O.1.1: ***Physical activity and body mass index are associated with skeletal muscle mass index after menopause***

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Introduction: One in eight women have their ovaries removed before reaching natural menopause (premenopausal bilateral oophorectomy; PBO) for cancer prevention [1]. This may contribute to accelerated aging processes and is associated with a higher risk of multi-morbidity compared to women who undergo natural menopause [2]. A recent study reported that women who undergo PBO, particularly before 45 years old, have an elevated risk of sarcopenia (characterized by loss of skeletal muscle mass, strength, and function) compared to women who undergo natural menopause [3]. Physical activity is associated with a lower risk of sarcopenia in postmenopausal women [4]. However, there is limited information regarding physical activity and its relationship with low skeletal muscle mass in women with PBO. Therefore, we investigated the differences in daily step counts and skeletal muscle mass index (SMI; appendicular skeletal muscle mass (ASM) normalized to body weight [5]), and the association of daily step counts with SMI in women with PBO and referent women. We hypothesized that women with PBO would have lower daily step counts and poorer SMI, and that daily step counts would be positively associated with SMI. Methods: Fifty women with a history of PBO and 50 age-matched referent women (median ages: 66 and 65 years, respectively) received DEXA scans to estimate SMI and wore ankle accelerometers for 7 days. Daily step counts were calculated for each participant from acceleration data [6]. Differences between women with and without history of PBO were assessed using paired Wilcoxon Mann Whitney U-tests. Associations of daily step count with SMI were assessed using linear regression. Covariates included age, BMI, type of menopause (PBO or natural), age at menopause, and hormone replacement therapy (HRT; ever vs. never used). Results & Discussion: BMI was higher, and SMI was lower for PBO versus referent groups (p<0.04). Although the daily step count was lower for PBO versus referent groups, the difference was not statistically significant ($p=0.22$). The lack of significance was partly due to insufficient statistical power for the observed effect sizes. In addition, referent women with HRT use history had lower step counts and younger age at menopause compared to referent women with no history of HRT use, and also compared to PBO women with a history of HRT use. In the linear regression model, daily step count ($\beta=0.125$, $\rho=0.014$) and BMI ($\beta=0.217$, $\rho=0.001$) were significant predictors of SMI, explaining 51% of the variability (Fig. 1). Significance: Higher daily step count and lower BMI are associated with larger SMI. Larger sample sizes are needed to determine if PBO history results in lower daily step counts. Given the elevated risk of sarcopenia for women with PBO history, remote monitoring of daily step counts could provide a means to guide physical activity-based interventions for sarcopenia prevention. References: [1] Howe (1984), Am J Public Health; [2] Mucowski et al. (2014), Fertil Steril; [3] Karia (2021), Cancer Epidemiol Biomarkers Prev; [4] Keller (2019), Wien Med Wochenschr; [5] Kim (2016), J Intern Med; [6] Fortune (2014), Med Eng Phys.

O.1.2: ***The influence of workload on muscular fatigue, tissue properties, and postural stability in older and younger workers***

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Background: Most Western countries are currently facing numerous challenges linked to demographic aging. In Quebec, there is a noticeable increase in the workforce population aged over 55, accounting for nearly 20% of full-time employees in 2017. The presence of older workers may require adaptations in tasks to accommodate their physical capacities and limitations. Notably, aging involves a substantial decline in muscle mass, leading to decreased strength and muscle quality, impacting approximately 27% to 59% of women and 30% to 45% of men over 60. Furthermore, aging results in degenerative alterations of the musculoskeletal and sensorimotor systems (e.g., intervertebral disc height and postural stability). Despite these changes, job requirements and workloads, including both physical and cognitive aspects, are rarely tailored to the specific attributes of older workers. Despite the significant rise in the number of aging workers over the past 15 years, scientific data regarding the effects of physical and physiological changes accompanying aging in the workplace are lacking. Given the high prevalence of low back pain across all age groups, our study focuses on investigating the structure and functionality of the lumbar region.Objective: This research aimed to evaluate the impact of a workday involving physical exertion on tissue properties, the onset of muscular fatigue, and postural stability among both older and younger active workers.Methods: A total of 41 workers, 20 aged over 50 and 21 under 40 years old, engaged in working tasks requiring at least 50% of their work shift to be spent standing, were recruited for this study. To achieve our objective, three tests were conducted at the beginning and end of a standard work shift to assess the effects of the workday on tissue properties, muscle fatigue, and postural stability. Initially, disc height was measured using a stadiometer in a seated position. Then, muscle fatigue was assessed via an isometric contraction of the lumbar erector spinae muscles until exhaustion (Sorensen test). Electromyography was used to quantify a neuromuscular marker of fatigue (median frequency slope). Finally, participants' postural stability was evaluated using a force platform measuring root mean square, median frequencies, velocities in the anteroposterior and mediolateral directions, and displacement areas. Participants stood on the platform continuously for 30-second intervals under three conditions (eyes open, eyes closed, and on an unstable surface). Differences between older and younger worker groups were analyzed using repeated-measure ANOVAs.Preliminary Results: Initial findings indicated significant differences in postural stability (ML and AP velocities), endurance of the low back muscles, and stadiometer measurements (p<0.05) between the beginning and the end of participants' work shifts. Postural stability, endurance, and stadiometer measurements were deteriorated after the workday. Additionally, differences between older and younger workers were observed in postural stability (velocity AP, RMS AP) (p<0.05), with older workers demonstrating a decrease in postural stability than their younger counterparts.Research Implications: This study tends to understand the physical limitations and changes in older workers for adapting tasks and job requirements. The study's focus on the lumbar region and could provide insights into preventive measures or interventions to reduce the incidence of low back pain.

O.1.3: *Potential biomarkers extracted from multi-channel sEMG for sarcopenia early screening among community-dwelling Seniors*

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BACKGROUND AND AIM:Sarcopenia is a clinical syndrome manifested as an age-related decline in muscle mass, muscle strength, and function. The incidence rate among the natural population ranges from 10% to 27% and usually leads to irreversible serious adverse health conditions if not treated early. Because of its insidious onset, it is often ignored until too late. Therefore, it is important to develop novel early screening tools for Sarcopenia in community settings. In this study, we hypothesized that biomarkers can be extracted from surface EMG (sEMG) for such a purpose. We investigated how multi-muscle coordination is altered by sarcopenia by symmetry analyses of sEMG data acquired during different levels of handgrip contractions.METHODS: Ten senior individuals diagnosed with sarcopenia and ten age-matched healthy seniors were recruited for this study. The diagnosis was performed according to AWGS 2019. Participants performed handgrip tests for three trials to determine maximum voluntary contraction (MVC) with the dominant hand. Then they were asked to maintain a ten-second grasp at 20% and 50% of MVC randomly for four trials, respectively. EMG signals were acquired from brachioradialis (BRA), flexor carpi ulnaris (FCU), flexor carpi radialis (FCR), extensor carpi ulnaris (ECU), flexor digitorum superficialis (FDS), extensor digitorum (ED). Zero crossing (ZC) and median frequency (MDF) were extracted from the sEMG. Hexagon plots were based on the normalized values of six channels. Incenter-circumcenter distance (ICD) of the hexagon was used to measure its geometric symmetry. An unpaired t-test was used to compare group means with a significant level of 0.05. For nonparametric tests, the Mann-Whitney U-test was used for group comparisons.RESULTS: There were no differences between the two groups in age, calf circumference, BMI, and SMI. The duration of the 5-time chair-to-stand test was prolonged significantly in the patient group, which indicated that the lower limb function decreased more rapidly than the upper extremities. ICD of ZC had a statistically significant difference between the two groups ($p=0.015$) at 20% MVC, but no significance was found at 50% MVC ($p=0.105$). This result showed that the ZC differences between the groups are more pronounced at lower levels of contractions and suggested a potential relation to local muscle fiber changes or control strategies. There was no significant difference ($p=0.481$) in MDF at either contraction level.CONCLUSIONS: These results suggested that, at low contraction levels, the deviation from the maximal contraction patterns is larger in the healthy group. Conversely, the upper limb force generation pattern is more consistent across contraction levels. The difference observed in ZC indicates a potential biomarker for sarcopenia detection, and further research is warranted.

O.1.4: *Impact of motor unit firing patterns on exercise pressor response in older hypertensive individuals*

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Older hypertensive individuals exhibit significant variability in exercise pressor response (Delaney et al. 2010). Blood pressure (BP) increases with the activation of fast-twitch motor units (MUs) (Petrofsky et al. 1981). Since MU recruitment adheres to a hierarchical firing pattern, where low-threshold MUs (slow-twitch) discharge at a high frequency and high-threshold MUs

(fast-twitch) discharge at a low frequency during submaximal exercise, an exaggerated exercise pressor response is less likely occur with relatively low-intensity exercise. However, this hierarchical MU firing pattern diminishes with aging (Watanabe et al. 2016). This study aimed to determine the relationship between the hierarchical MU firing pattern and exercise pressor response in older hypertensive individuals. We hypothesized exercise pressor response is exaggerated in hypertensive individuals without a hierarchical MU firing pattern.Fourteen older hypertensive [systolic BP (SBP≥130 mmHg), mean±SD, 74.7±5.5yr, 8 females] and 13 normotensive individuals (SBP<130 mmHg, 70.5±7.6yr, 8 females) were included in this study. High-density surface electromyography signals recorded during the ramp-up exercise until reaching 70% of their maximal voluntary contraction (MVC) were utilized to assess the MU firing pattern. This assessment involved evaluating the hierarchical MU firing pattern by analyzing “the slope” of the linear regression between firing rates of individual MUs and their recruitment thresholds. Forearm BP was measured before and during each intensity level of the incremental rhythmic isometric knee extension exercise (Ex) from 10 to 70% MVC.During Ex from 10 to 40% MVCs, the change in SBP from baseline (ΔSBP) was more pronounced in hypertensive group compared to the normotensive group (interaction, p=0.006). The hypertensive group also showed a higher variability in exercise pressor response than the normotensive group, especially at 30%MVC (hypertensive vs normotensive, 22±17 vs 10±5 mmHg, p=0.010). The slope was significantly different between the groups (p=0.030), but there was no difference in the post hoc test. Notably, within the hypertensive group, there was a positive correlation between ΔSBP and slope at 30%MVC (r=0.660, P=0.010).Restricted muscle blood flow associated with increased intramuscular pressure occurs during isometric exercise at 30-50% MVC (Osada et al. 2015). Hypertensive individuals with a steeper slope (indicating a significant disappearance of the hierarchical MU firing pattern) might require MUs with a high recruitment threshold discharge at a higher frequency. This scenario potentially prompts a quick restriction of muscle blood flow, leading to a more substantial elevation in SBP in contrast to hypertensive individuals with a less steep slope.In the hypertensive group, the increase in exercise pressor response during submaximal exercise is greater in individuals with a more pronounced loss of hierarchical MU firing pattern.

O.1.5: *Modulation of motor unit discharge rate as a function of contraction intensity in young and older adults*

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Background and aim: Older adults undergo alterations in the neuromuscular system ultimately leading to reduced muscle force generating capacity. The force exerted by a muscle is controlled by motor unit (MU) recruitment and discharge rate, with the latter having been shown to decrease with advancing age. However, less is known about MU discharge rate modulation with increased contraction intensity in aged compared to younger individuals with alterations in motoneuron structural integrity, ionotropic synaptic input, and neuromodulation indicating potentially greater age-related effects at higher contraction intensities. Therefore, we aimed to examine tibialis anterior (TA) MU discharge rate modulation across a wide range of contraction intensities in older compared to young adults.Methods: Fourteen young (6 female; 24±5 years) and 14 older adults (6 female; 71±4 years) matched for physical activity levels (3938 [2723, 6661] vs. 3431 [2068, 4795] MET.min/week, p=0.57) performed isometric dorsiflexion contractions both of a trapezoidal (10 s hold phase) and triangular shape (10 s ascending/descending phase) at 30%, 50% and 70% of maximum voluntary force (MVF). Multichannel electromyography signals were recorded from TA with a 64-channel array and were decomposed using Convolution Kernel Compensation algorithm into MU spike trains. From MU spike trains identified during trapezoidal contractions mean discharge rate during the hold phase was calculated. The MU spike trains during triangular contractions were smoothed with support vector regression, followed by the calculation of the onset-offset hysteresis of pairs of MUs (ΔF) to estimate the magnitude of persistent inward currents. Linear mixed effects models were used to determine if MU properties were predicted by age, contraction intensity and their interaction with MU recruitment threshold as a covariate.Results: Dorsiflexion MVF was not significantly different between young and older adults (322 [278, 366] vs. 262 [222, 302] N; p=0.06). There was a significant interaction between age and contraction intensity for MU discharge rate (p=0.006). However, post hoc testing did not indicate any differences at individual contractions intensities (30% MVF: 14.5 [13.0, 16.0] vs. 12.7 [11.2, 14.1] pps, p=0.49; 50% MVF: 19.4 [17.9, 20.9] vs. 18.0 [16.5, 19.4] pps, p=0.71; 70% MVF: 26.0 [24.5, 27.5] vs. 25.3 [23.9, 26.8] pps; p=0.99). A significant age by contraction intensity interaction was also noted for ΔF (p<0.001), with greater ΔF noted for young compared to older adults at 70% (6.3 [5.7, 7.0] vs. 4.5 [3.8, 5.2] pps, p=0.006), but not 50% (5.8 [5.1, 6.4] vs. 4.4 [3.7, 5.1] pps, p=0.077) or 30% MVF (4.8 [4.1, 5.5] vs. 4.1 [3.4, 4.8] pps, p=0.6).Conclusion: These findings demonstrate that MU discharge properties are differentially modulated from low to high contraction intensities between young and older individuals in the TA, suggesting alterations in the gain modulation of aged motoneurons.

O.1.6: *Daily quercetin ingestion alters the effects of moderate-intensity resistance training on muscle strength and motor unit behavior in older adults*

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INTRODUCTION: As motor units are recruited according to the size principle, moderate-intensity resistance training cannot recruit motor units with a high recruitment threshold (Miller et al., J Strength Cond Res., 2020). Therefore, high-intensity resistance training is necessary to adapt to neurological factors in older adults and has been considered a viable strategy to prevent age-related muscle strength decline (Unhjem et al., J. Gerontol. A Biol. Sci. Med. Sci., 2021). Quercetin ingestion lowers the motor unit recruitment threshold and alters motor unit activity during a single session of resistance training (Nishikawa et al., Eur J Appl Physiol. in press; Nishikawa et al., Appl Physiol Nutr Metab. in press). These results suggest that quercetin ingestion induces recruitment of motor units with high recruitment thresholds during moderate-intensity resistance training, which may enhance the adaptation of motor unit activity and muscle strength. This study investigated whether quercetin ingestion would improve adaptations in motor unit activity and muscle strength to moderate-intensity resistance training in older adults. METHODS: Twenty-six older adults (72.2±4.4 yr, 11 males, 15 females) were assigned to either quercetin (QUE) or placebo groups (PLA). They participated in 6 weeks of isometric knee extension training and daily capsule ingestion intervention. Maximal voluntary contraction (MVC), motor unit firing properties and lower extremity muscle mass were measured before and after the intervention. As motor unit firing properties, motor unit firing rate, and the regression line between the recruitment threshold and firing rate were calculated by high-density surface electromyography and the Convolution Kernel Compensation method (Holobar et al., Clin Neurophysiol., 2009). Mixed-2way ANOVA (Time x Group) assessed statistical differences. RESULTS: There was significant interaction for MVC (QUE, 93.9±24.9 to 105.9±25.0 Nm; PLA, 111.2±46.5 to 117.1±48.9 Nm; p<0.01), and change in MVC was greater in QUE than PLA (QUE, +15.1%; PLA, +5.3%; p=0.01) (Fig.1A). There was significant interaction for motor unit firing rate (QUE, 14.1±3.4 to 16.0±4.4 pps; PLA, 13.9±3.7 to 14.2±4.7 pps; p=0.02), and post-hoc tests indicated motor unit firing rate increased in QUE (p=0.01), but not in PLA (p>0.99) (Fig.1B). Additionally, there were significant interactions for the intercept (QUE, 16.5±1.4 to 18.9±2.4 pps; PLA, 14.9±2.4 to 15.4 to 3.6 pps; p=0.04) and slope (QUE, -0.05±0.06 to -0.12±0.11 pps/%MVC; PLA, -0.05±0.01 to -0.03±0.03 pps/%MVC; p=0.01) from the regression line. There was no significant interaction (QUE, 12.5±2.0 to 12.3±1.9 kg; PLA, 14.1± 2.9 to 14.0±2.9 kg; p=0.61) and no main effects of Time (p=0.33) for muscle mass (Fig.1C). CONCLUSION: Daily quercetin ingestion altered motor unit firing properties and improved muscle strength by approximately 10% compared to placebo, through 6 weeks of moderate-intensity resistance training in older adults.

O.1.7: *Vastus lateralis motor unit discharge characteristics in knee osteoarthritis*

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Background and aim: Knee osteoarthritis (OA) is a degenerative condition of the knee joint characterised by joint pain, stiffness, inflammation, and swelling leading to functional impairments. The latter are commonly underpinned by reduced knee extension strength and quadriceps voluntary activation (VA). In this study, we examined differences in vastus lateralis (VL) motor unit (MU) discharge properties in individuals with knee OA compared to age-matched controls as a potential basis for reduced VA.Methods: Fourteen individuals with confirmed knee OA (7 female; 72 ± 7 years, WOMAC score: 29 ± 14) and 14 controls (7 female; 71 ± 4 years, WOMAC score: 1 ± 2) performed unilateral maximal isometric knee extensions during which they received percutaneous nerve stimulation of the femoral nerve to quantify VA. Subsequently, participants performed trapezoidal contractions at 10, 20, 30, 50, and 70% of maximal voluntary force (MVF) with multichannel electromyography (EMG) recordings of VL. The EMG signals were decomposed using Convolution Kernel Compensation algorithm yielding individual MU spike trains, from which discharge rate at recruitment and derecruitment, and the plateau phase of contractions were quantified. Additionally, coherence of MU spike trains obtained during 10% and 20% MVF contractions was calculated in the delta (0-5 Hz), alpha (5-12 Hz), and beta (12-30 Hz) bands. Results: Both groups had similar MVF with no differences between legs (group by leg interaction: F=3.4, p=0.0668; OA: affected vs. less-affected leg, 339 [270, 407] vs. 382 [313, 450] N; Control: 401 [332, 470] vs. 396 [328, 465] N). A group by leg interaction was found for VA (F=6.1, p=0.0138) with differences between the legs detected for OA (82.7 [78.4, 87.0] vs. 90.2 [86.1, 94.4] N, p=0.0095), but not for controls (88.4 [84.1, 92.7] vs. 88.6 [84.4, 92.4] N). A significant group by contraction intensity interaction was observed for mean VL discharge rate (F=50.7, p<0.0001), suggesting a smaller relative increase in discharge rate with greater contraction force in OA individuals compared to controls. The between-leg discrepancy between groups was detected for MU discharge rate at recruitment

(F=13.1, p=0.0003) and at derecruitment (F=13.1, p=0.0030) with the affected leg exhibiting lower initial discharge rate compared to less affected leg in OA (6.7 [6.3, 7.1] vs. 7.0 [6.6, 7.5] N, p<0.0001), but not in controls (6.9 [6.3, 7.1] vs. 7.0 [6.6, 7.5] N, p=0.0545). Greater coherence was found in OA individuals compared to controls in the alpha (z-score: 0.46 [0.42, 0.50] vs. 0.39 [0.35, 0.43], p = 0.0121), but not in the delta (p=0.8821) or beta bands (p=0.4189).Conclusions: The lower VA in the affected leg of knee OA individuals is accompanied by smaller VL MU discharge rate at recruitment and greater oscillations of MU discharges in the alpha band. These findings further our understanding of neural underpinnings of reduced VA levels in knee OA.

O.2.1: *Muscle control strategies of the central nervous system (CNS) in terms of muscular coactivation and muscle synergies when performing unfamiliar tasks*

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The central nervous system (CNS) controls the coordination and execution of complex movements, regulates muscle activation via functional modules (synergies), acquires new motor skills, and supports joint stability. Particularly when acquiring new motor skills, modifications in the muscular activation patterns occur (i.e., increased coactivation of antagonist muscles), and even new muscle synergies may rise alongside alterations in the existing ones. Moreover, movement velocity seems to influence these modifications in muscular activation patterns and the appearance of new muscle synergies. AIM: The aim of this work is to investigate how muscle synergies and muscle coactivation change while performing unfamiliar elbow flexion/extension tasks with different movement velocities. METHODOLOGY: Twenty healthy subjects were recruited, and the muscular activation of the biceps, brachioradialis, and triceps was recorded during elbow flexion and extension movements in the sagittal and transverse planes. Movements in the transverse plane were selected to represent movements rarely used in daily life and, therefore, unfamiliar to the subjects. Additionally, a 3D motion capture system was used to determine elbow joint position, movement velocity, and movement direction. The resulting sEMG envelopes of both conditions were time-normalized and categorized based on the type of contraction (concentric/eccentric) and different angular velocities. Finally, muscle synergies for each category were extracted using a non-negative matrix factorization algorithm. RESULTS: Regarding changes in muscle coactivation, the results showed statistically significant differences between both conditions, with an increase in the sEMG envelope of the three muscles when the measurements were performed in the transverse plane. Moreover, this increase was also detected for increasing angular velocity, with significant differences between slow and fast movements. Concerning muscle synergies, no differences between the sagittal and transverse planes were observed in the number of synergies. However, one muscle synergy was primarily found during elbow flexion on both conditions and during elbow extension, two muscle synergies were identified in half of the participants on both conditions. Additionally, the synergy weights in the transverse plane were higher than in the sagittal plane. These changes were also observed when moving with different angular velocities, where the synergy weights increased for all three muscles with increasing angular velocity. However, no effect of movement velocity on the temporal activation of the synergies was found in both conditions. CONCLUSION: Unfamiliarity with a task requires suitable neuromuscular coordination patterns. Since changes in functional modules are solely visible with increasing practice of a movement, when confronted with inexperienced tasks, the CNS only applied increased muscle coactivation to control posture and movement velocity.

O.2.2: ***The influence of contraction intensity on muscle activity of the triceps surae in males and females during isometric plantarflexion***

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Introduction:Plantarflexion is pivotal in gait, balance, and activities of daily living (ADLs). The triceps surae muscle group is the prime mover for plantarflexion and is primarily comprised of the gastrocnemius and soleus muscle. Few studies have used surface electromyography (sEMG) to examine the triceps surae during plantarflexion and fewer have used high-density sEMG (HDsEMG) to examine muscle activation and synergies across a range of contraction intensities. Better understanding of the triceps surae muscle group during plantarflexion can provide valuable information to aid in training programs, injury rehabilitation plans, and lower leg muscular models. Aim:The purpose of this study was to compare HDsEMG spatial features and co-contraction indices (CCI) of the triceps surae muscles during low, moderate, high, and maximal plantarflexion contractions to examine muscle synergies. Methods:Ten participants (5 males, 5 females, mean age = age=22.6 2.2 years) completed ramped (trapezoidal) isometric plantarflexion contractions using an isokinetic dynamometer (Cybex, HumacNorm) with feedback at low, moderate, and high intensities. High-density sEMG electrode grids (HD10MM0804) were placed over the medial and lateral gastrocnemius (GM and GL respectively) and soleus (SM and SL respectively) of each leg and muscle activity was recorded wirelessly (OTBioelettronica, Turin, Italy). HDsEMG features including average rectified value (ARV) and median frequency (MF) along with CCI were compared between muscles and across intensities. Significant differences were determined using an Analysis of Variance (ANOVA). Tukey's post-hoc tests were completed when an ANOVA resulted in a p-value less than the alpha value, 0.05.Results:Preliminary results indicated no significant differences in amplitude between the four muscles (measured as ARV) regardless of leg and contraction intensity (p=0.999). However, for each leg, the four muscles produced significantly greater ARV values at 100% MVC compared to 25% MVC (p<0.05). Statistical tests indicated no significant differences between CCI values. However, preliminary results suggest differences in synergistic muscle behaviour based on mean CCI values.Conclusions:While the triceps surae plays an important role in many ADLs, often the soleus muscle is omitted in sEMG studies. The present study explored both heads of the gastrocnemius and soleus during maximal and submaximal plantarflexion contractions. It was found that all muscles demonstrated greater ARV at 100% MVC than 25% MVC for both legs indicating that as contraction intensity increased, the muscle activation increased. However, the rate of increase was not examined, and this could provide greater insight regarding plantarflexor muscle synergies. While no significant differences were found, CCI mean values varied for muscle pairs. Specifically, CCI values that compared the medial and lateral soleus indicated high agreement between the two muscle heads across all contraction intensities. The CCI values that compared the gastrocnemius and soleus indicated less involvement from the soleus muscle as contraction intensity increased (Figure 1). Overall, CCI values indicated as plantarflexion contraction intensity increased the involvement of the soleus muscle decreased. Data collection is ongoing, and it is possible that with a larger data set, significant differences will be detected for CCI.

O.2.3: *Neuromuscular control changes in Parkinson's disease after deep brain stimulation: insights from muscle synergy parameters*

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BACKGROUND AND AIM: The bilateral Deep Brain Stimulation of the SubThalamic Nucleus (STN-DBS) was proven successful in alleviating the motor symptoms of patients suffering from Parkinson's Disease (PD). Although recent advances highlighted that muscle synergy analysis constitutes a powerful tool in the investigation of PD motor control changes after STN-DBS [1], a few quantitative parameters have been introduced so far in the literature, to be used as outcome measures. This work aims at presenting specific parameters extracted from muscle synergies for objectively evaluating the possible modifications of PD motor control strategies after STN-DBS neurosurgery. More specifically, the following parameters were computed: Full-Width at Half Maximum (FWHM) and its Coefficient of Variation (CoVFWHM) to assess the duration and the repeatability of the activation coefficients, respectively.METHODS: A group of 20 PD patients underwent a 5-minute gait analysis (including sEMG recordings from 12 lower-limb and trunk muscles) at 3 different time points: before STN-DBS (T0), at 3 months after STN-DBS (T1), and at 12 months after STN-DBS (T2). A group of 20 age-matched controls was also tested, to have a reference dataset. Muscle synergies were computed from the sEMG envelopes as described in Ref. [1]. Then, FWHM was computed from the activation coefficients as the number of points exceeding half of the curve's maximum, after subtracting the minimum [2].RESULTS AND DISCUSSION: On average, FWHM is increased in PD patients compared to controls, at every time point (T0: p<10-5, T1: p<10-6, T2: p<10-4), revealing widened activation coefficients in PD patients due to pathology-related motor impairments. CoVFWHM is also increased in PD patients at T0 (p=0.004), but then it becomes not different from that of controls at T1 (p=0.1) and T2 (p=0.2), revealing more repeatable motor control strategies over task duration after STN-DBS. The preliminary results obtained revealed that FWHM and CoVFWHM, extracted from the muscle synergy activation coefficients, are appropriate outcome measures for assessing the changes in neuromuscular control due to pathology-related motor impairments and STN-DBS neurosurgery, respectively.ACKNOWLEDGMENTS: This study was carried out within the «PD-DBS» project (protocol N° 2022KWSJJT) – funded by the Ministero dell'Università e della Ricerca – within the PRIN 2022 program (D.D.104 - 02/02/2022). This manuscript reflects only the authors' views and opinions and the Ministry cannot be considered responsible for them.REFERENCES[1] Ghislieri, M. et al. Muscle synergies in Parkinson's disease before and after the deep brain stimulation of the bilateral subthalamic nucleus. Sci Rep 13, 6997 (2023). doi: 10.1038/s41598-023-34151-6[2] Cappellini, G. et al. Immature Spinal Locomotor Output in Children with Cerebral Palsy. Front. Physiol. 7:478. doi: 10.3389/fphys.2016.00478

O.2.3: *Impact of electrode placement on muscle synergy extraction: insights from lower-limb sEMG signals*

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BACKGROUND AND AIM: It is widely accepted that the central nervous system simplifies motor control by selecting and modulating a reduced number of motor modules, called muscle synergies. Muscle synergies are extracted from surface electromyographic (sEMG) signals through different factorization techniques. SEMG signals are typically collected through a bipolar electrode configuration, usually placing the pairs of electrodes on the muscle's belly. However, recent research has indicated that different muscle regions may contribute to distinct mechanical functions [1]. Therefore, this study tests the hypothesis that sEMG taken from different regions of individual muscles may affect muscle synergy compositions.METHODS: Twenty healthy volunteers participated in the study at the Motion Analysis Laboratory of the PolitoBIOMed Lab of Politecnico di Torino (Turin, Italy). SEMG signals were acquired from 8 lower-limb muscles during a treadmill walking task. For six out of eight muscles (i.e., rectus femoris, vastus medialis, biceps femoris, semitendinosus, gastrocnemius, and soleus), sEMG signals were acquired considering two different electrode placements (i.e., proximal and distal placement). First, the sEMG envelopes calculated from the proximal and distal electrodes were compared to test differences in the muscle activation patterns between the two regions. Then, muscle synergies were extracted from the sEMG envelopes through the non-negative matrix factorization algorithm [2] and their compositions were assessed to test the influence of sEMG electrode placement on muscle synergies.RESULTS AND DISCUSSION: Statistically significant differences were found in the sEMG envelopes of 4 out of 6 muscles (i.e., rectus femoris, vastus medialis, biceps femoris, and gastrocnemius) between proximal and distal placement, revealing that different muscle regions may show different muscle activation patterns and contribute to different biomechanical functions. Nevertheless, not all the differences observed in the sEMG envelopes between the proximal and distal placements had an impact on the muscle synergy composition. This result can be interpreted in two ways depending on the application context. On the one hand, the muscle synergy model may not be sensitive to the excitation of different muscle regions. On the other hand, at least for the condition we tested, the excitation of distinct regions of the leg muscles may be of limited relevance.REFERENCES[1] Watanabe, K. et al. Novel Insights into Biarticular Muscle Actions Gained from High-Density Electromyogram. Exerc Sport Sci Rev 49, 3 (2021). doi: 10.1249/JES.0000000000000254[2] Ghislieri, M. et al. Muscle synergies in Parkinson's disease before and after the deep brain stimulation of the bilateral subthalamic nucleus. Sci Rep 13, 6997 (2023). doi: 10.1038/s41598-023-34151-6

O.2.4: *Flexible and independent control of synergist muscles during standing balance*

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Neural control of synergistic muscles is commonly thought to involve a shared synaptic drive to these motor pools. We demonstrate that the synergists within the human triceps surae can receive entirely opposite neural drives, enabling independent control of synergist muscles in a task-dependent manner. Ten healthy young adults participated in a series of dual and single-leg standing trials on independent force plates, during which high-density electromyography (EMG) was collected from the right soleus (SOL), medial gastrocnemius (MG), and lateral gastrocnemius (LG). Offline, the EMG data were decomposed into individual motor units and cleaned using a semi-automated algorithm. The center of pressure (COP) was calculated for each trial. A rotation matrix was iteratively applied at 5º increments to the 2-dimensional COP data, generating 72, 1-dimensional time series corresponding to COP movement about 360 degrees. Prominent peaks were identified in each COP time-series. EMG data were triggeraveraged to these peaks and the amplitude of event-related EMG was calculated to construct EMG tuning curves. During two-legged standing, active muscles of the triceps surae showed nearly identical EMG tuning curves, with maximal excitation oriented primarily along the sagittal plane. However, during one-legged standing, significant deviations in the tuning curves were observed, with the LG showing a nearly orthogonal activation pattern compared to the SOL and MG. In particular, LG was maximally excited with eversion but inhibited with inversion, whereas SOL and MG were maximally excited with inversion but inhibited with eversion. These findings were confirmed with peristimulus frequencygrams generated from the decomposed motor unit data. These results demonstrate that, depending on the nature of the balance task, muscles of the triceps surae can contribute to corrective ankle torques outside of the sagittal plane. The muscles of the triceps surae act as a functional unit during bipedal standing but can operate independently during single leg stance. This independent control allows muscles that normally function as synergists to act as antagonists, accommodating the biomechanical constraints of specific tasks.

O.2.5: *Athletes with hamstring injuries exhibit lower EMG-EMG coherence of posterior chain coordination muscles during a single-leg postural lean*

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Background: Athletes with hamstring strains display activation deficits and poor motor control during functional tasks. However, there is limited evidence on how the strains affect coordinated activation of the hamstrings and associated muscles during postural control in the athletic population.Methods: 10 hamstring injured athletes (4 with LH and 6 with MH injuries; 22.20±3.26 years old with 8.40±5.48 months of injury) and 10 healthy-matched controls (21.60±1.35 years old) were recruited. Surface EMG electrodes were attached to the gluteus maximus (GM), lateral hamstring (LH), medial hamstring (MH), and medial gastrocnemius (MG). Participants completed three trials of single-leg postural stability, each lasting 15 seconds, with eyes-closed and eyes-open, while leaning forward and backward. EMG-EMG coherence was assessed for five muscle pairs (LH-MH, LH-GM, LH-MH, MH-GM, and MH-MG) on the injured leg and matched leg, within the alpha (5-15Hz) and beta bands (15-45Hz). Concurrently, COP trajectories were analyzed for both directions. A two-way repeated measure ANOVA was employed to compare group and muscle pair differences in both directions, with a significant level set at 0.05.Results: A significantly lower coherence was observed in the injured group, specifically in the α band for LH-MH during both forward and backward leans (F=19.928, p<0.001 and F=9.316, p=0.007, respectively). This trend was also observed for LH-MG during forward leans (F=18.050, p<0.001) and backward leans (F=7.456, p=0.014), as well as for MH-MG during forward leans (F=8.261, p=0.010) and backward leans (F=14.976, p=0.001) compared to the control group. Regarding the eye effects, the eyes-closed resulted in lower coherence in the β band for LH-GM (forward: F=6.277, p=0.022; backward F=11.571, p=0.003), MH-GM (forward: F=19.778, p<0.001; backward F=41.831, p<0.001), and MH-MG (forward: F=7.649, p=0.013; backward F=25.296, p<0.001). Deficits in muscle synchronization in the injured group led to a higher 95% sway area during backward leans (F=5.125, p=0.036). Furthermore, the eye conditions influenced the AP and ML sway range and the 95% sway area, with all p<0.001 except for the 95% sway area in the forward lean (F=17.065, p=0.001).Conclusion: Athletes with hamstring injuries exhibited lower EMG-EMG coherence in the hamstrings and associated muscles compared to the control group. This indicated a

decrease in the synchronous activation of the corticospinal inputs in athletes with hamstring injuries. Impairment in muscle synchronization resulted in poorer balance performance during challenging balance tasks in both forward and backward directions. Moreover, we found that the eyes-closed conditions had lower EMG coherence compared to the eyes-open condition. Therefore, our findings suggest that rehabilitation programs should focus on improving muscle synchronization to enhance postural stability by incorporating different eye conditions into training programs.

O.2.6: *sEMG on muscle groups innervating the hand and fingers in hanging onto a thin hold in sport climbing.*

Katsura Konishi, Keio University; Yuji Ohgi, Keio University

Sport climbing requires different grip techniques depending on the types of hold shapes. For a small and thin hold, crimp, half-crimp and slope grips are commonly used by climbers. Interestingly, the climber has their own strong and weak grip techniques. Previous studies have suggested that configuration of the wrist joint plays an important role in each grip technique.The purpose of this study was to clarify the influence of the wrist joint and fingers configuration on each grip technique by using surface electromyography measurements. An experimental climbing wall was settled up for this study. All thin hand holds were equipped with a single-axis load cell to measure vertical reaction forces. The subjects performed a hanging position and two sequential climbing motion with the left hand and the right hand in that order by three different grip techniques. Five male climbers aged 20 to 23 who are Japanese national team level were recruited. The Ag/AgCl surface electrodes (ϕ6) were affixed on the right arm at flexor digitorum superficialis (FDS), flexor digitorum profundus (FDP), flexor carpi ulnaris (FCU), flexor carpi radialis (FCR), extensor carpi ulnaris (ECU) and extensor carpi radialis (ECR). The sampling frequency was 1 kHz. The acquired data were smoothed using a Butterworth low pass filter, then the average rectified value (ARV) was calculated. The median of each muscle ARV in the crimp grip was used as a reference and compared to those in the half-crimp and slope grips. For all subjects, their ARV amplitude of extensor carpi ulnaris (ECU) showed at least 20% greater in the crimp grip rather than those of the half-crimp and slope grips. Also, except one subject, their ARV amplitude of flexor digitorum superficialis （FDS) obviously larger than those of other five muscles. Especially, the difference between ARV of FDS and FCR was distinguished.

O.3.1: *Effect of anticipation and sex on trunk and knee biomechanics during side-step cutting: implications for noncontact ACL injury*

Mika Konishi, Universirty of Tsukuba; Nicholas C Clark, University of Essex; Masahiro Takemura, University of Tsukuba; Nelson Cortes, University of Essex

BACKGROUND AND AIM: Anterior cruciate ligament (ACL) sprains are among the most severe athletic knee injuries with an incidence 2-3 times higher in females than males. ACL injuries typically occur in rapidly changing, unanticipated, and noncontact athletic situations. Combined dynamic knee valgus, tibial internal rotation (IR), ipsilateral trunk tilt, and contralateral trunk rotation are considered the most common biomechanical characteristics for noncontact ACL injury, where all are exacerbated during unanticipated versus anticipated side-step cutting. We investigated the effect of anticipatory conditions and sex on these variables during side-step cutting. METHODS: Thirty-two recreational athletes (16 males, 16 females) performed anticipated and unanticipated 45° side-step cutting tasks from a 30 cm high box using the dominant leg. In the unanticipated condition, a visual light stimulus was randomly triggered using a wireless sensor (Swift Neo wireless systems, Swift Performance, Australia) during the motion of hopping down from the box. Three-dimensional motion analysis and a force plate were used to quantify kinematics and kinetics (VICON, Oxford, England). Dependent variables included: trunk and knee biomechanics at initial contact (IC), the peak kinematic/kinetic values within 0-50% stance phase, and peak vertical ground reaction force (vGRF). We analysed variables using a two-way repeated-measures ANOVA to determine the effect of anticipation, sex, and any interactions. RESULTS: Significant interaction effects of anticipation and sex for peak trunk rotation angle toward non-dominant leg (F1,32=4.694, p=0.038) and peak vGRF (F1,32=4.274, p=0.047) were evident: peak trunk rotation angle toward the non-dominant leg was significantly lower in females versus males (p=0.016) and peak vGRF significantly increased in males (p<0.001) during unanticipated cutting compared with anticipated cutting. During unanticipated cutting, significant increases in peak knee valgus angle (KVA) (F1,32=4.543, p=0.041), peak knee IR moment (F1,32=4.544, p=0.041), peak trunk tilt angle toward dominant leg (F1,32=52.165, p<0.001), and peak vGRF (F1,32=28.006, p<0.001) occurred during unanticipated versus anticipated cutting in both males and females. Females showed significantly greater IC and peak KVA (IC: F1,32=8.846, p=0.006; peak: F1,32=7.708, p=0.009) and lower IC and peak trunk flexion angle (IC: F1,32=14.565, p<0.001; peak: F1,32=23.681, p<0.001) compared with males in both cutting conditions. CONCLUSIONS: Our findings suggest that trunk rotation in females contributes to absorbing landing impacts in unanticipated situations. In unanticipated cutting, both males and females demonstrated biomechanical features linked to increased risk for noncontact ACL injury. Furthermore, females demonstrated more trunk/knee features linked to noncontact ACL injury versus males. Improving trunk kinematics may reduce the risk of noncontact ACL injuries, especially in females.

O.3.2: *Whole-body angular momentum during cross-slope walking in unilateral transfemoral prosthesis users*

Genki Hisano, Arts et Metiers Sciences et Technologies; Helene Pillet, Arts et Métiers Sciences et Technologies; Xavier Bonnet, Arts et Métiers Sciences et Technologies

Background: Outdoor walking for transfemoral prosthesis users (TFPUs) is challenged by uneven terrain, including cross-slope (Villa C et al., 2017). To achieve the dynamic balance during walking, TFPUs are required to regulate the whole-body angular momentum (WBAM) about body center of mass (COM). In particular, the increase in the positive and negative integrated WBAM (iWBAM) reflect the increase in the body's counterclock- and clock-wise rotation about the body COM throughout the gait cycle. Thus, the integrated WBAM (iWBAM) is used to quantify the effect of perturbed conditions on the dynamic balance (Leestma et al., 2023). In this study, we aimed to evaluate the dynamic balance of the TFPUs during cross-slope walking by comparing iWBAM with level-ground. Methods: Five unilateral TFPUs performed walking along a level surface and a 6° (10%) inclined cross-slope surface at a self-selected speed. Three-dimensional kinematic data were collected using reflective markers and an optical motion capture system. For each of the three surface conditions (Level-ground, Cross-slope with bottom side prosthetic, and with top side prosthetic), four successful trials were selected. The sagittal, transverse, and frontal WBAM was calculated using a 15-segment model and normalized by body mass, height and walking speed. The positive and negative iWBAM per prosthetic gait cycle were calculated as the positive and negative area under the curve of

WBAM, respectively. Further, net iWBAM was calculated as the sum of positive and negative iWBAM. One-way repeated measures ANOVA was performed to compare the variables among three surface conditions. If significant main effects of surface conditions were observed, Bonferroni post-hoc multiple comparisons were performed. Statistical significance was set to P < 0.05. Results: No significant main effects of surface conditions were observed in the sagittal and transverse planes for the net, positive and negative iWBAM. In the frontal plane (refer to Figure 1), while the net iWBAM showed no significant main effect, significant main effects of surface conditions were observed for both positive (P = 0.008) and negative iWBAM (P = 0.001). Post-hoc analysis found no significant difference in the positive iWBAM. However, the negative iWBAM of cross-slope conditions are significantly smaller than that of level-ground condition (bottom side prosthetic: P = 0.005, top side prosthetic: P < 0.001). Conclusions: TFPUs exhibited greater negative iWBAM during cross-slope walking compared to level-ground, particularly in the frontal plane. This suggests that TFPUs experience more rotation about the body COM on cross-slope, indicating a need for advancements in prosthetic design and rehabilitation strategies. By addressing these specific dynamic balance challenges, we may significantly improve the mobility and safety of TFPUs in varied walking conditions.

O.3.3: *Unilateral vs bilateral skipping gaits: asymmetric limb functions lead to temporally more demanding but mechanically less loading*

Genki Tokuda, Tokyo University of Science; Ryota Morishima, Tokyo Univercity of Science; Hiroaki Hobara, Tokyo University of Science

IntroSkipping gait includes the double support phase and flight phase. Based on the step patterns, the skipping gaits are classified into two patterns: unilateral and bilateral skipping. Unilateral skipping is an asymmetrical pattern, where the trailing and leading limbs are fixed to either the left or the right limbs, respectively [1]. In contrast, bilateral skipping is a symmetrical pattern, with the trailing and leading limb exchanges bilaterally every stride [1]. While unilateral skipping gait is commonly adopted in many quadrupedal animals, bilateral skipping gait is prevalent in bipedal humans [2]. The strategic difference may be due to the biomechanical characteristics of each skip pattern, but it remains unclear. The present study aimed to investigate the temporal and biomechanical parameters of unilateral and bilateral skipping gait at various speeds.MethodsEight healthy male subjects without musculoskeletal impairments in their lower limb performed unilateral and bilateral skipping gait at 9 speeds (2.0 – 10.0 km/h with increments of 1.0 km/h). Both skipping gaits were performed on an instrumented treadmill (FTMH-1244WA, Tec Gihan, Kyoto, Japan), where the ground reaction forces (GRFs) were collected at 1000 Hz. Then, we determined the cadence for both skipping gaits. Since both skipping gaits has multiple GRF peaks, we further determined the peak vertical GRFs (,), negative (,) and positive peaks of anteroposterior GRFs (,), respectively. The Shapiro–Wilk test was used in both data obtained from two skipping gaits to confirm data normality. To compare GRF variables between the bilateral and unilateral skipping gaits at each speed, we used two-way repeated measures ANOVA (9 levels) and a post-hoc comparison when the data were normally distributed. If the data were not normally distributed, the Friedman test (9 levels) and a Wilcoxon signed rank test were used. Statistical significance was set at p < 0.05. RESULTSCadence decreased with increasing speeds in both skipping gaits, but the cadence of unilateral skipping was significantly higher than those of bilateral skipping in a wide range of speeds. Further, we also found that the peak vertical GRF () stayed nearly constant, but peak vertical GRF () gradually increased with increasing speeds in both skipping gaits, respectively.

However, there were no significant differences in and between two skipping gaits at all speeds. We also found that the peak anteroposterior GRF (,,, ,) increases consistently in unilateral skipping. In contrast, the increase of peak anteroposterior GRFs were observed only at lower or higher speeds in bilateral skipping. Additionally, unilateral skipping generally had a smaller peak anteroposterior GRFs (,,, ,) compared to bilateral skipping.DiscussionWe found that the cadence of unilateral skipping was significantly higher than bilateral skipping. However, the braking and propulsive forces of unilateral skipping were less pronounced than those of bilateral skipping. These results suggest that the unilateral skipping may be temporally more demanding but mechanically less loading than bilateral skipping.Reference[1] Alberto Minetti, Proc. R. Soc. Lond. B (1998)[2] Pieter et al. J Exp Biol, 216 (7): 1338–1349(2013)

O.3.4: *Validation of a novel limb symmetry index to discriminate movement strategies during bilateral jump landing in individuals with ACLR with and without a history of ankle sprains.*

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BACKGROUND AND AIM: The Limb Symmetry Index (LSI), computed from kinetic parameters, tracks knee functionality post Anterior Cruciate Ligament Reconstruction (ACLR). However, LSI may lack accuracy in individuals with ACLR and ankle sprains, as it overlooks kinetic chain coordination across lower limb joints. Previous ankle sprains (AS) contribute to altered neuromuscular control in ACLR, emphasizing the need to evaluate within-limb coordination during bilateral tasks to prevent secondary ACL injuries. The effect of Energy Absorption Contribution (EAC) on joint work provides insight into the coordination between joints during observed movements. Thus, the purpose of this study was to validate a novel LSI based on EAC for discriminating movement strategies in bilateral drop vertical jump landing (DVJL) among individuals with ACLR and ACLR-AS. METHODS: 39 healthy athletes, including 13 ACLR-AS, 13 ACLR, and 13 healthy controls, were matched by age, height, weight, sex, sport, and limb dominance. Participants performed five DVJLs with kinematics and ground reaction forces recorded. Individual joint work (M) and EAC were calculated and averaged across the middle three trials to compute the LSI on individual joint work (LSIM) and EAC (LSIEAC). Negative LSI indicates asymmetry toward the unaffected-limb (UL), while positive LSI indicates asymmetry toward the affected-limb (AL). A 3x2x3 repeated measures analysis of variance was utilized to analyze interactions between groups, the LSI method, and joint. Tukey's LSD post-hoc analyses were used to examine within and between groups (alpha=0.05). RESULTS: There was a significant interaction between the group, LSI method, and joint (F4,72=5.297, P<.001). Both LSIM and LSIEAC revealed limb asymmetry at the hip (LSIM: P=.005; LSIEAC: P=.002), knee (LSIM: P=.005; LSIEAC: P=.017), and ankle (LSIM: P=.030; LSIEAC: P=.029) for the ACLR-AS group compared to healthy controls. For the ACLR group, LSIM revealed limb asymmetry at the knee (P=.039) while LSIEAC revealed limb asymmetry at the hip (P=.026) compared to healthy controls. Within the ACLR-AS, a significant difference in the degree of asymmetry at the hip (P=.011) was identified toward the UL with LSIM (-0.25) and LSIEAC (-23.23) toward the UL. Within healthy controls, both LSIM and LSIEAC revealed a significant difference in the degree of asymmetry toward AL at the hip (P=.030) and ankle (P=.037) and toward UL at the knee (P<.001). CONCLUSIONS: Only LSIEAC was able to distinguish group differences in asymmetry at the hip for individuals with ACLR-AS and ACLR compared to healthy controls, as well as at the knee and ankle for those with ACLR-AS. Moreover, LSIEAC identified asymmetry at the hip toward AL, which is supported by existing literature, implying the use of a hip strategy to unload the surgical knee. When taken as a whole, LSIEAC offers a more complete picture of movement strategies utilized during DVJL, especially for individuals with ACLR-AS. Therefore, LSIEAC is better suited for tracking the progression of rehabilitation following ACL-R to return to activity.

O.3.5: *Effects of blood flow restriction and band tissue flossing technique on ankle stability and muscle control in athletes with chronic ankle instability*

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Ankle sprain is one of the most common lower extremity joint injuries and has a 20%-30% recurrence rate, and up to 75% of them will become chronic ankle instability (CAI). Blood flow restriction (BFR) training has emerged as a novel training approach for individuals with non-surgical musculoskeletal conditions. BFR training combines low-intensity exercise with the restriction of blood flow, achieving the effects of high-intensity training. However, the cost of BFR training system is on the high for individuals. Another technique to induce vascular occlusion is band tissue flossing (BTF), which provides a more affordable and have the similar effects to the benefits of BFR. However, to date, BTF has yet to be compared to the BFR in discerning differences in the efficacies of these methods. Therefore, the purpose of this study is to evaluate the effects of BFR and BTF training on ankle stability and muscle control in individuals with CAI.Thirty participants with unilateral CAI were recruited in this study, age between 20 to 40 years, and randomly allocated to 3 different groups: BFR, BTF, and non-training as control group (CON). A four-week intervention, 30 min per day, and three days per week, the assessments were conducted pre- and post-training. A Vicon motion analysis system, AMTI force plate and Noraxon Electromyography (EMG) system was synchronously collected for joint angles of lower limb, ground reaction force (GRF), and EMG data during a single-leg jump landing. EMG electrodes was attached on medial gastrocnemius, tibialis anterior, tibialis posterior, and fibularis longus muscles of both sides. A repeated-measures ANOVA was conducted to determine the effects of groups and test times, and Bonferroni corrected were calculated and used in the post-hoc pairwise comparisons. p < 0.05 was considered statistically significant.Results showed larger ankle dorsiflexion (p < 0.05), peroneus longus and tibialis anterior muscle activations (p < 0.05), and lower GRFs (p < 0.05) during landing after training in BFR and BTF groups than those of control groups, but no significant differences between BFR and BTF groups. which peroneus longus and tibialis anterior muscles are activated to provide a dynamic defense mechanism. An increasing ankle dorsiflexion increases people absorb the landing force with the gastrocnemius–soleus complex. Conclusion, ankle mobility provides a buffer during landing, and peroneus longus activation inhibits ankle inversion; together, they can effectively minimize the risk of ankle inversion injuries. Results supported the use of BFR or BTF in treating CAI, which would in turn prevent ankle sprain and injury to neighboring joints.

O.3.6: *Limb coordination in people with Parkinson's disease is differently modulated by dopamine medication and directional subthalamic deep brain stimulation*

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IntroductionSubthalamic deep brain stimulation (STN-DBS) is an effective intervention to treat motor signs in people with Parkinson's disease (PDD). However, no or less improvement in gait and freezing of gait (FOG) after STN-DBS has been reported in about 1/3 of patients, with better effects for STN-DBS localized in the STN central part, i.e. the FOG sweet-spot. FOG has also been related to a loss of limb coordination. Here, we aim to examine the effects of dopa and directional STN-DBS applied in different STN sub-territories on limbs coordination in freezers PPD.MethodGait kinematics of 10 freezers PPD (F/M=2/8, mean age=59.5±6.7 years and FOG-Q=25.7±5.3) were recorded using a motion capture system, before surgery both OFF and ON dopa, and 6 months after surgery in 6 STN-DBS conditions: 1) ring mode, or 2) directional sensorimotor-posterior area, 3) central-FOG sweet-spot, 4) falls sweet-spot (localized within the zona incerta), 5) outside the STN, and 6) OFF DBS. Sagittal joint angles of the trunk, lower and upper limbs were processed, and coupling angles were computed between each joint pair (i.e., trunk-pelvis, trunk-shoulder, etc.) by using vector coding techniques. As measurement of limb coordination, coupling angles variability (CAV) average over time was considered. Principal component analysis (PCA) was used to reduce the complexity of the results, and non-parametric tests applied to compare each treatment conditions. Ten age-matched healthy volunteers were also included for comparison.ResultsThe first two components explained 76% of the dataset variance (Figure 1A). The first PCA-1 (Figure 1B) positively correlated with all the pairwise coupled joints angles and was considered as a global coordination index with higher scores indicating higher CAV and a lower limb coordination. The PCA-1 improved both with dopa and all STN-DBS conditions, with respect to OFF dopa, with better effects with FOG sweet-spot and outside STN-DBS conditions. PCA-2 (Figure 1C) positively correlated with trunk-pelvis and axial upper limb segments variability and negatively correlated with segmental inter-limb coupled joint angles. It was considered as an indicator of upper intra-limb coupling and segmental inter-limb coordination, with scores closest to zero indicating better coordination. PCA-2 was improved both with dopa, directional hotspot FOG and outside the STN-DBS conditions. Ring-mode and other directional STN-DBS conditions did not improve limb coordination.ConclusionLimb coordination in PPD during walking is better restored by directional STN-DBS of the FOG sweet-spot, relative to posterior STN-DBS. This could reflect the preferential modulation of the STN-descending mesencephalic pathways when STN-DBS is applied in this central STN area. Further studies are needed to investigate neurophysiological implication of our findings, and propose directional STN-DBS of the FOG sweet-spot in PPD with residual FOG after STN-DBS.

O.3.7: *The Influence of a stroke on reciprocal control of the stretch reflex during posture*

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Introduction: Stroke is the leading cause of disability in the United States, disrupting neural pathways that contribute to smooth, controlled movement. The spinal stretch reflex is one such neural pathway, and evidence suggests its dysfunction is a contributor to ineffective muscle activations in post-stroke movement disorders. A hallmark of a healthy stretch reflex is the ability to modulate across tasks, and it was recently demonstrated that there is strong reciprocal control, or the effect of agonist and antagonist voluntary activation, of stretch reflex sensitivity during active tasks. We aimed to determine if and how stroke changes reciprocal control of the stretch reflex during various levels of voluntary muscle activation. Doing so is critical to understanding impaired motor control in people with stroke, improving our ability to create effective rehabilitation strategies.Methods: Stretch reflexes were measured from elbow muscles in 5 stroke survivors and 12 healthy controls at various levels of muscle co-activation (0-10% maximum voluntary contraction (MVC)). Reflexes were elicited in each subject's dominant arm (and paretic arm for stroke survivors) by imposing a continuous sequence of 0.03 rad perturbation about the elbow via a rotary motor. Electromyograms (EMGs) were recorded from the biceps brachii (a flexor) and the triceps long head (an extensor). Real-time EMG feedback guided subjects to maintain constant activation levels within each trial. Background EMG and reflex EMG were computed as the average rectified EMG 10-40 ms prior to and 20-50 ms following each perturbation, respectively. We determined the effect of agonist and antagonist background activity, referred to as gains, on biceps and triceps reflexes by fitting mixed-effects models with reflex EMG as the dependent variable, background EMG as continuous factors, subject group (control vs stroke) as a fixed factor and subject as a random factor.Results: Across all levels of background activity, stretch reflexes were substantially greater in the stroke group. Our model fit the data well (R2=0.82 for biceps reflex, R2=0.77 for triceps reflex). Notably, agonist gains were 2 to 5 times higher in the stroke group when compared to the control group. Antagonist activity had no significant effect on the biceps reflex in either group but inhibited the triceps reflex in the stroke group only.Discussion: In both groups, we see very little effect of antagonist and a large positive effect of agonist on the stretch reflex. This is consistent with our previous work in controls during posture. Contrary to previous findings, our results suggest that agonist gains increase after a stroke. Furthermore, it has been suggested that reciprocal inhibition, or antagonistic suppression of muscle activity, may diminish after a stroke, but our antagonist gains contradict this. Future work with more subjects is needed to validate our results and investigate the mechanisms behind this observed behavior.

O.4.1: *Effects of 10 days of unilateral lower limb suspension followed by 21 days of retraining on motor unit conduction velocity*

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BACKGROUND AND AIM: Motor unit conduction velocity (MUCV) is an EMG-derived physiological parameter related to muscle fibre membrane and contractile properties. In particular, because of its biophysical relation with muscle fibre diameter, MUCV is considered a 'size principle parameter'. Furthermore, its non-invasive estimation provides an indirect window into the electrophysiological properties of the sarcolemma, which are known to be affected by a training stimulus. Conversely, at present it is unknown whether MUCV can be altered by short-term disuse or immobilization. Thus, in the present study we investigated adaptations of MUCV to 10 days of unilateral lower limb suspension (ULLS) followed by 21 days of active recovery based on resistance training (AR21), using high density surface electromyography (HDsEMG). METHODS: All measures were performed at baseline (L0), after 10 days of ULLS (LS10) and after AR21. Ten healthy young male volunteers underwent to HDsEMG recording during linearly increasing trapezoidal isometric contractions executed at 25 and 50% of maximal voluntary contraction (MVC) using a 64 electrodes grid positioned over the VL muscle, aligned in the direction of muscle fibers. MUCV and action potential amplitude (MU RMS) were computed during the ascending phase of the trapezoidal contractions on the double differential derivation of MU action potential waveforms propagating along the electrode columns. At least three double differential channels from the same electrode column were selected, with a preference for channels exhibiting the highest cross-correlation coefficients (>0.8). A validated multichannel maximum likelihood algorithm was adopted to calculate MUCV, and MU RMS was computed on the same selected channels. In addition, biopsies from the vastus lateralis (VL) muscle were collected to estimate muscle fibers type and diameter. RESULTS: Average MUCV (m.s-1) was reduced at LS10, both at 25% MVC (from 4.36 ± 0.10 to 4.05 ± 0.11; P<0.001) and at 50% MVC (from 4.64 ± 0.12 to 4.28 ± 0.12; P<0.001). Nevertheless, it returned to LS0 values after AR21. In contrast, MU RMS did not change at any time point. Moreover, no differences were identified for both type I and type II muscle fibers diameter (ATPase staining) during the interventions, although type I muscle fiber percentage increased after AR21.CONCLUSIONS: These novel findings revealed that 10 days of ULLS were sufficient to induce significant alterations in MUCV, which in turn could be reversed by 21 days of active recovery. Since MUCV adjustments were not associated with changes in muscle fiber size, our results suggest that 10 days of ULLS may lead to reversible alterations in the electrophysiological properties of muscle fiber membrane. These data can contribute to expand our understanding of the neuromuscular alterations that can be present in people exposed to a short-term disuse period. PRIN 2022 Cod. 2022T9YJXT "MOPLAST"

O.4.2: *Cross-Education and motor unit adaptations: insights from high-density electromyography*

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Background and Aim: Cross-education, the phenomenon where untrained limbs exhibit increased strength following a training period of the contralateral limb, has been associated with increased excitability in ipsilateral corticospinal pathways and reduced short-intracortical inhibition, hypothesised to be linked to inter-hemisphere interactions facilitated by transcallosal projections. The aim of this study is to investigate the cross-education effect on motor unit (MU) behaviour by examining both trained and untrained limb MUs.Methods: High-density electromyography was used to analyse motor unit adaptations in the biceps brachii of twenty participants, randomly assigned to either an intervention or a control group. The intervention group completed an 8-week unilateral strength training protocol involving 4 sets by 6 repetitions of eccentric contractions of the elbow flexors thrice weekly. Participants were

assessed at baseline (T0), after four weeks (T1), and after eight weeks (T2), performing maximal voluntary contractions to determine maximal voluntary force (MVF) and ramp contractions at 35% and 70% MVF. Raw HDsEMG signals were decomposed into individual MU discharge timings and identified MUs were tracked across experimental sessions (T0 vs T1 vs T2) for a robust comparison.Results: In the intervention group, both the trained and untrained limbs showed significantly increased maximal voluntary force at T1 (+10%MVF, +8%MVF, respectively) and T2 (+18%MVF, +10%MVF, respectively). However, statistically significant differences between T1 and T2 were only observed in the trained limbs (p<0.0001). A significant decrease in recruitment threshold was observed at T1 (trained: from 35.9±12.8% to 28.0±11.6%; untrained: from 34.4±13.3% to 29.3±11.3%, p<0.0001) and T2 (22.9±9.2%; 29.1±12.1%, p<0.0001, respectively), with significant differences between T1 and T2 observed exclusively in the trained limbs (p<0.0001). Changes in the DRMEAN (estimated neural drive) were observed only in the trained limbs at T1 (from 17.0±3.47 pps to 19.15±4.22 pps, p=0.01) and T2 (21.28±3.60 pps, p<0.0001), with significant differences between T1 and T2 (p=0.002). The control group showed no significant differences. Discussion: These findings align with previous reports concerning resistance training adaptations, highlighting specific effects observed in the contralateral limb, likely mediated by the central nervous system modulating firing and recruitment strategies. Cross-education may be attributed to inter-hemisphere interactions, leading to increased excitability in the ipsilateral corticospinal pathways. The absence of direct stimuli likely accounts for the lack of neuromechanical enhancements between T1 and T2 in untrained limbs.

O.4.3: *High density surface electromyographic (HDsEMG) technique to differentiate between coracobrachialis and short head of biceps activity*

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Background:Arthroplasty surgeries of the shoulder, such as the reverse total shoulder arthroplasty and the Latarjet have been reported to alter the coracobrachialis (CB) and short head of biceps (SB) moment arms. There is a lack of evidence in the literature regarding the activity of both muscles during shoulder movement. Investigating healthy CB and SB muscle activity will allow us to better understand the post-operative changes due to surgical interventions. However, it is difficult to separate or identify the selective neuromuscular activation of CB muscle. We aimed to test whether CB and SB activate separately for different shoulder movements and whether CB muscle activity can be identified by high-density surface EMG mapping. Methods:For this case study, we recruited 3 healthy male volunteers. The mean (standard deviation) age, height, weight, and body mass index (BMI) of the cohort were 36 (5) years, 1.8 (0.1) meters, 79.1(9.8) kgs, and 24.7(1.9) BMI. To isolate CB and SB, the volunteers were supine on a bed with their dominant arm in the “banzai” position. Their arm was abducted to an angle of 135° with respect to the thorax. The shoulder was also positioned at maximum external rotation. The participants’ dominant arm axilla was shaved, and ultrasound measured of the underarm region, using a linear array probe. The border of the CB muscle was thus identified and marked. One 16-channel pin electrode was placed on the marked region of the CB muscle. Another 16-channel pin electrode was placed on the superior aspect of the SB muscle to avoid the innervation zones. The participants were asked to 6 perform isometric maximum voluntary contraction (MVC) during elbow flexion (EF) followed by shoulder adduction

(SA). Muscle activation was recorded, as a differential signal, for 5 seconds where the first 3 seconds were used to ramp and the last 2 seconds for holding the MVC. The 16-channel electrodes were replaced by a 64-channel surface electrode with a 10mm inter-electrode distance, placed on the same outlined region as the two 16-channel pin electrodes. EF and SA were performed in the same order as before and the muscle activities were recorded as monopolar signals. For data analysis, the final 2 seconds of MVC were used to calculate the amplitude rectified value (ARV). Subsequently, EF/AD ARV was calculated for the two 16-channel electrodes and for the 64-channel, after calculating the differential signals for the latter.Results:The average EF/SA for the CB and SB muscles were 0.6 and 2.4 respectively and were significantly different (p<0.001). The ratio for each channel of the pin electrode suggests that the proximal channels might be better at detecting CB activity while the distal channels' signal might be influenced by the SB activity. Only considering the proximal half of the sensors the EF/SA for CB and SB muscles were 0.3 and 2.3 respectively. EB/SA color map as presented in Figure 2 also suggests that the ratio was high for SB compared to CB.Conclusion:This pilot research study provides conclusive evidence that CB muscle activity can be selectively detected using the HDsEMG technique.

O.4.4: *Biomechanical changes in muscle length directly influence shared synaptic inputs to spinal motor neurons*

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BACKGROUND AND AIM: Alpha band oscillations in the shared synaptic input to the alpha motor neuron pool can be viewed as a source of common noise interfering with optimal force output control. Recent evidence has suggested that various factors can modulate this tremor frequency range in the common synaptic input to motor neurons [1-2]. This study investigated the impact of altering muscle length on the shared synaptic oscillations to spinal motor neurons and force steadiness. We also conducted a second set of experiments to explore how changes in muscle length affect the low-pass characteristics of the muscle twitches.METHODS: Fourteen participants performed trapezoidal isometric dorsiflexion contractions at 10% of maximal voluntary contraction while the ankle joint was placed at 90° (shortened) and 130° (lengthened). For both conditions, high-density surface electromyography (HDsEMG) recorded from the tibialis anterior (TA) was decomposed into motor unit spike trains [3], and motor unit coherence within the delta (1-5 Hz), alpha (5-15 Hz) and beta (15-35 Hz) bands was calculated. Torque steadiness and torque spectral power within the tremor band were quantified. In a second set of experiments, evoked torque twitches were recorded in five participants with the ankle joint placed at 70° and 130°. Wilcoxon signed-rank tests were used to compare the torque steadiness and power between conditions. Linear mixed models were applied to compare motor unit coherence between conditions. RESULTS: There were no significant differences in torque steadiness between ankle joint positions (P = 0.715). In contrast, torque power within alpha band significantly decreased between 90° and 130° (P = 0.009). Similarly, z-coherence within alpha band significantly decreased as TA length changed from 90° to 130° (from 1.20 [0.95, 1.45] to 0.99 [0.73, 1.24]; P < 0.001), with no changes for delta or beta bands (P > 0.117 for both). Comparison of the evoked potentials between 70° and 130° revealed an 8.3-14.1 ms increase in twitch duration. These changes in twitch duration induced alterations in the

TA low-pass filtering characteristics, as the cut-off frequency was found to be lower when the muscle was lengthened than shortened. A simple computational simulation supported these experimental results, demonstrating that similar excitatory drives arriving at motor neuron ensembles with different twitch durations resulted in distinct alpha band coherence between motor unit spike trains.CONCLUSIONS: Our experimental results, supported by a simplified computational simulation, suggested that the increase of motor unit twitch duration resulting from increased muscle length directly influences the translation of the alpha band (physiological tremor) oscillations to force output. Therefore, this study provides valuable insights into the interplay between muscle biomechanics and neural adjustments.REFERENCES: [1] Laine et al., 2014. [2] Yavuz et al., 2015.[3] Negro et al., 2016.

O.4.5: ***Changes in cortical beta inputs to spinal motoneurons during the acquisition and retention of a new visuomotor skill task***

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Background:The primary motor cortex (M1) plays a crucial role in acquiring and retaining new motor skills, yet the precise regulatory mechanisms of M1 on the motor unit pool during skill learning remain unclear. Corticomuscular coherence offers insight into the connection between brain oscillations from M1 and motor unit activity. However, conflicting evidence exists regarding the impact of motor skill acquisition and retention on the coupling between electroencephalographic (EEG) and electromyographic (EMG) signals.Purpose:This study aims to investigate the influence of visuo-motor skill acquisition and retention on the coupling between EEG activity recorded from M1 (Cz) and motor unit activity recorded from the triceps surae during the learning of a novel visuomotor plantar-flexion force-matching task.Methods:High-density surface electromyography (HDsEMG) was collected from the Gastrocnemius Medialis (GM), Gastrocnemius Lateralis (GL), and Soleus (SOL) muscles. Twelve healthy young adults (average age 29 (7) years, 7 males and 5 females) performed 15 trials of an isometric plantar-flexion force-matching task on two consecutive days (day 1: acquisition and day 2: retention). EEG and HDsEMG signals were recorded concurrently. The first and last three trials of each day, representing the beginning and end of skill acquisition and retention, were concatenated and decomposed into motor unit spike trains. The combined signal from the cumulative spike trains of the three muscles (GM, GL, and SOL) was used to assess corticomuscular coherence between triceps surae motor units and cortical oscillations from M1 (Cz).Results:Participants demonstrated improved learning performance, significantly reducing force matching error from the beginning to the end of acquisition (p<0.01). Retention day error levels (both beginning and end) resembled those at the end of acquisition (p=0.3). Coherence in the beta band (15-35 Hz) peaked at the beginning of acquisition and significantly decreased by the end of acquisition (p=0.008). This reduction in corticomuscular coherence persisted during the beginning and end of retention (p>0.05).Conclusions:The study reveals that cortical beta inputs to spinal motoneurons innervating the triceps surae group diminish after the acquisition and retention of a motor skill. This suggests dynamic evolution of cortical inputs to motoneurons during skill learning, requiring heightened cortical input initially, followed by a decrease once the skill has been learnt.

O.4.6: ***Effects of repeated bouts of split-belt walking on locomotor adaptation, physiological arousal, and cortical activation***

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Background & Aims: Data suggest anxious arousal modulated by the autonomic nervous system (ANS) affects how we adapt motor strategies during static balance tasks. This relationship has not been tested during adaptation to a continuous walking challenge. Split-belt treadmills allow the exploration of gait adaptation through measures of step length symmetry (SLS). Individuals adjust step length bilaterally to achieve a symmetrical gait pattern during split-belt walking despite differing belt speeds. This study aims to understand how anxious arousal, cortical activation associated with attentional demands, and motor adaptation co-modulate during repeated exposure to a single session of split-belt treadmill walking.Methods: Twenty (10F) healthy young adults (aged 26.8(+/-3.3) yrs) completed a single-session, repeated-block design on a split-belt treadmill, with three, 3.5-minute split-belt walking adaptation blocks (2:1 speed ratio), interspersed with tied-belt blocks. Anxious arousal (electrodermal activity (EDA), attentional demand (prefrontal cortex (PFC) activation from functional near-infrared spectroscopy oxyhemoglobin (HbO) response) and SLS (embedded force platforms) were measured. Data from early (first 30 strides) and late phases (last 30 strides) of each block was analyzed. Linear-mixed-effects models (LMM) and Spearman/Pearson's correlations explored trial effects on EDA, SLS, and HbO mean/variance of signals in the PFC for each block and phase.Results: LMM revealed differences in SLS, EDA, and PFC mean activation between early and late phases in split block1 only. SLS increased while EDA and PFC activation decreased ($p \leq 0.05$) in the late phase of block1. Neural variability in the PFC increased from early to late phase within each block (1-3, $p \leq 0.05$). In block1, a moderate negative correlation (r= -0.62, p<0.001) was observed between early phase SLS and EDA. Weak correlations (r= -0.25, p=0.06) were found between SLS and mean PFC activation and between EDA and mean PFC activation (r=0.15, p=0.29).Conclusion: The initial split-belt exposure induced significant changes in SLS, EDA, and PFC activation between early and late adaptation. Early exposure to split-belt walking showed a relationship between heightened anxious arousal response and more asymmetrical gait, suggestive of an association between error detection and ANS response in walking. Repeat exposures during blocks 2 and 3 of split-belt walking revealed that both levels of anxious arousal and SLS showed minimal further adaptation after block1. Interestingly, variability in activation increased in the PFC in each of the 3 blocks. The increase in neural variability from the early to late phases in all 3 blocks is suggestive of decreased attentional demands with each exposure. These findings inform our understanding of the co-modulation of anxious arousal and attentional demands during locomotor adaptation and provide novel insights into processes underpinning motor learning.

O.4.7: ***Associations between delayed onset trunk muscle soreness, altered EMG-torque relationships, and lumbar kinematics in dynamic contractions***

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Background: People with chronic low back pain (CLBP) often show reduced trunk torque steadiness (TS). This finding is based on observational studies with a limited ability to draw causal inferences. As a pain model, delayed onset muscle soreness (DOMS) can help us better understand the effect of pain on trunk. Surface electromyography (sEMG) and force relationships are crucial in linking muscle activity to force output, given the correlation between the low-frequency component of force and rectified interference sEMG oscillations. Research on the lumbar erector spinae (ES), where decomposing high-density sEMG (HDsEMG) signals is challenging, can benefit from such approaches. To date, it remains unclear whether DOMS can influence dynamic trunk muscle control, potentially leading to alterations in EMG-torque relationships and patterns of thoracolumbar movement.Purpose: To evaluate the influence of DOMS on TS and HDsEMG features recorded from the lumbar ES muscle of asymptomatic people during concentric/eccentric submaximal (25%, 50% maximum voluntary contraction) trunk extension contractions. Methods: Twenty individuals attended three lab sessions (24h apart). HDsEMG signals were recorded unilaterally from the thoracolumbar ES with two 64-electrode grids and from the rectus abdominis and external oblique muscles using one 64-electrode grid each. Torque was measured using an isokinetic dynamometer, and TS was quantified as the coefficient of variation (CoV) and standard deviation (SD) of torque. The interplay between HDsEMG signals and torque was explored via coherence (0-5Hz) and cross-correlation analysis. PCA was employed to reduce HDsEMG data dimensionality and improve HDsEMG-torque-based estimations.Results: Muscle soreness and sensitivity in the thoracolumbar area, assessed using the visual analogue scale (VAS) and pressure pain threshold, increased 24h and 48h post-DOMS induction (VAS scores: 2.6 ± 2.1; 2.9 ± 1.8). For eccentric trunk extension, improved TS (SD) was observed after 24h and 48h, with greater flexion movement at higher forces. A decrease in δ band HDsEMG-torque coherence and cross-correlation was observed at 48h. Associations indicated that more flexion during eccentric trunk extensions correlated with better TS and higher levels of muscle soreness and that decreased TS was related to increased HDsEMG cross-correlation. During concentric trunk extension at 48h, improved TS (CoV, SD) was observed and was accompanied by reduced sagittal thoracolumbar movement, implying a preference for a more neutral lumbar spine position. Associations revealed that increased muscle soreness is associated with reduced improvements in TS and that minimal sagittal thoracolumbar movement is associated with better TS.Conclusions: In the presence of DOMS, individuals had better trunk concentric/eccentric TS. This improvement may be attributed to the observed adaptation of movement and recruitment strategies and a learning effect from the training exposure in the first session.

O.5.1: *The decoding of extensive samples of motor units in human muscles reveals the rate coding of entire motoneuron pools*

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Movements are performed by motoneurons transforming synaptic input into an activation signal that controls muscle force. The control signal is not linearly related to the net synaptic input, but

instead emerges from interactions between ionotropic and neuromodulatory inputs to motoneurons. To advance our understanding of the neural control of muscle, we decoded the firing activity of extensive samples of motor units in the Tibialis Anterior (129±44 per participant; n=8) and the Vastus Lateralis (130±63 per participant; n=8) during isometric contractions of up to 80% of maximal force. From this unique dataset, we characterised the rate coding of each motor unit as the relation between its instantaneous firing rate and the muscle force, with the assumption that the linear increase in isometric force reflects a proportional increase in the net synaptic excitatory inputs received by the motoneuron. This relation was characterised with a natural logarithm function that comprised two phases. The initial phase was marked by a steep acceleration of firing rate, which was greater for low- than medium- and high-threshold motor units. The second phase comprised a linear increase in firing rate, which was greater for high- than medium- and low-threshold motor units. Changes in firing rate were largely non-linear during the ramp-up and ramp-down phases of the task, but with significant prolonged firing activity only evident for medium-threshold motor units.Contrary to what is usually assumed, our results demonstrate that the firing rate of each motor unit can follow a large variety of trends with force across the pool. From a neural control perspective, these findings indicate how motor unit pools use gain control to transform inputs with limited bandwidths into an intended muscle force. We will show how these results can help to design linear or non-linear decoders that aim to predict muscle activation or muscle force from descending inputs recorded in supraspinal centres, with the will to generalise their performance across movements.

O.5.2: *On time effectiveness of manual editing of motor unit spike trains*

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BACKGROUND AND AIM: Automatic methods for motor unit (MU) spike train identification from HDEMG are extensively used, but segmentation of the MU spike trains into discharge patterns still requires manual editing. This represents one of the major bottlenecks in analysis. We explored how the time efficiency of manual editing depends on the quality of the identified spike trains (Pulse-to-Noise Ratio - PNR), the operator's level of experience, and muscle contraction levels.METHODS: Experimental signals were acquired from the First Dorsal Interosseous, Tibialis Anterior, Vastus Lateralis, and Biceps Brachii (BB). Two male subjects performed isometric contractions for every muscle at 10, 30, 50, and 70% of MVC. The contractions were ~25 seconds long and were measured with a 13×5 electrode array. The same contraction levels were simulated in Soleus and BB with a 9×10 electrode array and 20 dB noise. All signals were decomposed using the Convolution-Kernel-Compensation method and manually edited by 9 operators (2 beginners with < 50, 2 intermediates with < 200, 3 advanced with < 1000, and 2 experts with > 1000 edited signals worth of experience). All operators underwent a tutorial to standardize the editing procedure. Results were analyzed with a linear mixed-effects model of editing_time ~ PNR * contraction_level * operator's _experience * signal_type + (PNR | muscle:subject). We only examined MUs with a PNR of 25 dB or higher.RESULTS: The editing time decreased with PNR (F=63.9, P<0.0001) with 55.9 ± 80.3 s and 8.1 ± 15 s spent for editing of MUs with PNR of 25-39 dB and 40-54 dB, respectively. Editing time increased with the contraction level (F=10.9, P<0.0001) as 42.6 ± 63.2 s, 54.2 ± 82 s, 57.8 ± 83.8 s, and 60 ± 82.9 s were spent editing the 10, 20, 30, 50 and 70% contraction level. The level of experience predicted the editing time (F=10.5, P<0.0001). Beginners required 65.9 ± 90.4 s, intermediates 55.1 ± 72.4 s, advanced operators 51.9 ± 90.9 s and experts 37.1 ± 40.6 s. Signal type (synthetic or experimental) did not influence editing time but was in significant interaction with contraction level (F=6.4, P=0.001), and operator's level of experience (F=4.7, P=0.003). There was also a significant interaction between PNR and contraction level (F=10.4, P<0.0001), PNR and operator's level of experience (F=7.1, P<0.0001), and contraction level and operator's level of experience (F=3.3, P=0.001). CONCLUSION: The time required for MU editing reduces almost linearly with the operator's level of experience and is dependent on the contraction level and PNR.FUNDING: This research was funded by the European Union's Horizon Europe Research and Innovation Program [HybridNeuro project, GA No. 101079392]. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

O.5.3: *Quantifying the collective synchrony of motor units using multi-variate coherence*

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BACKGROUND AND AIM: Synchronization in neuronal firing is widely studied as a potential mechanism supporting the encoding and transmission of information throughout the nervous system. Recent developments in multi-unit recording systems have enabled the activity of populations of neurons to be detected in both cortex and muscle (through motor unit recordings). This paper presents the multi-variate (MV) coherence estimate, a method of estimating both the collective synchrony of a neuronal sample and assessing the contributions of individual neurons to the total synchrony.METHODS: The MV coherence estimate was tested and compared against the most widely used method of estimating motor unit coherence, described in [1], using both a computational model and experimental data. The model consisted of a biophysical motoneuron pool model based on the first dorsal (FDI) interosseous muscle [2]. Each motoneuron received some synchronous synaptic inputs, representing efferent cortical signals, in order to generate weakly correlated spike trains from the model. The MV coherence estimate was also applied to experimental motor unit firing data recorded from the FDI (N=18) during index finger abduction during forces ranging from 10% to 40% maximal voluntary contraction (MVC). Discriminable motor unit were extracted from the surface EMG using decomposition algorithms (Delsys, Inc.).RESULTS: Simulations from the computational model revealed that the MV method provides a more reliable and stable coherence estimate when compared with existing methods of estimating motor unit coherence, particularly for gamma-band coherence. Simulations demonstrated that the MV coherence method was less sensitive to the number of motor units included in the estimate, compared with existing methods that exhibit an approximately linear increase in coherence as the number of motor units is increased. When the synchronous inputs to the motoneurons were varied, the MV coherence was also able to estimate the change in the magnitude of these synchronous inputs more accurately. When the MV coherence estimate was applied to experimental motor unit data from the FDI muscle, it revealed an increase in gamma-band coherence with force level. A distinct coherence peak at ~40 Hz (piper rhythm) was also observed during the contractions at

40%MVC.CONCLUSIONS: This is the first time that the Piper rhythm has been detected in a study correlating activity between single motor units. The method enabled the detection of an increase in gamma-band coherence at higher muscle contraction forces, which was not identified using the cumulative spike train coherence method. Multi-variate coherence enables the effective detection of beta- and gamma-band synchronization in neuronal firing, which will be essential for future studies investigating the functional role of neural synchrony in both brain and muscle.[1] Farina D et al. (2014) J Physiol 592: 3427-3441.[2] Senneff, S. et al. (2019). 41st Annual International Conference of the IEEE EMBC (pp. 2293-2296). IEEE.

O.5.4: *Activity index outperforms cumulative spike train and amplitude envelopes in surface EMG coherence analysis*

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BACKGROUND AND AIM: Coherence is frequently used to study functional coupling between two motor neuron pools. Decomposing surface electromyograms (sEMG) into spike trains of individual motor units (MUs) and summing them into cumulative spike train (CST) [1] may improve the coherence estimates provided by sEMG amplitude envelopes (AE), mainly due to removal of MU action potentials (MUAPs). However, the coherence estimation in CST depends on the number of MUs and reaches optimal values at several tens of detected MUs. Such a high number of MUs cannot always be guaranteed. Conversely, activity index (AI), which constitutes the first step of the CKC algorithm [2], compensates the MUAPs and combines contributions of all the MUs active in the detection volume of sEMG electrodes. In this study we compare coherence calculations using AE, AI and CST in synthetic and experimental sEMG.METHODS: 10 biceps brachii muscles were simulated with 500 MUs each. 20 s of 9×10 sEMG channels were simulated and sampled at 2048 Hz. Excitation levels of 10%, 30% and 50% of MVC were simulated with superimposed 10 Hz sinusoidal modulation with amplitude of 5% MVC. Experimental sEMG was acquired by 5×13 electrode array from gastrocnemius medialis (GM) and lateralis (GL) muscles of 5 healthy subjects during 20 s long 30% MVC contraction. All sEMG signals were decomposed by CKC algorithm [2], yielding MU spike trains and AI. MU spike trains with pulse-to-noise ratio > 25 dB were summed into CST and spatial average of rectified sEMG was used as AE. Coherence was calculated between all pairs of sEMG signals from two different simulated muscles and between simultaneous recordings of GL and GM. We evaluated the coherence values at 10 Hz (synthetic signals) and at the coherence peak on the 8-30 Hz interval (exp. signals).RESULTS: 14.2±6.1 and 26.1±16.7 MUs were identified from synthetic and exp. sEMG. In synthetic case, the AI yielded significantly higher (P<0.001) coherence values at 10 Hz (0.97±0.01) than the AE (0.83±0.07) and CST (0.78±0.23). In exp. signals coherence peaks were significantly (P<0.05) higher in the AI (0.48±0.20) than in the AE (0.35±0.26) or CST (0.24±0.07).CONCLUSION: The AI yielded higher coherence values than the AE and CST, likely due to the larger number of MUs (compared to the CST) and MUAPs compensation (compared to the AE).FUNDING: This research was funded by the European Union's Horizon Europe Research and Innovation Program (HybridNeuro project, GA No. 101079392). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.[1] Farina et al. The

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O.5.5: *Interfacing with motor unit activity using high-density thin-film electrodes following targeted muscle reinnervation*

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Background: Targeted Muscle Reinnervation (TMR) involves the surgical transfer of peripheral nerves, originally innervating muscles of the missing limb, into targeted muscles above the amputation level (Kuiken et al., 2009). After TMR, these muscles are probed using non-invasive electromyographic (EMG) or intramuscular EMG electrodes to record the myoelectric activity triggered by the rerouted nerves. Classic methods to estimate the human motor intent typically extract global features from recorded EMG signals. However, Farina et al. (2017) introduced a paradigm shift in human-machine interfacing where the neural activity of individual motor neurons was decoupled from high-density surface EMG signals and used for prosthesis control in TMR patients. Muceli et al., 2018, proposed multi-channel epimysial EMG electrodes to overcome the limitations of non-invasive sensing and to establish a high-throughput neural interface for detecting single motor neuron spiking activity in animal models of TMR. Our current study is the first exploration of this human-machine interface paradigm in TMR patients. Methods: In contrast to classic TMR and prior investigations, which measure from spacially distinct myoelectric sites to minimise the signal interference, we used 40-channel thin-film electrodes (Muceli et al., 2015) to obtain a single highly dense sample of EMG activity from ten muscles where peripheral donor nerves with large cognitive control were redirected through TMR. Each volunteer performed isometric contractions at 10-20% of the maximum voluntary contraction while thinking about different movements ranging from single Degree of Freedom (DoF) tasks (e.g., pinky flexion) to a combinationof DoF tasks (e.g., tripod). Firstly, we investigate how changes in the neuromuscular morphology following TMR impact the morphology of motor units (MU) by examining the MU action potential amplitude, duration, and MU territories. Secondly, we examine the MU firing characteristics during the entire task execution. Finally, we provide a comparative discussion of the characteristics of MUs active fordifferent tasks. Results: We demonstrate that the TMR muscles exhibit high compartmentalisation likely due to hyper-reinnervation following TMR (Bergmeiste et al., 2019). This muscle compartmentalisation corresponds to a functional heterogeneous innervation: the probed muscle fibres are innervated by clusters of motor neurons associated with different functional tasks. Thus, decomposition methods can be used to unmix EMG signals and extract neural activity uniquely associated with motor functions. Conclusions: Our results indicate that TMR offers an efficient biointerface for prosthesis control. Additionally, our observations on the functional heterogeneity of active motor units indicate that common synaptic input is shared across the motor neurons that have the same functional role (Hug et al, 2023).

O.5.6: *Estimating low-threshold motor unit twitch responses in high-force trials: towards real-time estimation of neuromusculoskeletal function through motor unit-driven approaches*

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BACKGROUND: Interfacing with motor units (MUs) in intact humans in vivo is key for understanding the interaction between alpha motor neurons and the innervated muscles. Recent advancements in high-density electromyography (HD-EMG) decomposition techniques allow the non-invasive identification of MU firing and contractile properties. In combination with musculoskeletal modeling, this enables decoding the individual contribution of MUs to muscle force generation [1]. However, due to MU action potential (MUAP) amplitude cancellation and the volume conductor effect, it remains challenging to decode low-threshold MUs in high-force tasks. In this study, we combine a peel-off decomposition approach [2] with the refinement of MU filters obtained from low-force trials to enrich the estimation of MU-specific activation dynamics in high-force tasks.METHODS: Experimental protocol: Four healthy subjects performed isometric dorsi-plantar flexion contractions across different levels of force, during which HD-EMGs and torque measurements were collected. Decomposition procedures: The HD-EMGs were decomposed offline into MU firing events using a convolutive blind source separation technique [3]. For the high-force trials (>50% MVC), we estimated MUAP waveforms from the HD-EMGs [2]. Subsequently, we employed the found MUAPs to obtain EMG residuals. For the peel-off approach, we further decomposed the EMG residuals by refining MU filters found in low force. We eliminated duplicates and spike trains with low silhouette values.MU-specific activation dynamics: We estimated discharge rates and recruitment thresholds. We computed a linear combination of these firing features through principal component analysis and projected them onto their eigenvector [1]. We linearly mapped the firing features with twitch properties found in humans. We employed the estimated contraction times and peak amplitudes to design twitch responses for each MU. The total MU-specific activation was defined as the sum of the individual twitch responses.RESULTS: Preliminary results on the tibialis anterior showed that the activation estimated from spike trains of the peel-off approach provided a higher correlation with force than the activation derived from the conventional decomposition (0.55 ± 0.14 and 0.70 ± 0.06, respectively).CONCLUSIONS: We proposed a framework that integrates a peel-off decomposition approach, refinement of MU filters, and characterization of MU properties for decoding a more diverse subset of MUs from HD-EMGs, with a wider range of recruitment characteristics. This not only improved the estimation of muscle activation but also opens avenues for designing highly efficient neuro-modulative strategies. Future work will further integrate this framework with musculoskeletal modeling to achieve optimal control neuro-rehabilitation devices in real-time. REFERENCES: [1] A. Gogeascoechea et al, IEEE TNSRE, 2023.[2] M. Chen et al, IEEE TNSRE, 2016.[3] F. Negro et al, J. of Neu. Eng. 2016.

O.5.7: *Magnetomyography can provide new insights into motor units in living humans*

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BACKGROUND AND AIM: Magnetomyography (MMG) measures the magnetic field induced by the activation of muscle fibers and is a complementary method to well-established electromyographic (EMG) recordings. Although MMG was scarcely explored in the past, mainly due to technological limitations, the MMG’s physical properties motivate the investigation of the method. Most importantly, the magnetic permeability of the human body is (nearly) the same as in free space. Thus, MMG can be measured contact-free, and the MMG signal is potentially less affected by the body properties and anatomy than EMG. In this contribution, we explore whether these theoretical advantages can be leveraged to obtain new insight into motor unit (MU) physiology in living humans. METHODS: We use a biophysical model of EMG and MMG to perform MU decompositions in a controlled environment. To focus on the physical properties of the signal (and not the performance of the decomposition algorithm itself), we derive an in-silico trial framework integrating the biophysical model into the spike estimation step of blind source separation-based MU decomposition algorithms. MUs with a silhouette score higher than 0.9 are considered identifiable. First, the performance of MMG-based and surface EMG-based MU decompositions are compared. Further, the influence of the magnetometer properties (e.g., noise, bandwidth, vector field components, and density) is explored. As proof of concept, blind source separation-based MU decomposition is applied to experimental data, i.e., isometric contractions (5%, 10%, 20%, and 30% MVC) of the abductor digiti minimi muscle. All experiments were conducted in a magnetically shielded room (ak3b) of the MEG center in Tübingen. The MMG is measured with 15 commercially available optically pumped magnetometers (OPMs) (FiledLine Inc.) arranged through a custom-made 3D-printed sensor holder. The simultaneous measurement of high-density EMG was only possible through a specifically designed new high-density EMG electrode (OT Biolelectronica). RESULTS: The in-silico trials show that MMG-based MU decomposition is theoretically superior to surface EMG-based MU decomposition. The number of decomposable MUs increases by 76%. Decomposing MMG can identify MUs with depths higher than 2 mm that are typically not identifiable through surface EMG. In detail, the MMG detects 88% of the superficial MUs (i.e., up to 2 mm in depth) and 41% of the deep MUs (more than 2 mm in depth). In contrast, the EMG identifies 67% of the superficial MUs and 4% of the deep MUs. Through two-source validation, the proof-of-concept in-vivo experiments illustrate that it is possible to decompose MUs from high-density MMG data. However, the performance of MMG-based decompositions is currently limited by the performance of the detection system. The in-silico experiments revealed that the most relevant limitation is the bandwidth and the noise level of the utilized magnetometers. DISCUSSION: The presented research provides new insights into methods to study MUs in living humans. Unlocking the full potential of MMG-based MU decomposition requires further developments of the detection system.

O.6.1: ***The process of filling of the sEMG signal with motor unit potentials as force is gradually increased in the quadriceps***

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BACKGROUND AND AIM:As the force of an isometric contraction is gradually increased, the number of active motor unit increases, larger units are progressively recruited, and already recruited units increase their firing rate. However, several questions related to this increase remain unresolved: (1) Does the increase in sEMG amplitude occur gradually and smoothly or does it occur in steps? (2) Is the sEMG activity at low force levels “pulsatile” (composed of a few large-amplitude spikes) or “continuous” (formed by many small-amplitude MUP spikes)? (3) What is the force level at which the sEMG signal is completely filled up? There is no complete understanding of the way in which the surface EMG signal progressively fills with MUPs as force

increases. We sought to investigate this sEMG filling process.METHODS: Surface EMG signals were recorded from the quadriceps muscles of 33 healthy subjects as force was gradually increased from 0 to 40% MVC in 60s (see Fig. 1a). The sEMG filling process was analyzed by measuring the EMG filling factor, calculated from the non-central moments of the rectified sEMG signal.RESULTS: (1) As force was gradually increased, one or two prominent abrupt jumps in sEMG amplitude appeared between 0 and 10% of MVC force (mean 2.5% MVC) in all the vastus lateralis and medialis muscles (Fig. 1b).(2) The jumps in amplitude were originated when a few large-amplitude MUPs, clearly standing out from the previous sEMG activity or from noise, appeared in the sEMG signal (Fig. 1b).(3) Every time an abrupt jump in sEMG amplitude occurred, a new stage of sEMG filling was initiated (Fig. 1b).(4) The filling factor decreased significantly every time an abrupt jump in sEMG amplitude occurred, and this index increased progressively as additional MUPs are successively incorporated to the sEMG signal (Fig. 1c).CONCLUSIONS:It has been found that, as force was slowly increased in the vastii muscles, prominent abrupt jumps in sEMG amplitude occurred at low force levels (<10% MVC). Thus, the filling process of the sEMG signal occurred one or two stages in these muscles, with the sEMG being almost completely filled at very low forces (2-12% MVC).SIGNIFICANCE:The filling factor is a useful promising tool to analyse the EMG filling process.

O.6.2: *Asymmetry in the onset of paraspinal muscles activity during rapid arm movements differs in adolescents with idiopathic scoliosis compared to those with a symmetrical spine.*

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BACKGROUND Adolescent idiopathic scoliosis (AIS) occurs in ~2-4% of adolescents globally.1 The 3D spinal deformation is associated with progressive wedging, translation, and rotation of multiple vertebrae.1 The curvature typically begins between 9-12 years of age, develops rapidly, and has no known cause or cure. There is growing evidence of altered muscle activation in AIS however many previous studies are limited by insufficient clarity on tasks performed, and data recording and processing techniques.2 Muscle activation is one of the factors that contribute to muscle force generation. If an asymmetry in paraspinal muscle activation is present in AIS, it may contribute to an asymmetry in forces applied to the spine, and curve progression. OBJECTIVE To determine if symmetry of paraspinal muscle activation differs in those with AIS compared to controls during a simple, highly repeatable movement task.METHODS Girls with AIS [n=24; primary right thoracic curve; Cobb angle 39.5(16.4)°, age 13.8(1.5) years], and matched controls [n=20, age 13.1(1.8) years] participated. Surface electrodes were placed bilaterally on anterior deltoid, and erector spinae adjacent to C7, T9, T12 and L5 vertebrae. In response to a visual (light) signal, participants performed a bilateral rapid arm flexion while holding a small wooden rod (in both hands to aid movement symmetry). Muscle activation onsets were manually selected while blinded for group, from 6 trials for each participant. Activation symmetry (i.e. onset left – right) was calculated for each muscle pair. To compare between groups, a linear mixed model with group and muscle as fixed factors and participants as random intercepts was used.RESULTS Right anterior deltoid onset was earlier than the left in

65% of trials, however there was no difference in this asymmetry between groups (χ^2 p=.22). There was a significant Group×Muscle interaction (p<0.01) for activation asymmetry, with the difference between groups identified at T9 (mean difference 14ms; 95%CI: 4-25ms, post hoc p<0.01). Activation was 6ms (95%CI: 6-12ms) earlier on the right (convex) side of the curve in AIS. In contrast activation was 8ms (95%CI: 1-15ms) earlier on the left side in controls (Fig 1). There were no group differences at other vertebral levels (all post hoc p>0.44).CONCLUSION The result of this study provides evidence of a difference in paraspinal muscle activation onset at the level of the curve apex in AIS during a well-controlled symmetrical upper limb movement task. It is likely that the longissimus muscle contributes the greatest to the recorded muscle activation at T9. The longissimus is a powerful extensor and lateral flexor that attaches to the transverse processes and the lower rib angles. These bony structures are known to present with deformation in AIS. Future studies are now justified to investigate the underlying mechanisms for this difference in activation, and its potential consequences on spine deformity. 1.Negrini S et al. Scoliosis and Spinal Disorders. 2018.2. Ng P et al. Journal of Electromyography and Kinesiology. 2022.

O.6.3: *Long-term effects of ACL reconstruction with a hamstring tendon autograft on neural control of the vastii muscles at different knee-joint angles*

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BACKGROUND AND AIM: After anterior cruciate ligament reconstruction (ACLR), the ability to activate and contract the knee-extensor muscles in the injured leg often fails to recover for months or even years after surgery despite exercise rehabilitation. Furthermore, evidence suggests potential for greater quadriceps inhibition at extended compared to flexed knee-joint positions. Whilst long-term muscle inhibition post ACLR has been demonstrated on the whole muscle level, adjustments at the motor unit (MU) level remain largely unexplored. This study examined MU discharge properties of the vastii muscles at different knee-joint angles and compared individuals 1-5 years post ACLR and healthy controls.METHODS: Twelve participants 3.1 ± 1.3 (range: 1.2-5.1) years post a primary, unilateral ACLR with a hamstring tendon autograft and twelve sex-, body mass- and physical activity-matched controls performed unilateral trapezoidal isometric knee-extension contractions at 30, 50, and 70% of their maximal voluntary torque (MVT) at 25, 55, and 85° of knee flexion (full extension: 0°). High-density surface electromyography signals were recorded from the vastus lateralis and medialis muscles and decomposed into discharge timings of individual MUs. Discharge rate during the contraction plateau (DRplat), and at recruitment (DRrec) and derecruitment (DRderec) were quantified for individual MUs. Linear mixed models were constructed to examine whether the outcome variables were predicted by group, leg, knee-joint angle, and contraction intensity, with MU recruitment threshold included as a covariate in the statistical models.   RESULTS: In the ACLR group, MVT was similar for both legs at all knee-joint angles, with no differences compared to the control group (ACLR, injured vs contralateral leg: 246 [216, 275] vs 246 [216, 276] Nm, respectively; control: 229 [199, 259] vs 226 [196, 256] Nm; all interactions: p ≥ 0.5042). A group*leg interaction for DRplat (p = 0.0447) suggested lower DRplat in the injured compared to the contralateral leg in the ACLR group; however, post hoc testing did not indicate any side-to-side differences in either group (ACLR: 12.2 [11.3, 13.2] vs 12.9 [11.9, 13.8] pps; p =

0.0596; control: 12.8 [11.8, 13.7] vs 12.9 [11.9, 13.8]; p = 0.964). No significant group*leg interactions were observed for DRrec (ACLR: 8.1 [7.3, 8.8] vs 8.4 [7.6, 9.2] pps; control: 8.4 [7.7, 9.2] vs 8.6 [7.9, 9.4] pps; p = 0.6026) or DRderec (ACLR: 6.1 [5.7, 6.5] vs 6.2 [5.8, 6.7] pps; control: 6.0 [5.6, 6.5] vs 6.2 [5.8, 6.6] pps; p = 0.5498). For DRplat, DRrec, and DRderec, no group*leg interactions with knee-joint angle and/or contraction intensity were detected (p ≥ 0.1594).CONCLUSION: These results suggest that despite having successfully restored their knee-extensor strength, ACLR individuals may exhibit subtle long-term deficits in MU discharge properties of the vastii muscles of the injured compared to the contralateral leg.

O.6.4: ***Characterization of spinal circuits with high density surface electromyography (HDsEMG)***

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Spinal circuits are fundamental in the control of movement, with spinal interneurons defining motoneuron excitability and shaping the patterns of motor output. Local spinal networks are affected in many neuromuscular disorders, such as Amyotrophic Lateral Sclerosis (ALS) or dystonia. For instance, ALS changes the synaptic wiring contributing to motor dysfunction that might appear before denervation. Standard neurophysiological techniques used to assess spinal circuits in clinics are based on the use of surface EMG, which has a poor temporal resolution to identify circuit features, such as latency or duration; or needle electrodes, which are invasive and allow identification of only a few motor units (MUs) (typically < 3 MUs per needle). HDsEMG allows non-invasive identification of a pool of MUs at a time and more accurate study of motor pool properties. Only two studies have previously proposed the use of HDsEMG to study reciprocal inhibition through the decomposition of individual MUs. Latest advances on HDsEMG acquisition and decomposition methods have allowed sampling larger proportion of the motor pool even at low force levels; while new protocols have been proposed to study recurrent inhibition based on stimulation of motor axons and recording MUs using intramuscular electrodes. In this study, we propose to use the state-of-the-art HDsEMG technique to characterize spinal circuits, particularly recurrent and reciprocal inhibition, in large population of MUs.HDsEMG grids of electrodes were placed on the Tibialis Anterior (TA) and Soleus (SOL) muscles of healthy participants. Individuals had their foot strapped to a dynamometer and were to produce isometric contractions at low force levels (5% and 10%) of MVC. During the steady contractions, inhibitory responses were activated by nerve stimulation with single pulses at an interstimulus interval (ISI) of 1s or 2s to silence the ongoing muscle activity. Essentially, recurrent or reciprocal inhibitory circuits to inhibit SOL activity were evoked by nerve stimulation of the tibial nerve to stimulate SOL motor axons to antidromically activate recurrent inhibition (SOL-to-SOL); or the antagonist common peroneal to stimulate TA Ia fibres to orthodromically activate reciprocal inhibition (TA-to-SOL). A similar approach was followed for TA muscle activity: antagonist SOL Ia fibres (for reciprocal, SOL-to-TA) and TA motor axons (for recurrent, TA-to-TA) were stimulated. Individual MUs were decomposed with a blind source separation algorithm and their stimulus-triggered responses were investigated to determine the inhibition latency and duration using peristimulus histograms based on their instantaneous firing rate or occurrence. For the first time, we non-invasively estimated the latency and duration of recurrent inhibition in the TA and SOL muscles in a large population of MUs. At the same time, we characterized optimal experimental conditions (contraction level and ISIs) to measure both spinal circuits.The technique and results derived from this study will allow to develop neurophysiological biomarkers which might contribute to early diagnosis or monitoring the progress of neuromuscular diseases, such ALS. In addition, this study aimed at favouring the translation of HDsEMG into clinical practice and neurophysiological research as a technological advancement.

O.6.5: *Modulation of subthalamic nucleus activity during gait initiation in parkinson's disease patients: a biomarker for freezing*

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BACKGROUND:Freezing of gait is a major debilitating motor symptom in people with Parkinson’s disease (PPD). While increased beta band (12-35Hz) oscillatory activity in the subthalamic nucleus (STN) has been linked to motor symptom severity, identifying a clear biomarker for gait disorders and FOG in PPD remains elusive. In this study, we recorded STN neuronal activity in PPD experiencing FOG during walking, particularly focusing on gait initiation, a phase significantly affected in these patients. Our goal was to uncover the relations between STN neuronal activity modulation and gait and balance disorders, aiming to identify a potential biomarker for FOG. METHODS:We simultaneously recorded STN neuronal activity and gait kinetics and kinematics parameters in 31 PPD who underwent STN deep brain stimulation (23M/8F, age = 58 ± 9 yrs, disease duration = 11 ± 4 yrs), using a force plate, motion capture system, and an embedded EEG amplifier. Patients were recorded both in the OFF and ON-dopa states (UPDRS-III score OFF-dopa = 38 ± 13 and ON-dopa = 8 ± 6). STN neuronal activity and gait recordings were subsequently analyzed offline. RESULTS:OFF-dopa, 10 patients experienced FOG episodes during gait recordings, while 21 did not. In non-FOG patients OFF-dopa, we observed beta desynchronization alongside alpha and gamma hypersynchronization at gait initiation. Beta desynchronization primarily occurred in the posterior-motor part of the STN. Conversely, in FOG patients, beta desynchronization was more widespread across the posterior and central parts of the STN during gait initiation. During trials with FOG, this desynchronization was predominant in the central part with relatively less desynchronization in the posterior part. DISCUSSION AND CONCLUSION:In PD patients with FOG, beta desynchronization is broadly distributed within the STN during successful gait initiation trials, indicating higher central-associative modulation but reduced posterior-motor involvement when a FOG episode will occur. This potentially reflects the activation of executive networks to compensate for the motor

function loss during successful gait trials and a failure of this compensatory mechanism during FOG episodes. These findings could potentially serve as a biomarker for FOG, crucial for the development of closed-loop adaptive DBS systems. ACKNOWLEDGEMENTS:We are deeply thankful to the patients for their participation and implication. Study supported by Boston Scientific, Agence Nationale de la Recherche.

O.6.6: ***Feasibility of high-density surface electromyography for the detection of neuromuscular disorders in children***

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Background: The diagnosis of neuromuscular disorders in children is challenging. Concentric needle electromyography (CNEMG) is the current standard for electrophysiological examinations; however, this technique has multiple limitations that may compromise the assessment of neuromuscular function in children. First, these assessments are invasive and can be uncomfortable. Second, limited muscle sampling can be performed due to small recording area of electrodes and lack of tolerance in small children. High-density surface electromyography (HDsEMG) might overcome these limitations as it is non-invasive and better tolerated than CNEMG, and has higher spatial resolution, allowing the identification of a greater number of motor units (MUs) from different muscle regions. Purpose: To assess the feasibility of HDsEMG MU decomposition in children referred to Birmingham Children's Hospital (BCH) for electrophysiological examination and determine potential MU firing parameters allowing discriminating between children with diagnostic impression of neuropathy, myopathy, and normal examination. Methods: Fifty-four children (8.9 (5.2) y, range 0 to 16 y) that attended to BCH for electrophysiological examination underwent a CNEMG study followed by a HDsEMG assessment using a 64-channel electrode grid on tibialis anterior or biceps bracchi. Participants were requested to contract for 15s at 20% of the maximal EMG or perform a spontaneous contraction (depending on age). EMG signals were then decomposed into individual MU spike trains by convolutive blind source separation. The total number of MUs identified per participant and, the association between the number of identified MUs and age were assessed. In addition, MU firing properties were compared between groups of children with a diagnostic impression of neuropathy, myopathy, or normal electrophysiological examination (according to CNEMG results). Results: MUs could be reliably identified in 87.0% of the children. On average, 5 (4) MUs, with a complete firing pattern could be identified per child. The number of identified MUs did not depend on the diagnostic impression (p=0.129), nor sex (p=0.211), but was dependent on age (r=0.504, p<0.001), as the MU yield increased in older children. Mean discharge rate was similar across groups (p=0.734), however, discharge rate variability (quantified as the coefficient of variation for the inter-spike interval, CoVisi) was significantly higher in children with a diagnostic impression of myopathy (p=0.036). Conclusions: The results of the present study demonstrate the feasibility of HDsEMG MU decomposition in children with neuromuscular disorders, enabling the examination of full MU firing patterns in this population. This can potentially open the door for the identification of new biomarkers allowing an improved diagnosis and monitoring of neuromuscular disorders in children.

O.6.7: ***On the origin of short and medium latency soleus stretch reflexes: how do the amount and speed of ankle joint rotation relate to the spinal stretch reflexes in humans?***

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Stretch reflexes are thought to contribute to various motor functions. To better understand how stretch reflexes may contribute to plantarflexor force generation, in this study, we aimed to examine how different amounts and speeds of ankle joint rotation relate to the spinal components (M1 and M2) of soleus stretch reflexes. For this, we varied only the amount and speed of ankle joint rotation. Unlike previous stretch reflex-related studies, in the present setup, the participant remained seated with a fixed joint posture for all measurements, so that we would be able to control for and maintain factors that could influence the spinal reflex excitability such as joint position and muscle contraction level.Twelve adults with no known neurological conditions participated. All measurements were made while the participant sat in a custom-made chair. The amplitude and onset latency of M1 and M2 reflexes were measured in 2 experiments; experiment 1 in which 6-12 degrees of dorsiflexion rotations were tested at a single speed (≈200deg/s), and experiment 2 in which 6 degrees of dorsiflexion rotations were tested at five different speeds (≈75–225deg/s). To characterize different rotation speed conditions, the time to reach the initial 2deg of dorsiflexion (TR2deg) and the rotation speed over the initial 2deg were calculated. The stretch reflexes were elicited while the participants maintained ≈10% MVC level of soleus background EMG.The experiment 1 results show that the amount of rotation did not affect the M1 and M2. When the rotation speed increased (experiment 2), the M1 and M2 amplitudes increased (p<0.05); the M1 latencies did not change across the speeds; the M2 latencies and TR2deg progressively shortened with increasing speeds from 63.1±5.0 to 54.1±3.2ms, and 33.6±0.9 to 10.6±0.3ms, respectively (p<0.05). To further quantify the speed dependency, the correlations between the rotation speed in the initial 2deg and the M1 and M2 amplitude, and TR2deg and M1 and M2 latency were examined. The M1 amplitude was highly correlated with the rotation speed (r=0.86±0.08), but the speed did not affect the M1 latency (r=0.19±0.20). The M2 amplitude was moderately speed dependent (r=0.55±0.16), and the M2 latency was moderately correlated with the assigned speed (r=0.60±0.12).The present results confirm past studies that the origin of M1 is likely the velocity sensitive Ia afferents from the muscle spindles. We speculate that the length-sensitive afferents (group II) may importantly contribute to the M2 having their own unique threshold muscle lengths. The longer latency of M2 with a slower speed would reflect this threshold length because a slower joint rotation would delay the timing for the group II afferents to reach the thresholds. The M1 and M2 responses can, together with intrinsic properties of the contracted muscles, be interpreted as a fist line of neural response to stabilize the joint position to an unexpected external event.

O.7.1: *Respiratory sEMG measurements for quantitative comparison of bipolar electrode leads*

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Surface electromyography (sEMG) of respiratory muscles has applications in assisted mechanical ventilation. It has been proposed as an approach to quantifying spontaneous breathing activity and monitoring patient-ventilator interaction by recording the diaphragm and accessory muscles. Due to the anatomy of these muscles and the presence of crosstalk respiratory sEMG usually has a small signal-to-noise ratio (SNR). To date, there is no consensus on acquisition procedures and electrode positions. The current study contributes to the standardization of respiratory sEMG measurement by conducting a quantitative comparison of bipolar leads.Measurements of respiratory sEMG were performed using the SAGA 64+ (TMSi, Oldenzaal, Netherlands) amplifier with 64 electrodes. Electrodes were placed bilaterally on the midaxillary line (MAL), anterior axillary line (AAL), midclavicular line (MCL), and parasternal line (PSL). Subjects performed a baseline measurement of muscle relaxation, 300s of quiet breathing, 5 maximum inspiratory maneuvers (MIP), and resistance breathing at 20% of maximum MIP. Cardiac artifacts were suppressed using wavelet denoising, and differential sEMG envelopes were calculated. Three metrics were determined to quantify the SNR, namely the ratio between the sEMG amplitude reached during inspiration and (1) tonic muscle activity (SNR_tech), (2) expiratory muscle activity (SNR_cross), (3) ECG interference.The current study included 11 healthy subjects (female=5 / male=6, age=25.64±3.04 years, BMI=24.30±3.58 kg/m^2), leading to the following preliminary results. Regarding the diaphragm, we evaluated the performance of bilateral electrode pairs at the standard position (costal margin). The MCL and PSL attained the highest SNRs (SNR_tech: 7.04±5.26 dB and 5.78±2.85 dB, SNR_cross: 3.05±1.15 dB and 3.00±0.97 dB, resistance breathing), outperforming the MAL and AAL. On the MCL, superior placement 2.5cm above the costal margin attained higher SNRs (SNR_tech: 9.63±8.16 dB, SNR_cross: 3.53±1.21 dB, resistance breathing) than the standard and inferior position. Regarding the intercostal muscles, we compared bilateral electrode pairs at the 2nd and 3rd intercostal space (ICS). Differences were less pronounced than for the diaphragm. On the MCL and PSL, both the 2nd (SNR_tech: 4.10±2.99 dB and 3.42±2.33 dB, SNR_cross: 2.08±0.61 dB and 2.40±0.56 dB, resistance breathing) and 3rd (SNR_tech: 3.71±2.77 dB and 3.30±2.44 dB, SNR_cross: 2.06±0.50 dB and 2.01±0.46 dB, resistance breathing) performed similarly. ECG generally was highest for positions closer to the heart, reaching up to -27.64±2.86 dB on the MCL 5cm above the costal margin and up to -24.97±5.58 dB on 3rd ICS (for quiet breathing).The presented study enables a comparison of different electrode pairs for recording respiratory muscle activity, thus providing important evidence for standardization. In the future, we intend to evaluate further electrode combinations and resistance levels.

O.7.2: *Muscle activity mapping by 3-dimensional localization of motor unit action potentials from high-density surface electromyography*

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Background: The spatial activity pattern of muscle contractions can provide information required to quantitatively assess individual muscles recovering from injuries such as stroke. Patients recovering after lost motor function may compensate the impairment of individual muscles with increased synergistic contractions of other muscles, which changes the activity pattern. Furthermore, distinguishing the activity of individual muscles may provide a path for direct translation between prosthetic control and user intent. A robust non-invasive tool for the mapping of distinct muscle contractions is therefore in high demand. High-density surface electromyography (HDsEMG) provides a large amount of information on muscle activity, which can be used to estimate the spatial origin of motor unit action potentials (MUAPs).Method: In a new approach, we identified MUAPs and estimated their positions and fibre directions using a

custom surface fit and a cylindrical volume conductor model. The surface fit was applied to the to the distribution of each MUAP signal across the HDsEMG grid. The estimated parameters from each surface fit were used to directly calculate the spatial origin of each signal. By localizing thousands of action potential firings, substantial robustness is achieved in muscle discrimination. To test the method, HDsEMG data was recorded with two 5-by-13 electrode grids, from the posterior forearm during isolated isometric low force contractions of the wrist and finger extensors.Results: The MUAP activity of all finger and wrist extensors was consistently separated into distinct regions and motor unit paths in a cylinder model. MUAPs from wrist extensions with radial and ulnar rotation were localized at the radial and ulnar edges of the model respectively. MUAPs from finger extensions were localized in between the estimated regions of the carpi muscles. Furthermore, clear medial-lateral discrimination was observed between index, ring, and little finger extensions, while proximal-distal discrimination was observed between middle finger extension and all other movements. We generate 3-dimensional and cross-sectional plots of the estimated positions for clear visualization. Lastly, an energy estimate for each muscle is generated, taking muscle position into account.Conclusions: With this method, assessments of individual muscles can identify and account for compensatory synergistic contractions of other muscles. Furthermore, the nuances of individual finger movements could be used in a real-time application to improve the intuitive control of prosthetic devices.

O.7.3: ***Identification of mutual motor unit expression in two independently decomposed HDsEMG signals***

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Background. High-density surface electromyography (HDsEMG) systems have been used to identify the activities of motor units (MUs) during voluntary contraction. Adaptation of the neuromuscular system to interventions, injuries, or diseases may affect the behavior and properties of MU. To evaluate changes in a specific set of MUs during intervention or disease progression, identification of the expression of the same MUs is required. This study aimed to propose an algorithm to identify mutual motor unit expressions across testing visits.Methods. Fourteen healthy subjects (26 ± 4 yr., BMI 24.1 ± 3.3 kg/m2, mean ± SD) were tested on a number of visits within a span of 30 days. They were placed in a pronate position, their knees fully extended, and their ankle joint was secured in a boot attached to a load cell. After skin preparation, a 64-channel HDsEMG grid (13 rows, 5 columns, 8 mm inter-electrode distance) was placed on the anterior tibialis with columns parallel to the proximal-distal muscle axis. The monopolar HDsEMG signals and torque were recorded at a sampling rate of 2000 Hz while the subjects performed isometric dorsiflexion following a trapezoidal torque trajectory: 10 s sustained torque at 10% of the maximal voluntary contraction (MVC) and 2% MVC/s torque increment and decrement rate.HDsEMG signals from two random visits separated by 12–16 days were selected. After independent MU decomposition in a monopolar configuration using the Convolution Kernel Compensation algorithm, column-wise single differential MU action potential (MUAP) shapes were calculated using spike-triggered averaging. MUs with a pulse-to-noise ratio (PNR) <28 dB were discarded. Mutual MU expression was then identified using the MUAP image registration method. The performance of the proposed algorithm was evaluated by comparing the PNR, precision, and sensitivity of the firing patterns with reinforcement before and after the application of the algorithm.Results. The Wilcoxon paired test showed no significant difference in MVC (31.7 ± 8.0 Nm and 32.4 ± 8.1 Nm, p = .71), number of identified MUs (16 ± 7 and 14 ± 5, p = .11), and average PNRs (34.2 ± 3.5 dB and 35.2 ± 4.9 dB, p = .85) between the two visits. On average, the proposed algorithm could identify the mutual expressions of 61% of the identified MUs in 11 participants and failed in 3. There was a significant improvement in the average PNR from 25.9 dB to 34.1 dB (p < .001), an increase in the average sensitivity from 59% to 92% (p < .001), and an increase in the average precision from 64% to 92% (p < .001).Conclusion. We proposed an algorithm to identify the expression of mutual MUs in two testing visits. This approach will help expand our understanding of the characteristics of MUs across testing visits.Funding. S.D.H.S. and Y.Y.D. are supported by NIAMS (1R01AR069176-01A1). A.H. is supported by the Slovenian Research Agency (J2-1731 and P2-0041).

O.7.4: ***Is spinal motion preserved following vertebral body tethering for adolescent idiopathic scoliosis? A prospective study***

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Purpose: Adolescent idiopathic scoliosis (AIS) is a 3D structural deformity of the spine, characterized by abnormal curvature and rotation of the vertebral column, often requiring early intervention to stop or slow curve progression, or surgery in severe cases. The gold-standard surgery is posterior spinal fusion and instrumentation (PSF); however, significant loss of range of motion (ROM) has been reported, which can lead to long-term complications. Vertebral body tethering (VBT) is a novel minimally invasive surgical technique that has shown preservation of ROM in computer-simulated and animal models. Results from pilot work retrospectively evaluating ROM suggest that spinal motion is preserved in the transverse plane (Maksimovic et al., 2023); however, the effect on spine ROM has not been explored prospectively. The purpose of this work is to prospectively compare spine ROM in 4 groups: 1) VBT; 2) PSF; 3) untreated/braced AIS; and 4) controls (CTRL). Methods: 51 participants (8 PSF, 11 VBT, 13 AIS, 19 CTRL) have completed a baseline assessment, and 16 participants (1 PSF, 7 VBT, 7 AIS, 1 CTRL) have completed 1-year follow-ups. Aligning with our previously validated protocol (e.g., Beange et al., 2023), 3 inertial measurement units were placed over C7, T12, and S1 vertebrae (locations confirmed via ultrasound imaging to ensure sensor placement reliability between visits). Participants performed 2 repetitions each of spine forward flexion, and bilateral lateral bending, axial rotation, and circumduction to their end ROM in 2 conditions: constrained (at the hip) and unconstrained. Fused quaternion data were extracted and converted to rotation matrices. Relative thoracic (C7 relative to T12), lumbar (T12 relative to S1), and total (C7 relative to S1) orientation was computed and converted to Euler angles using a transverse-frontal-sagittal rotation sequence. Orientation was zeroed to a standing position, and axial ROM was calculated by computing the maximum orientation (for bilateral movements, right and left ROM were averaged). Box plots were constructed to evaluate between-group and between-visit differences.Results: Results for constrained lateral bending are presented, as previous pilot work showed significant differences between groups for this task. Total ROM (Figure 1c) decreased between baseline and follow-up visits, and there is a slight increase in lumbar ROM, which is likely a result of compensatory movement to offset decreased ROM in the thoracic region (most commonly affected region). Conclusion: While it is difficult to draw conclusions from all groups (e.g., N=1 in PSF and CTRL follow-up groups), ROM estimates in the current study align with results from pilot work. Results for the remaining tasks and 1 year follow-up visits will be presented at the conference. It is expected that spine ROM will be preserved in VBT patients compared to PSF, and that post-treatment ROM will assume the following order: CTRL > AIS > VBT > PSF.

O.7.5: ***Continous knee dynamics monitoring: combining inertial measurement units and multichannel electromyography***

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The assessment of human joint kinematics and muscle activity is crucial for understanding movement and function, particularly in diagnosing and treating musculoskeletal conditions. This research focuses on Cerebral Palsy (CP), a common childhood motor impairment syndrome characterized by a variety of movement and posture disorders. CP arises from brain lesions or abnormal development, especially in motor control regions, leading to symptoms like spasticity, muscle weakness, and impaired postural control.This paper introduces a novel multimodal approach that synergizes inertial measurement unit (IMU) sensors with electromyography (EMG). Except for the precise measurement of knee angles in individuals suffering from CP, the use of EMG provides valuable complementary data, offering insights into the patterns of muscle activation which are essential in understanding the complexities of CP-affected gait. This hardware features a minimal design for seamless integration into clothing, ensuring user comfort during extended periods. It employs two IMUs placed on the thigh and shank for precise, non-intrusive knee angle measurements, overcoming the drawbacks of traditional mechanical sensors. The system also includes an 8-channel EMG amplifier to monitor muscle activity. An embedded ARM M7 microcontroller manages sensor communication, real-time signal processing, and data storage. For continuous, all-day knee activity monitoring, the device is powered by a 5000 mAh external battery pack, conveniently carried in the user's trouser pocket. In this paper, our focus was on examining the efficacy of this integrated approach, particularly the accuracy of IMU sensors in tracking knee joint movements, EMG signal quality, and synchronous data acquisition suitable for further analysis. This angle accuracy was benchmarked against an optical motion-tracking system, a standard in the field. The EMG signal quality was estimated during self-paced walking on a treadmill. The results show that the knee angle estimation error of the presented device falls within the state-of-the-art devices (mean RMSE of 6°) while the signal-to-noise ratio of the 8 EMG channels exceeded 100 dB. The synchronization between knee angle and muscle activity was qualitatively evaluated using observed perturbations in the gait cycles. While the primary aim of developing and evaluating this system was its inclusion in an ongoing clinical CP study, the design of both the hardware and algorithms is not limited to CP patients. This allows the device to be applicable in measuring joint activity across various human joints and in different protocols.

O.7.6: ***Design and validation of a versatile and flexible electrode grid for US-transparent acquisition of HD-sEMG signals***

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BACKGROUND AND AIM. High Density EMG (HD-EMG) and ultrasound (US) imaging provide complementary information about the physiological mechanisms underlying force generation. Their combination can reveal how neural and mechanical variables interplay during a muscle contraction. Although different approaches have been proposed, the use of US-transparent electrode grids seems the most suitable way to implement this integration. Despite the progresses made in this field[1], current US-transparent electrodes have two limitations: 1) the minimum inter-electrode distance (IED) achievable with the current manufacturing technology (10 mm), limiting electrodes' density and recordings from small muscles; 2) the 50 Hz/60 Hz common mode voltage injected by the US probe, leading to power line interference in HD-sEMG signals. While the latter factor was minimized by ground-floating and miniaturized amplifiers[2], the first one still requires technological improvements. The aim of this work is to design, develop and test a highly-conformable and US-transparent HD-sEMG grid.METHODS. The electrode grid is composed by a thin silicone substrate integrating a flexible silver electrode grid. Two 8x4 grids with 5 mm and 10 mm IED were prototyped (Fig 1.a) and characterized with electrical and functional tests. The electrical characterization included an impedance analysis performed though a custom-made impedance meter. The electrode-skin impedance (ESI) was measured on the biceps of six subjects and compared with that of standard HD-sEMG electrodes. Afterwards, HD-sEMG signals and US images were concurrently acquired during isometric elbow flexions at 5%, 10% and 30% MVC. MEACS system (LISiN and ReC Bioengineering Laboratories, Italy) and ArtUs (Telemed, LT) were used to collect HD-sEMG and US images respectively. Signal quality was assessed through visual inspection and quantified through the SNR. HD-sEMG decomposition was applied to verify the possibility of identifying the activity of single motor units. RESULTS. The magnitude of the ESI at 50Hz was 89kΩ±23kΩ and was comparable to that of standard electrodes for HD-sEMG[3]. The SNR was always higher than 46dB. HD-sEMG decomposition allowed to extract the firing pattern of 5.8±2.3 MUs per contraction (PNRR=29.3±5.2). The comparison between the US images detected with/without the presence of the grid between the US probe and the skin showed no alterations in the image quality (Fig 1.b).CONCLUSIONS. The developed detection system represents an improvement of the current technology for the concurrent acquisition of HD-sEMG and US images opening the possibility to use denser grids and to investigate smaller muscles. Its characteristics in terms of conformability and electrode-skin interface makes the proposed solution a valid option for the collection of high-quality HD-sEMG signals also in general-purpose scenarios.REFERENCES[1] Botter et al. 2013 JAP[2] Cerone et al. 2029 IEEE TBE[3] Piervirgili et al. 2014 Phys. Meas.

O.8.1: *Statistical and physiological variations in single motor unit reflex amplitude estimation*

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BACKGROUND AND AIM: The peri-stimulus time histogram (PSTH) and peri-stimulus frequency-gram (PSF) are two common methods for analyzing reflex responses of motor units (MU). In both methods, it is assumed that the size of synaptic input to MU is correlated with the size of its reflex response. However, the variation in MU reflex response is multi-factorial. For example, the size of reflex amplitude changes with the discharge rate and membrane noise. These phenomena complicate using measured reflex responses to estimate the size of the input current and the input-output gain. In the present study, we aim to investigate factors correlated with reflex size among a MU population. We hypothesized that the numerical discrepancies between PSTH and PSF can be sources of uncertainty that influence the estimation of synaptic input among a MU population, each sensitive to different discharge properties of MUs.METHOD: We analyzed Hoffmann (H-) reflex amplitude variability among a MU population using experimental and simulation data. In-vivo MUs were identified by decomposing high-density surface EMG signals from tibialis anterior muscles. The reflex is elicited by stimulating the common peroneal nerve during sustained dorsiflexion contraction (10% and 20% of maximum voluntary contraction). In the simulation, we created 200 motoneurons using a model with soma and dendrite compartments. To obtain a motoneuron pool, the membrane resistance and compartment size were exponentially distributed across motoneurons. The supraspinal neural drive was modelled with common and independent noise, while the monosynaptic reflex input (EPSP) was kept the same for the entire pool. The reflex amplitude was measured using the cumulative sum of PSTH and PSF for experimental and simulation data. RESULTS: For experimental data, we found a significant positive linear correlation between reflex amplitude measured from PSF and background discharge rate in 4 of 6 subjects (R = 0.40-0.72, P <0.05). The slope of the regression between background discharge rate and reflex amplitude was correlated with the amount of total membrane noise computed as the coefficient of variation of the inter-spike interval (R=0.50 and P=0.04). PSTH did not confirm the same relation. This discrepancy between PSTH and PSF was further investigated using a computational model. The simulations confirmed that the reflex amplitude is nonlinearly influenced by the discharge probability (discharge rate and variability of inter-spike intervals). However, the effect differs between PSTH and PSF. The PSF was sensitive to the distribution of the soma resistance (MU type) that was induced in the simulation, while the PSTH method was not particularly responsive to that. CONCLUSION: These results can be interpreted in such a way that the choice between PSF and PSTH depends on the specific research question and the level of analysis. For example, the PSF can be a better method to analyze the distribution of reflex size among a motor unit population with different phenotypes.

O.8.2: *Comparsion of FES induced muscle fatigue during isometric and isotonic forearm muscle contractions*

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Background: Fatigue limits the practical applicability of Functional Electrical Stimulation (FES). As fatigue is not avoidable, the classification and management becomes a priority. An effective implementation of this strategy requires an understanding of the current state of fatigue and the fatigue behavior of the muscles. Previous studies on fatigue have focused on the lower extremities and investigated the forces and torques generated. However, when applied to the hands forces and movements are of importance. It is therefore crucial to identify indicators of fatigue that consider force and movement aspects. The aim of the present study is to compare the dependence of fatigue on the stimulation parameters during isometric and isotonic contractions and to collect data for a future fatigue management system. Methods: In our study, we examined nine healthy volunteers (8M,1F; Age:38.1±11.9y; Ht:1.78±0.07m; Wt:76.6±9.4kg) who each completed 16 stimulation sessions of 20 minutes one week apart. We separately measured the movements and forces of the flexor digitorum superficialis (FDS) and extensor digitorum (ED) muscles under four different stimulation conditions (15 Hz 70 µs, 15 Hz 300 µs, 30 Hz 70 μs, 30 Hz 300 μs) and 70% of the max. tolerable stimulation current. We choose a stimulation cycle (SC) with a ratio of 12 seconds stimulation and 4 seconds pause. Muscle activity was recorded using sEMG, force and motion measurements were performed with self-developed devices. We classified fatigue into four levels based on amplitude decay: none (NF): up to 10%; light (LF): up to 25%; moderate (MF): up to 50%; and high (HF): over 50%. Results: The force and movement measurements on the ED and FDS showed significant differences under all conditions (p < 0.05). In isometric contractions, LF occurred after an average of 9±6 and MF after 24±8 SC, while in isotonic contractions LF was observed after 16±9 and MF after 35±12 SC. HF was observed in isometric contractions in five cases after 43±10 cycles and in isotonic contractions only in one case after 59 cycles. At 15 Hz (36±12 SC) MF occurred under all variations up to twice as late as at 30 Hz (17±8 SC). The two pulse lengths show little difference 70 μs (27±8) vs 300 μs (25±14). Due to the small sample size, a trend is recognizable, but without statistical significance. Conclusion: Fatigue manifests differently under isometric and isotonic contractions. LF and MF occur sooner in isometric contractions compared to isotonic ones, indicating a quicker onset of muscle fatigue in the former. HF was less frequently observed and appeared later, particularly in isotonic contractions. At 15 Hz, the time until MF was almost double compared to a higher frequency of 30 Hz, suggesting that lower frequencies may be more beneficial for delaying fatigue. However, the difference in pulse lengths (70 μs and 300 μs) showed minimal impact on fatigue. A larger group of participants is necessary to validate these trends.

O.8.3: *Modulation of spinal motor neuron excitability by transcranial electrical stimulation*

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Neuromodulation of corticospinal excitability can be achieved through transcranial electrical stimulation (TES) and may be used to promote motor rehabilitation. The stimulation site and waveform parameters can be tuned to target spinal motor neurons of specific muscle groups. Most studies of TES measure motor evoked potentials (MEPs), which are compound muscle action potentials generated by the synchronous activation of motor neurons in response to stimulation of corticospinal neurons. While MEPs represent clear and direct effects of TES on corticospinal activity, the threshold for evoking MEPs by TES is typically very high, requiring high amplitude stimulation that is uncomfortable or even painful. For TES to be suitable as a rehabilitation tool, it is necessary to develop stimulation protocols that avoid causing extreme discomfort in patients. In this study, we hypothesized that TES could be used to modulate the excitability of spinal motor neurons at stimulation intensities below the threshold for evoking MEPs. We used high-density electromyography (HDEMG) and motor unit decomposition to measure the spontaneous discharge of motor units recorded in flexor muscles of the forearm of participants performing isometric wrist flexion tasks. TES was applied over the contralateral motor cortex, targeting the wrist flexor muscles. MEPs were recorded to confirm the target location for the anode, which was found to be at C3 and the cathode was located at CZ.We estimated motor neuron excitability using the delta-F method on the motor unit spiking data. Participants performed isometric wrist flexion as a ramping force contraction by following a force trace prompt. The force profile was monotonically increasing for 30 seconds and then monotonically decreasing for 30 seconds. During wrist flexion and relaxation, TES was delivered to evoke MEPs. We also repeated the experiment with sham stimulation applied at a different location, 5 cm posterior to the forearm flexor representation, to control for persistent inward current (PIC) modulation as a response to the pain of stimulation. We decomposed the isometric wrist flexion HDEMG data to get motor unit (MU) firing information. The MU decomposition was performed through the Convolution Kernel Compensation (CKC) algorithm. From the motor unit firing information we identified test and reporter MUs for the delta-F method of motor neuron excitability. This early finding can provide insights to improve the design of TES protocols for motor rehabilitation and future studies to unravel the mechanism of modulation of spinal motor neuron excitability.

O.8.4: ***Caffeine attenuates discharge rate reduction during maximal sustained contractions***

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INTRODUCTION: Caffeine is a methylxanthine with proved ergogenic effects on exercise performance and known to influence the central nervous system by increasing the release of monoamines. Recent research shows that repetitive sustained maximal contractions reduced PIC contribution to motoneuron discharge rates, despite the consumption of caffeine. Yet, caffeine consumption attenuated torque loss during repetitive fatiguing contractions. This suggests an effect of caffeine on intrinsic motoneuron properties that might contribute to torque production during repetitive fatiguing contractions.PURPOSE: To investigate if caffeine consumption would change motor unit discharge rates during maximal repetitive sustained contractions.METHODS: In a crossover, double-blind design, six individuals performed four isometric maximal contractions and sustained them until torque production dropped to 60% of maximum capacity after consuming either 6 mg· kg-1 of caffeine (CAF) or placebo (PLA). Tibialis anterior motor unit discharge rates were recorded from a 64-channel electrode and analysed from high-density surface electromyograms (HD-EMG). HD-EMG signals were decomposed into single motor unit discharge events and then converted into instantaneous discharge rates. Motoneuron discharge rates were recorded at the beginning and end of each contraction. Total torque-time integral was measured during the repetitive sustained maximal contractions.RESULTS: No differences in discharge rates were observed between CAF and PLA at the beginning of the contractions [P= 0.99; mean difference 0.15 Hz (95%CI: -0.82,1.14)], but were 2.7 Hz (95%CI: 1.7, 3.7) higher during CAF at the end of the contractions (p<0.001; d = 1.1). Overall, discharge rates reduced 5.4 Hz (95%CI: 4.4, 6.5) for CAF and 8.0 Hz (95%CI: 7.1, 8.8) for PLA from the beginning to the end of the contraction (p<0.001, CAF: d= 2.2 and PLA: d= 3.3). Participants produced 337 Nm.s (95%CI: 49.9,624) (d=0.63) more torque integral during the repetitive sustained maximal contractions after caffeine consumption.CONCLUSION: Caffeine-attenuated the reduction of discharge rates during repetitive maximal sustained contractions. This allowed participants to endure maximal torque production for longer.

O.8.5: ***Changes in recruitment and motor unit firing patterns with deep brain stimulation for Parkinson's disease***

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Deep Brain Stimulation (DBS) and dopaminergic medication are well-established therapies for reducing the symptoms of Parkinson’s disease. The manner in which they influence motor unit and muscle activation patterns, however, are not well-understood. The aim of this study was to gain insight into the underlying mechanisms through which DBS and medication improve motor function and , specifically, how they influence motor unit firing and recruitment patterns. High density electromyography (HD-EMG) signals were recorded in 14 participants with bilateral DBS for Parkinson’s disease under four different conditions representing all combinations of Medication ON and OFF, and DBS ON and OFF. Data were recorded from the first dorsal interosseus muscle during submaximal isometric index finger abduction at 10 %, 20 % and 30 % of maximum voluntary contraction (MVC). HD-EMG were decomposed into individual motor unit spike trains using convolutive blind source separation [1], [2]. Individual motor units were tracked across conditions using methods based on multi-dimensional representations of motor unit action potentials and surface EMG features, motor unit firing and action potential properties estimated and compared across conditions. A total of 1,822 units were decomposed from the steady state of the contraction in 252 trials and 495 motor units tracked across conditions. Both medication and DBS led to a significant increase in MVC force (p << 0.01 and p = 0.031). In parallel to the increase in force, DBS led to a significant increase of the mean firing rate of the tracked motor units when participants were off medication (p = 0.043). Simultaneous application of DBS and medication led to a significant decrease in mean firing rates when compared to single-treatment conditions (p = 0.039 and p = 0.005). Both the peak-to-peak amplitude of the decomposed motor unit action potentials and the median frequency of the HD-EMG signal increased with this reduction in firing rate, consistent with the recruitment of higher threshold motor units.The results indicate that DBS leads to an increase in motor unit mean firing rate when medication is OFF but alters the relative contribution of firing rate and recruitment in favor of recruitment when on dopaminergic medication. The results provide insights into the way in which motor unit firing and recruitment patterns are altered by DBS resulting in increased force generating capacity.[1] F. Negro, S. Muceli, A. M. Castronovo, A. Holobar, and D. Farina, “Multi-channel intramuscular and surface EMG decomposition by convolutive blind source separation,” J. Neural Eng., vol. 13, no. 2, p. 026027, Feb. 2016, doi: 10.1088/1741-2560/13/2/026027.[2] A. Holobar and D. Zazula, “Multichannel Blind Source Separation Using Convolution Kernel Compensation,” IEEE Trans. Signal Process., vol. 55, no. 9, pp. 4487–4496, Sep. 2007, doi: 10.1109/TSP.2007.896108.

O.8.6: ***Serotonergic modulation of lower and higher threshold motoneurones via 5-HT2 receptors in humans***

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Introduction: Recent human work has utilised pharmacological interventions to influence 5-HT activity within the central nervous system and assessed the effects of 5-HT2 receptor antagonism on motoneurone excitability. The results of these studies suggest that reduced activation of 5-HT2 receptors can influence the excitability of the motoneurone pool and reduce motor unit firing rates during voluntary efforts, primarily through the modulation of persistent inward currents (PIC). During voluntary muscle contractions, a proportion of the motoneurone pool is recruited, made up of smaller and larger threshold neurones, which are differently affected by PICs. The contribution of PICs to the firing characteristics of smaller motoneurones is greater than larger motoneurones due to the prolonged firing characteristics of smaller motoneurones. Currently, it remains unclear whether different motoneurones within a pool are affected differently by 5-HT2 modulation, as most assessments of motoneurone activity encompass a large proportion of the pool including low- and high-threshold neurones. Methods: Eight healthy individuals (aged 24 ± 3yr) participated in two testing sessions, where either a placebo, or 5-HT2 antagonist cyproheptadine (8mg) was administered. All measures were obtained pre- and post-pill ingestion for the placebo and cyproheptadine condition. Participants performed low-intensity elbow flexions to 10%, 20% and 30% of their maximal torque capacity with cervicomedullary motor evoked potentials (CMEP) measured from the biceps brachii during each contraction. Two stimulation intensities (low and high) were used to produce CMEPs. Low intensity stimulation would likely recruit a small portion of the motoneurone pool, and only motoneurones which are active or close to firing during the voluntary contraction. During low intensity contractions, this proportion of neurones recruited into the CMEP response would be lower threshold due to low descending drive. High intensity stimulation recruits a large portion of the motoneurone pool, and this portion of the motoneurone pool would probably include both low- and high-threshold neurones. All CMEP responses were normalised to relevant Mmax values.Results: For the placebo condition, there were no differences (p > 0.05) in maximal force production or CMEP amplitude following ingestion of the placebo. However, cyproheptadine reduced maximal torque production by ~5% (p = 0.008), and increased CMEP amplitude for low intensity stimulation (~20%) and high intensity stimulation (~15%) across each contraction intensity. The change in CMEP amplitude from baseline was greater in the cyproheptadine condition compared to placebo for low intensity stimulation (p = 0.001) and high intensity stimulation (p = 0.042) at all contraction intensities. Conclusion: Antagonism of 5-HT2 receptors provide insight to the effects of serotonergic neuromodulation. Our results suggest that 5-HT2 receptors modulate both lower and higher threshold motoneurones, and these effects may be greater on lower threshold motoneurones. In addition, it appears that greater descending drive to the motoneurone pool is required to achieve submaximal torque targets when activation of 5-HT2 receptors is reduced. This project provides further insight to the role of serotonin in regulating motoneurone activity during voluntary muscle contractions.

O.9.1: *Uncertainty aware hand posture classification for better assistive devices in spinal cord injury patients*

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Individuals with motor-complete spinal cord injuries (SCI) (Rupp et al., 2023) experience a complete loss of hand motor control, significantly impacting their ability to perform daily tasks. Recent findings from surface electromyography (sEMG) studies (Ting et al., 2019) indicate that certain motor units (MUs) located below the injury site remain unaffected. Based on this discovery, we hypothesize that the signals from the preserved MUS could be utilized to predict the desired hand posture. However, while it is known that the sEMG signal exhibits variability within the same task, existing classification algorithms do not offer any means to measure uncertainty. This limitation often results in undesired movements being executed.We utilized two datasets comprising 13 healthy individuals and 8 subjects with complete motor impairment

(C4-C6) due to chronic SCI for our analysis. Each participant imitated hand movements—finger flexions, grasps, and pinches—displayed digitally on a screen. During these actions, sEMG data from the forearm was captured using 320 electrodes. We employed our previously published AI model (Sîmpetru et al., 2023), capable of real-time prediction of hand kinematics, which we trained for each subject (Fig. 1A). To use the model for classification, we projected its high-dimensional latent space using the Uniform Manifold Approximation and Projection technique (McInnes et al., 2022) into 2D representations (Fig. 1B). We classified the movements using the 2D projections by employing a support vector classifier (SVC). To gauge the certainty of classification, we adopted the Regularized Adaptive Prediction Sets (RAPS) conformal calibration technique. This method provided prediction sets with a 95% guarantee of containing the true class. The quantity of classes within the set enables us to assess uncertainty levels: one class represents certainty, while the maximum number of classes (in this case, 8) indicates uncertainty and lack of reliability (Fig. 1C). We found that the AI system could make proportional hand kinematic predictions for healthy individuals, but when applied to SCI patients it could, as expected, only predict a subset of movements (p < 0.001, n = 60480 predictions; 2880 per subject). When used for classification, we achieved 99.8% accuracy for the healthy subjects and 98.2% for SCI using the SVC on its own. The sets predicted using RAPS have been used in two ways. First, if we found an uncertain prediction (Fig. 1B & C, more than one prediction in set), we used prior certain predictions to guess the best solution. This improved the accuracy to 99.3% for SCI. The other way, which may be of higher benefit for real-life, is to not output an uncertain prediction at all. This attempt brought the accuracy to 99.7%, showing that in some cases the AI model was certainly wrong in its prediction.Although the results have been tested on offline data and online assessment is now in progress, we believe that uncertainty aware classification can provide valuable rehabilitation prospects for patients and could help mitigate unwanted gesture switches. Further, the uncertain regions could provide insight into whether a motor command is recoverable or not, as uncertain areas might be a sign of damage.

O.9.2: *Conditional generative models to simulate motor unit action potentials during dynamic contractions*

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BACKGROUND AND AIM Forward modelling of volume conductors provides a fundamental tool to study the generation process of surface electromyogram signals. Current state-of-the-art models use numerical methods, which describe anatomically accurate geometries but are computationally consuming to simulate dynamic contractions. We propose that an alternative approach to modelling realistic volume conductors during dynamic movement is to combine transfer learning with conditional generative models. METHODS We propose BioMime, a conditional generative model that aims to capture the underlying distribution of the motor unit action potentials (MUAPs) by distilling knowledge from the limited outputs of an advanced numerical model. BioMime takes the form of a semi-supervised deep latent generative model with an encoder-decoder structure and is trained in an adversarial manner. This allows the model to embed the states of MUAPs into the latent representations and then generate new data by applying a dynamic change to the embedded states. By minimising the Kullback-Leibler divergence between the predicted distribution of the latent and a prior distribution, BioMime can also be used to generate new data by sampling from the prior distribution. BioMime was trained on the MUAP waveforms generated by an advanced numerical model. The dataset includes the waveforms of 1,500 MUs from eight superficial forearm muscles under 256 conditions, which capture the variance of motor unit locations, fibre density, current source propagation velocity, muscle fibre length, and innervation zone position. RESULTS We demonstrate that BioMime is accurate to generate MUAPs that are consistent with the ground truth (normalised root mean square error less than 2.0% on the held-out test dataset). When we feed BioMime with a sweep of continuously changed conditions, BioMime outputs MUAPs that change smoothly and match the ground truth waveform when the ground truth exists in the dataset. This indicates that the model is able to generalise the system states and could be used to simulate dynamic MUAPs. Lastly, we show that generating new data using BioMime is ultra-fast. It takes BioMime less than 0.3 seconds to generate MUAPs within one muscle under one condition. This effectiveness allows BioMime to be used for simulating MUAPs during dynamic contractions. CONCLUSIONS The proposed BioMime model is an example of a conditional generative model that embeds the volume conductor system into the weights of a neural network. The accuracy and efficiency provided by BioMime allow the generation of dynamic MUAPs during a voluntary movement with high temporal resolution. We anticipate the promise offered by BioMime will stimulate research in such dynamic simulations and biophysiological system designs.

O.9.3: *Development of an adaptive and generic model to forecast ankle motion based on EMG signals during walking at different speeds and inclines*

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Background and AimPredicting the motion intention of individuals accurately and reliably is critical to provide an intuitive interaction between humans and assistive robots. For this, electromyography (EMG) signals alongside the kinetics/kinematics information can be used as inputs for neuromusculoskeletal [1] or data-driven models [2]. However, creating a generic EMG-based motion predictor to match a broad range of activities for a wide population is challenging. Here, we propose a task- and subject-independent adaptive model without the need for prolonged calibration phases and evaluate its performance to predict ankle angles.MethodsAnkle angles in the sagittal plane measured via a motion capture system, and EMG signals from five muscles in each of the left and right legs were collected from 10 individuals walking at four speeds (1, 1.5, 2, and 2.5m/s) on a treadmill at three different inclines (-10%, 0%, and +10% slope). The study was approved by the local ethics committee. Training of the model was performed on the data of one participant walking at 1 m/s at 0 % slope, while the model's performance when predicting ankle angle was assessed from the whole dataset. The model was developed to predict the ankle angle 30 ms in the future (at 100 Hz) based on a 1 s window of EMG signals and ankle kinematics (Fig. 1). Data fusion of the raw input time series was performed before frequency- and time-based features were extracted and the best 50 features to predict ankle angles were selected using the Python library "tsfresh" [3]. A polynomial regression model then predicted the ankle angle. To build the adaptive model, the error between the forecasted ankle angle and the actual value was used in a feedback loop to update the model parameters if the error was more than 3°. Finally, the model performance in adaptive mode (with feedback loop) was compared to non-adaptive mode (without feedback loop). ResultsThe adaptive model predicted the ankle angles for unseen data at the various walking speeds and inclines with a root mean square error (RMSE) between 1.66° to 5.06° (coefficient of determination (R2) between 0.820 to 0.964), demonstrating its generic use across individuals and walking parameters. The adaptive model outperformed the conventional model by reducing the RMSE by ~70%.ConclusionsThe proposed model is responsive to walking speed changes, anatomical differences among people, and terrain diversity and achieved continuous and accurate predictions of joint kinematics. It paves the way for a stable and reliable control for wearable assistive robots for the ankle joint, where ankle angle measurements can be achieved with simple strain gauge goniometers.References1. Lloyd D.G et al., J. Biomech. 36:765-776, 20032. Zhang L et al., IEEE Trans. Auto. Sci. Eng. 18:564-573, 20213. Christ M et al., Neurocomputing 307:72-77, 2018

O.9.4: ***Automated movement screen: using smartphone videos to objectively appraise low back motor function***

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Introduction: Low back disorders (LBDs) are the leading cause of disability, affecting >500 million people annually across the globe [1]. Through the biopsychosocial model, there are many intersecting phenomena related to the disproportionately high chronicity of LBDs [2]. Using lab-based motion capture, studies have identified limitations in motor function associated with LBDs, leading researchers to emphasize the need to stratify LBDs based on motor control outcomes [3]. Recently, advancements in computer vision allow for the analysis of human pose using commercially available video. It is possible that kinematic data, derived from a smartphone (or similar) may have utility in objectively discriminating those with LBDs to streamline diagnoses or track rehabilitation outcomes. The purpose of the current work was to explore the ability of human pose data, derived from consumer-grade video cameras during the completion of common activities of daily living (ADLs), in the objective scoring of participant reported outcome measures (PROMs) related to low back function.Methods: A sample of 448 participants from across the globe completed the current study. After providing informed consent, all participants completed six PROMs related to perceived disability, kinesiophobia, pain catastrophizing, physical activity, and pain/discomfort. In addition, participants filmed their completion of four ADLs: (1) body weight squat, (2) small object pickup, (3) spine flexion/extension, and (4) sit-to-stand transitions. Following normalization to z-scores, PROM data were summed to calculate a composite index (CI) of low back function. Further, ADL videos were analyzed using an open-source pose estimator, MediaPipeTM whereby 33 body-referenced landmarks were obtained for all recorded video frames. Pose data from all videos were subsequently interpolated, filtered, cropped, and aligned using custom MATLAB script prior to input into Principal Components Analysis (PCA). PC scores explaining ≥99% variance within the dataset were retained and input as predictors into a stepwise linear regression model to predict CI. Results: Preliminary data from the body-weight squat movement suggest that PCs derived from video recordings with high quality (n = 359) maintain a significant multivariate linear relationship (p < 0.0001, R2 = 0.351, RMSE = 0.542) with CIs. Aggregate PCA reconstruction (Figure 1) depicts functionally relevant differences related to lower body joint range-of motion, trunk inclination angle, and movement velocity.Conclusions: Features derived from open-source pose estimators show moderate-strong relationships to PROM-referenced CIs of low back function. The data-driven approach explored with this work is novel for the use of computer vision algorithms to objectively track LBDs. References: [1] Wu, A et al. (2020). Ann

Transl Med 8(6):299; [2] O'Sullivan, P. (2005). Man Ther, 10(4), 242–255; [3] van Dieën et al., (2019). J Orthop Sports Phys Ther 49(6):370-9.

O.9.5: *The use of artificial intelligence and accessible smartphone technology for predicting the degree of spinal curvature in adolescents with adolescent idiopathic scoliosis*

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Introduction: Adolescent Idiopathic Scoliosis (AIS) is a spine deformity, characterized by three-dimensional curvatures of the spine. The current gold-standard for diagnosing AIS and monitoring curve progression is the measurement of the Cobb angle of the spine from posterior-anterior (PA) standing radiographs. The Cobb angle is defined as the angle between the endplates of the two most tilted vertebrae. Despite being the gold-standard, radiographs should be used conservatively as adolescents are particularly vulnerable to excess radiation exposure. Therefore, adolescents should not be prescribed a radiograph unless there is reason to suspect an underlying spine deformity. The purpose of this research is to use accessible smartphone technology to create a deep learning (DL) algorithm that can screen for AIS and predict the Cobb angle of the spine, enabling at home assessments and radiation free monitoring of spinal curvatures. Methods: 68 participants (53 AIS, 15 control) were recruited from the Children's Hospital of Eastern Ontario. Prior to study participation, all participants received their normal standard of care, which included a PA spinal radiograph and Cobb angle measurement. Participants were imaged in standing and forward bending positions with a smartphone containing a depth sensor. The resultant red-green-blue-depth (RGB-D) images were then labelled according to Cobb angle and were separated into train and test datasets with an 80:20 split. Two DL algorithms with a Resnet-34 architecture were developed: 1) A binary classification algorithm that classified the images according to diagnosis (i.e., AIS or control); and 2) a regression algorithm that was trained to predict the largest Cobb angle of the spine. The performance of these algorithms was assessed on the test dataset of 'unseen' participants (participants not used in training). The binary classification algorithm was assessed by measuring the accuracy of the classifications, as well as the sensitivity and specificity of the models' predictions. The regression algorithm was assessed by measuring the root mean squared error (RMSE) between the predicted and ground truth Cobb angles. Results: Data collection and analysis is ongoing; however, preliminary results indicate that the developed algorithm can identify Cobb angles >10° with an accuracy of 96% from RGB-D images captured with a smartphone. The sensitivity and specificity were found to be 99% and 82%, respectively. The algorithm was able to predict the Cobb angles within 8° of the ground truth Cobb angles, which is comparable to the degree of error seen with manual measurements from spinal radiographs.Conclusions: These results demonstrate that accessible and inexpensive technologies, such as modern smartphones, can be used to predict the degree of spinal curvature in adolescents with AIS. This has the potential to make health care more accessible to patients, allowing at home screening and monitoring.

O.9.6: *Prediction of upper limb function from simple activity of daily living using deep learning in patients with stroke*

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IntroductionClinical measurements are most widely used to measure upper limb function in stroke patients. However, these methods are time-consuming and require trained clinicians. An objective method for measuring upper limb function in stroke patients is the 3D computerized motion analysis test. However, this method can only obtain massive joint kinematic data, making it difficult to interpret upper limb function and required experts to conduct complex post-processing after examination to obtain results. With the development of artificial intelligence, simpler methods to quantitatively measure the impairment of body function are expected.Objectives The aim of this study was to predict the clinically measured upper limb function from 3D coordinate data during simple activity of daily living using deep learning in stroke patients.Materials & Method We collected Fugl-Meyer Assessment - Upper Extremity (FMA-UE) score and Box and Block Test (BBT) score in 265 stroke patients. And we collected the temporospatial parameters including Movement Time (MT), Index of Curvature (IC) and Number of Movement Units (NMU) and Arm Profile Score (APS) calculated from 3D motion capture during Reach & Grasp Cycle. The number of data was 624 for FMA-UE, 621 for BBT, 575 for temporospatial parameters, and 575 for APS. The input data for deep learning to predict upper limb function consisted of 3D coordinates of 10 markers: C7, T10, Clavicle, Sternum, Shoulder, Elbow, Wrist (2). and Finger (2). And time normalization was performed using TimeSeriesResampler to set all data frames to 2000. A Convolutional Neural Network was used to classify the patients into 3 groups according to the severity of upper limb dysfunction measured by FMA-UE and BBT and to estimate temporospatial parameters and APS. 80% of data was assigned for training & validation, and 20% for test.Results The accuracy, precision, recall, and f1-score of FMA-UE classification were 0.91, 0.90, 0.90 and 0.90 and BBT classification were 0.79, 0.72, 0.73 and 0.73, respectively. (Fig. 1) The correlation coefficient between the predicted MT, IC, NMU and APS and the true values were 0.54, 0.75, 0.60 and 0.78, respectively. (p<0.01)Conclusion The deep learning method gave highly promising results in predicting upper limb function of stroke patients using coordinate data obtained from 3D motion capture during simple activity of daily living: reach and grasp the cup. The upper limb dysfunction could be classified according to its severity measured by FMA-UE and BBT. Also, temporospatial parameters and APS showed moderate to strong correlation between the predicted values and true values.

O.9.7: *Planting the CEDE: Co-designing and co-developing knowledge translation strategies to implement current expert-based recommendations on electromyography – bridging evidence to practice*

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While electromyography (EMG) technology rapidly develops, its application faces frequent errors in use and interpretation. Over the past 5 years, the Consensus for Experimental Design in Electromyography (CEDE) project has developed matrices to guide planning, performance, and interpretation of EMG studies. Their implementation requires planning and involvement with end-users. Without targeted knowledge translation, CEDE recommendations may not reach the intended researchers, clinicians and patients. This project aims to co-design and co-develop strategies for optimal CEDE recommendation implementation.The project followed three phases (Figure 1). Phase 1 assessed awareness, interest, and/or use of CEDE recommendations through an online survey (n = 105) and explored perspectives of researchers (including ~50 EMG users from early to senior career levels) during a workshop held at the 2022 ISEK Congress. 60% of survey participants reported being “aware of CEDE matrices but not tried” or “preparing to use but haven't yet”. Common challenges included the length of the tables, formatting issues, lack of understanding of some methods, and general difficulty in using EMG. Participants during the ISEK workshop proposed various alternatives to disseminate these resources, including having a webpage, utilizing social media, and developing graphical content. To enhance the uptake and use of these matrices, researchers recommended implementing a decision-tree algorithm to guide the navigation process of the matrices. They also emphasized the need to develop a clinician-specific resource. In Phase 2, we employed a modified Experience-Based Co-Design approach to co-design and co-develop a strategy for implementing the “CEDE Amplitude Normalization matrix”. This involved ten researchers with a diverse range of expertise in EMG, and the strategy was informed by their views and needs through an iterative process. Following consensus meetings, a decision-tree algorithm was collaboratively agreed upon as the focal point for co-design workshops. Design principles were then applied to the development of the decision-tree via a series of questions/answers. Co-design focused on determining the elements of the decision-tree (i.e., entry points and key questions), design principles to address the development of the tool and the improvement of the content delivered. Phase 3 will involve a usability test of the decision-tree algorithm among co-design collaborators and extended end-users, utilizing user experience design principles. The implementation and evaluation of this co-designed tool may promote and facilitate the uptake and use of the CEDE recommendations in research, adhering to best practices when using EMG in research projects.

O.10.1: *Differences in the muscle activity pattern of the superficial trunk extensor muscles to the onset of the rectus femoris in the active straight leg raising score in the functional movement screen*

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Introduction: Active straight leg raising (ASLR) is a common test for multisegmental control in the trunk and lower limbs and is included in the Functional Movement Screen (FMS). The FMS is a valid and reliable system for grading movement competency with 4 grades (score 0–3) in each of the seven screening tests. In the FMS, a subgroup of those with a score of 1 due to limitations in the ASLR but not in the passive straight leg raising (PSLR) is considered to have a stability or motor control dysfunction (SMCD). This study investigated whether there is a difference in the relative latency between the onset of the superficial trunk extensor muscles and the rectus femoris (RF) during ASLR depending on the ASLR score in the FMS.Methods: A total of 30 participants were recruited; 10 in the FMS-ASLR score group 1 (FMS-ASLR1), 10 in the FMS-ASLR score group 2 (FMS-ASLR2), and 10 in the FMS-ASLR score group 3 (FMS-ASLR3). Inclusion criteria for participants were as follows: (1) ≥18 years of age without neck pain, back pain, or lower extremity pain and (2) PSLR > 70°. The FMS-ASLR scores were evaluated by the author, an international certified qualification holder. A surface electromyography system synchronized with the promotion inertial sensor system was used. Surface electrodes were applied to the left- and right-longissimus thoracis (L-LT and R-LT), left- and right-iliocostalis lumborum (L-IL and R-IL), left- and right-multifidus (L-MF and R-MF), and right RF; EMG signals were recorded during ASLR. The onset of muscle activity for each muscle was identified by using a manual onset detection method after blinding the participant's FMS-ASLR score and the muscle type. As outcomes, the relative latency of the onsets of L-LT, R-LT, L-IL, R-IL, L-MF, and R-MF to the onset of the right RF during the right ASLR was calculated, and a one-way analysis of variance was performed.Results: The statistical analysis showed no significant difference in the relative latency of the trunk superficial extensor muscles to the right RF during right ASLR depending on the ASLR score in the FMS ($P \geq 0.05$). As a post hoc test, Pearson's correlation coefficients (r) were calculated for combinations (15 combinations) of the relative latency of the six superficial trunk extensor muscles in each FMS-ASLR group.Significant positive correlations were observed in 12 of 15 muscle combinations in FMS-ASLR1, 8 of 15 muscle in FMS-ASLR2, and 1of 15 muscle combinations (L-MF and R-MF) in FMS-ASLR3.Conclusion: This study showed that there was no statistically significant difference in the relative latency of the trunk superficial extensor muscles to the right RF during right ASLR depending on the ASLR score in the FMS.

O.10.2: *Modulation of activity and synchrony of ankle muscles during quiet standing by emotional intervention*

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BACKGROUND AND AIM: Quiet standing is influenced by emotion. In quiet standing, the balance is maintained by mainly regulating ankle torque. Center of pressure (COP) is often used as an index reflecting ankle torque. While previous studies have shown that aroused emotions increase the frequency of COP, indicating increased ankle stiffness, the neuromuscular mechanisms underlying the COP frequency changes remain unclear. This study aimed to investigate effects of emotional intervention on ankle muscle activities during quiet standing. Because COP is controlled by the combined contribution of ankle plantar/dorsiflexor muscles, we focused on individual muscle activity and inter-muscular synchrony in these muscles. METHODS: Twenty-four healthy males (24.5±2.4 yr) participated. Emotional states can be represented as a two-dimensional model of arousal and valence. We set four conditions composed of two valences (Pleasant and Unpleasant) and two arousals (High and Low). The participants stood on a force plate, viewing a monitor 1 m ahead. Each of the four blocks began with a 30 s preparatory phase followed by a 72 s intervention phase, displaying 12 condition-specific pictures for 6 s each. During the task, ground reaction forces and moments were measured from the force plate and COP was calculated. Electrodermal activity (EDA) was measured to quantify autonomic nervous activity. Electromyogram (EMG) was recorded from tibialis anterior (TA), soleus (SOL), medial (MG), and lateral gastrocnemius (LG) muscles, and then root mean square (RMS) of EMG was calculated. Inter-muscular coherence (IMC) of SOL-MG, SOL-LG, and MG-LG pairs was calculated at 0–4 and 8–12 Hz bands to quantify inter-muscular synchrony. The former and latter bands are linked to muscle activity associated with postural sway, and with physiological tremor to enhance ankle stiffness, respectively. RESULTS:

High arousal showed a significantly higher mean EDA amplitude (p < 0.001, Aligned rank transformed ANOVA) than Low arousal, indicating sympathetic activation and successful arousal intervention. Also, High arousal showed a significantly higher mean power frequency of COP (p < 0.001) than Low arousal, indicating greater ankle stiffness. RMS of SOL was significantly lower in High arousal (p = 0.015) than in Low arousal, while other muscles showed no significant difference. Mean IMC at 0–4 Hz of all muscle pairs was not significantly different among the conditions. In contrast, mean IMC at 8–12 Hz of SOL-MG (p = 0.036) and MG-LG (p = 0.049) were significantly higher in High arousal than in Low arousal. CONCLUSIONS: Our results indicate that aroused emotion with sympathetic activation would increase ankle stiffness during quiet standing. Notably, while aroused emotion decrease SOL activity, the coherence between plantarflexor muscles. Our findings would lead to a better understanding of the association between emotion and postural control.

O.10.3: ***Distribution of forearm SEMG amplitude during isolated and combined activation of extrinsic hand and finger muscles***

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Background:Distinguishing activity of individual forearm muscles during hand and finger movement is generally considered a difficult task. Due to their size and layered arrangement, combined activation of multiple muscles often results in significant crosstalk. Common setups for surface electromyography (SEMG) with only a few hand-placed electrodes can therefore only provide a rough overview of flexor and extensor activity. Applications like SEMG biofeedback therapy could benefit from the ability to better distinguish between forearm muscle activity. Feeding characteristics of amplitude maps measured across the forearm into a fuzzy classifier might be a possible approach. To generate the necessary design data and assess feasibility, we conducted a preliminary study.MethodsSeven healthy subjects performed isometric contractions of extrinsic hand and finger muscles under varying complexity and intensity while SEMG signals were measured across a wide portion of the forearm. A custom hand force meter was used for measuring resulting hand and finger forces. Subjects performed simple contractions, where only few muscles were active, as well as more complex contractions, where several muscles were activated simultaneously. Electrodes were applied using a custom forearm sleeve, equipped with 6 rings of 16 equally spaced dry electrodes. With a total length of 10 cm, the electrode matrix covered a section of the forearm from approx. 25 % to 65 % of the distance from the lateral epicondyle to the ulnar styloid process. Using measuring technology from DeMeTec, the monopolar SEMG signal was sampled at 1024 Hz and filtered with a band-pass between 10 and 500 Hz and a notch at 50 Hz. For signal quantization, root-mean-square was calculated in a moving window of 1 s.Results:Individual contractions of the hand and fingers generally resulted in the formation of distinct activity hotspots across the measured section of the forearm. While hotspots could generally be correlated to extrinsic hand and finger muscle activation based on anatomical and kinematic considerations, some contractions (e.g. flexion of the thumb) did not produce hotspots in the relevant part of the matrix. Peak amplitudes at the hotspots correlated with the applied force in an approximately linear fashion, though gradients differed substantially between muscles. Amplitudes on the dorsal forearm appeared generally higher than on the ventral forearm. Distinctiveness of hotspots during combined activation varied between muscles, depending on their proximity and degree of overlap. Hotspot locations between subjects showed similarities while not being

identical.Conclusion:The study reinforces our assumption, that position, shape and amplitude of activity hotspots across the forearm hold sufficient information to distinguish between activity of several forearm muscles during combined contraction. A suitable approach for converting the findings into a classifier is currently being developed.

O.10.4: ***Volitional muscular activation alters cortical processing of ankle joint proprioceptive afference***

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INTRODUCTIONCortical processing of proprioceptive stimulation can be assessed by means of corticokinematic coherence (CKC), and evoked and induced EEG responses to continuous and intermittent joint rotations. CKC quantifies the degree of cortical processing of proprioceptive afference [1], whereas evoked and induced responses reflect the strength of cortical activation and excitability. The effect of a maintained voluntary muscle activation on the cortical proprioceptive processing is still unclear. Thus, we used proprioceptive stimulation in active and passive conditions to evaluate respective modulation of CKC, evoked and induced EEG responses by muscular activity.METHODS25 healthy adults (14 males; 28.8 ± 7 y.o.) were recruited. A custom-made movement actuator delivered 2-min of continuous (2 Hz) or 100 intermittent (ISI 4 ± 0.25 s) rotations of the ankle joint, while 30-EEG signals were recorded with (active condition) and without (passive condition) isometric voluntary activation of the plantar flexors (5 Nm torque) [2]. CKC was computed between EEG and foot angular displacement, and it was defined as the maximum coherence value at the movement frequency [3]. Evoked responses were obtained by averaging EEG epochs with respect to the movement onset. Induced responses in the cortical sensorimotor beta rhythm were quantified through the temporal spectral evolution method [4]. A Wilcoxon signed rank test was used to evaluate between-conditions differences for (i) CKC strength, (ii) evoked response amplitude and (iii) induced beta suppression and rebound amplitudes. RESULTSProprioceptive stimuli during the active condition elicited significantly stronger (i) CKC (~333%), (ii) evoked responses (~26%) and (iii) beta suppression (~38%), but weaker (~–42%) beta rebound amplitudes than the passive condition (p < 0.05) at the Cz-EEG electrode corresponding to the foot area of the sensorimotor cortex SM1 (Figure 1).DISCUSSIONResults indicated (i) intensified cortical proprioceptive processing, (ii) enhanced cortical activation (evoked response and beta suppression) and (iii) weaker cortical inhibition (beta rebound) of the SM1 cortex during the active muscle activation. Therefore, we demonstrated that the cortical processing of the proprioceptive afference from the ankle joint is altered when a maintained volitional muscular activation is performed compared to a passive condition. The mechanisms could involve both peripheral (i.e. sensitization of the proprioceptors) and central (i.e. altered functional cortical state or stronger intra- and inter-hemispheric inhibition) factors. These findings may extend the use of the adopted metrics to assess the motor efference-proprioceptive afference relationship in various scenarios.REFERENCES[1] Piitulainen et al., Neurosci. 238: 361-370,2013. [2] Cerone et al. IEEE TNSRE 30: 61-71, 2022. [3] Halliday et al., Prog. Bio. Mol. Biol., 64: 237-278, 1995.[4] Salmelin and Hari, Neurosci. 60: 537-550, 1994.

O.10.5: ***Center of pressure displacements during gait initiation in healthy children : Temporal and positional analysis***

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[Objectives] Gait initiation must be transitioned from a bipedal standing position to a one-legged standing position. The shift of the body center of gravity (COG) to the support leg at gait initiation involves the displacement of the center of pressure (COP) to the swing leg. Such a reverse reaction phenomenon (RRP) are anticipated laterally and backward movements and are known as anticipatory postural adjustments (APAs). The aim of this study was to quantitatively characterize the strategy of children during gait initiation using parameters obtained from the COP track. [Methods] A total of 13 healthy children aged 6–12 years (3 females, 10 males ; height 1.31 ± 0.12 m) participated in this study. Measurements were taken using a force platform (UM-BAR; Unimec Co. Ltd., Tokyo, Japan) and recorded at 100 Hz. In the starting position, each foot was grounded in the center of the two platforms. COP plots were the coordinates of the most outward displacement of the COP to the swing leg (APAs1) and the COP to the support leg (APAs2). Statistical analysis was performed using SPSS Ver. 28.0.1.1 (IBM Co. Ltd., Amonk, USA) to analyze the relationship between each parameter.[Results] A positive correlation was observed between the time taken from the start of operation to APAs1 and the time taken from APAs1 to APAs2 (r = 0.956, p<0.001). When the COP coordinates were examined in relation to the start of movement, a positive correlation was observed both externally (r = 0.791, p<0.001) and posteriorly (r = 0.965, p<0.001) in APAs1. In APAs2, a positive correlation was observed only in the posterior direction (r = 0.593, p<0.045). The relationship between APAs1 and APAs2 showed a positive correlation only in the posterior direction (r = 0.641, p<0.018).[Conclusions] Lateral and posterior displacement of the point of COP to the swinging leg is important for APAs at gait initiation. APAs1 depended on the COP at the start of operation, but the influence of the anterior-posterior direction was significant. In contrast, APAs2 showed a significant correlation with COP at the beginning of operation only in the antero-posterior direction. In addition, it is characteristic that the correlation between APAs1 and APAs2 was found only in the anterior-posterior direction. Therefore, it is suggested that the travel time and distance of the COP in the front-back direction have a significant effect on the reverse response phenomenon of gait initiation. Similarly, the lateral and posterior location of the COG of the swinging leg in the gait initiation posture may also be involved. In the present study, healthy children, who are less affected by lifestyle and disease, were the subjects. Future experiments will be conducted on healthy adults and patients with joint diseases to compare the results.

O.10.6: *Changes in electromyographic signals of the prime movers during sustained submaximal isometric bench press*

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In sustained submaximal tasks, neural drive for recruitment of additional motor units is generated to compensate for the reduced contractile force caused by the fatigued motor units, resulting in the increase in the root mean square (RMS) amplitude of the EMG signals. The median power frequency (MPF) of the EMG signals is particularly sensitive to local metabolic disturbance and strongly associated with the muscle fiber conduction velocity which decreases in sustained submaximal tasks. Therefore, the RMS amplitude and MPF of the EMG signals are considered to be well suited for monitoring the progression of fatigue in sustained submaximal tasks. In this study, the changes in the RMS amplitude and MPF of the EMG signals was examined for the prime movers of the bench press during submaximal isometric bench press until exhaustion. Sixteen healthy males performed an isometric bench press in which the bar with 70% of the one-repetition maximum load was held at the elbow joint at 90 degrees until exhaustion. Surface EMG signals during the bench press was recorded from the pectoralis major (PM) , anterior deltoid (AD), and long head of the triceps brachii (TB). The RMS amplitude and MPF of the EMG signals was calculated for 1.0 second at 0%, 25%, 50%, and 75% of the time to exhaustion (TTE). The RMS amplitude was normalized by the RMS amplitude during the maximal voluntary isometric bench press (MVI), and the MFP was normalized by the MFP at 0% of the TTE. Significant increase in the RMS amplitude was observed from 0% to 75% of the TTE in the PM and AD and from 0% to 25% of the TTE in the TB. This finding suggests that the neural drive reached a maximum before exhaustion in all prime movers, especially in the TB. There was no significant difference between the prime mover muscles in the RMS amplitude at 0% of the TTE (PM, 71.1 ± 18.4%; AD, 56.6 ± 22.9%; TB, 61.7 ± 30.0% of the MVI), and no significant difference between the muscles in the RMS amplitude at 100% of the TTE (PM, 113.5 ± 30.0%; AD, 108.4 ± 32.2%; TB, 89.0 ± 39.6% of the MVI). This finding indicates that prime movers were similarly recruited at the beginning of the bench press and similarly fatigued at exhaustion. Significant decrease in the MPF was observed from 0% to 50% of the TTE in the PM and from 0% to 100% of the TTE in the AD and TB , which indicates that the PM fatigued the earliest of all prime movers. Taken together with the above findings, all prime movers of the bench press were fatigued during sustained submaximal isometric bench press, but it could not be clear which prime movers were most fatigued.

O.10.7: *Effect of inclined and declined slopes on postural balance and ankle muscle activity*

Siripatra Atsawakaewmongkhon, Paris Saclay University; Annabelle Couillandre, Univeristy of Orléans; Alain Hamaoui, Paris Saclay University

Sloped surfaces are frequently encountered in everyday life. They alter the function of the ankle joint, which plays an essential role in postural control, by modifying its flexion/extension angle and the tension of the muscles controlling its mobility. However, few previous studies have examined the combination of postural control and ankle muscle activity while standing on sloped surfaces. The study aims to evaluate the effect of sloped surfaces on postural balance and ankle motor muscle function. It is hypothesized that these changes induce an alteration in balance that varies with the direction and extent of surface inclination. Fifteen healthy subjects underwent five posturographic examination conditions, where the inclination of the support surface was varied in the sagittal plane: the horizontal control condition (H0, reference condition), dorsal flexion at 7° (DF7), and 15° (DF15), and plantar flexion at 7° (PF7) and 15° (PF15). These measurements were coupled with electromyography (EMG) recordings of the Tibialis Anterior, Soleus (Sol), and Gastrocnemius Medialis muscles. The repeated measures ANOVA, with a simple contrast test compared to H0, was used in our study. Analysis of the posturographic indices shows that the mean position of the center of pressure (CP) is significantly influenced by the amplitude and direction of inclination of the support surface, with a posterior shift in dorsal flexion (DF7 and DF15) and an anterior shift in plantar flexion (PF7 and PF15). It also appears that dorsal flexion induces a significant increase in mean CP deviation along the anteroposterior (P < 0.01 between H0 and DF15) and mediolateral (P < 0.05 between H0 and DF15) axes, as well as an increase in mean speed (P < 0.01 between H0 and DF7, and between H0 and DF15). Conversely, plantar flexion induced no significant increase in these indices and even decreased mean CP deviation along the anteroposterior axis in the PF7 condition compared with H0. Analysis of the EMG data revealed that the activity level of the three muscles tested was significantly increased when they were placed in a shortened position and significantly decreased when they were placed in an extended position.In line with previous studies, the inclination of the ground support surface alters postural balance and the function of ankle motor muscles. More specifically, this study shows that inclinations placing the ankle in dorsal flexion induce the most significant disturbances, probably due to the lower joint mobility in dorsal flexion, which limits compensation capacities and due to an altered sensory-motor mechanism. On the other hand, that postural balance can be improved by slight ankle plantar flexion, similar to that associated with wearing low heels. The factors behind these changes could be related to biomechanics, neurophysiology, and muscle physiology, which could guide management strategies for people at risk of balance loss when standing on sloped surfaces.

O.11.1: *Association between trunk rotation sequence and pitching velocity in college baseball pitchers using inertial measurement units*

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Introduction:The trunk rotation sequence during pitching involves sequential rotation of multiple segments. Previous studies found that achieving peak pelvic rotation velocity before peak upper torso axial rotation velocity is crucial for efficient pitching. Understanding this sequence is vital for performance enhancement. However, previous studies used motion analysis systems to detect the trunk rotation sequence, none have examined this sequence on the baseball court using inertial measurement units (IMU).The purpose of this study was to explore the association between the trunk rotation sequence detected by IMUs and pitching performance in college baseball pitchers. We hypothesized that the proper trunk rotation sequence has better pitching velocity.Materials and Methods:Pitchers aged 18 to 25 with no surgery history were recruited. Four IMU were attached to the pitching arm, thigh of stride leg, sternum, and pelvis. Each subject threw 10 maximal effort fastballs. IMU measured pelvis and upper trunk angular velocities, while the thigh IMU detected foot contact (FC), and the pitching arm IMU detected maximal internal rotation (MIR). Trunk rotation sequence was determined by the difference in percentage of peak pelvis rotation velocity (PPRV) and peak sternum rotation velocity (PSRV) between events. Pitching velocity was recorded by a radar gun, and parameters were computed using MATLAB R2022a.The top 5 pitches were classified as high velocity (HV), while the remaining 5 were classified as low velocity (LV). Differences of trunk rotation sequence between HV and LV were analyzed using the Wilcoxon signed-rank test. A p-value < 0.05 was considered statistically significant. PASW Statistics 18 for Windows (SPSS, USA) was employed for the analysis.Results:Eight college baseball pitchers were recruited (age: 22.38 ± 1.60 years; height: 173.25 ± 5.63 cm; weight: 65.13 ± 9.31 kg). Differences of trunk rotation sequence between HV and LV was significantly different (z = -2.52, p = 0.01) (Fig. 1).Discussions:The results supported our hypothesis that a proper trunk rotation sequence is linked to higher pitching velocity. Pitchers with a larger difference in timing between PPRV and PSRV tended to achieve higher pitching velocity. IMUs on the baseball field can help measure the trunk rotation sequence, aiding pitchers and coaches in optimizing training and improving performance.Acknowledgement:This work was supported by Ministry of Science and Technology (NSTC 112-2425-H-028-002) awarded to Dr. Wei-Li Hsu.

O.11.2: *Kinematic comparisons of taiwanese and japanese university baseball pitchers*

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INTRODUCTIONTaiwanese collegiate baseball players have high level skills by world standards. Studies regarding the throwing motion of Taiwanese pitchers are very few. The training methods depends on the culture of the country, resulting in a difference in pitching behavior, and it is considered that the results of survey by other pitchers cannot be applied perfectly to Taiwanese pitchers. To compare Taiwanese and Japanese collegiate baseball pitchers, it is thought possible to research and clarify the pitching motion characteristics of Taiwanese baseball pitchers. The purpose of this study was to clarify the characteristics of the pitching motion of Taiwanese baseball pitchers by using three-dimensional motion analysis method.METHODSTen Taiwanese right-handed over-throw pitchers participated in the experiment as subjects. Each participant performed 10 fastball pitches with full effort. The trials that showed the highest ball velocity were used for analysis. Three high-speed cameras (GC-L20B, Sports sensing Co, LTD, Japan) were used to collect movies at a rate of 240 Hz. Frame Dias IV (DKH Corp, Japan) was used to digitize 24 body segment points and ball manually, and calculated three-dimensional coordinates of these measuring points using the Direct Linear Transformation (DLT) method. Matlab (The MathWorks, Natict, MA) was used for data processing. The coordinate data were digitally filtered in the X, Y, and Z directions, respectively. Kinematic parameters such as the rotation angle and angular velocity of trunk and hip, as well as ball velocity were calculated and compared with Japanese baseball pitchers. RESULTSThe ball velocity thrown by Taiwanese baseball pitchers was slower than that thrown by Japanese baseball pitchers. Upper trunk rotation angle at ball release (define as REL) of Taiwanese has a larger angle then Japanese varsity baseball pitcher. However, the pelvis rotation angle of Taiwanese at REL was smaller than that of Japanese varsity baseball pitchers. Maximum trunk rotation angular velocity of Taiwanese was smaller than that Japanese collegiate baseball pitchers. Maximum pelvis rotation angular velocity of Taiwanese was the fastest compared with Japanese baseball pitchers.CONCLUSIONTo optimize the desired speed and direction in the crucial final throwing stage, coaches are recommended to employ targeted drills and exercises focused on enhancing torso rotation. The vital role of incorporating tailored drills and exercises designed to enhance torso rotation among Taiwanese college baseball pitchers. Coaches are strongly encouraged to prioritize refining power transfer during the final throwing stage, offering a pragmatic approach to enhance the overall performance of players.

O.11.3: *Muscular demand associated with three different techniques for moving patients vertically in a hospital bed*

Wayne Albert, University of New Brunswick; Luke Kell, University of New Brunswick; Elnaz Roudi, University of New Brunswick; Samantha Gaboury, Université de Moncton; Cynthia Dion, Univerity of New Brunswick; Puneet Singh, Université de Moncton

IntroductionSafe patient handling (PH) programs have been developed based on biomechanical principles to help reduce the physical strain of repositioning patients in their beds. In New Brunswick (Canada) two PH programs have been developed, Back in Form (BiF) and All the Right Moves (ATRM). There is limited research quantifying whether these PH programs actually succeed in reducing physical strain of the caregiver as they reposition a patient. This research study assessed the activity of eight muscles bilaterally when using patient handling techniques to move a patient vertically in the bed. The muscle activity was assessed in two phases: the preparation to repositioning the patient (PRP phase) and the repositioning of the patient (RP phase). MethodsTwenty-six university aged students between the ages of 19 and 35 and who did not suffer from low back pain or shoulder disorder during the study period (or 3 months prior volunteered for this study.The BiF program has two techniques for repositioning a patient vertically in their bed and are referred to as Hammock 1 and Hammock 2, respectively. The ATRM program has one technique referred to as Up in Bed. 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]. A ground electrode was placed on the right and left collarbone. Results/Conclusion The 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. Differences in maximum muscle activity were determined through a series of ANOVAs with corrections. In the RPR phase the participant braces for the repositioning technique and places themselves in a balanced position. Lower muscle activity was found for the AD, BB and BF on both sides and the LES on the right side only for the Hammock 2 technique; UT was lowest for the Hammock 1 technique. In the RP phase, there was significantly lower muscle activity in all muscles associated with the Hammock 1 technique, except for the LE on the right-hand side. The Hammock 1 requires distributing the weight equally into a squat position with a 45º counterbalance movement; this technique heavily relies on gravity. This technique has as the lowest risk of injury compared to the other two, with the least favourable outcome being that the patient does not move. The limitation of this technique is that there is a weight limit between the caregiver and the patient.

O.11.4: *The role of biarticular muscles during squat-to-stand task: a consideration of bimodal ground reaction force-time curves*

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Background/Purpose:The bimodality of ground reaction force (GRF)-time curves during closed kinetic chain lower limb extension (CKE) have been predominantly discussed for countermovement jumps. The authors observed similar bimodality of GRF during the squat-to-stand task, which has no relevant study. Scrutinizing the history of research for CKE, the hypothesis occurs that the variations (bimodality) of GRF-time curves during squat-to-stand tasks reflect the extent to which each actor utilizes the function of biarticular muscles. Therefore, the aim of this study was to examine the relation between the bimodality of GRF during squat-to-stand tasks and lower limb biarticular muscle function.Methods:Nine female students without knee problems (20.9±2.1years, 1.58±0.08m, 54.9±5.8kg) participated in this study. Squat-to-stand tasks were executed on the force plates to stand from a deep squat position as quickly as possible. GRF-time curves are recorded with 3D motion capture to establish initial joint angles and peak net joint moments. Surface EMG electrodes were placed on gluteus maximus (GMax), rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM), and biceps femoris (BF) to measure muscle activity (EMG) synchronization between monoarticular muscles and biarticular muscles. As a continuous variable representing the bimodality of GRF a depression area was defined between the two (fictitious for the second peak in some cases) peaks using the derivative of the GRF curves. EMG synchronization was expressed by the cross-correlation coefficient (R-value) between the two EMG signals during the propulsion phase. Furthermore, isokinetic maximum hip/knee extension torques were measured using the dynamometer as muscle strength.Results:The main findings were that the depression area (bimodality) had a strong correlation with initial knee flexion angle, an inverse correlation with R-value between VM and BF, a weak correlation with propulsion duration, and a weak inverse correlation with isokinetic maximum knee extension torque.Discussions:The strong influence of the initial posture on the shapes of GRF-time curves indicates that motor control during squat-to-stand tasks with deep knee bending is governed by the geometrical (biomechanical) constraints rather than the neurally based constraints, at least for young healthy women. The primary mechanical demand in the squat-to-stand task is to rotate the femur segment upright. Segment-based conception by Cleather et al.(2015) advocates that considering the relative sizes of moment arms suggests biarticular hamstrings cause an extension of the femur segment (towards leg extension direction) with the aid of quadriceps femoris. EMG synchronization between VM and BF in subjects with more unimodal GRF and shorter propulsion duration in the current study supports the theoretical proposition.Conclusions:Young healthy women with bimodality of GRF-time curves during squat-to-stand tasks tend to underuse biarticular hamstrings.

O.11.5: *Neuromuscular control at the ankle joint when completing a proprioceptive task wearing textured foot orthoses*

Kelly Robb, Wilfrid Laurier University; Daniel Schmidt, Technische Universitat Chemnitz; Andresa Germano, Technische Universitat Chemnitz; Stephen Perry, Wilfrid Laurier University

TITLE: Neuromuscular control at the ankle joint when completing a proprioceptive task wearing textured foot orthosesAUTHORS: Kelly A. Robb, Daniel Schmidt, Andresa Germano & Stephen D. PerryABSTRACT:BACKGROUND AND AIM: Degraded functioning of the somatosensory system, including reduced feedback from cutaneous inputs of foot sole skin [1] and proprioception inputs from the ankle joint [2], are known factors impeding balance control. It remains unknown if targeted interventions to facilitate cutaneous feedback from the foot sole can improve body position accuracy (proprioception) from the ankle joint to counteract or improve these motor performance declines. Thus, the purpose of this study was to assess the neuromuscular and proprioceptive control of the ankle joint, in healthy young and middle-aged adults, and to investigate if ankle joint position sense (AJPS) accuracy improves when increasing sensory feedback under the foot sole (using textured orthoses).METHODS: Forty-eight participants were divided into two groups: healthy young (n=31, 23.8±2.1 years) and healthy middle-aged (n=17, 43.3±10.5 years). All participants completed an ankle proprioception task, defined as ankle joint position sense (AJPS) reproducibility, while standing on a custom-built proprioceptive device in standardized footwear and wearing two different foot orthoses: a smooth non-textured orthosis and a textured orthosis. Starting in a neutral ankle position (90o), two trials of AJPS were tested per orthosis condition which manipulating both the a) target angle

(5o or 10o), or b) target angle direction (ankle plantarflexion or ankle dorsiflexion). Orthotic device exposure and experimental conditions were block randomized across participants.The study's primary outcome measures include the absolute target angle error (o), medio-lateral and antero-posterior center of pressure data (mm) (SF=100Hz, Pedar, Novel, USA), and root mean square of the tibialis anterior and medial gastrocnemius muscles (N) (SF=1000Hz, Trigno Wireless EMG System, Delsys, USA) at the start, middle, and end of the proprioceptive task. RESULTS: Preliminary results of this study demonstrate that accuracy in completing the proprioceptive tasks is modulated according to the direction of the task, target angle direction, and foot orthoses worn by participants of both age groups (Table 1). CONCLUSIONS: While this research fills an important gap in academic research and increases knowledge pertaining to sensory and proprioceptive impairments, preliminary results suggest that textured orthoses may provide a low-cost and effective conservative treatment option to improve balance control and reduce fall risks in young and older adults.REFERENCES: [1] Perry, SD (2006). Neurosci Lett 392: 62-67. [2] Chen, X & Qu X (2019). Hum Factors 61: 702-711.

O.11.6: ***Functional connectivity between muscle pairs decreases in the final stage of a 2000-meter all-out kayak ergometer test***

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BACKGROUND AND AIM: Optimal performance in flatwater sprint kayak requires high power output of the upper body musculature combined with technical proficiency. Technical proficiency is heavily related to muscle coordination which can be defined as the interplay between the onset/offset and activation level of the involved muscles. Normalized mutual information (NMI) has previously been used to assess functional connectivity between muscle pairs using surface electromyography (sEMG) recordings. The aim of this study was to assess changes in NMI values of upper body muscle pairs during a 2000m kayak ergometer test. METHODS: Fifteen elite kayak paddlers (11 males and 4 females) volunteered to participate in the study. sEMG was recorded using a bipolar configuration from eight muscles of the upper body on the dominant side during a 2000m all-out kayak ergometer test. Kinematics of the upper body were recorded using an Xsens Awinda motion capture system and synchronized with the sEMG recording. Based on the kinematics, the sEMG data was then divided into two separate stroke phases throughout the trial, with one phase representing the pulling motion and one phase representing the forward motion of the left hand, respectively. NMI between muscle pairs of the eight upper body muscles were then computed for each phase. Lastly, the NMI values of the entire 2000m trial were segmented into ten non-overlapping epochs and averaged, with each epoch representing the muscle coordination for one tenth of the trial. A one-way ANOVA with repeated measures was used to assess changes in NMI values between the ten epochs for all muscle pairs. RESULTS: For all combinations of muscle pairs, and for both the pulling and forward motion phase, the NMI values of the last epoch were significantly lower than the nine preceding epochs ($p \leq 0.05$). No significant changes were found between NMI values of the other epochs for any of the muscle pairs. DISCUSSION: The fact that NMI values decreased in the final epoch may be explained by the large amount of fatigue experienced during this period of the 2000m all-out kayak ergometer test. It is therefore possible that the functional connectivity between the investigated muscle pairs were altered in response to fatigue and that

this in turn may have influenced the technical proficiency during this part of the test. The decrease in NMI indicating lowered functional connectivity between most of the studied muscle pairs may also be explained by decreased muscle stabilization among kayak paddlers. CONCLUSIONS: NMI values of muscle pairs of the upper body are significantly decreased in the final stage of a 2000m all-out kayak ergometer test.

O.12.1: ***Surface electromyography thresholds as a measure for performance fatigability during incremental cycling in patients with neuromuscular disorders***

Nicole Voet, Radboudumc/ Klimmendaal

Neuromuscular disorders (NMD) affect 1 in 625 individuals worldwide. Patients with NMD do not always detect fatigability in real-time. As a result, for patients, it is difficult to cope with performance fatigability in daily life, which often leads to overuse and, in the end, a vicious circle of inactivity and a further decline in (muscle) performance. Valid measures for fatigability could help people with NMD find the right intensity of daily life activities and exercise. Previous research described that surface electromyography (sEMG) has excellent reliability for assessing signs of performance fatigability during a cycle test in healthy subjects. In healthy persons, there is an excellent relation between the timing of the (two) surface electromyography (sEMG) thresholds and the (two) ventilatory thresholds during exercise. The primary aim of this study was to determine the relative timing of both sEMG and ventilatory thresholds in patients with neuromuscular disorders (NMD) compared with healthy subjects during a maximal ergospirometry cycling test. We hypothesized that in patients with NMD, the sEMG thresholds would occur relatively earlier in time than the ventilatory thresholds, compared to healthy subjects, because performance fatigability occurs more rapidly. In total, 24 healthy controls and 32 patients with a neuromuscular disorder performed a cardiopulmonary exercise test on a bicycle using a 10-min ramp protocol, during which we collected ergospirometry data: power at both ventilatory and sEMG thresholds, and sEMG data of lower leg muscles. In line with our hypothesis, normalized values for all thresholds were lower for patients than for healthy subjects. These differences were significant for the first ventilatory (p = 0.008) and sEMG threshold (p < 0.001) but not for the second sEMG (p = 0.053) and ventilatory threshold (p = 0.238). Most parameters for test–retest reliability of all thresholds did not show any fixed bias, except for the second ventilatory threshold. The feasibility of the sEMG thresholds was lower than the ventilatory thresholds, particularly the first sEMG threshold. As expected, the sEMG thresholds, particularly the first threshold, occurred relatively earlier in time than the ventilatory thresholds in patients compared with healthy subjects. A possible explanation could be (a combination of) a difference in fiber type composition, disuse, and limited muscle-specific force in patients with neuromuscular disorders. sEMG measurements during submaximal dynamic exercises are needed to generalize the measurements to daily life activities for future use in prescribing and evaluating rehabilitation interventions. Further research is required to address a multi-model approach to measure performance fatigability in NMD to differentiate performance fatigability developed from the disease itself compared to normal physiological and aging processes, understand the concomitant nature of performance fatigability and perceived effort, identify appropriate therapeutic interventions to minimize performance fatigability in patients with NMD.

O.12.2: ***Dynamic networks of cardio-muscular interactions during exercise***

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BACKGROUND A fundamental question in cardiovascular and muscle physiology revolves around how the heart operates in concert with distinct muscles to maintain cardiovascular homeostasis, facilitate movement, and adapt to exercise demands and fatigue. However, the precise mechanisms by which autonomic regulation of heart rate variability facilitates coordination with distinct muscle fibers within muscles remain unknown. Here we investigate how cardio-muscular coordination evolves in time and respond to fatigue during a maximal squat test. METHODS: Thirty healthy young adults performed two maximal body weight squat sets until exhaustion. During the protocol, a Biopac MP150 unit (Biopac Systems Inc, Goleta, CA, USA) was used to collect synchronized electrocardiogram (EKG Lead II; BN-RSPEC2-T), and electromyogram (EMG; BN-EMG2-T) signals from the following muscles: left and right vastus lateralis (LegL, LegR); left and right erector spinae (BackL, BackR). EKG and EMG raw data were recorded at a sample frequency of 2000 Hz, and filtered online using a 0.5-150 Hz (EKG) and 5–500 Hz (EMG) band-pass filter. We first obtained instantaneous heart rate (IHR, representing heart rate variability) derived from the EKG signal (Pan-Tomkins QRS detection), and decompose the EMG recordings in ten frequency bands [F1-F10], which may represent the activation of distinct muscle fiber types. We next quantified pair-wise coupling (cross-correlation C; amplitude-amplitude coupling) between the time series for IHR and all EMG spectral power frequency bands in each Leg and Back muscle. RESULTS: During Set 1, low [F1-F5] EMG frequency bands, associated with type-I slow muscle fibers, exhibited stronger coupling with IHR (CMEAN = 0.35: SD = 0.03) compared to intermediate/fast frequency [F6-F10] EMG bands (CMEAN = 0.20: SD = 0.02). With progression of fatigue in Set 2, a significant overall decline in coupling strength between IHR and all EMG frequency bands was observed (~50%; p = 0.02). Notably, while the probability of positive-correlations significantly decreased (15%) with fatigue in Set 2, the probability for anti-correlations (negative) significantly increased (40%) . CONCLUSION: The overall stronger coupling between IHR and slower muscle fibers underscores the potentially vital role of heart rate variability in supporting the endurance-oriented function of these fibers, which rely on a steady supply of oxygen. The overall decline in cardio-muscular coupling with fatigue in Set 2, as well as the transition from positive to anti-correlated behavior, reflects the complex impact of exhaustion on cardiac and muscle function. This dynamic network approach introduces new avenues for the development of novel network-based biomarkers to characterize cardio-muscular interactions during exercise, assess fitness status or the effectiveness of cardiovascular and muscle injury rehabilitation.

O.12.3: *Quantitative estimation of maximum isometric torque and muscle fatigue on forearm supination-pronation*

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Quantitative Estimation of Maximum Isometric Torque and Muscle Fatigue on Forearm Supination-PronationHao-Yuan Hsiao1,2, Wen-Fan Chen1*, Yuan-Kun Tu2, Yi-Jung Tsai3, Chih-Kun Hsiao3*, Jing-Yu Chen1,31 Institute of Medical Science and Technology, National Sun Yat-

sen University, Kaohsiung, Taiwan2 Department of Orthopedics, E-Da Hospital, I-Shou University, Kaohsiung, Taiwan3 Department of Medical Research, E-Da Hospital, I-Shou University, Kaohsiung, TaiwanEmail: m8571409@yahoo.com.twINTRODUCTIONContinuous intense muscle contraction or performing a submaximal isometric contraction could lead to muscle fatigue or muscle damage. In several literatures, muscle fatigue is considered to be closely related to MSD, especially for muscle-related disorders. Although it is not difficult to know when one is fatigued, few principles have emerged to characterize the phenomenon of muscle fatigue. This study measured the pronation/supination torque and the EMG activity in forearm muscles during an isometric contraction in which a maximal isometric force was kept for as long as possible. The findings might provide valuable insights for scientifically-based fatigue management and prevention of forearm diseases.METHODSTwelve adults participated in this study, a 90-second fatigue test was performed on who exerted maximum isometric pronation and supination on their dominant and non-dominant forearms. EMG signals were captured on the biceps (Bic.), brachioradialis (Bra.), flexor carpi radialis (F.C.R.), extensor carpi radialis (E.C.R.), and extensor carpi ulnaris (E.C.U.) muscles. The time to failure, maximum isometric torque and reduction rate of EMG activation patterns were measured and compared as an indicator of muscle fatigue. RESULTSIn the dominant side forearm pronation, the F.C.R. muscle displayed the highest fatigue rate, with both EMG signal amplitude and torque values decreasing after 20 seconds, hitting below 50% torque value at 30 seconds. Similarly, during dominant supination, the E.C.U. muscle showed the highest fatigue, with both signals declining after 15 seconds, hitting below 50% torque value at 55 seconds. For the non-dominant forearm pronation, the F.C.R. muscle again exhibited the highest fatigue, with signals dropping after 20 seconds, reaching below 50% torque at 30 seconds. In non-dominant forearm supination, the E.C.U. muscle displayed the highest fatigue, with signals decreasing after 20 seconds, falling below 50% torque value at 55 seconds.CONCLUSIONThe first 20-30 seconds of continuous maximum isometric force on the forearm sends a signal of rapid muscle fatigue. This emphasizes the importance of scheduling breaks or interventions to prevent strain, reduce injury risk, and maintain performance during prolonged forearm tasks. High-intensity movements result in rapid onset of muscle fatigue, with the F.C.R. and E.C.U muscles experiencing the fastest decline in muscle strength and could yield fatigue faster than other muscles.

O.12.4: *Assessment of forearm muscle strength and performance fatigue during orthopedic spine surgery for bone screw fixation*

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INTRODUCTIONOrthopedic surgeons engaged in prolonged, repetitive operations at either high or low intensity, coupled with unfavorable hand postures, may experience forearm fatigue, leading to the development of chronic musculoskeletal disorders. In the event of injuries to orthopedic surgeons, the quality of surgical treatments may be affected, potentially contributing to a shortage of medical professionals. Given the limited research on occupational injuries specific to orthopedic surgeons, this study focuses on quantitatively assessing forearm muscle strength and muscle performance characteristics during the clavicle screw insertion process in orthopedic surgery.METHODSEight right-handed surgeons participated in the experiment, which was conducted in three stages. In Stage 1, measurements of pre-surgery maximal isometric force (MIF) were taken, including maximal isometric grip force (MIGF), maximal isometric driving torque (MIDT), and maximal isometric push force (MIPF). Each test was performed three times, with a 30-second rest between trials and a 5-minute break between different tests. Stage 2 involved performing surgery with the insertion of 10 bone screws. In Stage 3, post-surgery measurements of MIF (MIDT, MIPF, MIGF) were conducted. Each participant was required to insert 10 bone screws into a pig thoracic vertebra specimen (approximately 6 months old), and the testing platform was pre-adjusted to an appropriate level according to each participant's requirements. During the surgery, a digital handgrip dynamometer measured the maximal isometric gripping force (MIGF) before and after the screwing tasks. A six-dimensional load cell, synchronized with electromyographic (EMG) signals, captured experimental data, enabling the assessment of maximal driving torque (DT), sub-cycling forces, and the evaluation of muscle responses and fatigue levels in designated muscles (Medial Deltoid ： MD, Biceps brachii ： BB, Brachioradialis ： BR, and Extensor carpi ulnaris ： ECU).RESULTSUnder pre- and post-fatigue conditions, the post-test results for MIGF, MIDT, and MIPF were lower than the corresponding pre-test values. In both the MIPF and MIDT tests, the electromyographic (EMG) amplitude variations (ΔEMG %) for MD, BB, BR, and ECU were reduced in the post-test compared to the pre-test. Notably, the EMG amplitudes of these four muscles were lower at the 4th, 7th, and 10th screw insertions than at the 1st screw insertion.CONCLUSIONThe primary findings of this study underscore the influence of forearm muscle strength and fatigue on surgeons during bone screw operations: (1) There was a significant decrease in grip strength, driving torque (DT), and push force (PF) after the insertion of 10 bone screws. (2) Comparisons of MIGF, MIPF, and MIDT, as well as the ΔEMG % at screws 1, 4, 7, and 10, indicate that surgeons performing operations with more than 10 inserted bone screws may encounter muscle fatigue.

O.12.5: *EMG biomarkers for fatigue prediction during isometric wrist flexion*

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The identification of neuromechanical biomarkers can be a key factor for knowing a patient's physical status during a motor rehabilitation procedure. In this ambit, monitoring of muscle fatigability is essential to safely track physical improvement and can be a guide for therapist to evaluate the rehabilitation effectiveness. Some previous efforts have already classified discrete fatigue levels by analyzing surface electromyography (sEMG). The underlying aim of this study is to identify potential biomarkers for fatigue prediction, considering only isometric muscle contractions tasks in a more quantitative way using Multiple Linear Regression. To achieve this goal, ten subjects were involved in the experiment, where each participant seated comfortably in a chair and performed a wrist flexor movement to push a 6-axis force sensor, while locking the dominant wrist with a velcro strap. The muscle activity of flexor and extensor carpi radialis were recorded while the participant performed 3 isometric contractions at 40% maximal voluntary contraction (MVC) until muscle failure, with pauses between repetitions to recover from exhaustion. A preprocessing step was performed for noise filtering and features selection. In addition, the optimization of the window size and overlap to extract features was found at 1 second and 0.83 seconds, respectively. The proposed solution is a Multiple Linear Regression

model, where the input corresponds to a selected features matrix (containing features from both flexor and extensor muscles), and the output (labeled signal) assumes 0% fatigue at the beginning of the contraction and then 100% at the end. To validate the proposed model, the second isometric contraction was used to train the model, and the third isometric contraction to test it, using the correlation between the predicted signal in the test process and the control fatigue labelled (0% - 100%) as performance metric. From a group of 18 different features, our results suggest that the best features (hence, possible potential biomarkers) can be found at the Mean frequency, Median frequency, RMS, Integral EMG, Average Amplitude Change, Difference absolute standard deviation value, Zero-Crossing, Frequency Ratio, and 4th-level daubechies-2 wavelet, reaching 93.1331% ± 3.2229 averaged correlation among individuals. This work has the potential to deeply understand muscle fatigue, allowing its application in several field of motor rehabilitation, sport and optimal control of exoskeletons.This study has been developed within project MYOREHAB (PCI2023-143405), funded by MCIN/AEI/10.13039/501100011033 and the European Union.

O.12.6: *Recovery of muscle endurance and muscle fibres conduction velocity after intensive care unit discharge*

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Introduction: Following discharge from the intensive care unit (ICU), patients face several neuromuscular consequences, including reduction in muscle force and endurance, which can persist for up to 1 year or more [1]. This impairment has noticeable consequences on quality of life and life expectancy [2]. The conduction velocity (CV) of action potentials proved to be a valid estimator of muscle endurance and fatigue, whether examined from single motor units or the interference EMG signal [3]. The aim of this study was to investigate the changes in CV during isometric fatiguing contractions subsequent to ICU discharge.Methods: Ten patients (8 males and 2 females, average age of 61.3±7.8 years) underwent High-Density Surface EMG (HD-sEMG) recordings at 6 (T6) and 12 (T12) months post-ICU discharge. HD-EMG was recorded during sustained contractions at 50% of the maximum voluntary contraction up to exhaustion from the tibialis anterior muscle. Muscle fibres CV was estimated via a newly developed algorithm that takes advantage of the relation between spatial and temporal spectra of the multichannel EMG signals induced by the propagation velocity of the action potentials [4]. CV reduction during the sustained contraction was estimated via the slope of its linear regression and the maximum change in CV was estimated as the difference between the maximum and minimum CV values (usually at the beginning and at the end of the contraction, respectively).Results: MVC increased between T6 and T12 by 31% (from 14.9±2.1 to 19.5±2.1 Kg, p=0.002) and the time to task failure by 70% (from 117±24 to 202±26 seconds, p=0.003). During the same period, the slope of the regression line describing the CV adaptation was reduced by 42% (from -0.081±0.0013 to -0.047±0.0013 (m/s)/min, p=0.038) and both maximum and minimum CV values decreased. Specifically, maximum CV was reduced by 16% (from 4.58±0.29 to 3.83±0.29 m/s, p=0.086), while minimum CV was reduced by 19% (from 4.37±0.27 to 3.53±0.27 m/s, p=0.042), with a similar maximum change in CV (from 0.24±0.12 to 0.29±0.14 m/s). Discussions: Our findings indicate that, between 6 and 12 months post-ICU discharge, patients undergo a substantial improvement in muscle force and endurance. The increase in muscle endurance aligns with a slower decline of muscle fibres CV and, on average, with lower CV values required to sustain the same relative contraction intensity, suggesting a potentially more efficient excitation-contraction coupling.References:1) Huang L, et al. 1-year outcomes in hospital survivors with COVID-19: A longitudinal cohort study. Lancet. 2021.2) Cooper R, et al. Objectively measured physical capability levels and mortality: systematic review and meta-analysis. BMJ. 2010.3) Del Vecchio A, et al. Associations between motor unit action potential parameters and surface EMG features. J Appl Physiol (1985). 2017.4) Farina D, Negro F. Estimation of muscle fiber conduction velocity with a spectral multidip approach. IEEE Trans Biomed Eng. 2007.

O.13.1: *Shar wave tensiometry for the evaluation of Achilles tendon loading: a cross-sectional study on conservatively treated tendons after rupture*

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Background and aim:Achilles Tendon rupture (ATR) is a frequently occurring musculoskeletal injury, with an annual occurrence rate ranging from 5 to 50 cases per 100,000 individuals, potentially leading to significant disability. To date, clinical outcomes at 12 months post-injury appear to be comparable between those who undergo surgery and those who receive conservative treatment. Shear wave tensiometry is a recently described technology that uses accelerometers to measure wave propagation along the tendon in order to define tendon mechanical properties. This technology is based on the concept that the axial stress within the tissue affects the squared tendon wave speed. The aim of this study was to evaluate differences in shear wave speed (SWS) between a conservatively treated Achilles tendon after rupture and the unaffected contralateral tendon.Methods:Twenty-nine participants that underwent conservative treatment following ATR between 1 and 7 years ago were recruited. Participants were divided in two groups depending on the location of the rupture. Tendon loading was measured using a shear wave tensiometer consisting of four accelerometers fixed on the tendon. The accelerometers were placed on the tendon following an ultrasound imaging procedure to ensure proper positioning. The wave propagation along the tendon was manually elicited using a reflex hammer. Five repeated measurements were taken during isometric contractions of increasing intensity (0-35 Nm ankle plantar flexion torque) on both the left and right AT of each participant. The SWS was calculated based on the time delay between the different waves detected by the accelerometers and the mechanical wave propagation on the tendon. SWS between the ruptured and the unaffected side was evaluated using Friedman test.Results:The group with a mid-tendon rupture showed a significant SWS difference between sides but only at 3.5 Nm and 7 Nm ($p=0.001$ and $p=0.020$). No significant difference in SWS were found between the ruptured and unaffected side for those with a myotendinous rupture. Conclusion:The Achilles tendon treated conservatively following ATR appears to have restore its mechanical properties. The relationship between SWS and clinical features should be further investigated.An instrument capable of detecting changes in tendon loading over time has the

potential to improve our understanding of tendon behavior during the healing process and aid clinicians in tailoring rehabilitation protocols for individual patients.

O.13.2: *In vivo non-invasive assessment of skeletal muscle behavior using shear wave elastography: Active and passive force-length characteristics of the triceps surae muscle group*

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Background and AimCharacterizing skeletal muscle behavior is crucial for deciphering human movement and muscle adaptation. The understanding of muscle mechanics is built upon the force-length characteristics. Measurement of muscle forces directly from its tendon would be ideal; however, such data collection is limited due to its invasiveness [1]. Shear wave elastography (SWE) is a non-invasive method that offers insights into passive muscle stiffness [2,3] and active characteristics [3], assuming linear elastic, transversely isotropic material properties. Though relating muscle shear elastic modulus to its force production is challenging. Presently, we characterized the triceps surae muscle group in passive and active states, hypothesizing that SWE reveals the muscles' length and activity-dependent mechanical characteristics.MethodsGastrocnemius medialis (GM), lateralis (GL), and soleus (SOL) muscles of ten volunteers (24.7±1.7 years, 5 males) were studied during rest, maximal voluntary contraction (MVC), and submaximal isometric contractions (25%, 50%, 75% of MVC) at four ankle angles from 30° plantarflexion (PF) to 15° dorsiflexion (DF). SWE, electromyography, and ankle moment were recorded simultaneously. The lengths of the muscles were assessed sonographically.ResultsAt rest, muscle length (p<0.05), passive shear elastic modulus (p<0.001, Fig. 1), and ankle moment (p<0.001) increased from PF to DF. Although muscle resistance is not the only source of passive ankle moment, the increase in muscle stiffness indicates the passive force-length characteristics, hence increasing muscle force from shorter to longer lengths. MVC moment increased from 75.21±25.53 Nm at 30° PF to 159.15±43.88 Nm at 15° DF (p<0.001). At submaximal levels, the active shear elastic modulus increased with increasing level (p<0.001), demonstrating the potential of SWE for force estimation, and was unchanging for GL and SOL, and decreasing maximally 59.5% for GM (p<0.001) from PF to DF (Fig. 1). Interpreting these results as muscle stiffness-strain characteristics, i.e. the first derivative of the stress-strain characteristics, this indicates that the muscles operate at optimal or shorter than optimal lengths.ConclusionsSupporting our hypothesis, the derived passive and active muscle stiffness-strain characteristics may serve as a surrogate for in vivo force-length characteristics, contingent on validation through direct force measurements. This suggests the potential of SWE as an index of individual muscle force and together with mathematical modeling, it holds promise for establishing links between muscular adaptation and joint function.AcknowledgmentsThe DFG - German Research Foundation (GRK 2198, 277536708) and BMBF - Federal Ministry of Education and Research (3DFoot, 01EC1907B).References1.Brendecke E, et al., Front. Physiol. 14:1143292, 20232.Ates F, et al., Eur. J. Appl. Physiol., 118:585–593, 20183.Zimmer M, et al., J. Mech. Behav. Biomed. Mat. 137:105543, 2023

O.13.3: *Supraspinatus tendon thickness changes following therapeutic exercises for patients with rotator cuff-related shoulder pain; secondary analyses of two randomised controlled trials*

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Background: The mechanistic response of rotator cuff tendons to exercises within the context of rotator cuff-related shoulder pain (RCRSP) remains a significant gap in current research. A greater understanding of this response can shed light on why individuals exhibit varying responses to exercise interventions. It can also provide information on the influence of certain types of exercise on tendons. The primary aim of this article is to explore if changes in supraspinatus tendon thickness (SSTT) ratio differ between exercise interventions (high load vs. low load). The secondary aims are to explore if changes in SSTT ratio differ between ultrasonographic tendinopathy subgroups (reactive vs. degenerative) and if there are associations between tendinopathy subgroups, changes in tendon thickness ratio, and clinical outcomes (disability).Methods: This study comprises secondary analyses of the combined dataset from two randomised controlled trials in patients with RCRSP. In those trials, different exercise interventions were compared: 1) progressive high-load strengthening exercises, and 2) low-load strengthening with or without motor control exercises. In one trial, there was also a third group that was not allocated to exercises (education only). Ultrasound-assessed SSTT ratio, derived from comparing symptomatic and asymptomatic sides, served as the primary measure in categorizing participants into tendinopathy subgroups (reactive, normal and degenerative) at baseline. Results: Data from 159 participants were analysed. There were significant Group (p<0.001) and Group X Time interaction (p<0.001) effects for the SSTT ratio in different tendinopathy subgroups, but no Time effect (p=0.63). Following the interventions, SSTT ratio increased in the "Degenerative" subgroup (0.14 [95% CI: 0.09 to 0.19]), decreased in the "Reactive" subgroup (-0.11 [95% CI: -0.16 to -0.06]), and remained unchanged in the "Normal" subgroup (-0.01 [95% CI: -0.04 to 0.02]). There was no Time (p=0.21), Group (p=0.61), or Group X Time interaction (p=0.66) effect for the SSTT ratio based on intervention allocation. Results of the linear regression did not highlight any significant association between the tendinopathy subgroup (p=0.25) or change in SSTT ratio (p=0.40) and change in disability score.Conclusion: Findings from this study suggest that, over time, SSTT in individuals with RCRSP tends to normalise, compared to the contralateral side, regardless of the exercise intervention. Different subgroups of symptomatic tendons behave differently, emphasizing the need to potentially consider tendinopathy subtypes in RCRSP research. Future adequately powered studies should investigate how those different tendinopathy subgroups may predict long-term clinical outcomes.

O.13.4: *Development and validation of a MIMU-based wearable device for telerehabilitation: a reach-to-grasp protocol study*

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BACKGROUND AND AIM: Telerehabilitation has been found to be an effective alternative to in-person therapy sessions. It reduces costs and transportation-related challenges for patients and improves rehabilitation outcomes [1]. Magneto-Inertial Measurement Units (MIMUs) are commonly used for kinematic assessments in various pathological conditions. However, current MIMU solutions often work as data loggers and rely on external units for data processing. This study aims to introduce and validate an innovative MIMU-based wearable device for hand trajectory estimation during telerehabilitation protocols. METHODS: The newly proposed device (size: 63 × 35 × 16 mm) was designed and developed at the BIOLAB of Politecnico di Torino (Turin, Italy). It consists of a MIMU (LSM9DS1, STMicroelectronics), a Bluetooth Low Energy module, a floating-point microcontroller (SAME70, Microchip) to easily install and run custom algorithms onboard, a micro-SD card to store raw and processed data, and an 800 mAh battery. Twenty-five healthy volunteers (age: 22.5 ± 2.1 years; height: 1.7 ± 0.1 m; weight: 62.6 ± 10.2 kg) were enrolled to test the device during a reach-to-grasp protocol and to validate the algorithm for orientation estimation. The device was fixed to the subjects' wrist (dominant side) through adhesive tape and volunteers were asked to perform the reach-to-grasp movement 75 times following the experimenter's instructions (7 task repetitions per minute). Four reflective spherical markers were placed on the device to obtain the orientation reference through 12 infrared stereophotogrammetric cameras (Vicon T20, Vicon Motion Systems). The orientation estimation was performed in MATLAB® by applying the complementary Madgwick filter to the gyroscope and accelerometer readings (acquired at 119 Hz) [2]. To minimize the convergence time, the orientation was initialized by means of an algebraic quaternion obtained with the algorithm proposed by Valenti et al. [3]. The heading and attitude orientation errors were estimated considering different values of the filter's parameter β in the range between 10-5 and 1 by using a grid search approach [4]. RESULTS AND DISCUSSION: The minimum orientation error was obtained considering β equal to 0.06 rad/s and 0.025 rad/s for the heading and attitude errors, respectively. The average orientation error of 2.3 ± 1.2 deg in heading and 2.1 ± 0.7 deg in attitude revealed the high performance of the sensor fusion algorithm in estimating device orientation during the reach-to-grasp movements [4]. Future studies will focus on embedding the sensor fusion algorithm on board and on validating the device in patients affected by neurological disorders. REFERENCES [1] Ostrowska, P.M., et al. Healthcare (2021), doi: 10.3390/healthcare9060654 [2] Madgwick, S.O.H. et al. IEEE ICORR, (2011), doi: 10.1109/ICORR.2011.5975346 [3] Valenti, I. et al. Sensors, (2015), doi: 10.3390/s150819302 [4] Caruso, M. et al. Sensors (2021), doi: 10.3390/s21072543

O.13.5: *Effect of the ultrasound frame rate and beamforming method on fascicle tracking during dynamic contractions*

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BACKGROUND AND AIM. The ultrasound (US) tracking of fascicle length (FL) and pennation angle (PA) is a fundamental tool to investigate mechanical phenomena underlying force generation in healthy and pathological subjects. Several algorithms have been proposed to automatically quantify and track these parameters throughout the contraction. Regardless of the tracking approach, the image quality and the temporal resolution of the image sequence seem to play a crucial role in fascicle tracking, particularly during dynamic tasks where muscle architecture undergoes significant and rapid changes. Recent US devices enable access to

radiofrequency (RF) data at high frame rates, opening up possibilities to apply different beamforming approaches for improving the image quality in terms of image contrast and resolution. In this study we assess the impact of different frame rates and beamforming techniques on the performance of a fascicle tracking algorithm. The analyzed beamforming methods are the traditional delay-and-sum (DAS) algorithm and the filtered delay multiply and sum (FDMAS) [1]. METHODS. High frame rate US videos were acquired from longitudinal scans of the medial gastrocnemius muscle during two dynamic tasks (heel rise and walk). Starting from the raw RF signals, the DAS and FDMAS beamforming methods were applied to generate B-mode images. For each beamforming method, the original video at 1000 fps was downsampled to obtain four different frame rates (25, 50, 125, 250 fps). FL and PA were tracked with a modified version of a tracking algorithm [2]. The quality of the tracking was evaluated through the root mean square error (RMSE) and the correlation coefficient (CC) between the results of the automatic and the manual tracking. RESULTS. Overall, the DAS tracking results for heel rise (CC>0.85) showed higher correlations when compared with walking (CC>0.38). However, the CCs of the FDMAS walk video significantly increased (CC>0.7). The RMSEs of the FL and PA tracking on the heel rise DAS video were 3.74 mm and 1.73° for 25 fps, 2.69 mm and 1.11° for 50 fps, 2.92 mm and 1.53° for 125 fps, and 3.70 mm and 1.91° for 250 fps. Considering the walk task, the mean RMSEs using FDMAS (FL=6.11 mm, PA=1.98°) were significantly lower than using DAS (FL=15.54 mm, PA=3.97°). CONCLUSIONS. The results obtained suggest that the superior resolution and contrast obtained by means of the FDMAS beamforming method can improve the result of the automatic tracking. As for the effect of the frame rate, preliminary results show that frame rates higher than 50 fps do not lead to an improvement in the tracking quality. However, the effect of the velocity of the task (e.g. faster walk) needs to be further investigated.
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O.13.6: *Three-dimensional shape of skeletal muscle determines muscle strength in older adults*

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Skeletal muscle varies in size and shape across individuals. While a large body of literature has shown that the muscle size (e.g., volume) determines the muscle strength, whether muscle shape influences muscle strength has not been sufficiently investigated. Our study found that the three-dimensional shape of the vastus medialis muscle was associated with knee extension torque in young adults, with the possibility that muscle shape contributes to its force exertion even in older adults. However, it is unclear how well the analogy between young and older adults holds because muscle shape substantially changes with aging. Therefore, we explored whether the three-dimensional muscle shape determines strength exertion even in older adults using statistical shape modeling.T1-weighted images of the right lower limb were obtained from 86 older adults using a 3.0-T magnetic resonance imaging system. The heads of the quadriceps femoris muscle were classified on the image based on automatic segmentation, and the muscle shape model of each head was then created. Taking shape correspondence among individual models of each head using free-form deformation, the statistical shape model, which consists of mean shape and shape vectors encoding shape variations, was constructed by applying principal component analysis. An individual feature of muscle shape was defined as the representation in the shape vector space (i.e., the principal component score). Maximum isometric knee extensor torque was measured for the muscle strength using a dynamometer. To probe the association between muscle shape and muscle strength, stepwise regression was used specifying the knee extensor torque as a dependent variable and the principal component score and muscle volume as independent variables in each muscle.The statistical shape model was constructed for each muscle, where 80% of the individual variation in muscle shape was accounted for by less than four principal components for all muscles. Stepwise regression showed that only muscle volume was the dependent variable for the rectus femoris and vastus intermedius. Interestingly, not only the muscle volume but the principal component score was identified as the dependent variable for the vastus lateralis (R2 = 0.56) and medialis (R2 = 0.57) muscles. Specifically, significant principal components of both muscles represented the shape difference in the anterior-posterior direction, suggesting that this muscle shape might lead to efficient torque exertion by constraining the muscle force vector during muscle contraction.The shape of the vastus muscles is one of the determinants of the knee extension torque in older adults, similar to our previous findings in young adults. Taken together, because the analogy between young and older adults holds for the association between muscle shape and strength, the idea that skeletal muscle geometry is closely linked to its function can be generalized.

O.13.7: *Identifying motor unit spike trains in ultrasound images comprised of varying successive twitch-like shapes and degrees of fusion in isometric contractions*

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Ultrasound can detect the activity of a large population of motoneurons, which may be used for neural interfacing purposes. Detecting motor unit (MU) spike trains from ultrafast ultrasound (US) images was first introduced using a linear blind source separation (BSS) method focused on instantaneous mixtures to provide an optimal spatial filter. Although this approach can accurately identify the location and average twitch of MUs, it has low spike train detection accuracy because it does not include the temporal evolution in the separation process.A solution was to use convolutive BSS, which has shown a very high spike train agreement for a large population of MUs in superficial and deep muscle parts. However, the assumption of equal successive twitches may not be fully accurate, as previous studies showed. Therefore, how the accuracy of the BSS algorithm is affected by varying twitch shapes needs to be clarified. In addition, a related question is whether the degree of fusion of the tetanic contraction reflects the accuracy of the decoding algorithm.In this work, we aimed to investigate the accuracy of the convolutive BSS method in estimating MU spike trains in US images comprised of varying twitch-like shapes in response to neural discharges of each MU and a varying degree of fusion of the tetanic contraction. For these purposes, we performed 30-second in-silico experiments based on a MU recruitment model using current knowledge about the experimental spatial distributions and twitch characteristics of MUs.We found that we could identify a large population of MU spike trains across different excitatory drive and noise levels, even when the individual MU had varying twitch-like shapes. The identified MU spike trains with varying twitch-like shapes resulted in varying amplitudes of the estimated sources, as opposed to equal twitch-like shapes, which resulted in estimated sources with similar amplitudes, and these varying amplitudes were correlated with the ground truth amplitudes of the twitches. The

identified spike trains had a wide range (up to 35 Hz), i.e., the method is not selective to a higher degree of fusion. The spike train of MUs with larger twitch amplitudes was easier to identify than small amplitude ones unless the relative twitch amplitudes were not too large.Finally, we explored the consistency of the findings from the in-silico experiment with an in-vivo experiment on the TA muscle using thin-film intramuscular EMG as a reference for MU detection. We found a high spike train agreement between MU spike trains from US and EMG, as well as many spike trains not matched with EMG from 5% of maximum voluntary isometric force (MVIC) up to 40% MVIC. These identified MU spike trains showed features consistent with those in the in-silico experiments.These findings suggest the robustness of the BSS method for identifying MU spike trains under varying successive twitch-like shapes, degrees of fusion, and force levels.

O.14.1: *Sensorimotor control of quadriceps muscles after anterior cruciate ligament reconstruction: a case-control study*

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Introduction: The incident of anterior cruciate ligament reconstruction (ACLR) is commonly found in musculoskeletal patients. Furthermore, one of the major problems is weakness in the quadriceps muscle, which can affect their movement. The number of motor units (MU) and mean firing rate (MFRs) were recorded using a recent high-density surface electromyography (HDsEMG) device to determine the motor unit behaviors in the vastus medialis (VM), rectus femoris (RF) and vastus lateralis (VL) in injured and uninjured knees, Additionally, quantitative sensory testing (QST) and pressure pain threshold (PPT) were used to investigate the alteration of sensorimotor control. However, limited research has studied the change in sensorimotor control after surgery mechanism. Objective: This study aimed to evaluate QST, PPT, average peak torque, the number of MUs, and MU firing rates in the VM, RF, and VL muscles and whether it measured the alteration of sensorimotor function and motor units in individuals with ACLR. Methods: We explored data from eleven patients with ACLR and thirteen healthy for QST, PPT, and maximal isometric contraction (MVIC). Furthermore, bilateral quadriceps muscles with 50% MVIC as a trapezoidal contraction (30 s) were tested while using a Biodex dynamometer. The ACLR participant was asked to perform all processes after reconstruction. The EMG data were analyzed using Neuromap software version 1.2.1 (Delsys Inc., Boston, USA), and the independent T-Test was calculated to demonstrate the difference between limbs and groups of the outcomes. Results: Our finding revealed that ACLR-affected individuals had a lower average peak MVIC torque in the injured knee compared to the uninjured knee (p = 0.030) and groups (p < 0.000). There were no significant differences in PPT and QST between the limbs (p > 0.05) and between the groups (p > 0.05). Except for CS and WS in the medial area compared to the lateral area on injured and uninjured knees in individuals with ACL reconstruction (p = 0.041, p = 0.08, respectively). Similar to control outcomes. The WS threshold was lower in the medial area compared to the lateral area (p = 0.002, p = 0.045, respectively) in both limbs. A total of 1,601 MU (VM = 544: ACLR = 264, control = 280; RF = 530: ACLR = 219, control = 311; VL = 527: ACLR = 223, control = 304) were analyzed in this study. There was no significant difference between muscles, limbs, and groups (p > 0.05). Furthermore, the RF MFRs of the injured knees were slower in the injured limbs in individuals compared to match-injured limbs in control (p = 0.005). VM and VL did not show significant difference between limbs and the groups. Conclusions: Our finding suggested that the incline of MU recruitment could limit activated motor unit firing rates, contributing to the deficit in quadriceps muscle activation. Furthermore, QST and PPT have inadequate accuracy in determining the alteration of afferent input excitability due to the variety in an individual's perception.

O.14.2: *Predicting lateral perturbation-induced stepping leg with electromyography of the lower limb muscles*

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BACKGROUND AND AIM: Impaired lateral weight transfer and reactive stepping from a loss of balance are associated with falls after stroke. A mediolateral loss of balance loads the limb (ipsilateral) in the direction of the potential fall while unloading the opposite limb (contralateral). A lateral protective step requires unloading the ipsilateral leg. In contrast, the unloaded contralateral leg responds with a crossover or medial step without a transfer of body weight. Contralateral stepping responses are less biomechanically stable, require multiple steps, and are associated with falls in older adults. Understanding the muscle activation patterns underlying protective stepping is essential for developing interventions for reducing falls in stroke. The study aimed to characterize muscle activation patterns during mediolateral protective stepping in chronic stroke. The second aim was to determine whether the lower limb muscle activation patterns could predict the leg used to recover balance. METHODS: Twenty-nine individuals >6 months post-stroke and ten controls participated in the study. Participants performed 24 trials of randomly ordered lateral waist-pull perturbations at four magnitudes. The perturbation magnitude where participants transitioned from single to multiple steps, called the balance tolerance limit (BTL), was used for analysis. Surface electromyography (EMG) was measured bilaterally from the soleus (SOL), tibialis anterior (TA), rectus femoris (RF), biceps femoris (BF), gluteus medius (GM), and adductor longus (ADD) muscles. The outcome measures were initiation time of the muscle activity relative to the pull and rate of activation (RoA) of the lower limb muscles. EMG signals were processed according to ISEK standards. Group differences (paretic, non-paretic, controls) were determined for a right and left pull with multivariate analysis, adjusting for differences in BTL. Discriminate function analysis determined whether EMG initiation time or RoA could predict the leg used to step. EMG initiation time and RoA were used to predict the step leg by discriminant function analysis (DFA). RESULTS: No significant group differences were found in the EMG initiation time ipsilateral to the pull direction. However, the contralateral paretic RF (p=0.007) and ADD (p=0.03) muscles were delayed, and the TA (p=0.03) initiation time was earlier compared to controls after adjusting for BTL. The paretic GM RoA ipsilateral and contralateral to the pull was reduced compared to controls. The DFAs revealed that the contralateral RF and TA EMG initiation time could classify the leg used to step 68% of the time. CONCLUSION: The muscle initiation times in the contralateral limb may be more crucial for protective stepping responses in mediolateral balance disturbances after stroke. The RF and ADD may be more important for stabilizing the leg before the transfer of weight occurs, with the GM important for controlling the lateral weight transfer after stroke.

O.14.3: *Differences in ground reaction forces between the intact and prosthetic limbs during sit-to-stand task in individuals with unilateral transfemoral amputation*

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1. INTRODUCTION Sit-to-stand is a crucial task for individuals with unilateral transfemoral amputation (uTFA). Although a previous study demonstrated that peak vertical ground reaction force (GRF) during the sit-to-stand task was greater in the intact limb than prosthetic limb [1], time-series GRF profiles between the limbs were not evaluated. Therefore, the aim of this study was to investigate GRFs in both intact and prosthetic limbs during the sit-to-stand task in individuals with uTFA.2. METHODSWe recruited 8 individuals with uTFA (7 females and 1 male, 45.0 ± 16.3 years old, 1.7 ± 0.1 m, 69.9 ± 16.6 kg). All participants were instructed to perform the sit-to-stand task three times as naturally as possible with their daily-use prosthesis (6 microprocessor-controlled knees and 2 non-microprocessor-controlled knees). The sit-to-stand task was performed on two force platforms (TF-40120-CL and TF-40120-CR, Tec Gihan, Kyoto, Japan), which recorded GRFs at a sampling rate of 1000 Hz. GRF data were normalized to participant's body weight. We used a statistical parametric mapping (SPM) to assess the time-course difference of the anteroposterior and vertical GRFs during GRF development between the intact and the prosthetic limb. The sit-to-stand task initiation was determined when the derivative of the total anteroposterior GRF exceeded 2.5% of the peak-to-peak value [2]. The endpoint was defined as the peak value of vertical GRF of the intact limb. Furthermore, the force development was time-normalized to 0-100%. Statistical significance was set at p < 0.05.3.RESULTSThere was no significant difference in the anteroposterior GRF profiles between the intact and prosthetic limb. However, as shown in figure.1 , we found a significant difference in the vertical GRF profiles from 78% to 100% of the% GRF development.4.DISCUSSIONIn the sit-to-stand task for the individuals with uTFA, the vertical GRF plays a dominant role, while the anteroposterior GRF applies relatively less force. There was no significant difference in anteroposterior and vertical GRF in the earlier phase, suggesting symmetric force exertions between the intact and prosthetic limbs (including residual limb and prosthetic components). However, beyond 78% of the %GRF development, the vertical GRF exerted on the intact limb was greater than that on the prosthetic limb. The results of the present study suggest that sound-limb reliance for daily activities [3] and potential functional limitations (e.g. the prosthetic knee buckling risk) [4] may influence the asymmetric force exertion in the latter part of the sit-to-stand task.ACKNOWLEDGEMENTS We appreciate all subjects who participated in the study.REFERENCES[1] Highsmith et al, Gait Posture, 34: 86-91, 2011.[2] Kralj et al, J Biomech, 23: 1123-1138[3] Gailey et al, J Rehabil Res Dev, 45: 15-30, 2008[4] Fanciullacci et al, J. Neuroeng. Rehabilitation, 18: 168, 2021

O.14.4: *Effect of acute increase in estradiol level on cutaneous silent period in young healthy females*

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Background. It has been shown that both classical and non-nuclear estrogen receptors are expressed in the spinal cord. Therefore, fluctuation in estradiol (E2) concentrations may affect the spinal network and modulate the control of movement. Herein, we assessed the neuro-modulatory effect of acute increase of estradiol on sensorimotor integration at spinal and supraspinal levels by using cutaneous silent period as a model system. Methods. Ten healthy eumenorrheic females (25 ± 4 yr., BMI 25.5 ± 3.3 kg/m2, mean ± SD) were tested every other day for one menstrual cycle. They were placed in a pronate position, their knees fully extended, and their ankle joint was secured in a boot attached to a load cell. A pair of stimulating electrodes (5 x 5 cm) were placed on the arch of the foot and over the area between the first and second metatarsal. The tibialis anterior surface electromyogram (sEMG) was recorded using a bipolar electrode (inter electrode distance 10 mm, dimension 10 × 1 mm). Cutaneous silent period (CSP) was elicited by delivering 10 trains of five electrical pulses (1 ms width, 200 Hz) separated by a 15-20 s random interval, while the subjects performed dorsi flexion at 10% of their maximal voluntary contraction. The intensity of stimulus was set to 1.1 x motor threshold (lowest stimulus intensity that generated flexion reflex in relax condition). The sEMG envelope was then obtained using a 4th order zero-lag Butterworth low-pass filter on the rectified sEMG. CSP was defined as the sEMG envelope with amplitude ≤ 80% of the baseline activity and duration ≥ 15 ms. Baseline activity was obtained by calculating the average sEMG envelope 100 ms before the onset of the stimulus. To quantify the magnitude of inhibition, the inhibition index was computed as 1 – (mean of sEMG envelope during CSP / mean baseline sEMG). E2 and progesterone (P4) levels were obtained from blood samples. Data collected during menses and periovulatory periods were used in this study. Hormone levels and average CSP properties (latency, duration, and the inhibition index) were compared using the Wilcoxon paired test.Results. The E2 concentrations between menses and periovulation were significantly different (34.5 ± 13.5 pg/mL and 287.9 ± 109.9 pg/mL, $p = .002$), whereas the P4 concentrations remained low (0.6 ± 0.4 ng/mL and 0.8 ± 0.4 ng/mL, $p = .286$). An increase in E2 levels did not affect CSP latency ($p = .695$), duration ($p = .492$), or inhibition index ($p = .492$).Conclusion. CSP has protective role to avoid injury and may involve either inhibition of spinal motoneurons, interneurons, corticospinal tract, or a combination of these mechanisms. Our results suggest that acute fluctuation of estradiol concentrations during the follicular phase of the menstrual cycle did not associate with latency, duration, and inhibition index of CSP. Funding. This study is supported by NIAMS (1R01AR069176-01A1).

O.14.5: *Non-invasive brain stimulation effects on dual-task performances in patients with Parkinson's disease: A meta-analysis*

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BACKGROUND AND AIM: Parkinson's disease (PD) is a neurodegenerative disease leading to progressive motor and non-motor symptoms. Dual-tasking requiring simultaneous controlling motor and cognitive functions frequently occurs in daily life so that patients with PD experiences more impairments in successfully performing various dual-tasks (e.g., talking while walking). Given that non-invasive brain stimulation (NIBS) techniques may improve motor and cognitive performances by modulating neural activations across key regions, we investigated potential effects of NIBS on dual-task performances in patients with PD using meta-analytic approaches. METHODS: Ten studies were included in this meta-analysis. We extracted a total of 85 comparisons from the included studies: (a) motor performance = 73 comparisons from 10 studies, (b) cognitive performance = 12 comparisons from four studies. Effect sizes were calculated using standardized mean difference (SMD) by comparing changes in motor and cognitive performances during the dual-task between active and sham stimulation conditions. A moderator variable analysis additionally determined whether changes in the dual-task performance were different based on specific stimulation areas. Finally, we conducted meta-

regression analyses to identify potential relationship between demographic characteristics and changes in performances after receiving NIBS techniques. RESULTS: Random-effects model meta-analyses found that NIBS significantly improved motor and cognitive performances during the dual-task: (a) motor performance (SMD = 0.143; P = 0.001; prediction interval = -0.022 to 0.308) and (b) cognitive performance (SMD = 0.375; P = 0.001; prediction interval = -0.174 to 0.925). Moderator variable analyses reported that NIBS on the dorsolateral prefrontal cortex (DLPFC) significantly advanced motor performance (SMD = 0.211; P < 0.001) and cognitive performance (SMD = 0.283; P = 0.004; prediction interval = -0.112 to 0.679). Finally, meta-regression analyses revealed that decreased age and greater proportion of female in total participants were associated with improved motor performances. CONCLUSION: These findings suggest that applying NIBS on the DLPFC may be an effective option for improving both motor and cognitive functions in patients with PD facilitating more independent activities of daily living.

O.14.6: *Bilateral lower limb force control deficits in patients with Parkinson's disease*

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BACKGROUND AND AIM: Parkinson's disease (PD) is the neurodegenerative disorder inducing abnormal movements such as bradykinesia, limb rigidity, gait and balance deficits. Moreover, asymmetrical motor control between more affected and less affected side is often observed in patients with PD presumably interfering with coordinative actions in the lower limbs. Thus, we examined bilateral motor control capabilities in lower limbs of patients with PD using isometric force control paradigm. METHODS: Twenty patients with PD and 20 age-matched controls participated in this study. They performed bilateral ankle dorsiflexion force control tasks at two targeted force level (i.e., 10% and 40% of maximum voluntary contraction: MVC) with and without visual feedback. Force control capabilities were estimated by quantifying force accuracy, variability, and interlimb force coordination using the uncontrolled manifold (UCM) analysis. For all outcome measures, we used three-way mixed (Group × Vision × Force Level; 2 × 2 × 2) ANOVAs. RESULTS: The findings revealed that patients with PD showed significantly lower force accuracy at 40% of MVC for all vision conditions, and produced greater force variability collapsed across vision and force level conditions. For interlimb force coordination, patients with PD showed significantly lower bilateral motor synergies in vision condition for all force levels. CONCLUSION: These findings suggested that patients with PD may have deficits in bilateral lower limb force control potentially influencing postural control and locomotion performances.

O.14.7: *Influence of a subject's level of technology acceptance on muscular coactivation during usage of an assistive robotic system*

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BACKGROUND: The effect of coactivation of agonistic and antagonistic muscles (short: coactivation) has been described in the literature for a considerable time, while the specific reasons leading to coactivation have been debated. Coactivation appears as a neural control strategy for fine movement patterns, but can be observed in patients with chronic pain and fatigue as well. Earlier studies analysing the effect of assistive robotic systems on subjects' movement patterns suggested that a subject's level of technology acceptance might correlate with muscular coactivation during human-robot interaction. AIM: The objective of this study is to investigate, how a subject's level of technology acceptance influence muscular activation and the occurrence of muscular coactivation during a simulated robotic assisted caregiving task. METHODOLOGY: 30 healthy subjects were recruited (15 male, 15 female). To simulate a caregiving task, subjects lay in supine position, while a lightweight robotic arm (KUKA lbr med) or a caregiver held the subject's leg for 60 seconds with knee and hip flexed in the sagittal plane and the shank in a height of 25 cm. The task was performed in four conditions: 1. low robotic assistance, 2. mid robotic assistance, 3. high robotic assistance, 4. caregiver. The order of conditions was randomized. After each condition, subjects had a break for 60 seconds. Each subject indicated the condition they individually preferred. All subjects answered a standardized questionnaire based on the Technology Acceptance Model (TAM) to determine their level of technology acceptance. Here, a lower TAM value indicates lower technology acceptance. The muscular activation of two groups of muscles was recorded with surface electromyography (sEMG) according to SENIAM recommendations. Mind the position of the subject, muscle group 1 regarded muscles acting against gravity (gastrocnemius, biceps femoris, semitendinosus) and muscle group 2 considered muscles working in the direction of gravity (vastus lateralis, rectus femoris, tibialis anterior). The normalized sEMG envelopes were calculated and the root mean square (RMS) was used to characterize the amount of muscular activation. RESULTS: RMS of all muscles increased significantly when the TAM value was decreased. This effect was more pronounced in muscles of group 1 compared to muscles of group 2. Additionally, RMS of all muscles decreased during preferred conditions compared to non-preferred, with a higher effect for subjects with a lower TAM value. DISCUSSION and CONCLUSION: The results showed that muscular activation of all muscles of both groups increased when the TAM value decreased. Since muscles of group 1 and group 2 oppose each other, it can be assumed that coactivation of antagonistic muscles is increased when the technology acceptance is low. This supports the assumption that in human-robot-interaction muscular coordination is affected by psychological factors like technology acceptance.

O.15.1: *Prediction of the distribution of muscle damage among hamstring heads during Nordic hamstring and stiff-leg deadlift exercises*

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Thanks to Calibrated Electromyography Informed Neuromusculoskeletal Modelling (CEINMS), a recent study suggests that the effectiveness of rehabilitation exercises can be classified the relative muscle force. Unfortunately, this model does not take into account that muscle contractions at long muscle length induced larger alterations (i.e., muscle damage) and larger adaptations (i.e., muscle hypertrophy) while the relative muscle force decreases compared to intermediate length. We have developed a neuromusculoskeletal modelling (patent FR2308074) considering that the longer the muscle length the larger the contraction intensity (index of muscle stress), even beyond the optimal length, for a given excitation and contraction speed. The aim of this study was to compare the ability to predict the distribution of muscle damage among hamstring muscles between CEINMS and our neuromusculoskeletal modelling after the Nordic hamstring and the stiff-leg deadlift exercise. A total of 28 participants where splitted in equivalent two groups: Nordic hamstring exercise (23.6+/-3.4 years; 174.4+/-7.6 cm; 67.1+/-8.2 kg) and Stiff-leg deadlift exercise (23.0+/-2.5 years; 176.2+/-8.2 cm; 76.2+/-11.2 kg). They performed three experimental sessions. After a first familiarization session, the second evaluation assessed maximal knee flexion torque (before exercise), resting shear modulus (a proxy of muscle damage; before and 30 min after exercise) of the three main hamstring (semimembranosus (SM), semitendinosus (ST), biceps femoris long head (BF)). The excitation of the aforementioned muscles was assessed with surface EMG. Ground reaction forces were measured for calibration purposes of CEINMS. Lower limb kinematics was assessed using IMU. For both exercises, participants performed eight sets of eight unilateral eccentric repetitions at the pre-established 10 maximal repetitions. The third session was performed 24 hours after the exercise to quantify the strength loss. We found a significant strength loss at 24h after the exercises (-9.9+/-7.7% and -8.9+/-11.2% for Nordic hamstring and Stiff-leg deadlift exercise, respectively); without differences between exercises (P=0.677). According to our hypothesis, the increase in shear modulus was larger for ST (25.6+/-25.4%) after Nordic hamstring compared to Stiff-leg deadlift exercise (-7.1+/-11.2%; P<0.001), respectively), while the increase in shear modulus was larger for SM (12.4+/-18.8%) after Stiff-leg deadlift compared to Nordic hamstring exercise (-2.5+/-11.7%; P<0.001). We are still processing the data of the distribution of muscle force and stress through CEINMS and our approach, respectively. Nonetheless, our approach has been already applied on previously published data. Briefly, after a damaging seated leg curl session, we found that the distribution of damage was 70.8% and 50.3% larger in ST compared to SM and BF, respectively. The distribution of stress estimated through our approach was 50.7% and 35.0% larger in ST compared to SM and BF. Accordingly, we found a strong correlation (R = 0.77) between the distribution the increase in shear modulus and the distribution of muscle stress (figure 1). This provides the first impetus of our ability to predict the distribution of damage. A future study will determine whether these approaches predict the distribution of muscle hypertrophy after a training program.

O.15.2: *Scapular kinematics and associated muscle activity in scapular-focused closed and open kinetic chain exercises*

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Background: Scapular motor control deficits could contribute to subacromial pain syndrome (SAPS). The scapula and humerus work as a chain during scapular-focused exercises. Although these exercises have been proved to be effective in clinical symptoms of SAPS, effects on scapular motor control during exercises are inconclusive. Objectives: To compare the effects of scapular-focused closed and open kinetic chain exercises on scapular kinematics and associated muscle activity in individuals with SAPS and healthy controls. Methods: Twelve patients with SAPS and 12 healthy controls performed two closed kinetic exercises: horizontal row (HRC) and push-up plus (PUP), and two open kinetic exercises: horizontal row (HRO) and serratus punch (SP). Three-dimensional scapular kinematics and surface electromyography on upper trapezius (UT), middle trapezius (MT), lower trapezius (LT) and serratus anterior (SA) were collected during exercises. Comparisons between SAPS and healthy controls as well as closed and open chain exercises were conducted. Also, the characteristics of selected exercises were investigated through principal component analysis (PCA). Results: There were no significant differences in scapular kinematics and muscle activity between SAPS patients and healthy

controls during exercises. In HR exercise, higher UT activity (9.91±2.06%, p<0.001) was observed during open compared to closed chained exercise. Moreover, subjects showed higher SA (5.52±1.47%, p<0.001) and less UT (1.75±0.56%, p=0.007) activities in eccentric phase of PUP compared to SP. In scapular kinematics of HR, all participants performed more external rotation (10.2±2.0 degrees, p<0.001) and upward rotation (11.2±2.2 degrees, p<0.001) in concentric phase during open compared to closed chained exercises. Moreover, there was more upward rotation (10.3±2.6 degrees, p<0.001) during PUP compared to SP. In PCA of closed and open HR exercises, MT and LT muscle activities exhibited higher loadings of PC1 (0.84-0.94) throughout the entire phase. External rotation and upward rotation of the scapula demonstrated higher loadings of PC1 (0.74-0.93) during the concentric phase. In PCA of both PUP and SP exercises, MT and LT as well as upward rotation and posterior tipping of the scapula played dominant roles based on the PC1 results (0.67-0.94). Conclusions: Either closed or open kinetic chain HR and PUP exercises may be suggested to selectively activate specific scapular muscles to enhance scapular motor control. While HR is recommended for activating MT and LT, supported by PCA results, PUP is recommended for activating SA without excessive UT activation. As decreased external rotation and upward rotation of the scapula are related to winging scapula and shoulder impingement, respectively, restoring normal scapular kinematics is crucial. Based on our study, open kinetic chain HR is recommended for increasing external rotation, while PUP is recommended to induce more upward rotation.

O.15.3: *Consensus for experimental design in electromyography (CEDE) project: Application of EMG to estimate muscle force matrix*

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The neural system modulates the force generated by a muscle via two mechanisms: recruitment (activating additional motor units) and rate coding (changing the rate at which active motor units fire). However, the interpretation of muscle force directly from electromyographic (EMG) recordings can be problematic. Here, we provide a matrix developed by the Consensus for Experimental Design in Electromyography (CEDE) project, to suggest the appropriateness of global and motor unit-based EMG features to estimate the force generated by skeletal muscle during isometric and dynamic contractions.Consistent with previous CEDE matrices, the steering committee and the lead investigator prepared a draft of the matrix, which was then sent to the other CEDE members to reach consensus on the content following a Delphi process. Consensus was reached when >70% of contributors provided scores between 7–9 (appropriate) and <15% of contributors provided scores between 1–3 (inappropriate), with an interquartile range < 2 units. From the 19 CEDE experts who agreed to participate in the Delphi process, 18 (95%) replied to the first- and second-round questionnaires, after which consensus was reached.The matrix is organized according to the most common approaches to record and/or represent muscle activation: interference EMG which considers the interference pattern of summated action potentials separately for three electrode types: (i) bipolar surface EMG; (ii) high-density surface EMG and (iii) intra-muscular EMG and (iv) decomposition of motor units (from any electrode type). For each approach, the content was arranged into four tables that each consider a different application of EMG to estimate force. These were the use of EMG to: (1) identify the onset and (2) offset of muscle force during isometric contractions, (3) identify force fluctuations during isometric contractions, and (4) estimate force during dynamic contractions and in combination with muscle models. For each combination of EMG approach and application, we provide a recommendation regarding the appropriateness of using EMG to estimate force, as "yes", "caution", or "no" along with a detailed justification for the recommendation. This matrix is intended to facilitate the appropriate interpretation of EMG data in relation to muscle force, and more broadly to drive innovation, discovery, and translation in human movement studies.

O.15.4: *Movement specific beta-band modulation during movement cancellation in EMG*

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Cancellation of volitional movement has been shown to synchronise neuronal firing in the sensorimotor cortex, manifesting as an increase in spectral power within the beta band (15—30 Hz) of local field potentials [1]. Despite having no bearing on motor generation, this synchronisation is also reflected in the spectral content of EMG [2]. Whether this phenomenon is functionally relevant for motor control is not yet understood. To further characterise the projection of cortical dynamics to peripheral muscles we aimed to determine whether movement cancellation elicited spectral modulation in all active muscles or whether modulation was movement specific.In nine able-bodied participants, muscle activity was recorded from bilateral wrist extensors using EMG. Participants performed bimanual isometric wrist extensions at 10% maximum voluntary contraction. At the beginning of each trial participants were instructed to anticipate performing either a left or right ballistic wrist extension contingent on the appearance of an imperative go cue halfway through the trial. In 50% of trials the go cue did not appear at the expected moment. Participants maintained a steady contraction until the end of the trial in the absence of a go cue. There were 100 repetitions for each type of ballistic extension.EMG data from trials where no go cue was delivered were isolated for analysis. Trials that showed excessive deviation from the target force were excluded. EMG was high pass filtered at 10 Hz, rectified and decomposed into a time-frequency representation with Morlet wavelets (–2 to 2 s, relative to pre-stimulus interval; 10 to 60 Hz). The spectral power from the beta band range (15—30 Hz) was taken from 0 – 1 s relative to stimulus onset and normalised with respect to the mean of the pre-stimulus interval (–1 to 0 s). Laterality of beta band modulation was considered during movement cancellation for the two cancellation conditions. A two-way ANOVA was performed to compare the effect movement anticipation and muscle location had on beta-band power.Time-frequency decomposition showed that beta-band power was elevated during the no-go condition with respect to the pre-stimulus interval. Although an elevation in beta-band power was noted bilaterally, there was a lateralisation in power towards the side relevant to the movement task. During left wrist motor cancellation, the left wrist showed a 42% increase in beta-band power and the right wrist showed a 20% increase, with respect to the pre-stimulus interval. Further, right wrist movement cancellation resulted in the inverse: A 28% increase in the left side and a 43% on the right side. The results of a two-way ANOVA demonstrated a significant interaction effect between movement cancellation type and recording location ($p=0.028$), revealing a lateralisation of the effect.This study demonstrates that beta-band modulation following movement cancellation does not extend to peripheral muscles in a non-guided way but is specific in its projection to muscles. Future work will explore whether this specificity is directed from the cortical or spinal level.References[1] Wessel (2017)[2] Zicher et al. (2022)

O.15.5: ***A myoelectric pattern recognition method against electrode shifts with adaptive feature sampling***

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Background and Objective: Myoelectric pattern recognition can decode human movement intents and is widely used in rehabilitation robotics, prosthetic control, and other fields. Although the current myoelectric pattern recognition technology has achieved satisfactory performance under ideal circumstances, it still faces more difficult problems in practical applications. Among them, the electrode shift that occurs when repeatedly wearing the signal acquisition device is one of the more common interference factors, which will make the data feature space change, thus leading to the degradation of recognition performance. In this paper, we proposed an adaptive feature sampling method for robust myoelectric pattern recognition. Methods: A sampling grid generator was used to generate feature sampling locations for each input sample adaptively. By jointly training the sampling grid generator and classifier on samples with different shifts, the proposed methods can sample features that are invariant to the electrode shift. The proposed method enjoys two merits. First, it can be applied on different methods because it can be achieved by adding an extra sampling grid parameter estimator on existing methods. Second, different from previous methods that are designed to improve classification accuracy, the proposed method can explicitly estimate the electrode shift parameters, which makes it more explainable. The performance of the proposed method was evaluated via experiments of classifying six hand gestures using high-density myoelectric data recorded from ten intact-limbed subjects at six electrode positions. Results: The average classification accuracies of the proposed method were 97.01 ± 3.84%, outperforming the state-of-the-art baselines with statistical significance (p <0.05). Conclusion: This study provides a promising solution to mitigate the negative effect of the electrode shift, improving the performance of myoelectric pattern recognition. It can help build more robust and natural human-computer interfaces and promote the application of myoelectric pattern recognition in prosthetic limb control, consumer electronics, and rehabilitation engineering.

O.15.6: ***Enhance the robustness of myoelectric control in the presence of low-signal-quality electrodes***

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Background and Objective: Myoelectric control technology holds immense promise for developing neuromuscular interfaces, intelligent prostheses, and human-machine systems. However, in surface electromyography (EMG) signal acquisition, interferences such as friction between electrodes and the skin, electrode doffing, and hardware damage can lead to abnormal data recording in certain channels, significantly diminishing the robustness of myoelectric control. While previous studies have found that abnormal channels can be accurately detected, there remains substantial room for enhancing the quality of reconstructed data. This study aims to address this problem by constructing a deep-learning-based EMG data reconstruction model that alleviates the impact of abnormal channels on the robustness of myoelectric control. Methods: An autoencoder network (AEN) was developed to reconstruct the EMG feature map, and a support vector machine (SVM) was adopted for pattern classification. During the training phase, 1-3 channels in the feature map were randomly masked before being input into AEN. The mean square error between the output of AEN and the unmasked original feature map was calculated, optimizing the parameters of AEN to enable the model to learn the ability to reconstruct the original feature map. In the testing phase, feature data from abnormal channels was masked and input into the pre-trained AEN to obtain the reconstructed EMG feature map. For performance evaluation, both user-dependent and user-independent testing experiments were conducted (considering six different electrode abnormal conditions: one channel, two non-adjacent channels, two adjacent channels, three non-adjacent channels, two adjacent channels with another non-adjacent channel, and three adjacent channels) with ten subjects performing six gestures by wearing an 8-channel EMG armband on the forearm. Results: The average classification accuracies of the proposed method were 94.40 ± 4.74% and 81.77 ± 10.42% under user-dependent and user-independent testing conditions, respectively, and outperformed those of the existing interpolation-based data reconstruction method (85.73±9.24% and 73.07±8.20%) with statistical significance (p <0.05). Conclusion: The proposed method is demonstrated as a useful tool for reconstructing the EMG feature map in the presence of abnormal data in several channels, thereby enhancing the robustness of myoelectric control for practical clinical applications.

O.15.7: ***Effects of percussion massage therapy on exercise-induced muscle damage***

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BACKGROUND AND AIM: Percussion massage therapy (PMT) is a type of massage therapy that uses a device called a massage gun to deliver rapid blows to the soft tissue. This type of intervention is thought to increase blood flow and reduce muscle soreness, thereby assisting post-exercise muscle recovery. Interestingly, limited data supports the efficacy of this intervention. The purpose of the project, therefore, was to determine if PMT is effective in muscle recovery after a session of intensive elbow flexion eccentric exercise.METHODS: Twenty healthy adults (PMT group: n =10, age = 23 ± 2 years, height = 175.9 ± 8.4 cm, body mass = 80.1 ± 15.1 kg; Control group: n =10, age = 24 ± 5 years, height = 169.5 ± 10.6 cm, body mass = 78.2 ± 20.5 kg) completed this 5-visit study. After the first visit served as the familiarization, all subjects performed a session of unilateral (nondominant) elbow flexion eccentric exercises (six sets of 10 repetitions at 80% of the concentric 1-repetition maximum, with 2 minutes rest between sets) during the second visit to the laboratory. Before, immediately after, one day, two days, and seven days after the exercise intervention, indirect muscle damage markers from the exercised muscle (muscle soreness through visual analogue scale, elbow joint range of motion, upper arm circumference, elbow flexion isometric strength, biceps brachii muscle voluntary activation, and resting twitch) were measured. The PMT group received two, 2.5 minutes of percussive massage via a percussion massage gun (2800 RPM) at the end of the second, third, and fourth visits; and the Control group did not receive any treatment. Two-way (group × time) mixed factorial analysis of variance (ANOVA) tests were used to examine the potential changes in the indirect muscle damage markers through time between groups.RESULTS: There were no significant differences for all baseline characteristics and the 1-repetition maximum between the groups (p > 0.05). Additionally, ratings of perceived exertion (RPE) after each eccentric exercise set significantly increased (p < 0.001) throughout the exercise sets, but did not differ between groups (p = 0.966). For all the indirect muscle damage markers, the two-way ANOVAs indicated significant main effects for time (p < 0.05) but not for group (p > 0.05). A small treatment effect of PMT (Cohen's d = 0.3) was observed one day post-exercise for muscle soreness when compared to the Control group. CONCLUSIONS: The results from this study do not support that PMT can improve muscle recovery and performance following an intensive session of exercise.

O.16.1: *Influence of temperature on motor unit activity during ballistic contraction*

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BACKGROUND AND AIM: Temperature is known to influence motor performance, especially the rate of torque development (RTD) which has been shown to depend strongly on neural rather than muscle contractile properties. However, the temperature effects on motor unit activity (e.g. discharge rate and recruitment speed) during ballistic contractions remain largely unknown. This study aimed to clarify the influence of local limb temperature on motor unit activity, RTD, and their association during ballistic contractions in humans. We hypothesized that a decrease in temperature would decrease RTD via a reduction in motor unit discharge rate and/or recruitment speed. METHODS: Ten healthy males rested in a sitting position while immersing their right lower leg in water of different temperatures (Cold: ~10°C, Neutral: ~33°C, Hot: ~43°C) for 20 minutes each. Participants then completed three types of voluntary isometric contractions of dorsiflexors while maintained on water immersion in each temperature condition. Specifically, they were instructed to perform maximal voluntary contraction for 3 s (MVC), to develop joint torque as fast as possible to reach at least 75% of MVC torque (ballistic contraction), and to linearly increase torque for 10 s from rest to 20% MVC and sustain the torque for 20 s (ramp-and-hold contraction). Surface electromyography was recorded from the tibialis anterior muscle with grids of 64 electrodes (interelectrode distance of 8 mm) and decomposed into individual motor unit spike trains using the fast independent component analysis with the convolution kernel compensation algorithm. RESULTS: Compared to Neutral, MVC torque was lower in Cold (p = 0.02) but not in Hot. During ballistic contractions, the temperature had no significant influence on the “early” RTD (from 0 to 50 ms after the torque onset), but the “late” RTD (from 0 to 150 ms) was lower in Cold than in the other two (p < 0.001) even when normalized by MVC torque. On the other hand, the motor unit discharge rate at the time of recruitment was higher in Cold than in Hot (Figure A, p = 0.03), while the recruitment threshold decreased with the temperature (Figure B, p < 0.05). Moderate-to-strong correlations were found between the changes in recruitment threshold and the late RTD (r = −0.77, p = 0.01) and between those in discharge rate and the early RTD (r = 0.41, p = 0.09), although the latter was not statistically significant. During ramp-and-hold contractions, no significant change with temperature was observed in the discharge rate or recruitment threshold. CONCLUSIONS: We provide evidence that the decrease in local temperature due to cold water immersion leads to the decrease in recruitment threshold and the increase in discharge rate during ballistic contractions. These changes may act as a compensatory mechanism against the cold-induced impairment in contractile function, since the larger changes in motor unit activity were associated with the smaller reduction in RTD.

O.16.2: *Voluntary co-contraction of ankle muscles alters motor unit discharge characteristics and reduces estimates of persistent inward currents*

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BACKGROUND AND AIM: Voluntary co-contraction training, which involves voluntary and simultaneous contraction (i.e., co-contraction) of antagonistic pairs without requiring external apparatuses for loading, has shown promise for promoting strength gain and hypertrophy. The impact of voluntary co-contraction on intrinsic properties of motoneurons, such as persistent inward currents (PICs), key intrinsic properties that contribute to motoneuron function, are unknown. During co-contraction, motoneurons receive competing excitatory and inhibitory inputs, both of which affect PICs. Reciprocal inhibition from antagonist muscles are likely to attenuate PICs, while increased neural drive may counteract these effects on PICs. To study the underlying neural control of co-contraction, we estimated PICs from motor unit (MU) discharge patterns during voluntary co-contraction of ankle muscles.METHODS: Sixteen adults (7 females) performed triangular co-contraction (simultaneous dorsiflexion and plantarflexion) and isometric dorsiflexion ramps (10s up and down) to a peak of 30% of their maximum muscle activity achieved during a maximal voluntary contraction. We decomposed MU spike trains from high-density surface electromyograms recorded from the tibialis anterior (TA) using a blind source separation algorithm. To estimate PIC magnitude, we quantified discharge rate hysteresis (ΔF) by comparing the onset and offset of a higher-threshold MU in relation to the discharge rate of lower-threshold MUs. To garner insights into individual MU discharge behavior, we used a quasi-geometric approach to analyze non-linearities in MU discharge rates with respect to rectified EMG amplitude. We used linear mixed effects models to determine if outcome variables were predicted by the fixed effect of contraction type.RESULTS: Estimates of PICs were lower during co-contraction [χ2(1)=72.66, p<0.001] compared to isometric dorsiflexion (4.5 vs. 5.6 pps, respectively). Brace height (χ2(1)=19.65, p< 0.001), a quantification of non-linearity of discharge rate with respect to rectified EMG amplitude, and the angle between the acceleration and post-acceleration attenuation slopes (χ2(1)=18.12, p< 0.001) were both reduced during co-contraction compared to isometric dorsiflexion (45.9 vs. 51.0%; 229 vs. 237 degrees, respectively), indicating a more linear increase in discharge rate in the co-contraction condition.CONCLUSIONS: These findings suggest that, during voluntary co-contraction, the inhibitory input from the antagonist muscle overcomes the additional excitatory drive induced by the antagonist muscle contraction. The novelty of our approach, which concurrently considers both inhibitory and excitatory inputs arising from voluntary co-contraction, enhances our comprehension of the intricate coordination of motor commands that govern MU behavior.

O.16.3: *The influence of low-intensity vibration on motor unit firing rate and muscle fatigue*

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Background: Force-modulated vibratory stimulation (FVS) has demonstrated positive effects on strength training, primarily studied in the context of high-intensity muscle contractions, such as 80% maximal voluntary contraction (MVC) [1]. However, the impact and mechanisms of FVS on low-intensity contractions remain unclear. This study aims to investigate the effects of low-intensity vibration (LIV) on motor unit (MU) synchronization and muscle fatigue.Method: Ten healthy right-handed subjects used a previously established FVS system [1]. We measured each subject's biceps brachii isometric MVC with a load cell embedded in the FVS system, maintaining a 90-degree elbow angle. Subjects then performed multiple 60-second LIV trials with a baseline force set at 30% MVC, maintaining the same elbow angle. The vibration amplitude was set at 50% of the baseline force, with vibration frequencies ranging from 0, 15, 25, 35, to 45 Hz in various trials. Two 64-channel high-density electrode grids measured surface electromyography (sEMG) on each subject's biceps brachii. EMG data were decomposed into MU spike trains using the CKC algorithm, followed by manual editing to ensure a pulse-to-noise ratio exceeding 30 dB. For each FVS frequency, a firing rate histogram was generated from MU spike trains across all subjects. The synchronization index (SI) of MU was quantified as the ratio of firing rates within the vibration frequency and its subharmonics to the entire histogram. Additionally, muscle fatigue for each FVS trial was estimated by the slope of a linear regression applied to muscle fiber conductive velocity (CV) on manually identified channels using a 1-second sliding window. One-way ANOVA assessed the effects of vibration frequency on SI and CV slope. Result: All vibration trials exhibit significantly larger SIs than the control condition (0 Hz). The 15-Hz FVS trial's firing rate histogram displays a distinct peak at the vibration frequency, while other conditions show dominant peaks at the second, third, and fourth subharmonics. There is no significant difference in the CV slope across various vibration frequencies.Discussion: Prior studies suggest FVS superimposed on 80% MVC to produce a significantly larger degree of fatigue than the control condition [1]. However, in the present study, no significant effect can be observed when FVS is superimposed on 30% MVC, suggesting the effects of FVS on muscle fatigue depend strongly on the initial contraction level of the muscle. Yet, such low-intensity FVS yields significant MU synchronization at the vibration frequency and/or its subharmonics. The observed subharmonic synchronization may be because the maximum firing rate of the biceps brachii is below 30 Hz.[1] Xu, L., Cardinale, M., Rabotti, C., Beju, B., & Mischi, M. (2016). Eight-week vibration training of the elbow flexors by force modulation: effects on dynamic and isometric strength. The Journal of Strength & Conditioning Research, 30(3), 739-746.

O.16.4: *Exploring motor unit modes in repetitive isometric tasks*

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BACKGROUND AND AIM: The covariation in discharge rates can be used to estimate the motor unit (MU) modes (or common synaptic input components) underlying the activity of neuronal ensembles. Previous evidence suggested a principal component explaining fluctuations in MU discharge times within individual muscles [1], highly correlated with force output. Other findings proposed the existence of more than one factor, particularly in synergistic muscles [2]. This study used principal component analysis (PCA) and factorization analysis (FA) to investigate the consistency of MU modes during repetitive isometric tasks involving the same force output oscillations. METHODS: Two muscles, tibialis anterior (TA; 11 participants) and first dorsal interosseous (FDI; 7 participants), were assessed while participants completed 15 trials of an isometric force-matching task. Each trial involved following oscillations of a random signal for 30 s. The three consecutive trials with the smallest error between the force and target were selected. High-density surface electromyograms were decomposed into MU spike trains and MUs were tracked between trials. The number of components to be retained was determined using PCA with parallel analysis [3]. Subsequently, we applied PCA and FA (unrotated) to the standardized MU smoothed discharge rates. To explore the correlation between extracted MU mode fluctuations and force output, cross-correlation between these signals was calculated. Additionally, the cross-correlation between trials was computed to assess the consistency of the extracted MU modes. Linear mixed models (LMM) were used to compare main and interaction effect of trials and extracted MU modes on cross-correlation values.RESULTS: Parallel analysis revealed that one MU mode explained most of the variance of MU discharge rate in 11 out of 18 participants. In the other participants, two MU modes were extracted. We then opted to use two modes for subsequent analyses. For both muscles, the first MU mode was significantly more correlated with force output (~0.6 ± 0.1) than the second MU mode (~0.2 ± 0.1), regardless of the trial (LMM, P < 0.001 for all). Moreover, the first MU mode presented significantly greater correlation across trials (~0.5 ± 0.1) than the second MU mode (~0.1 ± 0.2; LMM, P < 0.001 for all). These results were consistent for both PCA and FA.CONCLUSIONS: Our main results demonstrated that the first MU mode showed high consistency across repetitive isometric tasks with similar force output, whereas the second mode did not. These findings suggest that motor units in individual muscles are mainly controlled by one low-frequency control synaptic input highly resembling the output force oscillations. In upcoming research, we aim to extend our methodology to synergistic muscles and examine how changes in the parametrization of PCA and FA might impact the results.REFERENCES:[1] Negro et al., 2009[2] Del Vecchio et al., 2023[3] Hayton et al., 2004

O.16.5: ***Motor unit firing properties of knee extensors immediately after repeated static stretching of rectus femoris in healthy males***

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Introduction: Static stretching (SS) immediately affects various neuromusculoskeletal components, including neuromuscular physiological alterations. Immediately after repeated SS of the triceps surae, the motor unit (MU) firing rate (FR) increased during low-intensity contraction (Mazzo et al. J Physiol. 2021), thus SS may alter MU firing properties. However, the impact of SS on the neural drive in both the stretched muscle and unstretched synergists is not well understood. Our motivation of this study was to clarify the differences in the neural drive strategies among synergist muscles after SS. Specifically, this study investigated alterations in MU firing properties of rectus femoris (RF) and vastus lateralis (VL) immediately after selective SS which reduced only RF stiffness. We hypothesized that MU FR increased or MU recruitment threshold (RT) decreased in RF or VL to compensate for the reduction of RF stiffness.Methods: Twelve healthy males (23.8±2.4 yrs) visited the laboratory on two separate days; SS or rest (control condition; CON) was performed each day. Maximal voluntary isometric contraction (MVC) torque of knee extension was measured, and high-density surface electromyography of RF and VL was evaluated to assess individual MU firing during 10% of MVC and ramp-up to 35% of MVC, and same MUs were tracked before and after each intervention. Before and after SS or CON, shear elastic moduli of RF and VL were measured using ultrasound shear wave elastography. SS was performed for 1 min with maximal hip extension and knee flexion where the participants could tolerate, and was repeated for six sets. In CON, the participants rested for 6 min. Mixed-model analyses of variance were performed.Results: The shear elastic modulus of RF significantly decreased only after SS (interaction: p = 0.032). However, the shear elastic modulus of VL did not change after either condition (interaction: p = 0.497). At 10% of MVC, MU FR of RF did not change in either condition (interaction: p = 0.192), while the MU FR of VL after CON significantly increased, but not after SS (interaction: p < 0.001). There were no interactions in MU FR in either RF (p = 0.809) or VL (p = 0.203) at 30-35% of MVC, but main effects of time were observed in both muscles, revealing MU FRs significantly increased (both p < 0.001). There were no interactions in MU RTs in either RF (p = 0.673) or VL (p = 0.204), but a main effect of time was observed, revealing MU RTs decreased (both p < 0.001). The MVC torque significantly decreased in both conditions (p < 0.001) without interaction (p = 0.444).Conclusion: The 6-min repeated SS with hip extension and knee flexion could decrease the stiffness of RF, but not VL. The MU firing properties of RF and VL were not affected by the selective SS of RF. When a selective muscle stiffness only decreased among the synergist muscles, it was suggested that MU firing pattern did not necessarily compensate for the change in muscle compliance.

O.16.6: *Common neural input to deltoid segments: preliminary findings on control*

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Introduction: Functional outcomes following total reverse shoulder replacement surgery vary. Our overall goal is to understand how the central nervous system controls shoulder muscles in health and disease, and if this control impacts recovery from surgery. To this end, our initial aim was to determine the complexity of neural drive to the deltoid muscle at the spinal motoneuron level in individuals with healthy shoulder function. The deltoid comprises of three main segments, the anterior, middle, and posterior deltoid. Each segment comprises of many individual muscle fibres, each innervated by a single spinal motoneuron, together grouped as a motor unit. By measuring the correlated activity of multiple single motor units, we gain direct insight into the common drive of a motoneuron pool. This approach has been used to reveal the control signals for other large skeletal muscles but not the deltoid muscles.Methods: Three high-density electromyography grids (GR08MM1305, OT Bioelettronica, Italy) were used to record deltoid activity during force-matched abduction tasks (45-degree shoulder abduction) in 10 participants with healthy shoulder function [1 female, age: 29 (10) yrs, height: 1.76 (0.09) m, weight: 73 (11) kg]. Signals were decomposed into motor unit spike trains using blind source separation, edited with MUedit software, and smoothed with a 400ms Hanning window. Cross-correlation analysis extracted common dynamics among multiple motor units (when at least 4 motor units were decomposed for a muscle segment). A significance threshold (95th percentile) was determined for each motor unit pair using bootstrapping. Common drive within and between muscles was estimated as the percentage of significantly correlated motor unit pairs. Activation level was determined from bipolar derivation of monopolar signals (2 x 5 channels, ied 24mm) and normalized to a maximum voluntary contraction.Results: Too few motor units were detected in two male participants; findings are therefore reported from n=8 participants. Smoothed firings were concatenated from two 8s contractions. During the plateau, participants activated their deltoid at (mean(SD)): anterior 11 (5) %MVC, middle: 15 (6) %MVC, posterior: 7 (4) %MVC. We identified: anterior: 8.4 (3.3), middle: 7.3 (3.6), posterior: 5.5 (3.9) motor units per participant. Estimated common drive was typically very high within a deltoid segment (anterior: 69 (22)%, middle: 76 (27)%, posterior: 76 (26)%, and low between deltoid segments (anterior-middle: 12 (13)%, anterior-posterior: 9 (16%), middle-posterior: 41 (20%)). Individual data is reported in Table 1.Discussion: Preliminary findings suggest complex and variable neural control of the deltoid muscles between individuals, with common neural input to each and across deltoid heads. This likely relates to force production and stabilization functions, offering crucial insights into the neural control of healthy deltoid muscles.

O.16.7: *Changes in discharge properties of longitudinally-tracked motor units after four weeks of isometric strength training in older adults*

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Background and aim: Aging is accompanied by significant losses of muscle mass and ability to produce muscular force. These dysfunctions could be partly underpinned by alterations within the nervous system, particularly at the motor neuron level, which in turn could be partly reversed by resistance training. Previous evidences in young adults showed that 4 weeks of strength training are sufficient to evoke changes in motor unit (MU) discharge rate, in turn mediating the increase in force. Nevertheless, the specific motor unit adaptations after strength training in older adults remain elusive. Thus, this study investigated the effects of 4-week strength training intervention on the behavior and properties of the same tracked motor units in older adults.Methods: Twenty-three participants were randomly assigned to either a strength training (INT, n = 13; 71.2±4.7 yr) or to a control group (CON, n = 10; 69.0±2.7 yr). ST group completed a 4-week combined strength training protocol involving ballistic (4 x 10) and sustained (3 x 10) isometric ankle dorsiflexions. Measurement sessions involved the recording of voluntary maximum (MVF) and submaximal isometric forces during ramp contractions up to 70% MVF. Concurrently, myoelectrical activity from tibialis anterior muscle was recorded with high-density surface EMG (HDsEMG). HDsEMG signals were decomposed into individual MU discharge timings and MU were tracked across experimental sessions (pre vs post), allowing a robust comparison of properties of the same motor units.Results: The total number of identified MU across participants, contractions and measurement sessions was 2672, of which 406 (~15%) were tracked across sessions. Maximum voluntary force increased in the INT group (+18%, P = 0.003). Similarly, average MU discharge rate increased at recruitment (+9%, P = 0.036) and plateau (+12%, P = 0.004) of the ramp contractions after the training, but it did not change at derecruitment. Interestingly, changes in MU discharge rate both at recruitment (P = 0.027) and plateau (P = 0.004) were observed mainly in lower threshold MU. On the other hand, normalized MU recruitment/derecruitment thresholds did not change with the training. Conclusions: Unlike what was observed in young adults, the increase in maximum voluntary strength was accompanied by increases in initial motor neuron discharge rate and absence of changes in MU recruitment threshold. However, similar to what observed in young adults, the training intervention increased the maximum muscular force and this was accompanied by an increase in MU discharge rate during the plateau phase of contractions. These findings may indicate different adjustments in the behavior and discharge properties of MU between young and older adults exposed to the same strength training protocol. Our results provide further evidence of the adaptability of the nervous system and particularly of motor neuron discharge rate to short-term exercise in older adults.

O.17.1: *Effects of subthreshold electrical stimulation with pink noise on treadmill walking*

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BACKGROUND AND AIM:Falling during walking is a serious problem in various populations. As a way to reduce the risk of falling, this study focused on the stochastic resonance (SR). SR is a phenomenon in which subthreshold noise enhances the detection and transmission of a weak signal in sensory systems. Previous studies have revealed that electrical noise stimulation improved postural control during standing via SR, and such SR effects were further enhanced by the stimulation of pink noise structure. However, the effects of pink-noise stimulation on walking remains unclear. Thus, we aimed to explore whether pink-noise stimulation improves walking ability.METHODS: Ten healthy young adults walked on a treadmill for 15 minutes, and the imposed speeds were 4.5 km/h and 2.7 km/h. Two noise conditions were employed for each speed. In the control (CONT) condition, no stimulation was applied during walking; whereas in the pink-noise (PINK) condition, pink-noise stimulation was applied to both knee joints 3-4 minutes after participants started walking. A triaxial accelerometer was attached to the low back (L4-L5 region) and body accelerations in mediolateral (ML), vertical (V), and anteroposterior (AP) directions were extracted for the last 10 minutes. For every minute, stride-to-stride variabilities of acceleration were computed to evaluate the walking ability. We also evaluated the average and coefficient of variation of stride time. For each speed, two-way ANOVAs with the factors Noise (CONT, PINK) and Time (10 levels) were performed to evaluate the noise effects over time ($\alpha = 0.05$). When the interaction effect was significant, post-hoc analysis with Bonferroni correction ($\alpha = 0.005$) was performed for differences between CONT and PINK conditions.RESULTS: At a normal speed (4.5 km/h), a significant interaction in the average stride time was found, and at the first two intervals, there was a tendency to increase the average stride time in the PINK condition (0-1 minutes: $p = 0.022$, 1-2 minutes: $p = 0.007$). At a slow speed (2.7 km/h), we found significant interactions in variabilities of ML and AP accelerations, but such an effect was not found in V acceleration. At the last time interval (9-10 minutes), AP variability was significantly lower in the PINK condition than in the CONT condition ($p = 0.004$). Similarly, ML variability tended to decrease during 9-10 minutes in the PINK condition ($p = 0.020$). There were no significant effects in the other indices.CONCLUSION: This exploratory study suggested that pink-noise stimulation may be beneficial in walking. Specifically, pink-noise stimulation tended to increase the average stride time in the early phase of noise application. Moreover, pink-noise stimulation decreased the variability of acceleration at the last phase of the 15-min walk, indicating that noise stimulation might improve walking ability after walking for a certain amount of time.

O.17.2: *Effect of Neuromuscular electrical stimulation on the humeral adductors in patients with rotator cuff tear*

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Introduction: In symptomatic patients with rotator cuff tear, MRI and radiographic studies have recognized the pain symptom to insufficient humeral head depression during arm elevations. The application of Neuromuscular Electrical Stimulation (NMES) to the lower trapezius and anterior serratus enhances AHD in addition to improving scapular kinematics. Humeral adductors such as the teres major (TM) or pectoralis major (PM) may assist in humeral head depression during arm elevation. The effect of neuromuscular electrical stimulation on the humeral adductors is still unknown. This study investigated the effects of NMES application on humeral adductors in AHD and scapular kinematics.Method: A cross-sectional study of NMES of the teres major and pectoralis major was conducted on 30 symptomatic subjects with rotator cuff tear. We employed a cross-over strategy to randomly stimulate the TM or PM to account for order effects. The acromiohumeral distance and scapular kinematics during arm elevation were measured by ultrasonography and a three-dimensional motion tracking system, respectively.Results: For the acromiohumeral distance, there was a significant increase during NMES on TM (0.43-0.88mm, p< 0.001) and a significant decrease during NMES on PM (0.78 mm, p< 0.001) compared to no NMES. However, the scapular kinematics of scapular upward rotation was greater with NMES on TM compared with those when NMES on PM (1.32-3.36°, p≤ 0.001). In addition, scapular external significantly decreased with NMES on PM than that with NMES on TM (p= 0.003).Conclusion: NMES of the TM can increase acromiohumeral distance and scapular upward rotation during arm elevation. However, the decreased upward and external rotation of the scapula during arm elevation with NMES of the PM may be associated with subacromial impingement.

O.17.3: ***Novel brace with neuromuscular electrical stimulation in patients with full-thickness rotator cuff tear: a randomized controlled trial***

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Introduction:A full-thickness tear of the rotator cuff can lead to subacromial pain, diminished abducted force, limited range of motion, and functional impairment. Rotator cuff deficits can result in the decentralization and augmented translation of the humeral head during arm elevations. Teres major (TM) is believed to play a compensation role in adducting, depressing, and centralizing the humeral head during arm elevations. However, limited studies have explored the impact of TM training in patients with full-thickness rotator cuff tear. This study aims to investigate the effects of a novel brace with neuromuscular electrical stimulation (NMES) plus exercise for 6 weeks in comparison with control therapy.Methods:Sixteen participants with full-thickness rotator cuff tears were split into the brace with an NMES group (BNMES) and an exercise control group. Characteristics, tear size, and location were recorded using ultrasonography or MRI. Humeral head migration was gauged at 0°, 60°, and 90° of shoulder abduction using ultrasonography. Shoulder muscle strength (upper trapezius, lower trapezius, serratus anterior, and TM), pain levels, and self-reported shoulder function (FLEX-SF questionnaire) were evaluated. Both groups underwent a 6-week intervention consisting of scapular-focused exercises, including scapula row, serratus punch, and adduction exercises performed at 10 repetitions per set for 3 sets daily. The BNMES group received additional NMES during exercises. Measurements were taken at the beginning, weeks 3, and weeks 6, and analyzed via a two-way mixed analysis of variance with group (BNMES and control) and time (beginning, weeks 3, and weeks 6) factors.Results:There was no significant time-group interaction, but the main effect was on time. Following the intervention, participants exhibited significant improvements in pain (2.2±0.5, p<0.005; 3.1±0.6, p<0.001) and function (2.8±1.0, p=0.048; 6.4±1.3, <0.001) at weeks 3 and 6, but no difference between weeks 3 and 6. Shoulder muscle strength also increased in the serratus anterior (3.5±1.1kg, p=0.021; 8.1±2.0 kg, p=0.004) and TM (2.5±0.9kg, p= 0.021; 4.6±.1.1kg, 0.004) at weeks 3 and 6. Lower trapezius strength only increased from weeks 3 to 6 (1.9±0.6kg, p= 0.026). However, the humeral head migration did not reveal significant differences post-intervention.Conclusion:Scapular-focused exercises plus shoulder adductor training demonstrated the potential to alleviate pain and enhance function in patients with full-thickness rotator cuff tears. The improvements may be attributed to increased strength in serratus anterior and TM. Six weeks of exercise can further improve lower trapezius strength with concurrent improvement in pain reached clinical difference. Notably, humeral head superior migration remained unchanged. Clinical practitioners could consider introducing these exercises to patients with full-thickness rotator cuff tears as a safe and promising option.Keywords: brace, teres major, neuromuscular electrical stimulation, full-thickness rotator cuff tear

O.17.4: ***The effect of femoral strapping on excessive hip internal rotation and pain response in females with patellofemoral pain***

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Introduction: Excessive hip internal rotation has been theorized to affect patellofemoral joint mechanics and contribute to patellofemoral pain (PFP). The SERF (Stability through External Rotation of the Femur) strap was designed to provide hip stability by pulling the thigh into external rotation during weight-bearing activities. The effects of the strap have not been assessed in persons with PFP who have excessive amounts of hip internal rotation during tasks when not wearing the strap. Thus, the purpose of our study was to evaluate the effects of the SERF strap on hip internal rotation (IR) and pain response during dynamic, weight-bearing activities in females with PFP who have excessive amounts of hip internal rotation.Method: Nineteen females with a diagnosis of PFP were tested while wearing the strap and not wearing the strap. Three-dimensional motion analysis was performed to obtain hip kinematic data, and a 10-cm visual analog scale was used to assess pain. Each subject performed 3 tasks, with and without the SERF strap: drop-jump, unilateral step-down, over-ground running. The stance phase of each task was identified, and 15 subjects who demonstrated 4 degrees or more of hip IR during at least 2 of the tasks while not wearing the strap were retained in the study for further analysis between strap conditions. Two-way (strap condition by task) ANOVAs were used to analyze the hip IR and pain data.Results: Significant main effects revealed reductions in peak hip IR (p<0.001) and pain scores (p=0.03) across tasks when wearing the SERF strap. Conclusion: When it is necessary to limit hip internal rotation during weight-bearing activities, the SERF Strap may be a useful treatment adjunct for persons with PFP who have excessive amounts of hip internal rotation.

O.17.5: ***Changes in tonic vibratory reflex after visually induced kinesthetic illusion therapy in post-stroke patients with spasticity***

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[Background and aim]Visually induced kinesthetic illusion (V-KI) is a psychological phenomenon in which a resting person feels as if a body part is moving or feels the desire to move a body part while watching film footage of a moving body part (Kaneko et al. Neuroscience, 2007). Miyawaki et al. (Front Syst Neurosci, 2021) showed that V-KI therapy combined with therapeutic exercise reduced the modified Ashworth scale (MAS) score, improving motor assessment scores. However, the MAS score largely reflects muscle degeneration due to long-term spasticity. Therefore, it is necessary to consider that the MAS score is influenced by the musculature components in addition to the degree of spasticity.Vibrating the flexor digitorum tendon at the appropriate location induces firing of Ia fibers owing to muscle spindle activity, generating an afferent input. Moreover, the firing frequency of Ia fibers is known to adjust to the vibratory stimulation frequency (Brown MC et al., J Physiol, 1967). The reflex triggered by vibration is known as the tonic vibration reflex (TVR). This study aimed to apply vibrations of different frequencies to a post-stroke patient with hemiplegia and spasticity and to clarify the relationship between TVR-induced surface electromyography (sEMG) and motor function changes following V-KI therapy.[Method]Fourteen post-stroke patients underwent a 15-day V-KI therapy, evaluated through vibratory stimulation before and after treatment. The participants were instructed to relax their wrist and finger muscles which were fixed on a table. Vibratory stimulation (eyes open) was applied three times for 3 s to the paralyzed finger flexor digitorum tendon. Frequencies of 40, 60, 80, and 100 Hz were utilized with sEMG recordings of the extensor digitorum communis and flexor digitorum profundus. Analysis was performed by applying a 5–500 Hz bandpass filter and calculating and normalizing the RMS mean values during stimulation by the maximum RMS mean value. The minimum RMS mean value served as the reference, and the slope of the maximum change in the RMS with frequency (RMS slope) was determined.[Result]In all participants, the RMS mean value during stimulation was lowest at 40 Hz. The RMS slope negatively correlated with motor function change after V-KI therapy. Although MAS improved significantly after V-KI treatment (Mann–Whitney U test, p<0.001), it was not correlated with improved motor function[Discussion]The TVR-induced sEMG signal originated from the stretch reflex arc. V-KI therapy may have affected stretch reflex gains, thereby affecting motor function. MAS and motor function were not correlated; however, the small sample size of this study compared with those of prior studies should be considered.TVR induction is straightforward and enables the investigation of neurological factors associated with the improvement of motor function. Thus, it is a clinically useful assessment in post-stroke patients.

O.17.6: ***Characteristics of electromyographic activity during yoga-applied lunge exercise***

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Introduction: Benefits of yoga for lower back pain have been reported. (Anheyer D et al, 2022.) Yoga lunge exercises (YLE) involve similar trunk and arm movements as general lunge exercises (GLE) and are used to improve thoracic spine mobility and trunk stability. We aimed to compare the muscle activity associated with GLE and YLE to clarify characteristic muscle activity patterns during YLE. Methods: Fourteen healthy men with no previous yoga experience were recruited. They performed GLE including front and side lunge. They also performed YLE including front lunge with arm elevation, 3 types of twist YLE with trunk rotation to stepping side (twist lunge, twist lunge with praying hands, twist lunge with arm elevation), and 4 types of warrior YLE with trunk rotation to non-stepping side (warrior, warrior with trunk side bend, warrior with arm elevation, and warrior with hand behind back) on both sides. Electromyographic (EMG) data was recorded for upper and lower trapezius (UT and LT), internal oblique (IO), Erector spinae, gluteus maximus, gluteus medius (Gmed), rectus femoris, and biceps femoris on the right side using surface electrodes. EMG activities were compared using Kruskal-Wallis tests between each exercise for each muscle. Results: UT and LT activities were significantly higher with YLE than with GLE. Gmed (twist lunge: 24.0±8.3% MVIC, twist lunge with praying hands: 23.9±10.7% MVIC, twist lunge with arm elevation: 22.6±1.5% MVIC) and IO activity levels (twist lunge: 19.2±7.8% MVIC, twist lunge with praying hands: 15.2±6.5% MVIC, twist lunge with arm elevation: 18.0±11.1% MVIC) on stepping side during twist YLE were significantly higher than those recorded during GLE. On the non-stepping side, the %MVIC value of Gmed activities in the twist YLE (twist lunge with praying hands: 15.1±15.3% MVIC, twist lunge with arm elevation: 32.5±26.2% MVIC), and IO activities in the warrior YLE (warrior: 19.4±10.8% MVIC, warrior with trunk side bend: 14.2±6.7% MVIC, warrior with arm elevation: 20.0±13.8% MVIC, warrior with hand behind back: 22.5±11.1% MVIC) were significantly higher than that in GLE. Discussion ： UT and LT activities were increased by upper limb elevation in YLE. The twist YLE on the stepping side involves ipsilateral trunk rotation, which increased IO activity. Twist YLE also resulted in hip flexion and internal rotation on the step side, increasing Gmed muscle activity due to increased hip internal rotation moment arm in the hip flexor position (Neumann DA. 2010). The Gmed, a hip rotator, on the non-stepping side also showed higher activity during twist YLE including hip rotation with trunk rotation. Additionally, warrior YLE on the non-stepping side increased IO activity due to trunk lateral flexion against the forward center of gravity. Thus, YLE is a promising trapezius activating exercise. Twist YLE also activates bilateral Gmed and IO on the stepping side, and warrior YLE activates IO on the non-stepping side.

O.17.7: *Influence of diaphragm and breathing on shoulder kinematics and associated muscle activity*

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Background: Diaphragmatic breathing training is widely used clinically. However, relationship between diaphragm function and shoulder pain is lack of evidence. Studies indicated that impaired diaphragm breathing function can increase activation of breathing accessory muscles. As these muscles are direct or indirect attached to shoulder girdle, they may affect the shoulder kinematics and muscle activities. Additionally, the diaphragm's role in postural stabilization might influence shoulder function. Further investigation is needed to know if diaphragm stabilization affects the shoulder kinematics and stability through kinetic chain. Purpose: (1) to characterize the kinematics, and muscle activations of the scapula in 3 breathing conditions during arm elevation task (2) to investigate the influence of diaphragm challenge on shoulder kinematics, and muscle activation during arm elevation in healthy adult.Methods:It's a cross-sectional study. 30 healthy adults were recruited. Participants were assessed for maximal inspiratory pressure (PImax), diaphragm ultrasonography and core stability test, then the shoulder kinematics and associated muscle activation were collected during weighted arm elevation in three breathing conditions, including quiet breathing, breath-holding at the end of inspiration (Apnea-I) and breath-holding at the end of expiration (Apnea-E). After 30-minutes rest, the inspiratory resistance loading protocol was applied to challenge their diaphragm function. Then the shoulder kinematics and associated muscle activation during weighted arm elevation in quiet breathing were collected. Finally, the first three tests were assessed again. Statistical analysis:Two-way repeated ANOVA was used to compare shoulder kinematics and associated muscle activation among 3 breathing conditions as well as the effect of diaphragm challenge. Statistical analysis was calculated by SPSS 22.0 with significant level set as 0.005 after the Bonferroni correction. Results:Comparing Apnea-I to quiet breathing, there was significant increase in scapular upward rotation (1.2°-1.7°±9.84) and internal rotation (1.3°±4.83) as well as increased UT (0.5%±14.2) and SCM (1.0-1.2%±3.5) muscle activities. Conversely, Apnea-E condition showed significant decrease in scapular internal rotation (1.1-5°±6.04) along with increase SA (3.0-5.8%±13.61) and LT (4.5%±23.65) as well as decrease UT (1.9%±19.1) and SCM (0.4-0.8%±3.59) activities. In addition, increased scapular upward rotation (0.8-2.38°±6.37) was found after diaphragm challenge. Conclusion:The differences between Apnea-I and Apnea-E may be caused by rib cage diameter and thoracic movement. We suggest Apnea-E as a more effective strategy to maintain ideal scapula kinematics and muscular activities. Though increased scapular upward rotation was found after diaphragm challenge protocol, the clinical relevance of the effect of high intensity breathing training in scapular kinematics still requires further research.

Oral.Award.1: *Site-specific assessment of the mechanical properties of each hamstring muscle in human cadavers using shear wave elastography*

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Background and aim: Hamstring strain, primarily caused by increased tensile stress, frequently manifests in the proximal long head of the biceps femoris muscle (BF) and the proximal and distal semimembranosus muscle (SM). Recent elasticity measurements using ultrasonic shear wave elastography (SWE) have revealed that the mechanical stress that increases with elongation differs among various muscles and sites. However, the inter- and intramuscular regional disparities in mechanical stresses related to muscle elongation remain unclear. This study aimed to investigate whether the mechanical stresses associated with increased elongation differ among hamstring muscles and multiple sites within the muscle using a soft-

embalmed Thiel cadaver. Methods: BF, Semitendinosus (ST), and SM muscles were dissected from eight cadavers. The proximal and distal hamstring tendons were affixed to a mechanical testing machine. Slack length (L) denoted the initial muscle length upon the application of a tensile load (P). Muscle length was measured using a tape measure, and the anatomical cross-sectional area (ACSA) of the muscle was determined at two sites—the proximal (33%) and distal (67%) using B-mode ultrasonography. For the loading protocol, the muscle underwent elongation from its slack length to a maximum of 8% strain at a rate of 20 mm/min, and the amount of displacement (ΔL) and tensile load, as well as shear modulus, were measured for each muscle. Strain (%, ΔL/L) and stress (kPa, P/ACSA) were calculated to evaluate mechanical properties. The shear modulus was measured using SWE at the same sites as ACSA measurements. For data analysis, the shear modulus and stress relationship was compared between each tested muscle region and analyzed using a least-squares regression line. Three-way analysis of variance was used to compare the changes in shear modulus with increasing strain among muscles and sites.Results: A linear correlation between the shear modulus and stress was evident for all the hamstring muscles in each region (P<0.01). The mean coefficient of determination (R2) for all muscles and sites was 0.98±0.02 (0.84–0.99). A significant interaction (muscle × site × strain) was observed in the shear modulus. Post-hoc tests revealed higher shear modulus in BF and SM than that in ST after 3% strain. Moreover, proximal BF exhibited higher values after 4% strain, whereas distal SM showed higher values after 6.5% strain compared with other sites within the same muscle (P <0.01). The average shear modulus at 8% strain, where the most substantial differences were observed, was ST (proximal: 26 kPa, distal: 25 kPa) compared with BF (proximal: 65 kPa, distal: 56 kPa) and SM (proximal: 44 kPa, distal: 58 kPa).Conclusions: The mechanical stresses applied to the three muscles at similar strains might be higher in the proximal BF and distal SM. Our findings indicate that elastic alterations in the proximal BF and distal SM during elongation elucidate the heightened incidence of muscle strain in these regions.

Oral.Award.2: *Antagonism of 5-HT2 receptors attenuates self-sustained firing of human motor units*

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Activation of 5-HT2 receptors on motoneurones play a critical role in facilitating persistent inward currents (PICs). Although facilitation of PICs can enhance self-sustained firing after brief periods of excitatory input to motoneurones, the relationship between 5-HT2 receptor activity and self-sustained firing in human motor units (MUs) has not been resolved. Therefore, this study examined how 5-HT2 receptor activity contributes to self-sustained firing of MUs in humans. MU activity was assessed from tibialis anterior in 10 healthy adults (24.9 ± 2.8 yr) during two contraction protocols. Both protocols featured steady-state isometric contractions with constant descending drive to the motoneuron pool, however one protocol also included an additional phase of superimposed descending drive during the steady-state contraction. Adding and then removing descending drive in the middle of steady-state contractions altered the MU discharge behaviour across the motor pool, where newly recruited units in the superimposed phase were unable to switch off due to their self-sustained firing (P = 0.0002), and units recruited prior to the additional descending drive reduced their discharge rates (P < 0.0001, difference in EMM (Δ) = 2.24 pulses/s). The 5-HT2 receptor antagonist, cyproheptadine, was then administered to determine if changes in MU discharge behaviour were mediated by serotonergic mechanisms. 5-HT2 receptor antagonism caused reductions in MU discharge rate (P < 0.001, Δ = 1.65 pulses/s), recruitment threshold (P = 0.00112, Δ = 1.09% MVC), and self-sustained firing duration (P < 0.0001, Δ = 1.77s) after the additional descending drive was removed in the middle of the steady-state contraction. These findings indicate that serotonergic neuromodulation plays a key role in facilitating MU discharge and self-sustained firing of human motoneurones, where adaptative changes in MU recruitment must occur to meet the demands of the contraction.

Oral.Award.3: ***Neuroplastic alterations in common synaptic inputs and synergistic motor unit clusters controlling the vastii muscles of individuals with ACL reconstruction***

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Background. Restoration of knee extension strength and control is a priority for the rehabilitation process after anterior cruciate ligament reconstruction (ACLR). This emphasis is due to the fact that, despite extensive rehabilitation, persistent quadriceps dysfunction is common post-ACLR, leading to severe consequences such as an increased risk of reinjury and knee osteoarthritis.1 Volitional force modulation is primarily governed by common synaptic inputs (CSIs) that are shared across motor neurons. Recent evidence has shown that, rather than projecting only to muscle-specific pools of motor units (MUs), CSIs are distributed across functional clusters of MUs that can change plastically to provide a flexible control of motor output.2-3Aim. This cross-sectional study aims to elucidate the neural strategies adopted by the central nervous system to coordinate the activation of vastus lateralis (VL) and vastus medialis (VM) muscles for the control of knee extension forces in individuals with ACLR. Methods. Eleven soccer players with ACLR (age: 24.8 ± 3 years; BMI: 23.3 ± 0.6 kg*m-2) and nine control players (age: 25.7 ± 2.5 years; BMI: 22.9 ± 0.5 kg*m-2) performed unilateral isometric steady knee extensions at 10% and 30% of their maximum voluntary force. Simultaneous recordings of high-density surface electromyography and force output were conducted to examine the discharge properties of VL and VM MUs and to estimate the CSI delivered to each muscle through intramuscular coherence analyses. A factorization analysis was adopted to investigate the neural strategies underlying the control of synergistic clusters of MUs. Results. MUs identified in the VL of the reconstructed side exhibited lower magnitude and proportion of CSI at low-frequency bandwidths (< 5 Hz), compared to those governing the VL in unaffected lower limbs (P < 0.05). Furthermore, the reconstructed side demonstrated a higher proportion of MUs identified in the VM muscle that were correlated with the neural input common to the synergistic VL muscle, compared to unaffected lower limbs (P < 0.01).Conclusions. The lower magnitude and proportion of CSI projecting to motor neurons of the VL muscle suggest an increased contribution of independent synaptic inputs to force control in the reconstructed side, compared to unaffected lower limbs. Additionally, the output of the factorization analysis indicated a plastic rearrangement in the neural input for the synergistic activation of VL and VM clusters of MUs that control knee extension forces in the reconstructed side. Further studies are needed to confirm and extend our findings. A comprehensive understanding of these neural adaptations could aid in designing targeted neurological rehabilitation approaches, often neglected in clinical practice.References1. Buckthorpe et al. Int J Sports Phys Ther. 2019;14(1):159. 2. Del Vecchio et al. J Neurosci. 2023;43(16):2860-2863. 3. Hug et al. J Physiol. 2023;601(1):11-20.

Oral.Award.4: ***Motor unit activity and muscle contractile properties during rapid contractions in long-term resistance trained and untrained individuals***

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Background and aim: Maximal rate of force development (RFD) is determined by neural (motor unit [MU] recruitment speed and discharge rate) and muscular properties. Though resistance trained (RT) individuals typically exhibit greater absolute RFD, the findings are equivocal regarding relative RFD (i.e., normalised to maximal voluntary force [MVF]), with studies reporting greater, similar, or even lower relative RFD in RT individuals. Nevertheless, chronic resistance training may confer neural adaptations including greater spinal cord output in RT compared to untrained individuals (UT), that facilitates faster RFD. Here, we assessed MU discharge characteristics and intrinsic muscle contractile properties within RT and UT individuals during maximal rapid contractions. Methods: Twenty-two RT and 22 UT (6 females per group) individuals produced maximal and rapid voluntary isometric dorsiflexion force (up to ~80% of MVF), to determine MVF and RFD (maximal slope of the force-time curve from force onset), respectively. Percutaneous nerve stimulation (25 pulses at 100 Hz and 8 pulses at 300 Hz) was administered to the common peroneal nerve at rest to record maximal evoked force (MEF) and RFD. A 64-channel grid electrode was placed on the tibialis anterior muscle of the dominant leg to assess myoelectrical activity (EMG). The EMG signals were decomposed into individual MU spike trains using Convolution Kernel Compensation algorithm. Discharge rate in the initial (first five spikes) and plateau period (20 spikes) of rapid contractions, and recruitment speed of the identified MUs were calculated. Results: MVF and MEF were significantly larger in RT (393 [337, 449] N and 245 [212, 278] N) compared to UT (296 [260, 331] N, p=0.014, and 174 [151, 198] N; p<0.001), respectively. Greater absolute RFD was observed in RT compared to UT during voluntary (1792 [1550, 2035] vs 1307 [1064, 1550] N/s; p=0.007) and evoked (2001 [1751, 2252] vs 1492 [1247, 1736] N/s; p=0.005) contractions. However, when normalised to MVF, there were no differences between groups for either voluntary (454 [429, 480] vs 420 [394, 445]%MVF/s, p=0.056) or evoked RFD (513 [447, 579] vs 493 [429, 557]%MVF/s, p=0.665). Compared to UT, RT exhibited greater discharge rate in the initial period of rapid contractions (73 [68, 79] vs 65 [59, 71] pps; p=0.022), but not during the contraction plateau (31 [28, 34] vs 28 [26, 31] pps; p=0.176). Both groups displayed similar MU recruitment speed (302 [203, 401] vs 281 [170, 392] MU/ms; p=0.767). Conclusion: RT individuals exhibited greater maximal strength and absolute RFD. However, despite greater initial MU discharge rate, relative RFD was similar between groups. The lack of differences in relative RFD likely stems from between-group similarity in intrinsic contractile properties and MU recruitment speed, two key determinants of maximal RFD.

Oral.Award.5: ***Ischaemic block of large-diameter axons increases motor unit discharge rate non-linearity and hysteresis***

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Background and aim: Persistent inward currents (PICs) provide gain control of motoneuron output and are influenced by both diffuse neuromodulation and local inhibitory inputs. However, if feedback from large diameter axons is lost, as is the case in some neurological impairments, amplification and prolongation of synaptic inputs by PICs is likely to be facilitated. Here, we tested the hypothesis that reduced Ia afferent transmission from lower limb muscles would increase tibialis anterior (TA) motor unit (MU) discharge rate hysteresis and result in greater non-linearity of MU discharge patterns, indicating a greater contribution of PICs to MU discharge.Methods: 10 neurologically intact adults (4 female) performed triangular shaped isometric dorsiflexion to 30% of maximum voluntary force (MVF) at the beginning of the experiment (PRE1), and after 20 minutes of rest (PRE2; control condition). A sphygmomanometer cuff was then inflated to 200 mmHg just above the knee to induce an ischaemic nerve block. Soleus H-reflex was monitored every 2 mins to assess when Ia afferent transmission was abolished (<10% original value; 15±4 mins per participant) after which the triangular contractions were repeated whilst the participant's leg remained occluded (POST condition). Myoelectrical (EMG) activity of the TA was measured using a 64-electrode array and EMG signals were decomposed into individual MU spike trains using a Convolution Kernel Compensation algorithm. From smoothed MU discharges (support vector regression), discharge rate hysteresis (ΔF) and non-linearity in the ascending modulation of MU discharge rate (brace height) were quantified.Results: Occlusion did not affect maximal M-wave (Mmax; 4.37 [3.41, 5.33] vs 4.76 [3.81, 5.71] mV; p=0.092), whereas H-reflex was lower at POST compared to pre-occlusion (3.21 [-6.21, 12.60] vs 42.08 [32.66, 51.50] %Mmax; p<0.001), indicating reduced Ia afferent input. Peak discharge rate at POST (28.3 [24.8, 31.7] pps) was greater compared to PRE1 (19.8 [16.3, 23.3], p<0.001) and PRE2 (20.9 [17.4, 24.4], p<0.001), with no differences between PRE1 and PRE2 (p=0.199). Discharge rate hysteresis at POST (5.14 [4.11, 6.18] pps) was greater than at PRE1 (4.65 [3.61, 5.68] pps, p=0.038) and PRE2 (4.55 [3.52, 5.58] pps, p=0.007), with no differences between PRE1 and PRE2 (p=0.869). Brace height, indicating the extent of non-linearity during the ascending discharge rate modulation, was greater at POST (39.8 [35.0, 44.7]%) than at PRE1 (32.5 [27.9, 37.1]%, p<0.001).Conclusion: An ischaemic block of large-diameter axons led to greater MU discharge rate hysteresis, and more non-linear discharge patterns, suggesting increased PIC contribution to discharge rate modulation in conditions of reduced inhibitory input. These findings provide insight into the role of Ia afferent input on MU discharge patterns and offer a possible explanation for spasticity in some neurological impairments.

Oral.Award.6: ***The neuromuscular control of the shoulder muscles in healthy individuals: a TMS study***

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Introduction: Coordination between the shoulder muscles is critical to maintain dynamic stability of the glenohumeral joint. This involves coactivation of the rotator cuff muscles to control glenohumeral translation and rotation during shoulder movements, e.g., activation of the rotator cuff such as subscapularis (SS) to control cranial glenohumeral translation when the middle deltoid (MD) abducts the shoulder. How this coordination is controlled by the motor cortex is poorly understood. Emerging evidence has proposed the concept of "functional somatotopy" of the primary motor cortex (M1), indicating its role in coding task-specific motor strategies. It is suggested that individual muscles are controlled by multiple brain regions that might each serve different functions, and that multiple muscles involved in a task are controlled by a common region. Based on this proposal we hypothesized that: 1) cortical representation of MD (and SS) would differ when the muscle performs different tasks, 2) the representation of MD and SS would overlap when are active in the same task, and 3) the representation would have little overlap when MD and SS are active in different tasks. Methods: The left-side motor cortex representations of MD and SS were mapped with transcranial magnetic stimulation (TMS) in seven right-handed healthy adults. MD and SS electromyography (EMG) was recorded with intramuscular electrodes. In separate trials, participants performed isometric shoulder abduction (ABD) and internal rotation (IR) in 90° abduction at 2% of maximal voluntary contraction. We identified the hotspot and active motor threshold (aMT) for each muscle. Using rapid TMS mapping we generated maps for MD or SS during ABD or IR. For each of the 4 maps, ~100 stimuli were delivered pseudorandomly over a 6x7cm grid at 120% aMT of the target muscle. After map interpolation, we calculated 1) area of map with intensity above 60% the peak amplitude for each map, 2) the area of overlap between the maps (as a proportion of summed total area) of MD or SS during ABD and IR (same muscle different tasks), MD and SS during ABD (different muscles same task) and MD during ABD and SS during IR (different muscles different tasks). Results: Figure 1 shows data for a representative participant. Preliminary analysis shows that: 1) the cortical representation for each muscle differs between tasks – MD 87(10)% and SS 80(15)% of the total map area did not overlap between tasks; 2) the cortical representations of MD and SS overlap when they are both active in ABD (9(7)%); and there is little overlap between cortical maps for MD in ABD and SS in IR (6(4)%). Discussion: These preliminary results suggest that the cortical representation for a muscle differs based on the task being performed (some overlap, but with a majority non-overlapping), the maps of two muscles overlap when they are both active in a single task, and the maps of two muscle have limited overlap when performing different tasks.