVA) with an alpha level set to 0.05 and post hoc tests (Tukey) conducted when p<0.05. Results: No significant differences were detected in HDsEMG features in the control group due to speed. Both prosthesis users demonstrated lower amplitude and frequency features compared to the control group on their amputated side, however entropy was similar, regardless of arm side. In addition, prosthesis users did not show differences in HDsEMG features due to contraction speed. Both clinical patients demonstrated lower amplitude and frequency HDsEMG features in their affected limb compared to their intact limb, except for entropy, which remained similar regardless of limb side. Conclusions: In this limited work, upper limb prosthesis users demonstrated similar muscle activity compared to a control group during isokinetic upper limb contractions in their unaffected side. While prosthesis users demonstrated lower HDsEMG amplitude on their amputated side, entropy was similar between control and clinical participants regardless of speed or side suggesting that muscle activity differences may be due to training status of the clinical participants rather than muscle fibre type. Data collection is ongoing and more clinical participants are needed. This preliminary work demonstrates that when designing training and rehabilitation programs for prosthesis users, it is important to recognize that while reduced muscle mass (may result in lower HDsEMG amplitude, muscle heterogeneity (estimated with entropy) may be similar to controls.

## P3.54-P: Relationship between finger dexterity and anterior horn cells of the spinal cord -Investigation by waveform analysis of F wave-

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〔Introduction〕 F waves are used in many situations as an indicator of the excitability of spinal anterior horn cells. F waves from normal muscles are known to show a diversity of waveforms, but F waves from patients with spasticity result in the appearance of repeater F, which show the same waveforms. However, there are no standard values for waveform diversity, and no valid analysis method has yet been established. Analyzing the waveform of the F wave provides clues to the state of the spinal cord anterior horn cells that make up the F wave. It could also be used as an evaluation of spasticity and voluntary movement due to spasticity. In this study, as a preliminary study in applying waveform analysis of F wave in spastic patients, we would like to analyze waveforms from F waves during isometric contractions in healthy subjects because spastic muscles are almost in a hypertonic state and examine the relationship with motor skills. 〔Methods〕 F waves were recorded from the abductor pollicis brevis muscle during isometric contractions at 20% and 50% maximal voluntary contraction of the opposing movements of the thumb and the index finger in 20 healthy subjects. In the analysis section, coefficients of variation for three parameters; amplitude value, onset latency, and coefficient of variation of peak latency, were calculated to reflect the diversity of the F wave. In addition, Chronodispersion, which indicates the difference between the shortest and longest latencies, and ORF (occupancy rate of repeater F-waves), which indicates the ratio of repeater F to the number of waveforms that appeared using cluster analysis, were calculated. The fingertip dexterity evaluation was a task in which the participants had to demonstrate individually defined strength for 30 seconds in a sustained manner. The evaluation method was established 5% before and after the specified value, and the percentage of correct responses within the time was calculated. 〔Results〕 The coefficient of variation of peak latency showed a decrease in negative peak at 50% MVC compared to resting, and a decrease in positive peak at 20% and 50% MVC, respectively, compared to resting. The relationship between hand dexterity and F-wave diversity was examined with coefficients of variation for negative and positive peaks below 0.03 in more than half of the cases with less than 50% correct responses. ORF was 0 in 18/20 cases, regardless of contraction strength, and the appearance of repeater F wave was extremely small. 〔Discussion〕 In this study, we investigated the relationship between finger dexterity and spinal cord anterior horn cell excitability during isometric contraction. With isometric contraction, negative and positive peak latencies appear at a constant latency, but the ORF values are extremely close to zero. Therefore, even though similar waveforms appear, various anterior horn cells of the spinal cord fire and are thought to be involved in muscle output.

## P3.55-P: The motor imagery content as a reflective report and the skill gains brought about by motor imagery may be consistent

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[Introduction]Motor imagery is a cognitive process that utilizes working memory and is defined as the reproduction of motor-related memories. Motor imagery content is often interpreted using the results of the subject's introspective reporting. Therefore, we examined whether introspective reports on the motor imagery content were consistent with subsequent changes in motor performance due to motor imagery. In addition, we recorded F waves during motor imagery to confirm whether the degree of excitation of spinal motor neurons varied with the motor imagery content.[Methods]25 right-handed healthy participants were included (13 males and 12 females, mean age 23.8 ± 6.1 years). Fingertip dexterity was assessed with a pinch task using the thumb and index finger of the left hand to determine baseline performance (Pre-BP). The motor task was an alternating force adjustment task in which the participants adjusted the pinch force to 50% and 10% MVC at 2-s intervals, and the index of fingertip dexterity was calculated as the absolute error (kgf) from the specified value. First, changes in the excitability of spinal motoneurons were measured during 30 s of rest (Rest). Next, six sets of repetitions of combined motor practice and motor imagery were performed. The excitability of spinal motoneurons was also assessed during motor imagery. Fingertip dexterity was again assessed with a pinch task using the left thumb and index finger (Post-BP). After the experiment, the visual analog scale was used to evaluate whether the participants were more enthusiastic about 50% or 10% MVC as the motor imagery content. The visual analog scale was marked with 10% MVC at 0 mm and 50% MVC at 100 mm from the left end. Absolute errors were compared to the Pre and Post-BP periods. In addition, Cosine similarity refers to the cosine value of the angle between two vectors in vector space (total performance and 50% MVC performance / total performance and 10% MVC performance). Cosine similarity and Euclidean distance were calculated. And, the pattern of change in total performance over time was strongly influenced by changes in either 50% or 10% MVC performance. We performed multiple comparisons of the F/M amplitude ratio during 6 repetitive motor imagery for changes in spinal motoneuron excitability, using Rest as a control. This study was approved by the Research Ethics Committee at Kansai University of Health Sciences (Approval No. 22-04).[RESULTS]The absolute error decreased for Post-BP compared to Pre-BP. Changes over time in performance were influenced by changes in the ability to adjust to 50% MVC performance in both cosine similarity and Euclidean distance. The mean value of the visual analog scale was 60.7 mm, and there was a trend toward 50% MVC. The F/M amplitude ratio was no difference between each motor imagery session with Rest as a control[Discussion]When force-regulation tasks with different intensity are given, the force-regulation skills corresponding to the contraction intensity of the motor imagery content improve. However, no difference in the degree of increase in spinal motor neuron excitability appears regardless of the contraction intensity of the motor imagery content, and it is possible that the increase in spinal motor neuron excitability during motor imagery is not consistently observed.

## P3.56-P: Effects of functional performance in professional athletes after ACL reconstruction on muscle fiber conduction velocity

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Background: After rupture of the anterior cruciate ligament (ACL), surgical reconstruction is the main treatment option, particularly for professional athletes aiming to return to their pre-injury level of activity. Even after a successful return to sport, neuromuscular impairments may persist in athletes after ACL reconstruction. Because positive correlations were found between training status and muscle fiber conduction velocities (MFCV), we expected lower MFCV values in athletes who scored lower in functional performance tests. This study was designed to examine the link between overall lower extremity performance at the time of return to sport and the MFCV of vastus medialis (VM) and lateralis (VL) muscles at different contraction intensities.Methods: Twenty professional team-sport athletes (soccer: 16, handball: 3, ice hockey: 1; age: 18-35 years) were recruited 6-12 months after primary ACL reconstruction. Participants performed four isometric ramp contractions at 20%, 40%, 60% and 80% maximum voluntary torque (MVT). Activity of the VM and VL was recorded in monopolar mode using a linear electrode array concurrently with the isometric force. From the raw signals, MFCV was calculated. In addition to the MVT, participants executed the drop jump and the vertical alternating foot tapping test. Outcomes of both functional tests were converted into z-scores. The latter were summed-up, resulting in the overall performance score (PS), with higher values indicating better performance. According to the PS, athletes were equally divided into lower (LPS) and higher (HPS) performers. Possible subgroup effects were verified using mixed-design ANOVAs separately on each contraction intensity. Practical relevance was estimated calculating partial eta-squared (ES) with values 0.01, 0.06, 0.14 indicating small, moderate, or large effects, respectively.Results: Independent from subgroup, on average, higher MFCV were found for the VM (20%: 5.0 (0.6), 40%: 5.6 (0.8), 60%: 6.0 (0.9), 80%: 6.2 (0.9) m/s) as compared with the VL (20%: 4.8 (0.7), 40%: 5.2 (0.8), 60%: 5.7 (0.9), 80%: 6.0 (0.8) m/s) muscle. The ANOVA results for the 20% MVT indicated no effect of subgroup (ES < 0.01), a moderate effect of muscle (ES = 0.07) and a moderate interaction effect (ES = 0.13). For the 40% MVT, no effect of subgroup (ES < 0.01), a large effect of muscle (ES = 0.20) and a large interaction effect (ES = 0.01) were found. For the higher contraction intensities, small effects of subgroup (60%: ES < 0.01, 80%: ES = 0.01), moderate effects of muscle (60%: ES = 0.08, 80%: ES = 0.04) and large interaction effects (60%: ES = 0.22, 80%: ES = 0.15) were found.Conclusion: The MFCV increased with higher contraction intensities consistently for both muscles. The large interaction effects found consistently over higher contraction intensities indicate that LPS athletes compensate with higher MFCV of the VM, whereas in HPS athletes higher MFCV of the VL muscle can be expected.

## P3.57-P: Operant conditioning of the H-reflex: can down-conditioning hyperactive H-reflexes help to improve motor functional recovery in people with chronic incomplete spinal cord injury?

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Through operant conditioning, modification of a behavior is brought about by the consequence of that behavior. In both animals and humans, operant down-conditioning of the H-reflex (a partial electrical analog of spinal stretch reflex) can decrease H-reflex size, which further induces CNS multi-site plasticity beyond the plasticity in the targeted H-reflex pathway (Front Integr Neurosci 2014;8:25). Thus, targeting beneficial plasticity to a specific spinal pathway (e.g., reducing the excitability of a hyperactive H-reflex pathway) may be used as a therapeutic tool. For example, in people with incomplete spinal cord injury (SCI) hyperexcitable excitatory spinal reflexes may be associated with function-limiting spasticity. Previously studies demonstrated that operant down-conditioning can decrease the soleus H-reflex size and can improve locomotion in people with chronic incomplete SCI (J Neurosci 2013;33:2365-2375; J Physiol 2021;599:2453-69 ). Our working hypothesis is that decreasing H-reflex size in spastic muscles not limited to the soleus is possible through operant down-conditioning, and that decreasing the H-reflex size can lead to motor function improvements in people with chronic incomplete SCI. Towards testing this hypothesis, we are currently applying H-reflex down-conditioning in the upper and lower extremity muscles of individuals with spasticity due to chronic incomplete spinal cord injury. Methods: The H-reflex down-conditioning protocol consist of 6 baseline sessions and 24 (in upper extremity) or 30 (in lower extremity) conditioning sessions (all at a pace of 3/week). In each baseline session, 225 control H-reflexes were elicited without any feedback on H-reflex size. In each conditioning session, 225 conditioned H-reflexes were elicited while the participant was asked to decrease H-reflex size and was given visual feedback as to whether the resulting H-reflex was smaller than a criterion value. Before and after H-reflex down-conditioning, EMG and kinematic measurements during dynamic motion, and functional assessments are performed. Results and Implications: In the lower extremity, we are currently conducting a clinical trial of the soleus H-reflex down-conditioning in individuals with chronic incomplete SCI, in order to capture the range and extent of sensorimotor function improvements associated with this approach (NCT05094362).In upper extremity, the first participant chronic C5 SCI has completed the flexor carpi radialis (FCR) H-reflex down-conditioning protocol. His FCR H-reflex decreased steadily over the course of 24 down-conditioning sessions, to the final reflex size (average of the last 3 conditioning sessions) of 30%. This offers the promising interpretation that H-reflex down-conditioning is not limited to the soleus muscle, and indeed has the potential to be effective in any muscle where an H-reflex can be elicited.

## P3.58-P: Transcutaneous spinal cord stimulation phase-dependently modulates spinal reciprocal inhibition induced by pedaling in healthy individuals

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Reciprocal inhibition (RI) plays an essential role in the smooth movement. RI is often impaired in patients with stroke, and impaired RI contributes to abnormal muscle co-activation during locomotion. Pedaling is a rhythmic movement that can increase RI in healthy individuals but not in patients with severe stroke. Transcutaneous spinal cord stimulation (tSCS) stimulates spinal neural circuits by targeting afferent fibers. Pedaling with simultaneous tSCS may modulate the plasticity of the spinal neural circuit, altering neural activity based on movement and muscle engagement. This study investigated the RI changes after pedaling combined with tSCS and determined the phase of pedaling in which tSCS should be applied for optimal RI modulation in healthy individuals. Twelve healthy men participated in Experiment 1, 11 of whom also participated in Experiment 2. In Experiment 1, the subjects underwent three interventions on different days: pedaling combined with tSCS in the early phase of lower extension (phase 1) of the pedaling cycle, pedaling combined with sham tSCS, and tSCS alone. In Experiment 2, the subjects performed pedaling combined with tSCS applied in the late phase of lower flexion (phase 4). The results were compared with those of phase 1. Active pedaling was performed at a comfortable speed for 7 minutes. The parameters of pedaling were set at a low level to accommodate patients with severe hemiplegia. For tSCS, a monophasic 100 Hz current (1 ms pulse width) was applied at the stimulation intensity of the motor thresholds of the trunk muscles for the activation of afferent fibers. The cathodal electrode was placed on the skin over the Th11–Th12 spinous processes and an anodal electrode was placed on the trunk above the umbilicus. At the assessment of RI, disynaptic reciprocal Ia inhibition from the tibialis anterior to the soleus muscle was assessed before and after the intervention. A two-way repeated measures analysis of variance of the factors of the interventions and time, and t-tests with Bonferroni adjustments for multiple comparisons were performed in Experiments 1 and 2. In the results, there was a significant interaction in Experiments 1 and 2. In Experiment 1, post hoc analyses revealed that pedaling combined with sham tSCS significantly increased RI after the intervention compared to before the intervention (P = 0.01), whereas pedaling combined with tSCS at phase 1 and tSCS alone did not significantly affect RI (P > 0.05). In Experiment 2, pedaling combined with tSCS at phase 4 significantly increased RI after the intervention compared to before the intervention (P = 0.02). And, there was a significant difference after the intervention between pedaling combined with tSCS at phases 4 and 1 (P < 0.01). The results demonstrate that tSCS modulates RI changes induced by pedaling in a stimulus phase-dependent manner in healthy individuals. Thus, pedaling combined with tSCS may modulate impaired RI in patients with severe stroke.

## P3.59-P: Eccentric cycling is more time-efficient than functional rehabilitation in recovering post-intensive care syndrome patients after Covid-19

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The recently experienced COVID pandemic left numerous patients with post-intensive care syndrome (PICS), which affected all aspects of the lives of the survivors. Eccentric training is a simple option, requiring less metabolic demand, and it could be ideal for these patients. Aim: to compare the effects of eight weeks of eccentric cycling rehabilitation versus a standard functional rehabilitation protocol on functional performance and quality of life of the patients. Methods: twenty survivors of the COVID infection (age= 50.8 ± 8.8 years old) who were recruited in critical units after hospitalization (14.5 ± 11.5 days). Both groups performed an eight-week control period. Participants were divided into a functional rehabilitation group (FUNCTIONAL) and an eccentric training group (arm and leg cycle ergometer; ECC). Both groups trained for a period of 8 weeks, then rested for two weeks and performed the control condition (no exercise) as a crossover design study. Body composition, functional performance, grip muscle strength, functional post-covid scale (FPCS), and quality of life (Patient Health Questionnaire; PHQ) were measured before and after interventions. Results: Muscle mass increased 1.2±3.4% and 0.1±2.5%, functional performance increased 20.4±8.1% and 16.2±10.7%, grip strength increased 35.4±28.0% and 28.0±19.4%, FPCS decreased 36.7±18.0% and 29.6±23.2%, and PHQ decreased 40.1±44.6% and 41.6±32.0% after ECC and FUNCTIONAL, respectively. No differences between FUNCTIONAL and ECC were observed in the main outcomes, while metabolic and psychological demand during training was lesser during ECC. Furthermore, training time per session was much lesser during ECC. Conclusion: Both interventions improve the functional performance of patients after hospitalization for COVID. ECC obtained improvements in functional performance at a lower cardiopulmonary demand, which may be desirable in patients with PICS.

## P3.60-Q: The Effects of Intensive Rehabilitation Using an Ankle Assistance Robot on push-off Motion in Stroke Patients

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Gait impairments, such as an insufficient ankle dorsiflexion angle during the swing phase and decreased push-off motion during the pre-swing phase, are often observed in stroke patients. These impairments have been reported to result in a reduction in propulsive force. In recent years, numerous robotic walking rehabilitation devices have been developed and researched. They can adjust assistance during the entire gait cycle, allowing detailed settings based on individual walking functions. This makes it possible to reproduce movement patterns as close to normal as possible in terms of temporal and spatial parameters, enabling repetitive practice. In particular, walking assistance robots specialized in ankle joint assistance have been reported to support improvements in foot clearance, push-off assistance, and heel contact during walking, aiming to enhance walking function. Therefore, this study aimed to investigate the long-term effects of using a robot specialized in ankle joint assistance on push-off motion in stroke patients.Ten stroke patients who agreed to participate and could walk under supervision participated in this study. They underwent 20 minutes of robot-assisted gait training in addition to their regular rehabilitation for two weeks. The robot used in this study was RE-Gait®, a close-fitting walking assistance device that electrically assists ankle dorsi-and planter-flexion. The settings  were tailored to the participant's gait, including plantar flexion assistance during the pre-swing phase, dorsiflexion assistance during the swing phase, and dorsiflexion assistance during the stance phase to achieve smooth weight shifting.The gait performance was assessed by performing a 10-meter walking test at a comfortable speed on the first day and after two weeks. Participants wore Inertial Measurement Unit (ULTIUM EMG, NORAXON Inc.) at four locations: midpoints of the left and right PSIS, right heel, left heel, and the paralyzed side's toe. The foot pressure distribution was measured using a myo PRESSURE device (NORAXON Inc.). The outcomes were heel clearance, knee joint angle, gait speed and stride length. Heel clearance was calculated using a inertial Measurement Unit attached to the heel. Knee joint angle was calculated using a markerless motion capture system.No significant differences were observed in gait speed and stride length. However, changes in the ankle and knee joints were found after two weeks of intervention, with a significant increase in heel clearance. From the above, it is suggested that continuous intervention with a robot specialized in ankle joint assistance may lead to improvement in push-off motion, resulting in increased propulsive force and potentially contributing to the improvement of gait.

## P3.61-Q: Changes in Knee Kinematics after Exoskeleton-Type Wearable Robotics Training in Individuals with and Without Reconstruction of Anterior Cruciate Ligament: A Pilot Study

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Background: The rupture of anterior cruciate ligaments commonly affects knee joints, impacting patients' daily life activities such as walking. A decrease in knee flexion is one of the problems after ACL Reconstruction (ACLR) during walking. Sit-to-stand is effective for measuring functional deficits in post-ACLR. Post-ACLR, patients display reduced specific angles and moments due to muscle weakness. Exoskeleton-type robot training alters motion ranges initially for nerve and muscle impairment. This intervention may reduce the risk of secondary ACL injuries. Aim: This study assessed the change in knee flexion angle after exoskeleton robotics training in individuals with and without ACL surgery in knee flexion during walking and sit-to-stand tasks. Method: Four participants were recruited for this experiment and separated into control without any lower-limb injury and ACLR groups (one male and one female in each group). The experiment used the OPENCAP program to record the data before and after the training sessions with the KEEOGO exoskeleton robot. The analysis focused on the peak knee flexion angle change before and post-intervention as a mean difference during walking and sitting-to-stand. Result: The results involved comparing peak knee flexion angles before and after KEEOGO exoskeleton robot training in control and ACLR groups. The control group showed a 1.63° increase in walking; the ACLR group demonstrated a 6.46° improvement. Similarly, in sitting-to-stand, the control group increased by 1.09°, while the ACLR group improved by 1.08°. Findings highlight the positive impact of KEEOGO training on knee joint mobility in both groups. Conclusion: KEEGO intervention immediately affects walking and sitting-to-stand (STS) tasks to improve the peak values of knee joint mobility.

## P3.62-Q: Controlling detached robotic hand with synergistic torso muscles to induce finger neuromotor adaptation in individuals with and without stroke

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Damage to neuromotor pathways due to stroke alters neuromotor activity and impairs hand function. While most robotic rehabilitation systems provide mechanical force to the impaired limb peripherally, we have invented a detached robotic rehabilitation system that focuses on the central nervous system without involving the impaired hand. To intervene the neuromotor system beyond standard mental practice, we have adopted the neuromechanical synergy of reaching and grasping to enable the active embodiment of a detached robotic hand. Our unique idea was to control the robotic hand by activating the corresponding torso muscles (external abdominal oblique and latissimus dorsi) for synergistic movements for reaching (trunk rotating inward and hand opening) and retrieving (hand closing and trunk rotating back), respectively. We aimed to clarify acute neuromotor adaptations during this intervention in eighteen healthy adults and to investigate the feasibility and trend in four post-stroke adults with mild impairment in their right hand. They were tested on their embodiment of the detached robot, right-hand motor function, and neuromotor excitability during various background tasks: visual

motor imagery, torso muscle interaction with the developed robotic system with (RoboMI) and without motor imagery (RoboNoMI), observation of robotic hand movements, and resting.  In healthy subjects, the embodiment score in RoboMI (5.09 ± 1.59) was higher compared with RoboNoMI (3.96 ± 1.80, p = 0.04) and observation (2.47 ± 1.99, p < 0.001). The score in RoboNoMI was higher compared with observation (p = 0.046). During the reaction time test with the biological finger, the reaction time was longer in all dual-task conditions compared with resting. Interestingly, the maximal rate of force development was greater for finger flexion in RoboNoMI for retrieving compared with resting (by 51%, p = 0.024). The maximal rate of force development was also greater for finger extension in RoboMI for reaching compared with resting (by 40%, p = 0.004) and motor imagery (by 36%, p = 0.046). Corticospinal excitability was not affected significantly by the background task. The increased maximal rate of force development without a change in corticospinal excitability suggests an improvement in premotor planning. In all four post-stroke adults, RoboMI was feasible with the embodiment score being 3.3-8.2 (Mean: 5.88), and RoboMI for retrieving showed a faster reaction time for finger flexion compared with motor imagery (by 67-366 ms, Mean: 144 ms) and a higher maximal rate of force development for finger flexion compared with motor imagery (by 57-114%, Mean: 73%) and resting (by 7-48%, Mean: 23%). RoboMI also showed a higher maximal voluntary contraction force compared with motor imagery in all four post-stroke subjects (by 27-361%, Mean: 121%). These findings and observations support the efficacy of the developed robotic system.Supported by NIH/NINDS (1R21NS118435-01A1).

## P3.63-R: **Muscular activity of upper limbs during rapid unique arm movement of pop dance in street dance**

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PurposeWhile previous studies of street dance have been conducted in hip-hop on injury and motion analysis (Olga Tjukov's, 2004, Sato, 2016), scientific studies focusing on Pop dance movements which is one of the street dances are still limited. In Pop dance, dancers perform unique movement called “hit” which the observer could perceive the hitting during this movement. The instruction by dance teachers is also likely provided without scientific knowledge. Therefore, the aim of this study was to clarify the muscular activity of the upper limb which is imitated this unique arm movement in Pop dance using surface electromyography in dance students with and without street dance experiences.MethodsTwenty-six healthy adult women participated in this study. They were divided into three groups: pop dancers(P)(n=9); women with more than two years of pop dance experience; other dancers(D)(n=11); women with dance experience other than pop dance; and non-dancers(N) (n=6); group of women with no dance experience. The participants were asked to sit in front of the box and place their right arms on the box with the right shoulder joint flexed at 90 degrees. They were instructed to perform rapid arm pronation which is imitated unique arm movement in pop dance as soon as they saw the light signal. Surface electromyography was used to measure muscle activity of the triceps brachialis, biceps brachialis and brachioradial muscles. A data logger system (BioLog, S&ME, Japan) was used to record surface EMG signals. Six EMG electrodes were applied to the participant’s right arm. The Data were sampled at 1,000 Hz, with high and low pass filters of 20 and 500 Hz. EMG data were full-wave rectified and root-mean-square smoothed. Maximum voluntary EMG force was the 3-second average of stable values, and movements mimicking the hit were normalized by dividing by this maximum voluntary EMG force Mean values of EMG activity across the three trials were assessed for each participant. The time from optical signal to the first 5%MVC detected was analyzed (T1), from the first 5%MVC to the maximum within the trial (T2), from the maximum within the trial to the last 5%MVC (T3), and from the first 5%MVC to the last 5%MVC as the. Total muscle contraction time (ToT). Co-contraction index was calculated by the equation from previous study (Falconer and Winter, 1985)Results and DiscussionA significant difference (p<0.05) was detected in T1 with 0.43±0.18(s) in group P and 0.14±0.05(s) in group D and in ToT was 0.44±0.18(s) in group P and 0.91±0.33(s) in group N in the brachialis triceps brachialis muscle. No significant differences in co-contraction index were observed.ConclusionFrom the results of this study, it is suggested that the unique arm movement observed in experienced pop dancers would be performed with longer reaction time to the onset of muscle contraction and shorter duration of muscle contraction of the arms.

## P3.65-R: **Electromyographic activity and perceived exertion during the performance of a training protocol with internal focus direction in the bench press exercise.**

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Background & Aim: Strategies that enhance neuromuscular adaptations through training are of interest to healthcare professionals. The use of verbal instruction aimed at directing the focus of attention to a muscle or muscle group during strength training may represent a strategy to increase neuromuscular responses. Thus, obtaining data on the impact of adopting a strategy to direct the focus of attention to a specific muscle (e.g., pectoralis major), with the intention of promoting a greater activation response in the muscle during the performance of an exercise (e.g., bench press), could show selective manipulation of muscle activation. The aim of this study was to analyze the electromyographic (EMG) activity of the pectoralis major (PM) and anterior deltoid (AD) muscles during the performance of the flat bench press exercise with (IF) or without (WIF) internal focus for the PM muscle. Methods: Thirteen strength-trained volunteers were subjected to three experimental sessions (48-hour interval). The first session consisted of familiarization with the one-repetition maximum (1RM) test, associated with the anchoring of the local subjective perception of effort (PE) for the PM and AD muscles. The second session involved performing the 1RM test and the PE anchoring procedure. After 10 minutes, a maximum voluntary isometric contraction (MVIC) test was performed and EMG recorded for normalizing the EMG data. Subsequently, after 10 minutes, the IF training protocol was performed. Finally, the third session consisted of the MVIC procedure, followed by the execution of the WIF training protocol. The IF and WIF conditions were performed with the following protocol: 3 sets of 8 repetitions, 50% of 1RM, with a 90-second rest interval between sets, differentiated only by the inclusion or not of verbal instruction for the direction of focus of attention. A two-way repeated measures ANOVA test was used to compare the normalized EMG signal during the protocols. The analysis of local PE was performed with the Friedman test. The significance level was α < 0.05, and Bonferroni post hoc test was applied when necessary. Results: No significant time x muscle interaction was found, indicating that there were no changes between the EMG activities of the PM and AD muscles between the IF and WIF conditions. However, a main effect of muscle was identified, demonstrating that the EMG activity of the PM was higher than that of the AD. We also identified no differences between the muscles for PE, or between the IF and WIF conditions. Conclusion: In conclusion verbal instruction aimed at directing the focus of attention to a specific muscle was not an effective strategy to increase the activation of the PM muscle during the performance of a strength training protocol. Also, the adoption of verbal instruction for focus direction did not increase the PE response associated with the PM muscle.

## P3.66-R: Enhancing Speed Skating Performance: A Comprehensive Analysis of IMU-based Motion Phase Identification Reliability

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This research examines the reliability of Inertial Measurement Units (IMUs) for motion phase identification in long-track speed skating. Fifteen skaters of varying levels participated in 500m trials, where IMUs provided real-time data. The study focuses on the reliability of IMU-based event identification using Intraclass Correlation Coefficients (ICCs) and Bland-Altman analysis to assess systematic and chance errors. Results show high intra-rater reliability with ICC(11) values ranging from 0.86 to 0.99, and inter-rater reliability with ICC(21) values between 0.81 to 0.99. The percentage of Standard Error of Measurement (%SEM) varied from 1 to 5%, and the Minimal Detectable Change (%MDC95) ranged from 2 to 15%. These findings validate the high reliability of IMUs in event identification, offering a valuable tool for enhancing skating techniques and contributing to sports biomechanics. The study's insights into IMU application in sports contexts highlight their potential for broader adoption in various sports.

## P3.67-R: Biomechanical analysis of wheelchair propulsion in a variety of disability and competition level of para athletics wheelchair racing

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Highly trained para-athletes in wheelchair racing exhibit unique modalities and extraordinarily enhanced upper limb motor functions that far exceed the daily use of wheelchair propulsion (Vanlandewijck et al., 2001). Although a classification system based on an individual's residual function exists for the fairness of competition (World Para Athletics, 2023), purposive performance differs depending on their disability and/or competition levels. For example, athletes with spinal cord injury for wheelchair racing are categorized as T51-T54: T51 has paralysis in both upper arm and trunk, T52 has partial paralysis and limited trunk function, T53 has limited trunk function, and T54 has intact upper arm and trunk functions. Elucidating the principles behind racing wheelchair propulsion as fast as possible with limited function is not only scientifically significant in understanding motor control strategies but also crucial in promoting athletic competitiveness. Therefore, this study aimed to characterize racing wheelchair propulsion using comprehensive biomechanical measurements. Fourteen wheelchair racers with diverse disabilities and competition levels participated in this study. Participants performed 30 strokes of wheelchair propulsion at approximately 80% of their

maximum effort. We recorded wheel torque/velocity and trajectories of body landmarks using a custom-developed wheelchair simulator and motion capture system. We analyzed spatiotemporal parameters including total torque during the push phase, angle at the timing of hand contact with the hand-rim (contact angle), release angle, and angle at the timing of maximum torque exertion. In addition, electromyography in the upper limb and trunk, including the paralyzed area, were recorded during wheelchair propulsion. We observed that the maximum torque angle was deeper in the elite level of athletes, and also in moderate level of disability. Moreover, a moderate correlation was found between scores corrected from personal best records for 100m/400m races for classifications and the maximum torque angle (r = -0.530, p = 0.005), indicating that competition level largely affects the wheelchair propulsion strategy. The backward shift in maximum torque exertion with disability/competitive level implies the potential importance of the racer's propulsive force generation and its tangential force transfer. Specifically focusing on the erector spinae muscle activity, higher cross-correlation coefficients (0.781 ± 0.090) and minimal lag (-0.032 ± 0.086 s) with wheel velocity were observed. The larger contribution of erector spinae muscle activity on wheelchair propulsion clearly suggests that involvement of trunk function affect to contribute the wheelchair racing performance. The above-mentioned comprehensive biomechanical analysis might suitably characterize the purposive performance of wheelchair racers in relation to disability/competition level.

## P3.68-R: Diurnal variations of neuromuscular system and inter-individual differences

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Introduction: Diurnal variations in maximal muscle strength are reported (ex. Knaier et al. 2022), but not in some studies (ex. Raphael et al. 2019). Muscle strength is determined by central and peripheral components of the neuromuscular system, i.e., central nervous excitability and muscle contractile properties. These components might be influenced by diurnal variations, independently, due to fluctuations in motoneuron pool excitations, core temperature and muscle temperature. Also, these fluctuations would have inter-individual differences due to chrono type. Understanding of diurnal variations and its inter-individual differences of central and peripheral components of the neuromuscular system would assist in establishing training strategy focusing on individual components of the neuromuscular system. This study aimed to investigate diurnal variations of the neuromuscular system and its individual difference. Methods: Ten healthy young men participated in the present study (age: 22.9±4.9years). At 10:00 (morning),13:30 (noon), 17:00 (evening), and 20:30 (night), the knee extensor maximal isometric voluntary contraction (MVC) torque, motor unit firing properties by high-density surface electromyography (HDsEMG) of vastus lateralis, electrically evoked twitch torque of knee extensor were measured. HDsEMG was recorded during 50%MVC ramp-up task. Individual motor unit was tracked among four times, and firing rate (FR) during 35-45%MVC was calculated. Results: MVC and twitch torque did not reveal significance change for time of day (p = 0.681 and 0.135, respectively). FR revealed a main effect for time-of-day (p < 0.001), and FR in the evening and night was significantly greater than that in the morning (p = 0.002 and p < 0.001, respectively). Inter-individual difference which was assessed by coefficient variation (CV) in diurnal variations of the neuromuscular system did not reveal significance among MVC, FR, and twitch torque (p = 0.085). Inter-individual CV on each time of MVC were 15.2, 17.1, 13.0, and 15.4%, those of FR were 14.2, 15.8, 14.3, and 14.1%, those of twitch torque were 17.7, 23.4, 19.3, and 19.6% at morning, noon, evening, and night. Discussion: Motor unit firing rate had diurnal variations, while electrically evoked twitch torque was unchanged during a day. These results suggest that the effects/adaptations of exercises such as resistance training, would be influenced by a time of day for central components of neuromuscular system. While intra-individual differences in diurnal variations were not difference between motor unit firing rate and twitch force, greater inter-individual difference was found in twitch force at noon. Exercise training focusing on peripheral muscle components might give different outcomes to each individual when the exercise is performed at noon. (2856/3000 characters)

## P3.69-R: The Relationship Between Ground Reaction Forces and Subjective Evaluations in Table Tennis Players' Forehand Drives: A Focus on Weight Transfer

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Table tennis is characterized by its rapid rally tempo and diverse techniques, performed in a relatively small area compared to other sports. This makes it challenging for players to objectively assess their own movements during a rally. Table tennis players heavily rely on their subjective sensations during play, but these sensations do not always correspond to their objective movements. Studies investigating the relationship between athletes' subjective perceptions and objective data, such as grading studies comparing athletes' subjective evaluations of force output to objective measurement data, have demonstrated their usefulness in coaching. Therefore, investigating how table tennis players' actual movements correspond with their subjective evaluations is crucial for enhancing player performance and providing effective coaching.In top-level table tennis matches, forehand drives account for 36% of all shots and are more frequently used by winning players, indicating their essential role in securing match victories. An important element in executing a powerful forehand drive is weight transfer. Instructional books and coaching practices often emphasize that for right-handed players, transferring weight from the right to the left foot significantly affects racket swing speed. From a kinetic chain perspective, the energy generated in the lower limbs is commonly transferred continuously to the racket, making lower limb weight transfer a critical component.Therefore, this study aimed to focus on the weight transfer during the forehand drive of table tennis players and examine the relationship between ground reaction force values and subjective evaluations. This research could provide insights for improving player performance and effective coaching. The participants were 20 university table tennis players. In the experiment, participants performed multiple forehand drives on a force plate to measure ground reaction force (GRF) during their trials. A motion capture system was used to measure movements and divide them into different phases, allowing for the calculation of GRF in each phase. The Visual Analogue Scale (VAS) was used for subjective evaluation of weight transfer. After completing their trials, participants used the VAS to rate, on a scale from 0 to 100, how much weight was on their pivot and stepping feet in each phase. To explore the relationship between GRF and VAS ratings, Pearson's correlation coefficient was calculated. Additionally, linear regression analysis was conducted with GRF as the independent variable and VAS ratings as the dependent variable to investigate how GRF influences VAS ratings.

## P3.70-R: Development of a novel training tool for sitting balance in chair ski athletes

Nadaka Hakariya, The University of Tokyo; Mikito Hikosaka, Research Institute, National Rehabilitation Center for Persons with Disabilities; Noritaka Kawashima, Research Institute, National Rehabilitation Center for Persons with Disabilities

BACKGROUND AND AIM: Chair ski is a highly unique paralympic sports category and enjoyable activity for individuals with lower limb dysfunction. Under the sitting posture, player could ski even on the same course as healthy skiers. Specifically for the athlete level of skier, it is necessary to take trial-and-error actual on-snow practice to acquire chair balance and turning skills, but the total amount of practice is limited within ski season and it is not easy to take practice many times due to transportation issue. In my presentation, we introduce our attempts on the development of a novel training tool for sitting balance in elite athlete chair skiers with the comparison of beginner level of skiers. METHODS: An elite Paralympic level and a beginner level of skier participated in this study. Both subjects were patients with chronic thoracic level of complete spinal cord injury. In order to realize a roll direction of whole chair tilting due to slope change in the real ski environment, their chair settled on a 65cm-diameter hemispherical balance board (BOSU® NexGen Pro, BOSU) with the placement based on pre-estimated the center of gravity (CoG) of whole body and chair skis. With the precise adjustment of chair and balance board setting, the roll angle was identical to the situation under gentle slope when sliding on snow while maintaining the regular sitting position. Under such a novel environment, the participants were asked to shift CoG toward left and right to simulate the turning motion, and then added forward and backward motion that imitate/simulate the "bending turn" skill. The center of pressure (CoP) was calculated by the data obtained from the ground reaction force (Kistler Inc.), and the absolute coordinate of the whole-body reference points was captured by the three-dimensional motion measurement system (Mac3D system, Motion Analysis Inc.). Surface electromyography was also recorded from five key muscles (Upper Rectus Abdominis, Lower Rectus Abdominis, External Oblique, Upper Trapezius, and Rhomboid). RESULTS: In the stationary position of the elite skier, the ski angle was 14.4º, which was similar to that of the gentle slope. On the other hand, the beginner skiers' ski angle was 8.1º, which was smaller than that of the elite skiers. In addition, the amount of COP movement to the left and right during the execution of the bending turn was greater for the elite skier. CONCLUSIONS: It is noteworthy that both of participants told us that the balance adjustment on the developed tool is quite similar to that during real skiing on-snow. One of the advantages of imitating skiing performance would be the capability of precise measurement during chair balance skills. Our custom build tool enable us not only to evaluate differences between elite and beginner skiers but also to deeply focus on certain aspect of chair balance skills to achieve more high level of technique even during off-days and seasons.

## P3.72-R: Effects of core muscle training in knee cartilage and sports performance of the soccer players

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Introduction: Soccer is one of the most popular games in the world, requiring high-intensity and long-term training. The risk of knee cartilage damage is extremely high, and injured cartilage has limited spontaneous healing ability due to age and other factors. In the past decade, the concept of core stability has been ubiquitous in various sports training. It is responsible for

stabilizing the trunk and transferring the strength of the body's core area to the limbs during sports actions such as running, batting, or throwing movements to increase jumping, sprinting, and shooting ability, as well as asymmetric movements of the lower limbs. The purpose of this study was to investigate through routine training and 6-week core stabilization training intervention, whether the thickness of abdominal muscles and knee cartilage thickness of the female professional soccer players would be related to functional performance. Moreover, it further explores whether core training can improve articular cartilage thickness. It was hypothesized that specific core stabilization training can increase cartilage thickness and functional performance.Methods: Thirty-eight healthy female soccer players aged 18 to 40 were recruited and randomly divided into two groups. All subjects received routine training as usual. The experimental group required an additional six weeks of core training. All subjects underwent ultrasound knee scans before and after training. The thickness of articular cartilage (the cartilage of the medial femoral condyle, intercondyle, and lateral condyle) and the thickness of abdominal muscles (internal oblique, external oblique, transversus abdominis) are measured. Moreover, T-shaped agility, triple jump on one foot, and 10-meter sprint were tested. Paired T tests was used to test the differences of the testing parameters before and after training, and the significance level was set at p<0.05.Results: Compared to the control group, the 10-meter sprint and triple jumps on both sides of the experimental group were increased compared with before intervention (P < 0.05), and the knee cartilage thickness at the right medial condyle, both lateral condyle, and both The lateral condylar spaces were all increased compared with those before intervention (P≤0.05).Conclusion: Core stability training is associated with changes in the thickness of lower limb knee cartilage and improved functional performance in female professional soccer players. This may imply that core training has the potential effect to reduce the risk of injury to lower limb cartilage and also has the ability to improve functional performance.

## P3.73-S: **Intelligent upper-limb exoskeleton using deep learning to predict human intention for sensory-feedback augmentation**

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The age and stroke-associated decline in musculoskeletal strength degrades the ability to perform daily human tasks using the upper extremities. Although there are a few examples of exoskeletons, they need manual operations due to the absence of sensor feedback and no intention  prediction of movements. Here, we introduce an intelligent upper-limb exoskeleton system that  uses cloud-based deep learning to predict human intention for strength augmentation. The  embedded soft wearable sensors provide sensory feedback by collecting real-time muscle signals,  which are simultaneously computed to determine the user's intended movement. The cloud-based deep-learning predicts four upper-limb joint motions with an average accuracy of 96.2% at a 200-250 millisecond response rate, suggesting that the exoskeleroaafton operates just by human intention. In addition, an array of soft pneumatics assists the intended movements by providing 897 newton of force and 78.7 millimeter of displacement at maximum. Collectively, the intent-driven exoskeleton can augment human strength by 5.15 times on average compared to the unassisted exoskeleton.

## P3.74-S: Changes in Upper Limb Usage 6 Months After Arthroscopic Rotator Cuff Repair and Its Relationship to Range of Motion, Muscle Strength, and Pain: A Study Using a Triaxial Accelerometer

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Introduction: Although arthroscopic rotator cuff repair (ARCR) has reported promising outcomes, changes in postoperative upper limb use in daily life and factors related to upper limb use remain unclear. Three-axis accelerometry enables an objective evaluation of upper limb usage in daily life. This study aims to examine changes in upper limb usage during daily life up to 6 months postoperatively and investigate their associations with range of motion, muscle strength, and pain. Methods: The study included 21 participants (mean age 68.7 ± 7.1 years) who underwent ARCR and rehabilitation between June 2022 and June 2023 and 12 healthy adults (mean age 64.8 ± 6.6 years) without a history of upper limb disorders. Participants who had difficulty wearing the accelerometer, had difficulty with continuous assessment up to 6 months postoperatively, and experienced retears postoperatively were excluded. Two three-axis accelerometers (wGT3X-BT, ActiGraph) were worn on both upper arms for three days, excluding bathing and sleep. From accelerometer data, upper limb usage was calculated as activity intensity, frequency, and symmetry. The activity intensity and frequency ratio were also calculated on the operated and non-operated sides. Clinical assessments included active range of motion (AROM), muscle strength, and visual analog scale (VAS) for pain during movement and nighttime. AROM and muscle strength were calculated as the operative and nonoperative side ratio. Accelerometry and clinical assessments were performed preoperatively and at 2, 3, and 6 months postoperatively. The Kruskal-Wallis test was used to compare activity intensity ratio, frequency ratio, and symmetry between postoperative volume and healthy adults. Spearman's correlation coefficient was used to examine associations between accelerometer data and six-month clinical assessments. Results: Activity intensity ratio and symmetry of ARCR patients showed significantly lower values than those of healthy adults at 2 and 3 months postoperatively and improved to comparable levels at six months. The frequency ratio of ARCR patients was significantly lower than those of healthy adults at two months and normalized at three months postoperatively. Regarding the correlation with clinical evaluation, flexion AROM showed significant positive correlations with intensity ratio, frequency ratio, and symmetry. In addition, external rotation AROM and flexion muscle strength showed significant positive correlations with frequency ratio and symmetry, while nighttime pain showed a significant negative correlation. Abduction AROM and muscle strength had significant positive correlations only for symmetry. Conclusion: The results of this study suggest that more time is needed to improve the activity intensity ratio and symmetry in upper limb usage in daily life after ARCR. Furthermore, it was considered that the flexion AROM was particularly relevant to the actual upper limb usage.

## P3.75-S: An innovative magneto-inertial measurement units-based method for accurate upper limb and shoulder kinematics assessment

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Introduction: Clinical methods to estimate active range motion such as a universal goniometer or visual estimation lack reliability and are limited to thoracohumeral shoulder angle. Magneto-Inertial Measurement Units (MIMU) present a potential alternative as sensors are small, relatively easy to use, can track the glenohumeral joint and can be used in the clinic. However, extracting meaningful anatomically relevant angles from sensors that are placed on the skin is challenging. Some of the issues are related to sensor-to-segment alignment and ability to account for skin movement artefacts. Overall Aim: to develop an MIMU-based method to obtain clinically meaningful shoulder joint angles. The specific aims were to determine the accuracy of a new method that aligns the sensor orientations to the actual orientation of the underlying bone using bony landmarks (i.e., sensor-to-segment calibration procedure). Methods: 5 participants volunteered with normal shoulder function (age (mean (SD)) = 27 (2.4) years, height 1.64 (0.08) m, weight = 68.1 (15.5) kg, sex = 4M/1F). Shoulder movements were concurrently recorded using 3D motion capture (Vicon) based on International Society of Biomechanics recommendations and MIMUs (ImeasureU) to track the thorax, scapula and upper arm movements. The MIMUs were aligned to the underlying bony segment using a manual sensor-to-segment alignment of the MIMUs. A calliper and scapula locator tools were used to point and estimate the orientation between palpable anatomical landmarks for the different segments. A gradient descent-based algorithm estimated MIMU orientation. Participants performed 3 repetitions of clinical range of motion assessments (e.g. thoracohumeral abduction, shoulder girdle elevation and depression, elbow flexion and extension) and functional movements (e.g. jogging, lifting a box). Differences between 3D motion capture and MIMUs were determined as the error quaternion which represents a rotation global space from one segment orientation to another as define by q_error = q_3dMoCap * conj(q_MIMUs). The rms error is expressed from each ZYX cardan sequence. Results: Across all tasks and axes, the errors between 3D motion capture and MIMUs were 4.2° [3.9°, 4.6°], 3.4° [3.1°, 3.8°], 3.8° [3.4°, 4.1°] for the humerus, scapula and thorax, respectively. Discussion: Preliminary findings suggest that the proposed system exhibits acceptable levels of accuracy in capturing joint angles for all segments across both clinical and functional movements. These findings suggest that the proposed MIMU-based method has the potential to provide accurate objective measurements of shoulder kinematics, thereby overcoming some of the challenges associated with traditional assessment methods.

## P3.76-S: **Wearable capacitive tactile sensor based on porous dielectric composite of polyurethane and silver nanowire for physiological signal monitoring**

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Flexible tactile sensors that can convert physiological stimuli into electronic signals have garnered significant attention for their potential use in electronic skin, healthcare monitoring, and human–machine interaction. The implementation of wearable and biocompatible tactile sensing elements with sufficient response is particularly intriguing but still challenging. Recently, capacitive tactile sensors possessing elastomeric dielectric rubbers/polymers have been intensively studied owing to their simple geometry, superior flexibility, inexpensive material cost, and low power consumption. Though, the sensing ability of these elastomer based capacitive tactile sensors is restricted by their compressibility. These elastomers cannot produce enough deformation, upon a small amount of applied pressure. Additionally, after the removal of pressure, the time required for restoration to their initial status is excessively long due to the viscoelastic property of the unstructured films. Hence, finding an augmentative means by comprehensively combining two or more aspects is very much key for high performance capacitive tactile sensing.Here, we propose a wearable all-polyurethane capacitive tactile sensor that utilizes a salt crystal-templated porous elastomeric framework filling with one-dimensional silver nanowire as the composite dielectric material. The former, holding unique conducting and dielectric polarization properties, has received widespread attention for optoelectronic, sensing, and energy harvesting applications; the latter has recently been adopted as a biomimetic membrane for artificial skin because of its good dimensional stability, air permeability, bio-safe property, and low-cost processability. With the aids of these cubic air pores and conducting nanowires, the fabricated capacitive tactile sensor provides pronounced enhancement of both sensor compressibility and effective relative dielectric permittivity across a broad pressure regime (from a few Pa to tens of thousands of Pa). The fabricated silver nanowire–porous polyurethane sensor presents a sensitivity improvement of up to 4–60 times as compared to a flat polyurethane device. An ultrasmall external stimulus as light as 3 mg, equivalent to an applied pressure of ∼0.3 Pa, can also be clearly recognized. Our all-polyurethane capacitive tactile sensor based on a porous dielectric framework hybrid with conducting nanowire displays the versatility required for use in various human activities, such as contactless airflow, finer bending, and spatial pressure distribution. Furthermore, the proposed sensor integrated with a data acquisition and Bluetooth transmission module can achieve wireless monitoring for radial arterial pulse, making it a promising candidate for artificial skin and healthcare electronics.