2019 EXERCISE NEUROSCIENCE GROUP CONFERENCE AGENDA

MONDAY, JUNE 17th, 2019 MORNING SESSION

8:00–8:30 AM	Arrival and Continental Breakfast		
8:30 – 9:15 AM	**Welcome and Keynote (Dr.Jayne Kalmar)** Topic: TBD		
SESSION 1			
9:15 – 10:45 AM	Haley Gabel	The effects of shortening-induced torque depression on fatigue resistance in males and females	Guelph
	Emma Plater	The effects of remote subthreshold stimulation on skin sensitivity in the lower extremity	Guelph
	Greig Inglis	Sex differences in force steadiness	Brock
	Evan Lockyer	What's the SITch: Does 2 weeks of arm cycling sprint interval training induce changes in the corticospinal pathway?	Memorial
	Kalter Hali	Frequency-dependent conduction block in chronic inflammatory demyelinating polyneuropathy	Western
	Rufeyda Cosgun	Development of a protocol to investigate the vestibulo-ocular reflex in sub-clinical neck pain	UOIT
10:45 – 11:00AM	Break		
SESSION 2			
11:00 – 12:30 PM	Kezia Cinelli	The task at hand: Fatigue-associated changes to corticospinal excitability during writing	Wilfred Laurier
	Robert Kumar	A denoising algorithm for surface EMG decomposition	Brock
	Leah Vardy	The effect of various TheraBand resistances on the barbell back squat and overhead squat in trained and untrained individuals	Memorial
	Kevin Gilmore	Microscopic muscle architecture in chronic inflammatory demyelinating polyneuropathy	Western
	Matthew Boston	The history dependence of force following short term unloading	Guelph
	Jules Miehm	Progressive vs. Relapse-remitting multiple sclerosis: Sensorimotor function is affected differently in upper and lower extremities	Massachu-setts
12:30 – 1:15 PM	Lunch		

MONDAY, JUNE 17th, 2019 AFTERNOON SESSION

SESSION 3			
1:15 – 2:45 PM	Aysha Basharat	Exercise and multisensory integration in younger and older adults	Waterloo
	Matthew Mallette	The effects of local forearm thermal manipulations on motor unit properties during light and moderate contractions	Brock
	Heather Brandon	Assessing bilateral neuromechanical outcomes of the upper-limbs during arm cycling: Do bilateral asymmetries exist?	Memorial
	Katie Kowalski	Force steadiness and motor unit firing variability following mental fatigue in young adults	Western
	Rhiannon Marion	Activation reduction during a position and torque task following active lengthening	Guelph
	Rowan Smart	Transfemoral amputation reduces low-torque plantar flexion steadiness and does not alter Achilles tendon mechanics	BC (Okanagan)
2:45 – 3:00 PM	Break		
SESSION 4			
3:00 – 4:30 PM	Niki Grzywnowicz	The effect of muscle fatigue on regional activation in the ankle plantarflexors	Western
	Lara Green	The use of surface electromyography for the estimation of persistent inward currents	Wilfred Laurier
	Chris Compton	What is the relationship between corticospinal excitability modulation and neuromechanical outputs during arm cycling?	Memorial
	Alexander Zero	Effects of low-load strength training combined with blood flow restriction or hypoxia on Wingate performance	Nippissing
	Tara Kuhn	Investigating the relationship between physical activity and the functional connectivity of the hippocampus and the prefrontal cortex	McMaster
	Joshua Cohen	Regional modulation of the ankle plantarflexor muscles associated with standing external perturbations across different directions	Western
4:30PM	Phoenix Social		

TUESDAY, JUNE 18th, 2019

8:00–8:30 AM	Arrival and Continental Breakfast		
8:30 – 9:15 AM	**Welcome and Keynote (Dr.Joyce Chen)** Topic: TBD		
SESSION 5			
9:15 – 10:45 AM	Domonique Arsenault	Postural control in response to unilateral and bilateral external perturbations: effect of cognitive load	Western
	Eli Haynes	Sex differences in age-related dynapenia: a literature evaluation	BC (Okanagan)
	Hamid Barzegarpoor	The effects of performing prolonged mental exertion during submaximal cycling exercise on fatigue indices	Memorial
	Matthew Russell	Altered Sensory Input to the Neck May Impair Shoulder Joint Proprioception	UOIT
	Tushar Sharma	Mechanically-evoked cutaneous reflexes are enhanced by noisy electrotactile stimuli	Guelph
	Patrick Siedlecki	The effect of balance perturbations on baroreflex sensitivity in young adults	Western
10:45-11:00AM	Break		
SESSION 6			
11:00 – 12:30 PM	Mathew Debenham	Acute effects of hypoxia on the vestibular control of balance	BC (Okanagan)
	David Copithorne	The effect of blood flow occlusion on tibilalis anterior motor unit firing rates during sustained low-intensity isometric contractions	Western
	Nikki Aitcheson-Huehn	Neural Mechanisms of Balance and Gait Adaptations after Downslope Walking	Wilfred Laurier
	Fattaneh Farahmand	The effect of 6 weeks of high intensity interval training on myelin biomarkers in a mouse model of multiple sclerosis	Shahid Beheshti/ Memorial
	Vincenzo Contento	Inhibitory signalling from the golgi tendon organ is increased in the force-enhanced state following active lengthening	Guelph
	Eric Kirk	A motor unit firing rate profile in humans: a first look	Western
12:30PM	CLOSING REMARK		

Thank You for Coming!
We hope you enjoyed the conference

The effects of shortening-induced torque depression on fatigue resistance in males and females

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Residual torque depression (rTD) is the decrease in isometric torque following active shortening of skeletal muscle, compared to a purely isometric contraction performed at the same muscle length and level of activation. Performance fatigability is defined as any exercise-induced reduction in voluntary force or power. Females are typically more fatigue resistant than males at low intensity isometric contractions. This study investigated performance fatigability in males and females during purely isometric (ISO) contractions and isometric contractions following active shortening (rTD). Fourteen females (age: 22 ± 2 year, height: 168 ± 5 cm, weight: 64 ± 5 kg) and 14 males (age: 23 ± 2 years, height: 182 ± 8 cm, weight: 78 ± 8 kg) performed three baseline maximum voluntary contractions (MVCs) of the dorsiflexors. The baseline MVCs were used to determine a 30% submaximal torque target, which participants traced as steadily as possible until task failure. The ISO fatigue task was performed at 10° plantar flexion. Prior to the same fatigue task in the rTD state, participants shortened across a 30° range to 10° plantar flexion. MVCs were performed immediately after task failure, 30 s after task failure and 1, 2, 3, 4, 5, 10, 20, and 30 mins after task failure to track recovery. Male's baseline MVC torque amplitude (32.1 ± 6.6 N·m) was 31% greater than females (22.3 ± 3.1 N·m) ($p < 0.001$, $\eta p^2 = 0.490$). Female's time to task failure was 44% longer than males in the ISO state ($p = 0.032$, $\eta p^2 = 0.164$). However, there was no sex difference in the rTD state ($p = 0.142$). It appears that the differences in fatigue resistance observed in a low intensity isometric task are abolished in the isometric state following a shortening contraction. *Supported by NSERC.*

The Effects of Remote Subthreshold Stimulation on Skin Sensitivity in the Lower Extremity

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Skin at the foot sole acts as an interface with the ground and can affect balance. In lower extremity amputation (LEA), the interface is between the residual limb and the prosthetic socket and is comprised of different skin with different sensory properties. A technique called stochastic resonance (SR) improves sensitivity in glabrous skin by adding noise. The main objective of the current study was to determine if remote subthreshold stimulation of the hairy skin on the posterior leg (analogous to the skin of a transtibial residual limb) can improve sensation to vibrotactile input. Secondary objectives were to compare this effect between 1) stimulation profile - electrotactile and vibrotactile noise, 2) stimulation at the heel and calf, and 3) older and younger individuals. 40 healthy subjects had a vibrotactile (test) input applied to the lower extremity (heel or posterior calf) at the same time that a second, noisy stimulus was applied more proximally (posterior calf or thigh).

Subjects were divided into 4 groups of 10:
Y-E-C (young/electrotactile/calf),
O-E-C (older/electrotactile/calf),
Y-V-C (young/vibrotactile/calf) and
Y-E-H (young/electrotactile/heel).

Following threshold determination, a two forced-choice protocol was used to determine detection ability of the test input, set at 80% of threshold, with varying noise levels applied simultaneously (0, 20, 40, 60, 80, 100% of threshold). An SR effect was identified when a greater percent-correct value was seen at any level of noise above that seen at 0% noise. A greater percent-correct value indicated better detection of the input. In all 4 groups, approximately half of the subjects showed an SR effect. The SR effect did not have a clear distribution across noise intensities. There were significant interactions between noise intensity and age (p=0.045) and between noise intensity and stimulation profile (p=0.047), but no significant effects on location. This indicates that, on average, SR effects occurred at different noise levels between different ages and profiles. Therefore, SR may be effective at improving skin sensitivity, but the intensity required varies between individuals. Testing in LEA is the next step, with the goal being to inform future technology in prosthetics to improve balance and prevent falls. *Funded by NSERC.*

Sex Differences in Force Steadiness

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Isometric force steadiness (FS) is the ability to maintain a constant force output, where force fluctuations lead to decreased steadiness. The degree of force fluctuations is affected by the level of force output. Motor unit (MU) behaviour along with the ability of the muscle to generate force, affects the amplitude of force fluctuations. Steadiness may also be influenced by motoneuron noise. This work examined the effect of sex differences in MU behaviour on FS.

Forty-eight (F=24; M=24) participants were seated with their hip and knee fixed at 90° and ankle fixed at 20° plantar flexion. Force was recorded from a load cell (JR3 Inc., Woodland, CA) beneath the distal metatarsals. An oscilloscope (Tetronix, TDS 460A, Beaverton, OR) provided real-time feedback of intramuscular EMG (iEMG) signal quality and force feedback with ± 2.5% error bars around the desired force output. Surface EMG (sEMG) was recorded from the tibialis anterior with monopolar Ag/AgCl electrodes (Grass F-E9, Astro-Med Inc., West Warwick, RI) and an intra-muscular electrode (Viasys Healthcare UK; Surrey, Eng) inserted 1 cm distal to the surface electrode. Participants completed 3 isometric dorsiflexion contractions at 20, 40, 60, 80 and 100% of a maximal voluntary contraction (MVC). Submaximal contractions were performed in balanced order with 100% MVCs pre and post submaximal trials. Each 8-second contraction was separated by 3-minutes rest. EMGlab (www.emglab.net) was used for MU identification. Submaximally, females had greater MU discharge rate (MUDR), MU recruitment and a greater incidence of doublet discharges (*p's* < 0.01). Females also had a reduced normalized FS (27%) at all force outputs and greater motor unit inter-spike-interval coefficient of variation (ISI-CV) (19.86%) and compared to males (ISI-CV, 18.08 %) submaximally (*p's* < 0.01). Additionally, the variability of the MUDR was linked with the magnitude of the raw force error ($r = 0.65$, $p < 0.01$). Females likely exhibited less FS than males due to a neural strategy to compensate for biomechanical differences (pennation angle, joint laxity and tendon compliance) during submaximal contractions. These differences resulted in the modulation of MU behaviour which increased the summation of twitch force twitches in a way that reduced FS.

What's the SITch: Does 2 weeks of arm cycling sprint interval training induce changes in the corticospinal pathway?

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The purpose of the present study was to investigate the influence of two weeks of arm cycling sprint interval training (SIT) on corticospinal excitability to muscles of the dominant arm. Six healthy male participants (age, 23.1 ± 1.3 yrs; height, 182 ± 6.0 cm; weight, 87.1 ± 11.4 kg), with various training backgrounds were randomly assigned to a SIT or control group ($n = 3$ each). Participants in the SIT group performed 6 training sessions over approximately 14 days, while the control group did not train. Each training session consisted of four to six repeats of 30 s 'all-out' cycling efforts against 5% of participant body weight with 4.5 minutes of rest/recovery between each sprint. At baseline and at post-testing, an incremental time-to-exhaustion (TTE) test was performed to provide an index of aerobic capacity for each group. Moreover, at baseline and post-training, corticospinal and spinal excitability were assessed for both groups using stimulus response curves (SRCs) elicited via transcranial magnetic stimulation (TMS) and transmastoid electrical stimulation (TMES), respectively. TMS-elicited motor evoked potentials (MEPs) and TMES-elicited cervicomedullary MEPs (CMEPs) were evoked at 8 different stimulation intensities (85-190% of active motor threshold) during the mid-elbow flexion phase of arm cycling (i.e. 6 o'clock position) at two cycling workloads (i.e. 25W and 30% peak power output obtained from the TTE test). Slopes for each SRC were calculated offline and compared. Preliminary results indicate that TTE performance was not significantly different between groups ($p = .494$) or over time (baseline to post-training; $p = .699$). Additionally, there were no significant group or time differences in MEP and CMEP SRC slopes recorded from the biceps brachii ($p > .05$ for all comparisons). The current findings suggest that aerobic capacity (i.e. TTE performance) is unaltered following two weeks of arm cycling SIT. Our findings also suggest that corticospinal and spinal excitability to the biceps brachii are not altered following two weeks of SIT as assessed via SRC slopes. A larger sample size is required before definitive conclusions can be drawn. *NSERC PGS-D to EJL*

Frequency-dependent Conduction Block In Chronic Inflammatory Demyelinating Polyneuropathy

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Chronic inflammatory demyelinating polyneuropathy (CIDP) is an acquired autoimmune neuropathy characterized by peripheral nerve demyelination. CIDP patients present with limitations in neural transmission such as neuromuscular instability and conduction block. The inability of a nerve to conduct action potentials across a demyelinated site at various frequencies with electrical nerve stimulation is referred to as frequency-dependent conduction block (FDB). The purpose of this study was to investigate the degree of FDB in a distal peripheral nerve of patients with CIDP. We hypothesized that CIDP patients will demonstrate a greater degree of FDB compared to healthy controls and that the FDB will be exacerbated at higher stimulation frequencies. Participants (n=8) laid supine with their ankle and knee secured at 90°and 180°, respectively. A compound muscle action potential (CMAP) was obtained from the tibialis anterior (TA) in response to a supramaximal stimulus in the disto-lateral popliteal fossa using a bar electrode held firmly on the skin overlaying the common fibular nerve. Only patients with CMAP negative peak amplitude (npAmp) values of above 4.0 mV were included in order to exclude patients with axonal loss. Next, 20 stimuli were delivered at frequencies in the following order: 5, 10, 15, 20 and 30 Hz. A 30 – 60s break was given between stimuli trains. Results show that CMAP npAmp of CIDP patients ranged from 4.2 – 11.2 mV. There was a 9, 24, 26, 33 and 37% mean decrease in CMAP npAmp recorded from the lowest to highest stimulation frequencies, respectively. Previous work has shown no change or an increase in CMAP npAmp recorded from the TA at frequencies as high as 30 Hz in a healthy population. FDB is present in these patients with higher frequency stimulations leading to greater percentages of conduction block. As such, FDB may contribute to the voluntary weakness and fatigue experienced by CIDP patients. Given the magnitude of percent conduction block found in CIDP patients compared to controls, FDB tests have the potential to be used as a diagnostic or disease progression tracking tool. *Supported by NSERC*

Development of a Protocol to Investigate the Vestibulo-Ocular Reflex in Sub-Clinical Neck Pain

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Visual perception is a dominant source of sensory feedback used by the cerebellum to control eye and body movement. This is a highly sensitive process that can be altered due to impairments in sensory integration. Sub-Clinical Neck Pain (SCNP) is mild-to-moderate recurrent and symptomatic neck pain that has not yet received treatment. Previous work has shown that SCNP alters cerebellar processing of sensory information that leads to how the brain represents body location in space. Sensory integration in SCNP populations can be tested using an experimental protocol involving the Vestibulo-Ocular Reflex (VOR). VOR gain is the ratio of eye velocity in relation to head velocity. This represents the ability to remain fixated on an intended target during head rotations. VOR was tested by having SCNP and control groups undergo a protocol of bilateral head rotations while remaining fixated on a target dot. Infra-red position markers synced to Optotrack Motion Tracking camera systems measured head rotation velocities and EyeLink II software measured the change in compensating eye velocities. Preliminary data shows that this protocol is suitable to elicit a VOR response in both control and SCNP populations without causing further pain. Preliminary data analysis highlights noticeable differences between the VOR gain of initial SCNP and control participants. SCNP participants

demonstrated lower VOR gains compared to a control participant. It is believed that this difference will remain when using larger sample sizes of SCNP and controls. These findings will reflect the impact of altered cerebellar processing on rapid and accurate eye movement and body control and how SCNP may impact motor control.

The task at hand: Fatigue-associated changes to corticospinal excitability during writing

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Voluntary movement is modulated by the brain's complex network of communicating circuits. Transcranial magnetic stimulation (TMS) is typically used to assess intracortical and corticospinal excitability (CSE), when the muscle is at rest or during submaximal isometric contractions. However, measures of CSE are dependent on the task performed at the time of stimulation. As such, this study sought to assess fatigue-induced changes in CSE during a functionally-relevant and familiar task (writing) and compare it to a conventional laboratory task (isometric finger abduction). We used single-pulse motor evoked potentials (MEPs) to provide a measure of CSE and cortical silent period (CSP) duration, and paired-pulse conditioned MEPs to assess short-interval intracortical inhibition (SICI) and intracortical facilitation (ICF) recorded from the right first dorsal interosseous (FDI) of 19 participants on two randomized and counter-balanced days. On both days these measures were recorded before (pre-test) and after (post-test) a fatigue protocol (intermittent, submaximal, isometric, finger-abduction contractions). On one day, the pre- and post-test measures were made during a writing task (writing "name" with a stylus). On the other day, these measures were made during isometric finger abduction at a target level matched to muscle activity during writing. Single-pulse MEP declined following the fatigue protocol ($F=10.5$ [1,18], $p=0.005$), but there was no effect of task. There was no effect of task or fatigue on SICI or CSP, but a trend towards a fatigue x task interaction for ICF ($F=3.4$, [1,18], $p=0.07$). We found that not all participants were able to write in cursive. Accordingly, we compared fatigue-induced changes in CSE in printers (n=8) and cursive writers (n=8). Following fatigue, SICI decreased (41%±55%) and ICF increased (35%±46%) in the printers but did not change in the cursive writing group (4%± 18% for SICI and 5%±13% for ICF). This study is the first to assess measures of corticospinal excitability during a handwriting task. Given that changes in intracortical excitability after a fatigue protocol depend on motor task used to assess CSE, future studies should use paradigms that mimic functionally-relevant motor tasks to better understand the role that CSE may play in the neural control of movement.

A denoising algorithm for surface EMG decomposition

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Recent developments have allowed investigators to automatically decompose surface electromyography (sEMG) signals (Nawab et al., 2010). While this has led to non-invasive measurement of motor unit (MU) properties, the validity of decomposition results has been a major concern (Farina et al., 2015). The aim of the present study was to remove erroneous discharges using a custom denoising algorithm, thus revealing a deterministic MU potential (MUP) shape. In the present study, 20 participants each completed two force tracking tasks of the wrist flexors to 60% MVC. A 5-pin decomposition (dEMG) electrode was placed over the flexor carpi radialis to record four channels of sEMG activity. The MU decomposition was accomplished using dEMG Analysis (Delsys, Natick, MA). The dEMG system creates a unique template for each sampled MU and outputs their discharge times. Using the MU discharge times from the decomposition, spike-triggered averaging was performed on the raw sEMG to create a shimmer plot and template for each channel. The denoising algorithm was then used to remove firings based on the following criteria: MUP correlation with a template created outside the dEMG system, amplitude distance of the MUP peak from the template peak, timing distance of MUP peak from the template peak. Differences between the four channels for each measure was explored first. There were significant differences for average MUP amplitude between all channels, and there was a significant decrease in amplitude (2.4%) after denoising. There were no significant differences between channels for MUP duration, or from denoising. As might be expected, denoising resulted in a significant increase in the SNR of 6.8% and a significant decrease in the VR of 20%. There was a 29.76 ± 10.61% decrease in discharge times from denoising. The mean inter-pulse interval (IPI) before denoising was 79.53 ± 22.52 ms. The error-filter estimation (EFE) algorithm (Stashuk & Qu, 1996) was applied to the denoised discharged times, resulting in an IPI of 80.68 ± 23.76 ms. Denoising allowed for the automatic selection of 'high confidence' MUP elements within a motor unit potential train to calculate discharge statistics and MUP template characteristics, excluding possible erroneous MUP elements.

The effect of various TheraBand resistances on the barbell back squat and overhead squat in trained and untrained individuals

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The squat is one of the most frequently used exercises in the field of strength and conditioning. The movement has biomechanical and neuromuscular similarities to a wide range of athletic movements and is therefore implemented in training programs to enhance performance. The squat can benefit the general population as it requires the recruitment of multiple muscle groups in a single movement that can be beneficial in improving everyday tasks. In clinical settings, it has become increasingly popular to implement the squat to strengthen lower-body muscles and connective tissue after a joint-related injury as it strengthens the hip, thigh and back musculature; which are important muscles for running, jumping and lifting. With the prevalence of the squat, it is important to observe common movement patterns during execution to optimize muscle recruitment and reduce the risk of injury. A common movement error typically observed in novice or untrained individuals when performing the squat is knee valgus. This results from the knee joint moving excessively medial in the frontal plane causing hip adduction and internal rotation which increases the risk of knee injuries such as anterior cruciate ligament tears, patellofemoral syndrome and degeneration of menisci. The TheraBand has been thought to act as a proprioceptive aid to reduce the medical collapse of the knees during squatting. Previous research has found contradictory results to the effectiveness of the TheraBand as a training aid. Therefore, the proposed research will investigate the effects of various resistances of the TheraBand on lower-limb kinematics and muscle activity in the barbell back squat and the overhead squat. Participants of this research will perform both the back squat and the overhead squat with three different TheraBand loops at varying resistances (light, medium, and heavy). Three-dimensional motion capture will be utilized to measure the knee flexion angle and knee width index with custom-designed, rigid bodies placed on the participants bilateral foot, shank, and thigh. Muscle activity will be recorded bilaterally from various lower-limb muscles using surface electromyography throughout the duration of the experiment.

Microscopic Muscle Architecture in Chronic Inflammatory Demyelinating Polyneuropathy

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Chronic inflammatory demyelinating polyneuropathy (CIDP) is an acquired autoimmune disease, primarily characterized by peripheral nerve demyelination. Patients present with sensory and motor deficits, including but not limited to symmetrical diffused muscle weakness. Studies to date focus mainly on the neuropathic aspects and immunological origins of CIDP and its involvement in paresis. Impairments in skeletal muscle quality and quantity may be a consequence of motor nerve deficits, but these aspects have not been investigated comprehensively. Thus, the purpose of this study is to investigate the microscopic architecture of skeletal muscle from CIDP patients using routine histological staining preparations and compared to healthy control muscle. Five men with

CIDP (ages 55–65 years) were recruited. A history, clinical, and electrophysiological features confirming a diagnosis of CIDP were performed by an experienced neurologist to exclude other causes of nerve injury (i.e. other polyneuropathies, compressive mononeuropathies, radiculopathies). Ten age and sex-matched control subjects were collected from the morgue at the University of Western Ontario. Control subjects had been deceased for 2-4 hours and no preservation or tissue embalming was performed prior to muscle extraction. Using the Bergstrom muscle biopsy technique, muscle samples were obtained from the vastus lateralis of CIDP patients and control subjects. Immunohistochemistry (IHC) and Haematoxylin and Eosin (H&E) stains will be used to quantify muscle fibre type composition and fibre morphology, respectively. Slow (type I) and fast (type II) muscle fibers are usually distributed in a checkerboard or mosaic-like pattern in healthy muscles. Histological processing is on-going, but we expect CIDP muscle tissue to show signs of muscle fibre atrophy (angulated fibres) as well as having significant fibre type grouping. These features are considered the myopathological hallmark of neurogenic change and these differences in CIDP muscle tissue compared to controls may explain muscle weakness that is present in CIDP. *Supported by NSERC*

The History Dependence of Force Following Short Term Unloading

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The history-dependence of force refers to an increase or decrease in steady-state isometric force, immediately following active muscle lengthening (residual torque enhancement; rTE) or shortening (residual torque depression; rTD). rTE has previously shown plasticity, being altered through resistance training, and increasing with age, or in states of reduced force output. Evidence for the plasticity of rTD is less clear, where damage may exaggerate the effects, but no changes have been observed with training. It has yet to be investigated if muscle weakness using a model of unloading will affect the history-dependence of force. Seven healthy young adults (m=4, f=3, age: 25.7 ± 6.3 years, weight: 73.5 ± 19 kg, height: 172.5 ± 10 cm) underwent 14 days of unilateral lower limb suspension where torque production, electromyography (EMG) and voluntary activation (VA) was assessed during maximal shortening, lengthening and isometric contractions of the knee extensors. Dynamic contractions consisted of a 50^{o} excursion at 30^{o}/s between 90^{o} and 140^{o} knee flexion. Torque output was then compared at the same joint angles, following either active lengthening or shortening with purely isometric trials. Maximal torque output decreased ~17% (p < 0.05) following unloading, despite that no change in VA. Prior to unloading, we observed ~8% rTD and ~6% rTE. While absolute torque decreased following unloading, relative rTD and rTE remain unchanged. As of yet, there does not appear to be significant alterations in the history dependence of force following unloading.

Progressive Vs. Relapsing-Remitting Multiple Sclerosis: Sensorimotor Function is Affected Differently in Upper and Lower Extremities

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Up to 90% of people with relapsing-remitting MS (RR_{MS}) transition to progressive MS (P_{MS}). Clinical measures that quantify disease progression in MS rely mainly on the ability to walk, although not all people with MS are ambulatory. Further, these measures do not capture upper-extremity function. Preliminary results from our laboratory suggest that, relative to RR_{MS}, decrements in lower-extremity sensorimotor function in P_{MS} precede changes in walking ability. Thus, there is a critical need for a sensitive test that can detect subtle biological changes, independent of ambulation. Our objective was to determine which non-ambulatory measures of sensorimotor function differ between RR_{MS} and P_{MS}, for both upper and lower extremities. 32 RR_{MS} (29 women, 52±10 yrs) and 31 P_{MS} (20 women, 60±8 yrs) were evaluated for vibration sensation (VS) for all hands and feet. Proprioception was measured bilaterally for the arm, elbow, and ankle during position-matching tasks. As an indicator of upper motor neuron (UMN) function, the number of rapid hand (HTT) and foot taps (FTT) in 10 s was quantified. For hand VS, the most apparent difference between groups was at the thumb ($p=0.04$, 95% confidence interval for difference between means (CI): [-4.9, -0.2]), some difference at the index finger ($p=0.07$, CI=[-6.0, 0.2]) and less so on the palm ($p=0.26$, CI=[-5.6, 1.5]). Differences were detected for foot VS at all locations ($p<0.01$): big toe (CI=[-17.8, -4.5], 5th metatarsal (CI=[-22.5, -7.2]), heel (CI=[-20.4, -6.2]). Differences in proprioception were detected for arms ($p=0.03$, CI=[-1.7, -0.1]) and elbows ($p<0.01$, CI=[-4.8, -1.0]) but not ankles ($p=0.51$, CI=[-1.8, 0.9]). UMN function differed between groups for FTT ($p<0.01$, CI=[3.0, 12.6] but not HTT ($p=0.45$, CI=[-3.3, 7.4]). Differences between RR_{MS} and P_{MS} were more pronounced in upper extremities for proprioception, and in lower extremities for upper motor neuron function. Cutaneous sensitivity (VS) differed between groups for both hands and feet. Proprioceptive and motor pathways may be affected differently between upper and lower extremities among MS sub-types. These results may aid development of a sensitive, non-ambulatory test that indicates disease progression, which could prompt earlier interventions for people who demonstrate subtle changes associated with a future transition to P_{MS}. *Supported by Department of Defense Research Grant W81XWH-16-1-0351.*

Exercise and multisensory integration in younger and older adults

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Everyday events give rise to sensations that span all of our senses; for example, watching someone speak gives rise to both auditory and visual information, which must be bound together in order to form a meaningful representation of the event. Multisensory integration represents the central nervous system's (CNS) ability to integrate information from multiple senses. However, determining the temporal coincidence of events is difficult for the CNS as it must deal with differences in signal intensity, transmission time, and transduction latencies. Previous research has found that multisensory integration becomes more difficult with aging, which has been related to decreased speech comprehension, increased susceptibility to falls, and poor decision making while driving. Thus, identifying an avenue through which multisensory integration can be improved is imperative. Recently, it has been hypothesized that a single bout of aerobic exercise may improve multisensory integration as arousal alters the signal to noise ratio and increases perceptual sensitivity. Here, we explore whether a single bout of aerobic exercise improves response time, accuracy, and precision obtained from audiovisual temporal order perception tasks including the simultaneity judgment (SJ), temporal order judgment (TOJ), and response time (RT) which are typically used to assess multisensory integration. In our study, 15 younger and 15 older adults will be recruited, and they will be asked to attend three sessions that are a week apart. Participants are asked to respond as quickly as possible to audio and visual stimuli (RT), or to assess whether an audiovisual pair of stimuli presented appeared simultaneously or successively (SJ), or which stimulus came first (TOJ), before and after exercise, rest, and a cognitively demanding task. In line with our prediction, the preliminary results from younger adults (n = 5) indicate a trend towards an improvement in multisensory integration after completing a single bout of aerobic exercise at moderate intensity or after performing a cognitively demanding task but not after rest. The anticipated results from this study can help inform rehabilitative interventions for integration deficits associated with aging.

The effects of local forearm thermal manipulations on motor unit properties during light and moderate contractions

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Human muscle can operate through a wide range of temperature, though optimal function may occur throughout a much narrower range. Muscle temperature directly impacts its contractile properties. Experimental designs that determine submaximal workloads from thermoneutral tests will be at different relative intensities if maximal force changes. We investigated how different local temperatures affected motor unit properties with contractions performed at the same normalized percentage of maximal force during each temperature. Ten males and females completed evoked, maximal and trapezoidal voluntary contractions during thermoneutral-, hot-, and cold-muscle conditions. Forearm temperature was controlled using 25-min of neutral (~32°C), hot (~44°C), or cold (~13°C) water circulated through a tube-lined sleeve. Motor unit properties were assessed with contractions above and below motor unit recruitment threshold for each temperature using surface electromyography decomposition. Changes to contractile properties from heating and cooling were evident in the twitch duration, rate of force development, and half-relaxation time, suggesting that muscle temperature was successfully changed (all $P < 0.05$). Maximal force was not different between neutral and hot ($P > 0.05$) but decreased in the cold ($P < 0.05$ vs both). For both contraction intensities, motor unit action potential amplitude and duration was larger and longer in the cold compared to neutral and hot ($P < 0.05$). The relationship between motor unit firing rate and recruitment threshold was not different across muscle temperatures ($P > 0.05$). Contractions above recruitment threshold in the cold decreased motor unit recruitment threshold compared to neutral or hot ($P < 0.05$). Increased cutaneous stimulation via local cooling depressed motor unit recruitment threshold. When contractions are normalized to maximal force of the respective temperature condition, the motor unit recruitment strategies remain similar. *The study was supported by NSERC Discovery Grants (D.A.G and S.S.C).*

Assessing bilateral neuromechanical outcomes of the upper-limbs during arm cycling: Do bilateral asymmetries exist?

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To date, locomotor research pertaining to examining measures of corticospinal excitability has predominately assessed the dominant limb. Yet is has been established that bilaterally asymmetries exist in the neural control of the limbs, with factors such as use-dependent plasticity and limb dominance likely contributing to the degree of asymmetry present. Whether bilateral asymmetries in corticospinal excitability are present during locomotor output when spinally located central pattern generators are active is unclear. Thus, the purpose of this research will be to determine whether differences in corticospinal excitability exist between the upper-limbs when arm cycling at a set workload. Participants will arm cycle at 25 Watts and 60 rpm and receive both transcranial magnetic stimulation (TMS) and transmastoid electrical stimulation (TMES) to assess corticospinal and spinal excitability, respectively. Responses will be evoked at two positions during arm cycling: 6 and 12 o'clock, defined relative to a clock face. These two positions will be assessed as they coincide to mid-elbow flexion (6 o'clock) and extension (12 o'clock) during cycling of the two muscles of interest: biceps and triceps brachii. Evoked potential amplitudes will be measured and made relative to the maximal compound muscle action potential (elicited via stimulation at Erb's point). Stimulus response curves will be generated at intensities ranging from 90% active threshold to 150% active threshold in 10% increments (7 stimulation intensities). Muscle activity will also be recorded bilaterally from the biceps and triceps brachii utilizing surface electromyography. Additionally, torque in the x, y, and z dimensions will be assessed and compared bilaterally with measures of corticospinal excitability. It is hypothesized that the dominant hemisphere will be more excitable in both right- and left- handed subjects when compared to their non-dominant hemisphere.

Force Steadiness and Motor Unit Firing Variability Following Mental Fatigue in Young Adults

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The neuromuscular mechanisms leading to impaired motor performance in the presence of mental fatigue remain unclear. It is also unknown if mental fatigue differentially impacts motor performance in males and females. The purpose of this study was to assess the impact of mental fatigue on force steadiness and motor unit firing behavior in males and females. Nineteen participants performed 10-s dorsiflexion (DF) isometric contractions at 20 and 50% maximum voluntary contraction (MVC) before, during, and after completing 22 min of the psychomotor vigilance task

(PVT), to induce mental fatigue. DF force and indwelling motor unit (MU) firings of the tibialis anterior (TA) were measured prior to and immediately following performance of the PVT (single task), and within the first and final minutes of the PVT (dual task). Force steadiness and motor unit firing rate variability did not change during or following the mental fatigue task at either contraction intensity ($p > 0.16$). Overall, females had more variability than males in MU firing rate during the 20% MVCs ($p = 0.03$), though no sex differences were identified during the 50% MVCs ($p = 0.20$). Mean MU firing rate decreased following mental fatigue in both sexes in the 20% MVC ($p = 0.02$), but only in males during the 50% MVC ($p = 0.01$). These results suggest possible sex and contraction intensity-specific neuromuscular changes in the presence of mental fatigue.

Activation reduction during a position and torque task following active lengthening

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There is an increase in torque producing capability during the isometric steady-state following active lengthening when compared to a purely isometric contraction. This history-dependent increase in torque is referred to as residual torque enhancement (rTE). When torque is matched in the rTE state there is less neuromuscular activity required to produce the same amount of torque, known as activation reduction (AR). Studies of rTE use a dynamometer to control joint angle and active lengthening, but less is known about rTE during position tasks. During a position task, control of joint angle and active lengthening is controlled by the participant. These tasks require alternative neuromuscular strategies, are more relevant for day-to-day movement, and have not been studied in history-dependent states. The purpose of the present study was to determine if AR is observed in position tasks, and if any differences would be observed in surface electromyography across tasks. 10 healthy male and female participants (mean age 22.6 ± 1.2 years; height 175.9 ± 9.5 cm; mass 72.2 ± 13.6 kg) performed ankle dorsiflexion on a dynamometer and electromyography was recorded from the tibialis anterior. Participants completed position and torque isometric and rTE tasks at 60% maximum voluntary contraction. rTE tasks were completed through 40° of active lengthening. AR and neuromuscular economy were quantified. A two-way analysis of variance with repeated measures (history dependence × task) was used to determine significant differences between tasks. Activation reduction was observed in both position (27.7 ± 13.8%) and torque (25.4 ± 8.0%) tasks (P=0.001) but no significant difference was observed between tasks (P=0.982). NME was enhanced from 2.9 ± 1.6 during isometric to 4.0 ± 2.3 in rTE states during position tasks and 2.5 ± 1.1 during isometric to 3.4 ± 1.6 in rTE states during torque tasks (P=0.001) but no significant difference was observed between tasks (P=0.144). These data indicate that rTE occurs during position tasks.

Transfemoral amputation reduces low-torque plantar flexion steadiness and does not alter Achilles tendon mechanics

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Plantar flexion (PF) strength and torque steadiness (TS) of the intact limb is reduced following unilateral transfemoral amputation resulting from trauma or vascular complications.[1] In non-amputees, greater Achilles tendon stiffness allows for steadier PF TS[2]. Amputees rely more on their intact leg for mobility, increasing the load experienced by the tendon and potentially altering mechanics. It is unknown how tendon mechanics contribute to PF TS in non-vascular transfemoral amputees. In this study we evaluated Achilles tendon mechanics and TS of the plantarflexors in the intact ankle of non-vascular amputees. Eleven male non vascular-related transfemoral amputees (50±15yrs) and age- and sex-matched non-amputee controls (49±14yrs) performed 8-second isometric PF contractions in a customized dynamometer at 5,10,25,50 and 75% of maximal torque. Resting Achilles tendon cross-sectional area and elongation during contraction were recorded on ultrasound to quantify mechanics of strain, stress and stiffness. TS was quantified as the coefficient of variation (CV) of torque around the target torque level. Influences of maximal torque, tendon strain, stress and stiffness on TS were evaluated at low (5,10%) and high (25,50,75%) torques using forward multiple regressions. Amputees and controls did not differ in maximal torque (67.0±29.5N.m), tendon CSA (64.7±6.8mm^2) and stiffness ($p>0.05$). CV of torque was 40% greater in amputees at 5% MVC ($p<0.05$) but did not differ between groups across all other torque levels ($p>0.05$). Tendon strain (5.0±1.4%) and stress did not differ between groups ($p>0.05$). At low torques, tendon stress predicted lower CV of torque in amputees (r^2=0.32) and maximal torque predicted lower CV of torque in controls (r^2=0.60) ($p<0.05$). At high torques, strain predicted lower CV of torque in amputees (r^2=0.22), while maximal torque (r^2=0.35) predicted lower CV of torque in controls ($p<0.05$). At 5% MVC, TS is less in amputees compared to controls. PF strength, high force TS and tendon mechanics are unaltered following non vascular-related transfemoral amputation. How the tendon elongates and distributes force (tendon stress) are the primary elements that contribute to reducing low force TS in non vascular-related transfemoral amputees. *NSERC, Mitacs Globalink*

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The Effect of Muscle Fatigue on Regional Activation in the Ankle Plantarflexors

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Upright standing posture is maintained by controlling the centre of mass within the base of support. The central nervous system (CNS) accomplishes this by activating motor units in different muscle groups to maintain standing balance. The triceps surae is a group of three ankle plantarflexor muscles: soleus, medial and lateral gastrocnemius (SOL, MG, and LG respectively) located in the posterior compartment of the shank that are fundamental for the maintenance of upright posture. A traditional biomechanical framework, the inverted pendulum model, is used to explain postural control during quiet stance. This model may be problematic as it assumes that the plantarflexor muscles function together as one synergistic group and overlooks the unique properties of each individual muscle and the ability for them to be independently modulated depending on the task.
Recent research has revealed that the CNS has the ability to regionally activate sub-volumes within a single muscle. Regional activation has been observed in the triceps surae in response to external perturbations, as it has been demonstrated that the plantarflexor muscles respond to perturbations in a direction-specific manner. That is, when perturbation direction moved from left to right, the gastrocnemius muscle opposite to the direction of pull of the perturbation showed the highest relative amplitude of activation. Currently it remains unknown if regional activation is influenced by changing conditions in muscle. Thus, the objective of this research is to determine the effect of muscle fatigue in one of the ankle plantarflexor muscles on regional activation in the other ankle plantarflexor muscles during postural perturbations. This study will answer the question: Can the CNS adapt to a loss of force generating capacity in one muscle by altering how it activates the other two non-fatigued plantarflexor muscles? It is hypothesized that regional activation will be abolished in the fatigued muscle (MG) and that the CNS will increase regional activation in the two non-fatigued plantarflexor muscles (LG and SOL) in order to maintain standing balance following perturbations. This research is important for understanding what neuromuscular strategies the CNS uses to compensate for muscle fatigue/injury in order to maintain standing balance.

The use of surface electromyography for the estimation of persistent inward currents

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Persistent inward current (PIC) is a motoneuron property that amplifies and prolongs motoneuron output in response to a given synaptic input via activation of voltage-sensitive, monoaminergic-dependent, L-type Ca^{2+} and persistent Na^{+} channels (Heckman et al., 2005). In humans, the paired motor unit (PMU) technique is used to estimate PIC from intramuscular electromyographic (EMG) recordings. This technique involves identification of motor units during low-level (~10-20% maximal force), triangular-ramp, isometric contractions. To date, PIC has only been assessed using indwelling (needle or fine wire) EMG which produces a fairly low yield of distinguishable motor unit trains. However, recent advances in the field of surface EMG have resulted in the ability to decompose a high yield of motor unit trains from the non-invasive signal. Therefore, the primary purpose of this study is to determine the feasibility of using surface EMG decomposition to estimate persistent inward currents (PIC). The proposed research will repeat a protocol known to modulate intramuscular estimates of PIC via spike threshold accommodation and spike frequency adaptation (Vandenberk and Kalmar, 2014). We hypothesize that estimates of PIC made using surface EMG decomposition will meet assumptions of the PMU technique.Twenty participants will be recruited for the study. Participants will complete a series of isometric knee extension contractions. Surface EMG will be recorded from the vastus medialis and lateralis using a surface decomposition system (*dEMG, Delsys Inc*.). In a subsample of participants, intramuscular (fine-wire) EMG will also be recorded and analyzed (*Spike2,* Cambridge *Electronics Design*). Participants will complete a series of 15 trapezoidal contractions to 15% of peak force that vary in rate of rise (to modulate spike threshold accommodation) and plateau duration (to modulate spike frequency adaptation). PIC will be estimated using the PMU technique for both surface and indwelling EMG. This technique quantifies the difference in firing rate (ΔFR) of a low-threshold motor unit at the recruitment and derecruitment of a high-threshold motor unit. *This work is funded by the Natural Sciences and Engineering Research Council of Canada.*

What is the relationship between corticospinal excitability modulation and neuromechanical outputs during arm cycling?

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Currently, corticospinal excitability research has largely been limited to tonic contractions, with relatively limited data during dynamic motor outputs. The primary goal of this exploratory study was to investigate the modulation of corticospinal excitability to the biceps brachii and the associated neuromechanical outcomes during arm cycling at various intensities. 12 university-aged participants (18-28 years, 11 males and 1 female) participated in this study. Supraspinal and spinal excitability were assessed using transcranial magnetic stimulation (TMS) of the motor cortex and transmastoid electrical stimulation (TMES) of the corticospinal tract, respectively. Bilateral force recordings were taken from the handles of the cycle ergometer from the X and Y direction, and an overall force vector (Z) was calculated. Motor-evoked potentials (MEPs) and cervicomedullary-evoked potentials (CMEPs) were elicited by TMS and TMES, respectively, and were measured at the biceps brachii via surface electromyography (EMG) at mid elbow flexion (6 o’clock relative to a clock face). Peripheral nerve stimulation was delivered at Erb’s point to elicit a Maximum M-wave (MMax). MEPs and CMEPs stimulation intensities were set to match 10-15% of the MMax peak-to-peak amplitude. Participants were asked to arm cycle at a cadence of 60 rpm during 25W, 50W, and 100W, while in a neutral grip position. During each intensity, participants received 8 TMS, 8 TMES, and 2 MMax separated by 7 seconds. The data have been collected and are currently being analyzed. Pearson’s R correlations are being used to assess if any relationship exists between force output (X, Y, or Z) 50ms prior to the stimulation and the associated corticolspinal evoked responses. Furthermore, force outputs are being used to characterise the cycling pattern (e.g. force output variability in terms of amplitudes and durations), something which has yet to be established in the literature. This is the first study to attempt to characterize the neuromechanics through corticospinal excitability during arm cycling. Dynamic movements are complex and require contribution from several systems. Findings from this study will provide insights into the relationship between measures of corticospinal excitability and the control of force outputs during a rhythmic, locomotor output in humans.

Effects of low-load strength training combined with blood flow restriction or hypoxia on Wingate performance

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Strength training is recognized to increase maximal peak force, muscle mass and contractile rate of force development (RFD), and these components are primary factors contributing to the generation of anaerobic power. Exercise induced muscle hypertrophy via blood flow restriction (BFR) training is well documented. Two suggested mechanisms of muscle hypertrophy associated with load-load strength training with BFR is metabolite accumulation and tissue hypoxia. A hypoxic intervention creates low muscle oxygenation without any excess metabolite accumulation associated with BFR. The Wingate is a reliable test of anaerobic capacity, providing measures of peak and mean power, and rate of fatigue. These measures will be used to quantify changes in anaerobic performance. Participants (30 men and women) will be randomly assigned to either BFR, or hypoxia (14% FiO2), or to no intervention (control) group and will perform back squats at 20% of their estimated one-repetition maximum (1RM). There will be 15 days of strength training with a minimum of 48 hours between laboratory visits and a maximum 96 hours. There will be four sets of 30, 20, 20, and 20 repetitions, with 30 seconds of rest between sets. The Wingate Cycling test will be performed twice in this study, before and after the strength training protocol. The proposed study will; 1) determine the relationship of intermittent hypoxia and low-load BFR strength training on anaerobic capacity and 2) delineate the role of muscle oxygenation on anaerobic performance. It is hypothesized that; 1) experimental groups (BFR and hypoxia) will have increases in their baseline scores of peak and mean powers and a decrease in rates of fatigue, and 2) lack of oxygen availability in the experimental groups will induce hypertrophic responses responsible for increased anaerobic performance.

Investigating the Relationship between Physical Activity and the Functional Connectivity of the Hippocampus and the Prefrontal Cortex

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Aging is associated with the atrophy of various brain regions such as the hippocampus, a structure crucial for memory. Engaging in physical activity has demonstrated the ability to increase hippocampal volumes. However, this increase in hippocampal volume does not necessarily result in memory improvement, suggesting connections between the hippocampus and other brain regions are important for memory performance, rather than hippocampal volume alone. The proposed research aims to examine the relationship between physical activity and the connectivity between the hippocampus and the prefrontal cortex (PFC). Young adults will perform a face-scene association task, designed to recruit both the PFC and the hippocampus, while being scanned using fMRI. Using questionnaires, physical activity will be correlated with memory performance and connectivity. We hypothesize that individuals who engage in more physical activity will perform better on the face-scene association task, and have greater connectivity between the hippocampus and the PFC. *This research is funded in part by NSERC.*

Regional modulation of the ankle plantarflexor muscles associated with standing external perturbations across different directions

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Maintenance of upright standing posture has often been explained using the inverted pendulum model. This model considers the ankle plantarflexors to act as a single synergistic group. There are differences in muscle properties among the medial and lateral gastrocnemius (MG and LG, respectively) and the soleus (SOL) that may affect their activation. Twelve volunteers participated in an investigation to determine whether the activation of the ankle plantarflexor muscles was modulated according to perturbation direction during unilateral standing perturbations of 1% body mass. High-density surface electromyography (HDS-EMG) was used to determine the amplitude and barycenter of the muscle activation and kinematic analysis was used to evaluate ankle, knee, and hip joint movement. The HDS-EMG amplitude and barycenter of MG and LG were modulated with the perturbation direction (MG: $p < 0.05$; LG: $p < 0.01$; one-way repeated-measures ANOVA). In soleus, the HDS-EMG barycenter modulated across the perturbation direction ($p < 0.01$ for X&Y coordinates) but the HDS-EMG amplitude did not change. A repeated measures correlation was used to interpret the HDS-EMG pattern in the context of the kinematics. The relative contribution of MG activation compared to the total gastrocnemii activation was significantly associated with ankle flexion/extension ($r_{rm} = 0.620$), knee flexion/extension and abduction/adduction ($r_{rm} = 0.622$ and $r_{rm} = 0.547$, respectively) and, hip flexion/extension and abduction/adduction ($r_{rm} = 0.653$ and $r_{rm} = 0.432$, respectively). The findings suggest that the central nervous system activates motor units within different regions of MG, LG and SOL in response to standing perturbations in different directions. This study was supported by the Natural Sciences and Engineering Research Council of Canada.

Postural control in response to unilateral and bilateral external perturbations: effect of cognitive load

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Balance is an important determinant of physical function and falls risk. It has been suggested that practicing recovery from external perturbations is more relevant than general strengthening exercise for balance retraining (McCrum et al, 2017). Most perturbations of the support surface are performed with both legs being perturbed. It is unclear how the postural responses are influenced by unilateral perturbations. The addition of a cognitive load simulates a more real-life scenario, where a loss of balance occurs when the mind is focused on another task. To determine the effect of unilateral and bilateral perturbations on leg muscle activity, as well as identify any muscle activation changes with the introduction of a cognitive load in healthy young adults. Using a split-belt treadmill system within a virtual reality environment, participants experienced 12 unilateral (left belt only) and bilateral accelerations of the treadmill, both of which caused anterior movement of the body's centre of mass (COM) but no stepping reaction. Surface electromyography from eight lower limb muscles was recorded from the right (stance) leg. Participants completed the balance perturbation tests for a second time while performing the Stroop cognitive task. Latency of muscle activation (ms) was determined from the treadmill acceleration onset. Root mean square (RMS) amplitude was calculated for 500 ms prior to acceleration onset and for the first 100 ms of the muscle burst produced by each perturbation and subsequently averaged. The muscles were activated 20.7 ms earlier ($p<0.001$) and the posterior chain muscles (biceps femoris, plantarflexor muscles) demonstrated larger EMG bursts (5.78 mv ± 3.13 compared to 3.54 ± 2.07; $p<0.001$) with bilateral than unilateral accelerations. With the addition of a cognitive load, there was an overall delay in the onset of muscle activation during unilateral and bilateral perturbations ($p<0.001$ and $p=0.03$, respectively). The cognitive task significantly increased the muscle activity during bilateral perturbations ($p=0.01$) but did not affect muscle activity during the unilateral perturbations. There are distinctive balance recovery mechanisms present depending on the perturbation type. Even in young, healthy adults, the addition of a cognitive load influences balance differently during unilateral perturbations than it does during bilateral perturbations.

Sex differences in age-related dynapenia: a literature evaluation

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Age-related loss of muscle strength (dynapenia) and the functional consequence of muscle weakness in older adults is well established. Yet, a comprehensive evaluation of muscle strength between males and females across the adult lifespan in upper and lower limbs has not been undertaken. To explore the rate of age-associated loss in muscle strength between sexes, a scoping review of articles in CINAHL, EMBASE, MEDLINE, and PsycINFO databases was undertaken. Articles published from 1990 – 2018 that reported both males and females in knee extension (KE), knee flexion (KF), elbow extension (EE), and elbow flexion (EF) were considered. The search examined 5613 articles; 58 met the inclusion criteria. The upper limb isometric and dynamic data were excluded because too

few studies stratified results by both sex and age (N=16 isometric, N=3 isokinetic 60°s^{-1}). Isometric and isokinetic 60°s^{-1} KE (N=41; N=17) and KF (N=13; N=9) had sufficient reporting for statistical evaluation. Piecewise regression analysis revealed that isometric KE and KF undergo a rapid decline in strength late in the 6th decade of life for both sexes. The rate of decline in isometric KE strength was significant before and after the 6th decade breaking point for males and females, and for KF in males the rate of decline was significant following the breaking point (p<0.05). For slow isokinetic KE, the age-related abrupt decline occurred much earlier in females (41.8 years) than in males (66.7 years) (p<0.05), and the rate of age-related decline was significant following the breaking point in both sexes (p<0.05). For isokinetic KF strength, an age-related breaking point was only identified in males (49.3 years) and the decline was significant after the breaking point (p<0.05). This evaluation indicates the current literature is insufficient to assess sex-specific differences in age-related dynapenia in the upper limb. Age-related isometric KE and KF dynapenia is similar between the sexes; however, dynamic KE strength loss occurs earlier in females which likely contributes to greater functional decline. Several physiological causes are suggested in the literature which require specific consideration relative to differences between muscle groups and contraction types.

The effects of performing prolonged mental exertion during submaximal cycling exercise on fatigue indices

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The present study aimed to investigate the effect of performing prolonged mental exertion during submaximal cycling exercise on exercise tolerance and fatigue indices in recreational cyclists. Nine males performed 5 experimental sessions. The first session included an incremental cycling test to determine peak power output (PPO). Sessions 2 and 3 included a cycling to exhaustion protocol at 65% PPO with mental exertion (session 2: cycling to exhaustion + ME) or while watching movie (session 3: cycling to exhaustion + movie). Sessions 4 and 5 included a cycling for 45-min at 65% PPO protocol with mental exertion (session 4: cycling for 45-min + ME) or while watching a movie (session 5: cycling for 45-min + movie). During sessions 2-5, the rate of perceived exertion (RPE) and heart rate (HR) were recorded while cycling. Cortisol and prolactin concentrations, psychomotor vigilance task (PVT), and maximal voluntary contraction (MVC) were measured pre- and post-sessions 2-5. During sessions 2 and 3, time to exhaustion was significantly ($p < 0.01$) reduced and RPE was significantly ($p < 0.01$) increased in cycling to exhaustion + ME compared with cycling to exhaustion + movie. Cortisol and prolactin concentrations, HR and PVT increased and MVC decreased from pre-to post-sessions 2 and 3 with no difference between sessions. Because the between session differences or lack of may be due to the time to exhaustion in session 2 and 3, participants completed time clamped (45-min at 65% PPO protocol) sessions 4 and 5. Cortisol and prolactin concentrations and RPE were significantly ($p < 0.03$) higher in session 4 than session 5. Again, HR increased and MVC decreased from pre-to post-sessions 4 and 5 with no difference between sessions. Based on these findings, performing prolong mental exertion during submaximal cycling exercise reduces exercise tolerance. The reduction in exercise tolerance due to mental exertion appears to be mediated by a higher perception of effort as opposed to a greater impairment in neuromuscular and cardiovascular function.
KEYWORDS: Mental fatigue, exercise tolerance, perceived effort.

Altered Sensory Input to the Neck May Impair Shoulder Joint Proprioception

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Altered sensory input to the neck as a result of fatigue of the cervical extensor muscles (CEM) diminishes joint position sense (JPS) at the elbow and wrist. There is a lack of research evaluating the influence of CEM fatigue on JPS of the shoulder, which is complicated

by its high mobility and multiple degrees of freedom. This necessitates a novel means by which shoulder JPS can be assessed. The goal of this study is to use a novel shoulder JPS measurement device to determine the degree of shoulder JPS decrement following a CEM fatiguing task. 20 healthy participants (10M, 10F) were recruited from the local university population. Participants interacted with a custom-designed shoulder proprioception device, which allowed for humeral rotation in the shoulder's plane of elevation (POE), while providing minimal cutaneous sensory information to participants. While seated and blindfolded, participants' arms were rotated to a randomized 'target shoulder position' between 30-60° in the POE. This position was maintained for 5 seconds and then passively returned to its original position. Participants were then asked to actively recreate the 'target shoulder position' for 5 seconds. This process was repeated for four sets of 3 JPS trials each, with a CEM fatiguing protocol between sets 2 and 3. Statistical analyses will compare interclass correlation coefficients (ICC's) of absolute, constant, and variable joint angle matching error using a repeated measures ANOVA with pre-planned contrasts to set 2 as baseline. Preliminary findings (n=7) suggest that absolute shoulder JPS error increases by 20% and variable shoulder JPS error increases by 100% immediately following acute CEM fatigue. These results contrast with previous findings that suggest stable shoulder joint angle recreation accuracy in participants who do not undergo altered sensory input stimulus to the neck.

Mechanically-evoked cutaneous reflexes are enhanced by noisy electrotactile stimuli

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During stance, cutaneous mechanoreceptors sense pressure distribution across the foot sole and evoke reflex responses in muscles to ensure successful maintenance of balance. Deterioration of these responses has been proposed to increase fall risk. Therefore, improving cutaneous reflex generation may be a mechanism of improving balance. This may be done using stochastic resonance, which involves the increased detection of a weak signal following the addition of optimal intensities of subthreshold noise. Noise-mediated enhancements have shown improvements in tactile detection, but have yet to be explored in cutaneous reflexes, thus the purpose of this study was to explore whether subthreshold noise could enhance cutaneous reflex generation. Nine healthy, young adults were recruited. During quiet stance, cutaneous reflexes were evoked by applying a vibrotactile stimulus to the plantar foot surface of the heel at an intensity of ten times perceptual threshold (PT). For the noise component, an electrotactile stimulus was concurrently applied. Electrotactile noise intensity varied between 0% (no noise) and 100% of noise PT. Both vibrotactile and electrotactile stimuli were Gaussian noise, low-pass filtered at 50 Hz. Electromyography was recorded from the soleus (SOL) and tibialis anterior (TA). Reflex magnitudes were quantified by comparing the peak-to-peak amplitude (PTP) of the cumulant density function and peak coherences across noise intensities. Compared to 0% PT noise (control), SOL PTP increased when 20% and 100% PT noise were applied (40% increase in reflex amplitude with 20% noise and 30% increase at 100%). In the TA, PTP was reduced at 20% PT and 60% PT noise (largest reduction at 20% PT) but increased at 80% PT noise. These results suggest that applying subthreshold tactile noise to the foot can modulate cutaneous reflex generation in lower limb muscles with the optimal intensity of noise being 20% PT where reflex magnitudes were optimally enhanced in the SOL (agonist) and reduced in the TA (antagonist). Peak SOL coherence occurred at 30 Hz, suggesting primary contributions from FAI mechanoreceptors. Overall, this information may inform the incorporation of noise components in biomedical aides such as shoe insoles to improve balance in clinical populations. *Funded by NSERC, CBS-GTS, QEII-GSST*

The effect of balance perturbations on baroreflex sensitivity in young adults

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The ability to regain control of balance is vital in limiting falls and injuries. The autonomic nervous system's (ANS) role in maintaining an optimal internal working environment is crucial to ensure a positive outcome during loss of balance. The ANS can be

assessed by monitoring baroreflex function, which modulates cardiovascular coupling between blood pressure and heart rate. However, little is known regarding how the baroreflex responds when maintaining balance and during recovery. Therefore, the purpose of this study was to examine how the baroreflex responds to balance perturbations of different intensities. Five healthy participants (3 males, 2 females; age *M*=26 years, *SD*=3.1) have completed the study. Participants had their blood pressure, heart rate, and respiratory rate recorded during a balance perturbation test in a single 60-90-minute session. Firstly, the Community Balance and Mobility Scale was completed to examine ambulatory balance. To test postural stability, participants stood on a treadmill while a posteriorly-directed translation of the support surface was applied. Three different perturbation intensity conditions (low, medium, high) were given in random order. Only the high perturbation intensity required a step to regain balance. Each condition consisted of 25 perturbations, 8-12 seconds apart with 1-minute rest in between. Baseline physiological data was collected in quiet stance for 5 minutes before testing, and again after to rule out a training effect. Baroreflex sensitivity (BRS) was calculated using a transfer function on MATLAB R2018b, although data collection and analysis are ongoing. Preliminary results indicated BRS increased during perturbations in 4 participants compared to baseline. Two participants had BRS increase linearly with perturbation intensity, while 3 had BRS higher during the low intensity compared to the medium. Additionally, the BRS difference between baselines was small, ranging from 0.04 to 0.8 mmHg/ms. The current data suggests that there are individual differences in the baroreflex response during periods of instability. Despite these differences, recovery strategies that required a step to regain balance resulted in the largest response from the baroreflex.

Acute effects of hypoxia on the vestibular control of balance

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During daily living, signals from the vestibular system are integrated seamlessly with other sensory signals and motor commands to maintain upright posture. However, hypoxia (high altitude) has been shown to increase quiet standing sway compared to normoxia (sea-level). Despite the presence of spontaneous and positional nystagmus at high altitude and altered vestibular neuron function in animal models during hypoxic exposure, it remains unclear how hypoxia influences the vestibular control of standing balance. The purpose of this study was to examine how an acute exposure to normobaric hypoxia (F_iO_2 = 0.12) – simulating an altitude of ~4300m – influences vestibular-evoked myogenic and whole-body balance responses compared to normoxia (~445m). Nine males (27.5±6.3yrs, 179.1±11.1cm, 79.4±17.5kg) and eight females (24.0±3.6yrs, 168.8±6.5cm, 63.6±6.5kg) were recruited from the university population. Right medial gastrocnemius (MG) surface electromyography was sampled over 2 randomized testing days: normoxia and hypoxia. To examine the vestibular control of balance ten, 90-s trials of binaural, bipolar electrical vestibular stimulation (EVS; 0-25Hz; peak-to-peak amplitude = ±5mA) with participants standing with their head rotated leftward on a force plate. During normobaric hypoxia, end-tidal oxygen ($PETO_2$) for males and females was reduced from 90±1 to 45±2mmHg and 100±2 to 51±2mmHg (mean±SD), respectively ($p<0.05$). Oxygen saturation (SpO_2) decreased during normobaric hypoxia for males and females from 95±2 to 75±1% and 96±2 to 80±2%, respectively, compared to baseline ($p<0.05$). Vestibular-evoked balance responses were characterized using a correlation-like analysis (cumulant density) to determine the input (EVS) and motor output (MG and anteroposterior ground-reaction forces; APF) relationship. A main effect of sex and vision was found ($p<0.05$), where EVS-MG EMG peak-to-peak amplitude was greater in females compared to males, and eyes closed trials compared to eyes open trials. There were no detectable differences between in EVS-MG EMG or EVS-APF peak-to-peak amplitude between normobaric hypoxia and normoxia. The vestibular control of standing balance appears to be unaltered during acute exposures of normobaric hypoxia (F_iO_2 = 0.12). Further studies are required at lower inspired oxygen fractions to determine if there more extreme levels of hypoxia affect vestibular function and standing balance. *Supported by NSERC*

The effect of blood flow occlusion on tibialis anterior motor unit firing rates during sustained low-intensity isometric contractions

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Low-intensity exercise in combination with blood flow occlusion (BFO) results in similar or greater neuromuscular adaptations compared to traditional high-intensity (>70% of maximal voluntary contraction, MVC) exercise. However, a limitation with BFO exercise is that blood flow can only be controlled in limb muscles by using blood pressure cuffs or elastic bands, whereas trunk muscles cannot benefit from BFO. The purpose was to determine whether blood flow occlusion distal to a working muscle causes similar neuromuscular fatigue as proximal occlusion and that this might indicate a benefit for muscle proximal to the site of occlusion. Five males participated in three protocols on separate days to test the effect of BFO on motor unit firing rates (MUFR) of the tibialis anterior (TA) at a contraction intensity of ~15% of MVC, until failure (participants unable to maintain the ~15% contraction intensity; FP). Two protocols used BFO (300mmHg), one with occlusion distal to the TA at the ankle (BFO_{dis}), and the other proximal to the TA over the distal thigh (BFO_{prox}). A third control protocol did not occlude blood flow and was time-matched to the BFO_{dis} protocol. MVC was collected before and after each protocol and was reduced in all trials (Control: ~15%, BFO_{dis}: ~27%, BFO_{prox}: ~41%), but was reduced to a greater amount following the BFO_{prox} compared to the control protocol ($P < 0.01$). Normalized submaximal EMG during each protocol increased but was not different among groups. MUFR for the BFO_{dis} and BFO_{prox} protocols were significantly reduced by ~14% compared to control at 50% of normalized time until FP, and BFO_{prox} MUFRs were reduced to a greater amount (~32%) than BFO_{dis} (~22 %) at the FP ($P < 0.01$). Results indicate that although occluding blood flow to a working muscle results in greater reductions of MUFRs than without occlusion, occlusion of blood flow distal to a working muscle still causes greater impairments compared to unrestricted blood flow. Therefore, blood flow occlusion may still be of benefit to (proximal) trunk musculature when blood flow is occluded in the upper limb. *Supported by NSERC.*

Neural Mechanisms of Balance and Gait Adaptations after Downslope Walking

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Downslope walking (DSW) is used as a therapeutic exercise intended to induce neuro-plastic changes that improve functional activity without invoking excessive fatigue. DSW increases tibialis anterior (TA) activity, decreases soleus (SOL) activity, and is associated with decreased H reflex amplitude. The mechanisms by which DSW may contribute to improved function are not known, however DSW involves eccentric contractions that increase 1a afferent feedback. Our aim was to determine whether changes in spinal motor neuron excitability following DSW impact static balance or transitional gait, and whether the changes in H reflex can be explained by changes in reciprocal inhibition. Thirty young adults (23±1.4y, 6 males) were randomly assigned to the DSW (-10°) or level (LW, 0°) condition. Participants completed a pre-test, walked for 30-minutes (DSW or LW), and then completed a post-test. The pre-test and post-test were identical and included a soleus H reflex recruitment curve, conditioned soleus H reflexes to assess reciprocal inhibition, and measures of balance and transitional gait. H reflexes were elicited during quiet standing via tibial nerve stimulation. Slope of the H reflex curve normalized to the slope of the M wave curve (H_{slope}/M_{slope}), H reflex threshold normalized to M wave threshold (H_{th}/M_{th}), and maximal H reflex normalized to maximal M wave (H_{max}/M_{max}) were recorded. Conditioned H reflexes were elicited via peroneal nerve stimulation at motor threshold, 2ms prior to tibial nerve stimulation at 15% M_{max}. Conditioned H reflexes were expressed as a percentage of unconditioned H reflex amplitude. A trend suggests that DSW may elicit a greater decline in H_{slope}/M_{slope} (46.9±15.4%) than LW (24.2±39.5%) [$t(15.57)= -1.94$, $p= 0.07$], however no change was found in H_{max}/M_{max}. DSW decreased H_{th}/M_{th} by 5.9% compared to LW which increased H_{th}/M_{th} by 3.4%, suggesting low threshold units may be more excitable following DSW

[F(1,25)= 4.76, p= 0.04]. Conditioned H reflex amplitude decreased following both DSW (-5.85%) and LW (-7.96%) [F(1,23)= 4.17, p= 0.05], thus H reflex depression following DSW is not likely due to changes in reciprocal inhibition. Regression analysis will be used to determine how changes in spinal excitability may predict effects of DSW on balance and transitional gait.

The effect of 6 weeks of high intensity interval training on myelin biomarkers in a mouse model of multiple sclerosis

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Multiple sclerosis (MS) is a neurological disorder in the central nervous system involving demyelination of white matter axons. There is increasing evidence that regular exercise can slow disease progression and/or reduce the severity of symptoms in both human and non-human animals. The purpose of this study was to investigate whether 6 weeks of high intensity interval training (HIIT) prior to induction of MS could attenuate the severity of symptoms and/or disease progression in an experimental autoimmune encephalomyelitis (EAE) mouse model. Forty female C57BL/6 mice were randomly assigned to exercise (Ex) or control (Con) groups. After 4 weeks of training, the mice were further divided into 2 exercise groups and EAE was then induced in half of the animals in Con and Ex. In one of the exercise groups training continued until the 6th week (EAE-EX1), whereas in other exercise group, exercise was stopped at the 4th week (EAE-EX2) upon induction of EAE. To assess the effects of HIIT on biomarkers of MS, Western blots and LFB (Luxol Fast Blue) were performed using cerebellar tissue. Specific proteins of interest were Klotho, PLP, and TNF-α. Western blot analysis showed HIIT significantly enhanced Klotho ($p \leq 0.001$) and PLP ($p \leq 0.001$) in EAE-EX1 group compared to the EAE control group (no exercise). In addition, EAE-EX1 mice had a significant decrease in myelin damage ($p \leq 0.01$) compared to the EAE control group (no exercise). Data demonstrate that short-term HIIT increased Klotho and PLP in a mouse model of MS. These proteins are associated with increasing myelination and further research is required to examine potential clinical relevance.
KEYWORDS: EAE, demyelination, Klotho

Inhibitory signaling from the golgi tendon organ is increased in the force-enhanced state following active lengthening

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Residual torque enhancement (rTE) is a history dependent property of muscle which results in an increase in steady-state isometric torque production following an active lengthening contraction as compared to a purely isometric (ISO) contraction, at the same muscle length and level of activation. Once thought to be an intrinsic property of muscle, recent evidence during voluntary contractions indicates rTE to be neuromechanically coupled, whereby spinal excitability is reduced in the torque-enhanced state. However, the mechanism by which this occurs has yet to be elucidated. The purpose of this study was to investigate inhibition arising from tendon mediated feedback (e.g., Golgi Tendon Organ; GTO) through tendon electrical stimulation (TStim) in the ISO and rTE states during activation matching (AM) and torque matching (TM) tasks. Fourteen participants (male; 22 ± 3 y) performed 10 AM contractions at 40% of their maximum tibialis anterior EMG amplitude (5 ISO/5 rTE), and 10 TM contractions at 40% of their maximum dorsiflexion torque (5 ISO/5 rTE). In both the AM and TM tasks, 10 TStim were delivered during the isometric steady-state of all contractions and the resulting tendon-evoked inhibitory reflexes were averaged and analyzed. Reflex amplitude increased by ~22% in the rTE state compared to the ISO state for the AM task, and no differences were detected for the TM task. The current data indicate an important relationship between afferent feedback in the torque-enhanced state and voluntary control of submaximal contractions. The history-dependent properties of muscle can likely alter spinal excitability through

modifications in peripheral afferent feedback, specifically Ib inhibitory signals arising from GTO receptors. *This project was supported by the Natural Sciences and Engineering Research Council of Canada (NSERC). Infrastructure was provided by the University of Guelph start-up funding*

A motor unit firing rate profile in humans: a first look

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Voluntary skeletal muscle force is regulated by motor unit (MU) recruitment and rate coding. Once recruited, MU firing rates increase at higher contraction intensities. Our purpose was to build a profile of neural control obtained from many skeletal muscles and how this profile might be affected when compared between young and old subjects. When measured and compared among muscles and two age groups, insight into MU output, affected by synaptic drive and the intrinsic/extrinsic properties, can be gained. Data were derived from prior publications and new MU firing rate data were generated for the first dorsal interosseous muscle in young (22-33 y) and old (81-93 y) men (n = 5 and 5, respectively). The data-set of mean MU firing rates was resampled with replacement (bootstrap) using a median statistic and bootstrap intervals were bias-corrected and accelerated. From observations in the resultant simulated data, linear regression models were fit to the original data-set to test hypotheses (see below) and statistical significance was determined by a likelihood ratio test comparing each null and full model. From the original data-set, mean MU firing rates from 17,216 trains in 13 muscles were used to build a composite view of the human somatic nervous system with regard to MU firing rates during isometric contractions at intensities varying from 25 to 100% of MVC. The superior trapezius muscle had the highest frequency range (45-50 Hz) and the soleus had the lowest (15-18 Hz) at maximal voluntary contraction intensities. Eleven of the 13 muscles had an age-related convergence towards a lower firing rate range except for the first dorsal interosseous and the soleus muscles. Muscle type had the biggest effect which was then followed by age group (young or old) and muscle location of either being in the upper vs lower portion of the body. Axon length (ranked factor) and innervation type (brainstem vs. flexor vs. extensor vs. intrinsic hand muscle) did not have a statistically significant affect on MU firing rates. This analysis provides evidence that muscle type may have a larger effect on MU firing rates than age-related differences.
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