ANS Sensorimotor Control Meeting

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Abstract Book

Contents

Conference Program

8.15 am	Meeting registration opens
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Keynote Talk

9:00 – 10:00 *NEURAL CONTROL OF BIMANUAL MOVEMENT AND AGE-RELATED EFFECTS*

Stephan P. Swinnen

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Aging is not only associated with changes in cognitive function but also affects control of movement. Clinical as well as instrumented bimanual tasks demonstrate age-related changes in behavioural performance. Here, I will elaborate on the neural changes in movement control and learning as a function of aging. First, I will address how fMRI studies demonstrate changes in functional activation during task-related conditions in older as compared to young adults. I will elaborate on increased brain activation levels in older adults during production of bimanual coordination tasks and during skill acquisition. Second, I will discuss lifespan structural changes in brain grey and white matter. More specifically, associations between structural brain metrics and coordination behaviour will be reported with a specific focus on the microstructural integrity of callosal connections. Finally, I will discuss age-related alterations in functional connectivity within the motor network during task-related and resting state conditions, as revealed by means of fMRI and/or TMS studies. The current systems level multimodal imaging approach appears promising in revealing lifespan alterations in brain and behaviour, more specifically brain structure, function, and connectivity.

Oral Presentations

10:00 – 11:00 Session 1: Movement preparation and control

Chair: Janet Taylor

TALK 1: *MODULATION OF CORTICOSPINAL EXCITABILITY OF TRUNK MUSCLES DURING ARM MOVEMENT PREPARATION*

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* Study realised at the Centre Interdisciplinaire de Recherche en Réadaptation et Intégration Sociale (CIRRIS), Université Laval, Quebec City, Canada.

Introduction: Voluntary movements are known to be accompanied by anticipatory postural adjustments (APA) required maintaining balance and posture, but the role of the corticospinal tract in the control of trunk muscles during movement preparation has not yet been investigated. This study investigated the modulation in corticospinal excitability (CSE) of trunk muscles during the preparation of arm movements.

Methods: Fifteen participants have been tested with transcranial magnetic stimulation (TMS) applied over M1 during the preparation of rapid arm flexions and extensions. Surface EMG was recorded from superficial multifidus (sMF) and rectus abdominis (RA). A Warning signal informed participants to prepare to move, followed by a Go signal. TMS was applied during baseline and at 5 time intervals before (Delay period) and after (Motor execution window) the Go signal.

Results: An inhibition of the sMF CSE was present during Delay period compared to baseline, for both flexion and extension movements (-9.2 to -15.2% change; $p<0.05$). During the Motor execution window for arm extension, sMF was even more inhibited (-28.4 ± 3.9%; $p<0.0005$) along with a large facilitation of RA (1083.6 ± 410.7%; $p=0.006$). During arm flexion preparation, sMF and RA both presented a trend toward facilitation compared to Delay period.

Conclusions: The results suggest the existence of two concurrent mechanisms underlying motor preparation for APA: (i) before the Go signal, a nonspecific inhibitory mechanism for sMF, likely to preclude motor program release; (ii) after the Go signal, a specific modulation of CSE according to the mechanical demand.

TALK 2: *DISTINCT MODULATION OF CORTICOSPINAL EXCITABILITY AND INTERHEMISPHERIC INHIBITORY MECHANISMS DURING MOVEMENT SELECTION AND PREPARATION REVEALS THE INFLUENCE OF COGNITION ON ACTION CONTROL*

Sarah Kemp[1], H. Fujiyama[3], R. Puri[1], S. Waitzer[1], P. Reissig[1], T. Stöckel[1,2], and M. R. Hinder[1]

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Responding as fast-as-possible to external stimuli involves numerous neural processes including those that prevent premature or undesired actions. Here participants responded to an imperative stimulus (IS) by abducting their left or right index finger; a warning stimulus (WS) preceded the IS, which was either uninformative, or informative, with regards to the required movement. Transcranial magnetic stimulation assessed corticospinal excitability (CSE) of right primary motor cortex (M1), and interhemispheric inhibition between left and right M1s with 10 (IHI10) and 40 (IHI40) ms interstimulus intervals, at various time points during movement selection and preparation.

Consistent with the impulse control hypothesis, CSE was suppressed prior to left- and right-hand actions, irrespective of WS type. Subsequent CSE increases occurred in the responding hand which were larger and occurred earlier following an informative WS. Importantly, these increases strongly predicted response speed. Following an informative WS, significant releases of IHI10 in the responding, but not in the non-responding, hand were observed. In contrast, IHI40 was released in both hands. These findings support the notion that IHI10 is mediated by a direct pathway between contralateral M1 regions, while IHI40 likely involves non-primary motor regions including prefrontal regions and thus reflects cognitive, rather than motor-specific, task components.

TALK 3: *POSTURAL CONFIGURATION INFLUENCES THE CONTROL OF EYE MOVEMENTS AND EYE-HEAD-HAND COORDINATION DURING REACHING*

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Eye-head movements are often tightly coupled to ensure correct visuomotor coordination. During reaching, evidence suggests that the integration of an arm movement may be enough to weaken this coordination (Pelz et al., 2001). Moreover, eye movements are known to change in latency during visuomotor tasks involving whole body movements, such as turning (Hollands et al., 2004; Anastasopoulos et al., 2009). To investigate if changing postural constraints affects eye-head-hand coordination, we varied starting postural configuration before eye movements and reaching.

Eleven healthy university-aged participants executed simple eye movements and reached with their preferred arm to 2 visual targets located 40° to either side of their midline while sitting and standing in three different postural configurations: standing at normal stance width (STAND), standing with the feet together (NARROW) and standing on a thin support base (BEAM). Trials were executed in randomized blocks of 50 trials. Arm and body movements were recorded using 3D kinematics and eye movements using electrooculography. Onsets were determined using various linear or angular velocities and/or acceleration criteria previously documented.

While the presence of reaching did not change eye onset latencies, some postural conditions did lengthen eye onset (STAND vs. BEAM; $p<0.05$). Delays in head ($p<0.05$) and finger onsets ($p<0.05$) during reaching also depended on target direction. Our results suggest that both postural constraints and the directional voluntary movement are influential in visuomotor and eye-head-hand coordination. Further insights into the muscular contributions of such coordination patterns are necessary to better understand the neural underpinnings of movement preparation.

References:

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2. Hollands, M. A., Ziavra, N. V., & Bronstein, A. M. (2004). A new paradigm to investigate the roles of head and eye movements in the coordination of whole-body movements. *Experimental brain research, 154*(2), 261-266.
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TALK 4: *BALANCE RESPONSES EVOKED BY PULLS TO THE BODY ARE MODULATED BY RELATIVE VISUAL MOTION*

Rebecca J. St George[1], I. Di Guilio[2], and B. L. Day[2]

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When a standing person is pulled by an external force it is unclear whether the relative visual motion has any effect on the postural response. Motion of the visual field (either forwards, backward, or stationary) was manipulated to occur simultaneously with a pull (either forwards, backwards, or no pull) and the kinematic, kinetic and electromyographic responses of twelve healthy control subjects were recorded.

When the visual field moved in the same direction as the pull so that the apparent velocity of the body reported by the visual input was reduced, subjects stepped at lower levels of pull force compared to when the visual field rotated in the opposite direction to the pull or did not move at all. Measuring in-place postural responses revealed that when the visual field was in the same direction as the pull, the body was displaced further in the direction of the pull. This was in part due to reduced muscle activity in the agonist muscle of the ankle joint resisting the pull and increased activity in the antagonist muscle within 80-140ms from the visual field motion onset.

In trials with no mechanical pull, there were still postural responses to the visual field motion, however these responses occurred 240ms later and were significantly smaller than when the visual motion was paired with a mechanical pull.

The results suggest that when the body is perturbed, visual motion of the environment is interpreted as body motion through space and this information is expedited to the postural muscles to modulate the long latency stretch reflex response.

11:30 – 13:00 Session 2: Clinical populations and Aging

Chair: Simon Gandevia

TALK 5: *PLASTICITY IN MOTOR CORTEX FOLLOWING ISCHAEMIC STROKE – IS THERE A CRITICAL WINDOW?*

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Background: In animal models there is a period of enhanced neuroplasticity after stroke, which is typically short-lived (2-3 weeks) and has be demonstrated in both lesioned and contralesional hemispheres. However, this phenomenon has not been well quantified in humans. TMS allows non-invasive measurement of neuroplasticity, but its reliability over extended time periods has not been established. We set out to use TMS to delineate this window of plasticity in recovering stroke patients, having first assessed its test-retest reproducibility in healthy controls.

Subjects: 19 stroke patients attended for TMS 2, 4 and 6 weeks after first ischaemic stroke. Test-retest reproducibility was assessed across 6 months in 18 healthy volunteers.

Methods: Subjects received cTBS in a spaced protocol to dominant (controls) or contralesional (patients) M1, with follow up MEPs over 30 minutes. Averaged normalized MEP amplitudes were analyzed in a two-way rmANOVA with factors SESSION and TIME.

Results: In healthy volunteers there was an effect of TIME ($p<0.01$) but no effect of SESSION ($p = 0.27$) indicating cTBS suppressed MEP amplitude but the effect did not differ between sessions. MEP suppression over the first 10 minutes of each session had an ICC of 0.65 ($p=0.02$), showing good agreement. In stroke patients there was a significant effect of SESSION ($p =0.03$), with reduced suppression from cTBS over 6 weeks indicating a drop off in plasticity over this period.

Conclusions: Data suggest that the window of enhanced plasticity in stroke patients is short (less than 6 weeks).

TALK 6: *IMPAIRMENTS IN GAIT, BALANCE AND STEPPING REACTIONS IN CERVICAL DYSTONIA*

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[1] University of Technology Sydney, Flinders University, SA, Australia.

Background: Impaired balance is common in neurological disorders leading to deficits in function and participation. Cervical dystonia is a neurological movement disorder affecting the head and neck. The effect of this aberrant head posture on physical function in this population is unknown.
Objectives: To compare balance, mobility, gait and stepping reactions between people with cervical dystonia and control adults.

Methods: Spatiotemporal gait parameters and walking speed was assessed using a computerized walkway. Step length and time, and time in single and double support were calculated. For balance, centre of pressure path length was assessed with eyes open and eyes closed to calculate a Romberg's Quotient. Simple and choice reaction times were measured for both lower limbs. Mobility was assessed using the timed up and go and gait speed. Self-reported scales included the Falls Self Efficacy Scale and the Dystonia Discomfort Scale.

Results: There was a difference between groups for most outcome measures. Significantly, timed up and go and walking speed was impaired in dystonia compared to controls. People with dystonia had lower falls self-efficacy. The reduced cervical ROM was correlated with; balance, stepping reaction time and mobility. Timed up and go was positively associated with stepping reaction time.

Conclusions: People with cervical dystonia in this study displayed deficits in balance, gait and stepping reactions, and had low falls self-efficacy. Studies to further elucidate functional imitations and their impact on activity and participation in daily life in this population are urgently required.

TALK 7: *FUNCTIONAL NEUROIMAGING OF PREFRONTAL CORTEX IN PARKINSON'S DISEASE USING NEAR INFRA-RED SPECTROSCOPY: EFFECTS OF COGNITIVE TASK DURING SEATED AND STANDING POSTURES*

Graham K. Kerr[1], M. Muthalib[1], R. Pegoraro[1], L. Roeder[1], I. Stewart[1], and S. Smith[1].

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In Parkinson's disease (PD), reduced executive function has been associated with poorer quality of life, decreased activities of daily living and increased balance and gait disturbance. Neural circuits involving activation of prefrontal cortex and involved in executive function are thought to be critical for control of balance and gait. Functional near-infrared spectroscopy (fNIRS) imaging was used to determine how prefrontal cortex activation was affected during concurrent cognitive and balance tasks.

Pre-frontal cortex alterations in concentration of oxy- (O2Hb) and deoxy-haemoglobin (HHb) in cerebral microcirculation blood vessels were recorded using fNIRS during performance of a cognitive task (verbal fluency) involving executive function. During this task, participants were either seated or standing quietly on a force plate. Early stage PD, healthy age matched control, and young participants were assessed according to the following protocol repeated 5 times during sitting and standing: Baseline - no activity (30s), Verbal Fluency (30s), Recital of days of the week (30s).

Both the young, control and the PD groups had similar performance in the verbal fluency and the week day recital tasks. In the young group, neuronal activation during the verbal fluency task (relative to baseline) caused a change in regional blood flow, which was characterised by an increase in O2Hb and a decrease in HHb in the right dorsolateral prefrontal cortical (DLPFC) region during the seated condition. These changes were observed in the DLPFC bilaterally during the standing condition. Similar, but reduced changes were observed for the age-matched control group. For the PD group during the verbal fluency task there was a bilateral increase in DLPFC O2Hb during the seated condition but this was greatly reduced in amplitude. During the standing condition there was negligible change in DLPFC O2Hb in both hemispheres for PD participants. There was negligible change in O2Hb during the week day recital task for all groups.

These changes in O2Hb indicate that PD participants have reduced activation of the DLPFC during the performance of cognitive tasks involving executive function. During standing activation of the DLPFC is further reduced, in contrast to young and control participants who have increased bilateral activation. This indicates that people with PD have either reduced activation of the same neural circuits or utilize different neural circuits to complete these tasks.

TALK 8: *IS THERE AN ABNORMAL CORTICAL CONTRIBUTION TO QUIET BREATHING IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE?*

David Nguyen[1,2], C. Boswell-Ruys[1,2,3], R. McBain[1,2,3], D. Eckert[1,2], S. Gandevia[1,2,3], J. Butler[1,2], and A. Hudson[1,2]

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Background: Current evidence indicates that the presence of an inspiratory load engages cortical mechanisms to defend ventilation. A cortical contribution to breathing is determined from the presence of a Bereitschaftspotential – a low amplitude negativity which begins ~1.5 s before inspiration. In chronic obstructive pulmonary disease (COPD), changes in the lung, chest wall and respiratory muscles induce an inspiratory load. We hypothesised a cortical contribution to quiet breathing in COPD and a relationship between a cortical contribution to inspiratory threshold loading and dyspnoea – a major symptom of COPD.

Methods: Electroencephalographic activity (EEG) was recorded in 15 COPD patients (10 males; age: 57-87) and healthy controls (11 age-matched and 15 young) during quiet breathing and inspiratory threshold loading (10% maximal inspiratory pressure). Two blinded observers evaluated the presence of Bereitschaftspotentials prior to inspiration from ensemble averages of 80 or more epochs of EEG at Cz and FCz. Dyspnoea was rated using the modified Borg scale.

Results: The incidence of a cortical contribution to quiet breathing was significantly greater in the COPD patients (7/15) than the young (0/15) ($P < 0.01$), but not the age-matched (3/11) ($P = 0.3$), controls. A cortical contribution to inspiratory threshold loading was associated with higher Borg scores in the young ($P < 0.05$) and age-matched ($P < 0.05$) controls, but not the COPD patients ($P = 0.4$).

Conclusions: This study provides evidence that age, rather than COPD, is associated with a cortical contribution to quiet breathing. A cortical contribution to inspiratory threshold loading may be associated with more severe dyspnoea, at least in healthy young and old people.

TALK 9: *AGE-RELATED DIFFERENCES IN ERROR PROCESSING DURING FORCE FIELD ADAPTATION: AN EEG STUDY*

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The ability to process errors is crucial for successful motor adaptation. However, the electroencephalographic (EEG) event-related potentials (ERPs) observed in response to errors are typically reduced with age. Here, we investigated how such ERP responses to errors relate to the ability of older adults to learn to reach when perturbed by a force field.

Twenty-four older (age 70.0 ± 4.7) and 26 young (age 19.2 ± 2.1) adults performed 600 reaches and received bimodal (hit vs. miss) audio-visual performance feedback after each trial. After 96 baseline trials, a velocity-dependent force field was introduced. Adaptation was characterised as the lateral force exerted against the wall of force channels that constrained reaches to follow a straight path toward the target. ERPs, time-locked to movement onset [error-related negativity (ERN)] and feedback onset [feedback-related negativity (FRN)], were analysed at electrode FCz.

There were no age-related differences in the ability to develop predictive control of the new dynamics, nor in the number of target hits. However, to achieve success once the field was introduced, older adults moved more slowly, suggesting that they compromised speed for accuracy. Older adults also showed reduced sensory- and reward-prediction error processing, as evidenced by reduced ERN and FRN difference-wave amplitudes (ERN: large - small error; FRN: miss-hit). Interestingly, the number of targets hit correlated with the amplitude of the ERN signal in older adults. This suggests that older adults with a greater neural correlate of error-evaluation are better able to reduce movement errors caused by a novel dynamic environment.

TALK 10: *THE INTERPLAY BETWEEN THE BRAIN, COGNITION AND GAIT IN OLDER PEOPLE*

Michele L. Callisaya[1,2]

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[2] Southern Clinical School, Monash University, VIC, Australia.

Introduction: There is growing awareness that even early changes in cognitive function are associated with impaired gait, and that these impairments may interact to increase the risk of falls. This presentation will examine the cognitive domains and underlying brain structures associated with impaired gait.

Methods: Participants were aged 60-85 years from the Tasmanian Study of Cognition and Gait (TASCOG). Gait and gait variability measures were obtained using the GAITRite walkway. A cognitive battery was used to obtain measures of memory, processing speed, executive function and visuospatial ability. Brain volume and markers of cerebral small vessel disease were obtained using magnetic resonance imaging.

Results and Conclusion: An overview of findings from TASCOG will be presented on the specific cognitive domains and underlying structural brain measures that were associated with gait and gait variability measures. A greater understanding of the specific cognitive domains and underlying brain structures that contribute to poorer gait is important in order to develop treatment and preventative programmes.

Invited Talk

14:00 – 14:30 *EXPLOITING RESPONSE VARIABILITY TO PROBE SENSORIMOTOR FUNCTION*

John C. Rothwell

University College London, Institute of Neurology, London, UK

Variability in the motor response to transcranial magnetic stimulation (TMS) is usually regarded as unwanted, unpredictable, “noise”, which is often removed by averaging the signal. However, it may be that the variability in motor output is not all random, and that parts of it may contain useful information about the motor system that can provide mechanistic insights. Two examples:

1. Application of intermittent theta burst (iTBS) TMS 10min before volunteers learn a ballistic thumb abduction task improves the rate of learning as well as the final performance after 10 min practice (Teo et al (2006) Cerebral Cortex). This is conventionally interpreted in terms of effects of iTBS on synaptic plasticity in the motor cortex: iTBS may increase plasticity and make the learning process more effective. However, in order to improve performance in this task requires participants to explore task space in order to find the optimal direction of movement and pattern of muscle activation that produces the maximal initial thumb acceleration in the required direction of movement. Previous work has shown that in such circumstances, learning rate depends on the initial variability of movement, so that people who have larger variability explore the task space more effectively and improve their performance faster. In our experiments we measured variability in the direction of TMS evoked thumb movements in relaxed indivduals. iTBS increased the variability. Thus iTBS might have improved task performance by increasing movement variability rather than synaptic plasticity.

2. MEPs are highly variable in amplitude from trial to trial. In a series of experiments (van den Bos et al unpublished), we found that in a simple reaction time task, variability decreased during the interval between the “go” signal and motor response. In fact, the decline in variability was proportional to the reaction time in that task (the faster the decline in variability the shorter the reaction time), suggestive of a link between reducing variability of motor output and the decision to initiate a movement. This change in variability was not seen in task irrelevant muscles. However it was present in muscles not involved in the movement if the participants were instructed to maintain their activity silent during focal contraction. Our hypothesis is that reducing the variability of motor output prior to initiation improves the consistency of movement performance.

14:30 – 15:15 Session 3: Exercise and Strength Training

Chair: Stephan Swinnen

TALK 11: *GREATER EFFECTS OF AEROBIC EXERCISE ON REDUCING SENSITIVITY TO NOXIOUS MECHANICAL COMPARED TO NOXIOUS HEAT STIMULI IN HEALTHY ADULTS*

Matthew D. Jones[1,2], J. L. Nuzzo[2,1], J. L. Taylor[2,1], and B. K. Barry[1,2]

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[2] Neuroscience Research Australia, NSW, Australia.

Introduction: Noxious mechanical and thermal stimuli are often used in studies of exercise-induced hypoalgesia (EIH), with exercise demonstrated to reduce sensitivity to both pain modalities. However, conflicting findings have been reported and it is unclear whether exercise influences mechanical pain more than thermal pain when the two stimuli are well equated.

Methods: In 16 healthy adults, mechanical and thermal pain sensitivity were assessed before and after 15 min of aerobic cycling exercise as well as before and after an equivalent period of light activity. Pressure pain thresholds (PPT), heat pain thresholds (HPT) and pain ratings to laser stimulation were used to quantify EIH. Laser evoked potentials were also recorded through electroencephalography (EEG) to examine the effect of exercise on the excitability of nociceptive pathways.

Results: After exercise, PPTs increased (26.9% increase, $d = 0.61$ and $p < 0.001$) whereas HPTs did not (4.2% increase, $d = 0.30$, $p = 0.27$). This was despite PPTs and HPTs being assessed using a similar stimulus pattern and at nearby stimulus sites. The difference between the increase in PPT and HPT was large and significant (effect size (95% confidence interval) of difference: $d = 1.77$ (0.82 to 2.87), $p < 0.001$). Like the HPTs, laser heat pain ratings and laser evoked potentials were also not changed significantly after exercise (d between -0.59 to 0.3, $p > 0.06$).

Conclusion: When the stimulus profiles are well equated, exercise is more effective in reducing pain perception for noxious mechanical versus noxious thermal stimuli.

TALK 12: *FOUR WEEKS OF STRENGTH TRAINING INCREASES VOLUNTARY ACTIVATION BUT NOT RESPONSES TO STIMULATION OF CORTICOSPINAL AXONS*

Jim L. Nuzzo[1,2], B. K. Barry[1,2], M. D. Jones[1,2], S. C. Gandevia[1,2], and J. L. Taylor[1,2]

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[2] University of New South Wales, NSW, Australia.

Introduction: Improvements in muscle strength within the first weeks of strength training are thought to arise from neural adaptations. This study examined if 4 weeks of strength training of the elbow flexor muscles alters voluntary activation and responses to stimulation of corticospinal axons.

Methods: Twenty-one subjects were randomized into strength training (n = 10) and control (n = 11) groups. Strength training involved 12 sessions of high-force isometric contractions of the elbow flexors. Before and after training, magnetic stimulation of corticospinal axons was used to examine changes in corticospinal transmission. The evoked responses, termed cervicomedullary motor evoked potentials (CMEPs), were acquired in resting biceps brachii. Transcranial magnetic stimulation was used to assess voluntary activation of the elbow flexors and surface electromyography (EMG) of biceps provided a gross measure of neural drive. Muscle adaptations were assessed via percutaneous electrical stimulation of biceps.

Results: Compared to the control group, the strength training group exhibited greater increases in maximal strength (mean ± SD: 12.8 ± 6.8% vs 0.0 ± 2.7%; $p < 0.001$), biceps EMG (27.8 ± 25.9% vs -5.2 ± 16.8%; $p = 0.002$), and voluntary activation (5.6 ± 4.6% raw change vs -0.1 ± 5.1%; $p = 0.016$). Biceps CMEPs and biceps twitch characteristics were unchanged by the training.

Discussion: Four weeks of isometric strength training of the elbow flexors increased muscle strength and voluntary activation, but did not alter corticospinal transmission. A cortical mechanism, or a spinal-level mechanism that is apparent only during voluntary contraction, likely caused the strength improvement.

TALK 13: *NEUROMUSCULAR CHANGES OF THE TRICEPS SURAE MUSCLES AND THE REPEATED BOUT EFFECT*

Patricio A. Pincheira[1], B. W. Hoffman[1,2], A. G. Cresswell[1], and G. A. Lichtwark[1]

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Introduction: Exercise-induced muscle damage occurs after an unaccustomed bout of exercise containing lengthening contractions, resulting in pain and strength loss. When a subsequent bout of exercise is performed, the magnitude of these indicators of damage is markedly reduced; known as the repeated bout effect (RBE). Although it has been suggested that the RBE arises with changes in the muscle's mechanical behaviour after the first bout, recent evidence shows that the RBE can occur in the gastrocnemius muscle without changes in muscle fascicle strain. Thus, it is possible that alternative mechanisms, like neuromuscular adaptations, are involved in the RBE.

Aims: To investigate whether neuromuscular adaptations contribute to the RBE in the triceps surae muscles.

Methods: Twenty subjects performed 2 bouts of 500 active lengthening contractions of the triceps surae, separated by 7 days. Surface EMG (medial gastrocnemius, lateral gastrocnemius, and soleus), maximal voluntary isometric torque (MVC) and soreness scores were collected before, two and 48 hours after each bout.

Results/Discussion: A RBE for MVC and soreness was present 2 hours after the repeated bout. However, EMG-rms, EMG-rms normalised to MVC and EMG-rms normalised to M-wave rms presented no significant changes in the repeated bout compared to the initial bout. Interestingly, median power frequency recorded during MVC decreased significantly 2 hours after the initial bout in the gastrocnemius muscle. Our results suggest that there are no global changes in activation of the triceps surae in the RBE, however, shifts in the frequency spectra may indicate a change in action potential conduction velocity.

15:45 – 16:30 Session 4: Plasticity and perception

Chair: John C. Rothwell

TALK 14: *THE ROLE OF NMDA RECEPTORS IN PLASTICITY INDUCED BY PAIRED CORTICOSPINAL-MOTONEURONAL STIMULATION*

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Repeated stimulation of corticospinal neurones and motoneurones (paired corticospinal-motoneuronal stimulation, PCMS) can modify corticospinal transmission and enhance voluntary motor output in able bodied and spinal cord injured humans, most likely through changes to corticospinal-motoneuronal synapses[1-3]. Similar types of plasticity require N-methyl-D-aspartate receptors (NMDARs). Here we used a non-competitive NMDAR antagonist, dextromethorphan, to determine whether NMDARs are involved in PCMS-induced plasticity. Transcranial magnetic stimulation elicited corticospinal volleys and electrical brachial plexus stimulation elicited antidromic motoneurone potentials. PCMS consisted of 100 pairs of these stimuli delivered each 10 s, using an interstimulus interval that produces facilitation of corticospinal-motoneuronal synapses supplying the biceps brachii. To measure corticospinal changes at a spinal level, biceps responses to cervicomedullary stimulation (cervicomedullary motor evoked potentials, CMEPs) were measured before and for 30 min after PCMS. Participants who had ≥10% increase in CMEP size after PCMS on a screening day were eligible to take part in a subsequent two-day, double-blind, placebo-controlled experiment assessing the effects of dextromethorphan on PCMS-induced facilitation. PCMS was delivered 3 h after oral ingestion of placebo or dextromethorphan, corresponding to peak serum levels of dextromethorphan[4]. On the placebo day, CMEPs increased to 127±46% of baseline after PCMS, whereas with dextromethorphan, CMEPs decreased to 86±33% (mean ± SD; placebo: n=11; dextromethorphan: n=10). The difference between days was significant ($p<0.0001$). To conclude, dextromethorphan suppressed the PCMS-induced facilitation. Thus, NMDARs are likely to be involved in PCMS-induced plasticity.

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TALK 15: *THE POTENTIAL CONTRIBUTION OF PACINIAN CORPUSCLE-ASSOCIATED AFFERENTS TO VIBROTACTILE FREQUENCY PERCEPTION WITHIN FLUTTER FREQUENCY RANGE*

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Introduction: The classical view is that vibrotactile stimuli evoke two qualitatively distinctive cutaneous sensations – flutter (frequencies <60Hz) and vibratory hum (frequencies >60Hz), which match the characteristic frequency ranges of two types of fast adapting tactile afferents - FAI and FAII, respectively.

Objectives: To investigate whether, and to what extent, FAII afferents can contribute to the perception of flutter range vibrotactile stimuli. In particular the aim was to test whether detection thresholds are independent of the spiking rate in FAII afferents, and whether FAII afferents have access to the neural circuits subserving perception of vibrotactile stimuli within flutter range frequencies.

Methods: First, the detection thresholds were tested using the method of limits when pure frequency spike trains were evoked in FAII afferents at a rate of 6, 24, 100 or 200 spikes/second. Then a two-alternative forced-choice paradigm was used to obtain psychometric functions of the frequency discrimination ability using FAII afferents within the flutter range. Six and fourteen subjects participated in the first and second experiments respectively.

Results: Detection thresholds subserved by FAII afferents were not influenced by the discharge rate increasing from 6 to 200Hz, thus showing no effect of temporal summation over vibrotactile frequency range. The psychometric curves of frequency discrimination within flutter range when FAII afferents were selectively activated were similar to those in the same subject when activating the population of both FAI and FAII afferents.

Conclusions: FAII afferents are capable of contributing to frequency perception and discrimination within the low frequency flutter range.

TALK 16: *THE CONTRIBUTION OF THE TONGUE MOTOR CORTEX IN PROCESSING REWARD AND AVERSIVE OUTCOMES*

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A current challenge for neuroscience is provide conceptual tools and methodologies for understanding the activity of reward system. According to the evidence linking the representation of tongue in the primary motor cortex (i.e., the Tongue Motor Cortex- TMC) to the reward system, I provide evidence in support of the suggestion that this cortical region might serve as target structure for detecting the neural activity along the reward-aversion continuum. Thus, I present the results of two recent studies investigating the impact of reward and disgust related outcomes to the excitability of this pool of neurons.

Poster Presentations

POSTER 1. *MOTONEURONE EXCITABILITY OF THE HUMAN QUADRICEPS MUSCLES DECREASES DURING A SUBMAXIMAL FATIGUING CONTRACTION*

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Introduction: Descending cortical input influences motoneurone excitability and can confound measures in exercising humans. To overcome this limitation, motoneurone excitability can be tested during the brief pause in descending cortical drive after transcranial magnetic stimulation (TMS). For the arm, this technique shows profound decreases in motoneurone excitability with fatigue (1). Here, we tested motoneurone excitability during fatigue of the quadriceps.

Methods: Participants (n=9) performed brief (~5s) isometric knee extension contractions before and after 10-min sustained contractions on two days. Contractions were targeted to 25% vastus medialis (VM) rmsEMG recorded via surface electrodes. Electrical stimuli to the femoral nerve elicited maximal M-waves (Mmax) and over the thoracic spine elicited thoracic motor evoked potentials (TMEPs). TMEPs were also elicited in the silent period 100 ms after TMS over the motor cortex (TMS-TMEPs). All stimuli were delivered during contraction. Thoracic stimulation was set to elicit large (~50% Mmax area) or small (~15% Mmax) TMS-TMEPs.

Results: During the 10-min contraction VM rmsEMG was maintained ($p=0.39$) whereas force decreased by 52±13% (mean±95% CI; $p<0.001$). Area of TMEPs remained unchanged ($p=0.9$), whereas TMS-TMEPs decreased by 49±28% and 71±22% for the large ($p=0.001$) and small responses ($p<0.001$) respectively. This decline was greater for the small TMS-TMEPs ($p=0.019$).

Conclusion: Without the influence of descending drive, TMS-TMEPs evoked in quadriceps become smaller during fatigue. This reduction was greater when the motoneurones tested were confined to those most active during the contraction. Thus, a mechanism related to repetitive activity likely underlies the reduction seen in motoneurone responsiveness with fatigue.

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POSTER 2. *INVESTIGATING THE FREQUENCY-DEPENDENT EFFECTS OF LOW-INTENSITY REPETITIVE TRANSCRANIAL MAGNETIC STIMULATION (LI-RTMS) ON HUMAN MOTOR CORTICAL EXCITABILITY*

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Low-Intensity rTMS (LI-rTMS) is a non-invasive form of brain stimulation that induces structural and functional changes in disordered cortical circuits in mice (Rodger et al. 2012) and reduces depressive symptoms in humans with treatment-resistant depression (Martiny, Lunde & Bech 2010). LI-rTMS may also contribute to the effects of other forms of non-invasive brain stimulation by changing cortical excitability. The purpose of this study was to investigate the frequency-dependent effects of LI-rTMS on human motor cortical excitability, comparing four stimulation conditions (10Hz, BHFS, cTBS and sham) after a single stimulation session. We also aimed to determine whether different factors may modulate LI-rTMS induced effects, and how these factors may contribute to variability of results.

We measured cortical excitability by recording motor evoked potentials (MEPs) from the hand muscle before and after LI-rTMS. LI-rTMS did not significantly change cortical excitability and no frequency-dependent effects of LI-rTMS were found after a single stimulation. However, an interesting time of day effect was demonstrated, with a significant increase in cortical excitability variability occurring in the morning compared to the afternoon for all stimulation conditions.

This study demonstrated that LI-rTMS does not significantly alter motor cortical excitability or exhibit frequency-dependent effects in humans. Further research is required to investigate whether LI-rTMS can influence the brain when using different stimulation parameters. An important finding from the current study was the influence of time of day on cortical excitability. This has implications for future research and clinical application of non-invasive brain stimulation.

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POSTER 3. *CORTICOSPINAL EXCITABILITY BEFORE AND AFTER LOW-INTENSITY ECCENTRIC AEROBIC EXERCISE*

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Acute bouts of exercise involving anisometric muscle contractions increase cortical excitability. Previously, the cortical mechanisms underlying eccentric and concentric muscle contractions have been examined using TMS. Elicited motor evoked potentials (MEP) in targeted muscles show that cortical excitability increases during single-joint concentric and eccentric muscle contractions, and following concentric aerobic exercise. Using paired-pulse TMS, intracortical inhibition and facilitation during contractions are reduced and increased, respectively. However, no one study has systematically investigated inhibitory and facilitatory effects of cortical excitability following a bout of eccentric aerobic exercise. Therefore, this study used paired-pulse TMS to determine the pre- and post short-intracortical inhibition (SICI) and intracortical facilitation (ICF) effects of eccentric cycling exercise on corticospinal excitation in an exercised (vastus lateralis) and non-exercised (FDI) muscle. Four, healthy, right-handed male subjects completed 30-mins of eccentric cycling at a specified low-intensity. TMS was applied to elicit MEP recordings at pre-, immediately post (iP) and 30-mins post exercise (30P). MEP amplitudes were used to quantify changes to resting motor threshold (rMT), SICI (2 ms) and ICF (15 ms). FDI rMT and SICI showed no meaningful difference iP or 30P compared with pre-exercise measures. ICF recordings of FDI were considerably increased iP and 30P exercise for all subjects. MEP recordings for VL showed no meaningful change across all subjects at pre-, iP or 30P measures. These preliminary findings suggest that eccentric aerobic exercise increases cortical excitation of a non-exercised muscle. However, at the motoneuron level of the eccentrically exercised muscle, no increase in excitation is evident.

POSTER 4. *EFFECTS OF ANESTHESIA ON MOTOR EVOKED POTENTIALS INDUCED BY TRANSCRANIAL MAGNETIC STIMULATION IN RATS: IMPLICATIONS FOR PLASTICITY STUDIES*

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Repetitive transcranial magnetic stimulation (rTMS) is primarily used in humans to change the state of corticospinal excitability, using Motor Evoked Potentials (MEPs) to compare stimulation protocols. Stimulation of the motor cortex produces a response twitch in a targeted muscle, the amplitude of which provides an indirect measure of the current state of the cortex. rTMS to the motor cortex can alter MEP amplitude, however results are highly variable between studies and the mechanisms underlying any change and its locus are poorly understood, prompting the use of in vivo animal models. These models necessitate the use of general anaesthesia, which can affect plasticity-like mechanisms and potentially contaminate the effects of an rTMS protocol. In the present study, we explored the effect of anaesthetic on MEP amplitude, recorded before and after the facilitatory rTMS protocol, intermittent theta burst stimulation (iTBS). MEPs were recorded in the brachioradialis muscle of the forelimb under two anaesthetics: a xylazine/zoletil combination and urethane. We found MEPs could be induced under both anaesthetics, with no differences in the resting motor threshold or the average baseline amplitudes. However, MEPs were highly variable between animals under both anaesthetics, with the xylazine/zoletil combination showing higher variability and most prominently a rise in amplitude across the baseline recording period. Application of iTBS did not facilitate MEP amplitude as was expected, under either anaesthetic condition. With the continued use of MEPs in humans as a means of assessing protocol efficacy, there is a continued need for animal studies to address the underlying mechanisms.

POSTER 5. *EFFECT OF JUMP HEIGHT VERSUS BODYMASS ON LOWER LIMB JOINT WORK DISTRIBUTION WITH INCREASING WORK DEMAND*

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The human body is able to perform a vast range of actions with many potential muscle coordination strategies. This study examined joint work contributions at the ankle, knee and hip during countermovement jumping in an effort to determine why particular coordination patterns are chosen to meet the work requirements of a jump. Previous studies have shown an important contribution of elastic energy stored in the Achilles tendon for jumping power with this energy primarily being stored in the tendon during standing, prior to jumping. The aim of this study was to examine if changing the energy available to be stored in the Achilles tendon would alter the ratio of joint work contributed to the overall movement. It was identified that increasing jump height resulted in significantly reduced ankle contribution. However, added body mass at a constant jump height resulted in a constant ankle contribution ratio. This finding was paired with higher moments about the ankle prior to jumping which likely resulted in increased elastic energy storage at the Achilles tendon. These findings suggest that the body prioritizes the use of energy already available by altering the coordination patterns of the lower limbs during jumping to maximize energy effectiveness.

POSTER 6. *INFLUENCE OF AGE AND COGNITIVE LOAD ON INTER-JOINT COORDINATION IN REACHING MOVEMENTS*

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Aims: The human motor system has the incredible capability to adapt to a constantly changing environment by flexibly adjusting movement coordination at the effector level to gain stability at the task level, i.e. the movement outcome. The present study investigated how the cognitive load of a motor task influences movement coordination, particularly the amount and structure of joint angle variability, in reaching movements under two cognitive load conditions.

Methods: Thirty-six participants, sitting in front of a computer screen, were visually presented with either a 5-element or 16-element sequence (simple or complex condition, respectively) comprising of five illuminating circles. After sequence presentation had stopped at a random position, participants pointed to the circle that they predicted was next in the sequence. Four blocks of 15 trials were conducted for each condition with movements in the seven joint angles of the arm as well as endpoint variability measured.

Results: Overall arm posture variability was significantly higher in the simple than complex condition ($p = .05$, $\eta_p^2 = .30$), while no statistically significant difference in endpoint variability was found between the two conditions ($p > .38$). Cognitive task load also affected covariation between joint angles, with condition-specific changes in significant positive covariation between upper arm and elbow torsion across the time course of movement execution.

Conclusion: The results suggest that the cognitive load of a task significantly influences movement coordination at the effector level, i.e. the amount and structure of joint angle variability, to produce stability at the task level, i.e. endpoint variability.

POSTER 7. *TEST-RETEST RELIABILITY OF AN UNPLANNED VOLITIONAL STEPPING TEST (CHOICE STEPPING REACTION TIME TEST) IN PEOPLE WITH MULTIPLE SCLEROSIS*

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Aim: People with multiple sclerosis (MS) experience frequent falls. One way of avoiding falls is by stepping appropriately and safely when there is a loss of balance (1). The simple choice stepping reaction time (CSRT) test was designed to evaluate the ability to respond and step quickly and appropriately. Although the CSRT test has been shown to have excellent discriminative and predictive validity in relation to falls in people with MS (2), its reliability and therefore usefulness as an outcome tool has not be established. Our aim was to examine the test-retest reliability of the CSRT test in people with MS.

Methods: 15 participants with MS aged 35 to 62 years (mean ± SD, 51±8 years) were recruited as part of a larger randomized control trial took the CSRT test on two separate days with a minimum of 7 days separating the two testing days. Test–retest reliability was evaluated with an intraclass correlation coefficient (ICC 2,1). Mean stepping time for the two days was compared using a paired t-test.

Results: Test–retest reliability for the CSRT was good (intraclass correlation coefficient=0.79, 95% CI=0.37–0.93, p=0.004). Mean difference for the two days was 1.2±6.0s (p=0.4).

Conclusion: The CSRT test is a simple 'low tech' measure of unplanned volitional stepping that has good test-retest reliability in people with MS. By establishing the reliability of the CSRT test and given its relation to falls risk, the CSRT is likely a good measure of falls risk and could be used as an effective outcome measure.

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POSTER 8. *RELIABILITY OF THE PHYSIOLOGICAL PROFILE ASSESSMENT SHORT FORM IN PEOPLE WITH MULTIPLE SCLEROSIS*

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Introduction: Falls are a common occurrence in people with multiple sclerosis (MS). The efficacy of falls interventions at reducing falls and falls risk in people with MS is unclear, as falls-specific outcomes are not frequently used (1). A falls-specific tool that is valid in people with MS, but has unknown test-retest reliability is the Physiological Profile Assessment (PPA) (2). Hence, this study aims to determine the test-retest reliability of the PPA falls risk score and its individual components for quantifying falls risk in people with MS.

Methods: Subjects (n=15; 1 male) with MS aged 35-62 were assessed with the PPA on two occasions with a minimum of 7 days separating assessments. Overall falls risk was calculated on FallScreen®. The PPA test-retest reliability was determined by calculating the interclass correlation coefficient (ICC) for falls risk and each component of the PPA (i.e. Edge contrast sensitivity (ECS), proprioception, quadriceps strength, hand reaction time, and postural sway).

Results: Test-retest reliability ICC for falls risk was excellent at 0.85 ($p<0.05$). Quadriceps strength, hand reaction time, and postural sway ICCs were 0.86, 0.81, 0.90, respectively ($p<0.05$). However, the reliability for ECS and proprioception was poor (ICC=0.30 and 0.07, respectively. $p>0.05$) despite the means being similar on the two days (mean ± SD; ECS: 21.73 ±1.33, 21.60±1.86; proprioception: 2.68±0.94, 3.16±2.33)

Conclusion: The PPA is reliable for assessing falls risk in ambulatory people with MS. Individual components of the PPA are best used as part of the composite measure since not all components are reliable.

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POSTER 9. *EFFICACY OF NEUROMUSCULAR CONTROL TRAINING OF THE ANKLE IN ADOLESCENTS AND ADULTS WITH CEREBRAL PALSY: TRIAL PROTOCOL*

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Cerebral palsy (CP) is a neurological condition resulting in motor impairment. In ambulant individuals with CP, altered neuromuscular control (NMC) of the ankle impairs walking ability. Whilst variable activation patterns, reduced voluntary activation and motor unit firing rates have been reported during maximal isometric contractions and walking in cross-sectional CP studies compared to typically developed individuals, it's unclear whether active movement training (AMT) can improve NMC.

Aims: To quantify potential neural adaptations and subsequent NMC of the ankle following AMT in CP and to assess functional transfer to improve gait parameters.

Hypothesis: Active performance of ankle force and movement error correction based training will lead to enhanced muscle activation control and task accuracy and elicit improvements in toe clearance and ankle power generation during functional movements like walking.

Methods: Twenty ambulant individuals with spastic hemiplegic CP (15-25yrs) will undergo a six weeks' control period followed by six weeks of novel motor training (3days/week) using custom built equipment and software to perform ankle positioning and force tracking tasks. Outcomes will be assessed at three time points over three domains: (1) NMC (H/M ratio, voluntary activation (interpolated twitch technique), EMG amplitude during selective motor control and functional tasks), (2) selective motor control (task accuracy index, selective control assessment of the lower limb, torque steadiness) and (3) function (gait kinematics and kinetics, 10m walk speed, timed upstairs).

Results: Preliminary neurophysiological data will be presented in CP and healthy individuals for discussion and feedback on the use and feasibility of neurophysiological testing in CP.

POSTER 10. *THE DIFFERENTIAL RECRUITMENT OF PARASTERNAL INTERCOSTAL MOTOR UNITS DURING INSPIRATION IS NOT PRESERVED IN A VOLUNTARY POSTURAL TASK.*

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Human parasternal intercostal muscles are obligatory inspiratory muscles, but they are recruited differentially across the first-to-fifth interspaces. These muscles are also active in ipsilateral rotation of the chest wall. However, it is not known if the differential recruitment of motor units across interspaces is preserved in a non-respiratory task of chest wall rotation.

Intramuscular recordings were made from the parasternal intercostal muscles in the 1st, 2nd and 4th interspaces of 5 healthy male participants. The recruitment of single motor units was compared during (i) quiet breathing and (ii) 'isometric' ipsilateral rotations of the chest wall during apnoea. For breathing, the recruitment of each motor unit was expressed relative to total inspiratory time (T_I). For rotations, the torque at which the motor unit was recruited was expressed relative to maximal rotation torque (max torque).

Single motor units active in both quiet breathing and ipsilateral rotations were discriminated from the 1st (n=23), 2nd (n=44) and 4th (n=56) interspaces. The inspiratory recruitment time of motor units for the 1st and 2nd interspaces was significantly earlier (~17% Ti) than for the 4th interspace (31% Ti). However, for the same motor units, the rotation torque at which motor units were recruited was lowest in the 4th and 2nd interspaces (~4%max torque), and delayed in the 1st interspace (8%max torque).

During the rotation task, there was a reversal of the differential sequence of recruitment across interspaces observed during inspiration. This suggests that parasternal intercostal motoneurone output at different spinal levels can change depending on task.

POSTER 11. *ABNORMAL MOTOR CORTICAL AND CORTICOSPINAL EXCITABILITY IN HUMANS WITH A HISTORY OF ILLICIT AMPHETAMINE USE*

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Increased excitability of the motor cortex and corticomotoneuronal pathway has been observed in adults with a history of illicit stimulant use. However, the class of illicit stimulant drug linked to this abnormality is unknown. The aim of the study was to determine which class of illicit stimulant drug is associated with this abnormal excitability. We hypothesized that history of illicit amphetamine use is associated with increased excitability, but not history of ecstasy use. Three groups of adults (aged 18-33 yrs) were investigated: nine participants with a history of illicit amphetamine use (amphetamine group), eight participants with a history of ecstasy use but minimal use of other stimulants (ecstasy group), and 21 participants with no history of illicit drug use (non-drug group). Single- and paired-pulse transcranial magnetic stimulation (TMS) was delivered over the first dorsal interosseous (FDI) motor area during relaxation and contraction of the contralateral target muscle. Electromyographic responses evoked by TMS (motor evoked potentials: MEPs) were recorded. At a given stimulus intensity (130% resting motor threshold), resting MEP amplitude was significantly larger in the amphetamine group than in the other groups ($P=0.039$), but there was no difference between the non-drug and ecstasy groups. No significant between-group differences were observed for duration of the silent period or response to paired-pulse TMS. Abnormal motor cortical and/or corticomotoneuronal excitability is associated with history of illicit amphetamine (primarily methamphetamine) use but, not history of ecstasy use. The abnormal excitability is evident months to years after cessation of drug use.

POSTER 12. *SEROTONIN REUPTAKE INHIBITION SHORTENS TIME-TO-FATIGUE DURING MAXIMAL ISOMETRIC ELBOW FLEXION*

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Introduction: While selective serotonin reuptake inhibitors are well-known for their use as antidepressants and anxiolotics, they can also modulate motor behaviour. For example, in healthy subjects a single dose of buspirone depresses motorneuron excitability via activation of 5-HT1A receptors in fresh unfatigued muscle. Although several studies propose that increased levels of CNS serotonin shortens time-to-exhaustion and increased levels of fatigue during endurance exercise, little is known about how serotonin influences fatigue during isolated muscle contractions.

Methods: This experiment is a human double-blind, placebo-controlled, cross-over design. Pilot data has been obtained from four healthy adults (27 ± 8 yr). Two sessions spaced a week apart were attended by each subject. A single dose of 20 mg paroxetine was administered in one session whereas a placebo was administered in the other session. Assessments of motor activity began 4 hours post- ingestion to align with peak plasma concentration of the paroxetine. A fatigue protocol was performed which consisted of 6 sets of sustained maximal isometric elbow flexion. Contractions continued until elbow flexion force decreased to 60% of MVC, and 40 s of rest was provided between sets. The area of force, bicep brachii EMG, and triceps brachii EMG were calculated for all contractions.

Results: Time-to fatigue and area of elbow flexion force was significantly reduced in the paroxetine condition compared to the placebo condition (p's < 0.05). Post-hoc analysis revealed that time-to-fatigue and force for each contraction set (i.e. set 1 for paroxetine compared to set 1 for placebo) was reduced following ingestion of the serotonin reuptake inhibitor (p's < 0.05). Area of bicep brachii EMG matched the area of force following ingestion of paroxetine (p's < 0.05), where biceps brachii EMG for each contraction set was reduced after ingesting of the serotonin reuptake inhibitor (p's < 0.05).

Discussion: Paroxetine is the most potent and highly selective inhibitor of neuronal serotonin reuptake, and only has very weak (to negligible) effects on dopamine reuptake, adrenoceptors, histaminergic and muscarinic cholinergic receptors. As such, this pilot data suggests that serotonergic activity in the CNS may directly impair the ability to perform strong prolonged contractions. This experiment will be extended to clarify mechanisms of action.