SHORT-TERM PERIPHERAL NERVE STIMULATION AMELIORATES MOTOR AXONAL DYSFUNCTION AFTER ACUTE SPINAL CORD INJURY

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Introduction: Recent studies utilising novel threshold-tracking techniques have identified abnormalities in peripheral nerves after spinal cord injury (SCI). Secondary axonal dysfunction contributes to peripheral neuropathies and neuropathic pain, leading to further functional impairment. In an attempt to ameliorate the downstream effects that develop following SCI, we examined the effects of an intensive, short-term peripheral nerve stimulation therapy (PNST) on motor axonal excitability after SCI. **Methods:** Axonal excitability studies were undertaken in 20 patients with recent traumatic SCI. One limb was randomly assigned to receive PNST whilst the opposite limb acted as control. PNST was delivered percutaneously (NeuroTrac®) over the median nerve (MN) at the wrist and common peroneal nerve (CPN) at the fibular head, 5 times/week for 6 weeks, and the compound muscle action potential (CMAP) recorded. Stimulus intensity was above motor threshold and pulses (450 μs) were delivered at 100 Hz with a 2 s duty cycle for 30 minutes. All patients continued with standard rehabilitation. **Results:** SCI patients had consistently high thresholds with a reduced CMAP consistent with axonal loss; in some patients, the nerves were completely inexcitable. Excitability studies revealed profound changes in membrane potential, especially in CPN, with a "fanned-in" appearance in threshold electrotonus, consistent with membrane depolarisation, and reduced superexcitability ($p=0.0033$) during the recovery cycle. This was reversed by 6 weeks of PNST, which produced a hyperpolarising effect ($p<0.016$); the contralateral, non-stimulated nerves remained depolarised. **Conclusion:** Short-term PNST ameliorates axonal dysfunction after SCI, providing an opportunity to prevent chronic changes in axonal and muscular function.

POST-STROKE CUTANEOUS AND PROPRIOCEPTIVE SENSORY IMPAIRMENT IDENTIFIED AFTER MODALITY-SPECIFIC STRATIFICATION

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Introduction: Reduced sensation after stroke negatively impacts independence and motor function, yet little is known of long-term changes or the relationship between motor and sensory impairment. **Methods:** Upper-limb cutaneous and proprioceptive sensation of 42 stroke patients was compared to healthy age-matched controls. Cutaneous sensation was quantified at 6 hand sites using von Frey filaments. Proprioception was assessed with passive-wrist and active-elbow position-matching tasks for position-matching and directional error. Motor function was tested with the Fugl-Meyer Assessment, Wolf Motor Function Test, and modified Ashworth Scale. **Results:** Cutaneous sensation was unilaterally impaired on the more-affected side for 36% of patients, and was 10-40% worse compared with healthy subjects depending on the site ($p<0.05$). The prevalence of impairment was only evident after motor stratification, but the magnitude of impairment only apparent after sensory-function stratification. The magnitude and direction of proprioception impairment became evident only after motor-function stratification. Proprioception was bilaterally impaired on the more-affected side for 26-50% of patients and on the less-affected in 14-21%, varying by joint and direction. Patients with low motor-function perceived all positions as more acute than healthy subjects. We hypothesise this reflects increased afferent signalling from hypertonicity of the flexor muscles. Cutaneous sensation was poorer in patients with low motor-function ($p<0.05$), although cutaneous sensation and proprioception error were only weakly related. There was no relationship between Ashworth scores and proprioceptive sensation. **Conclusion**: These results emphasise the prevalence of long-term bilateral proprioceptive and unilateral cutaneous sensory impairments post-stroke. Changes in post-stroke sensation may be significantly underestimated without modality-specific stratification.

LOW INTENSITY MAGNETIC STIMULATION INCREASES NEURAL CIRCUIT REPAIR AND EFFECTS CORTICAL NEURONS IN VITRO

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Introduction: Electromagnetic fields are widely used to non-invasively stimulate the human brain in clinical treatment and research, applying either high-intensity fields (~1 Tesla) in repetitive transcranial magnetic stimulation (rTMS) or low intensity (μT-mT) pulsed magnetic fields (PMFs). While the effect of such stimulation varies according to frequency and intensity, mechanisms called into play by these parameters remain unknown. **Methods:** We investigated the effects of different stimulation frequencies of low intensity PMF (12-14 mT) *in vitro*. We applied PMF to primary cortical cultures for 4 days and assessed survival and morphological changes. To understand underlying mechanisms, we measured intracellular calcium flux during PMF stimulation and changes in gene expression. Further, we investigated the effects of PMF on circuit repair. Organotypic murine hindbrains were stimulated for 2 weeks after cerebellar denervation to assess axonal reinnervation and cell survival. **Results:** We show frequency-specific effects of PMF stimulation. In cortical cultures, simple frequencies (1 Hz, 10 Hz and 100 Hz) impaired single cell survival, while more complex frequencies did not. Moreover, 1 Hz stimulation modified neuronal morphology, inhibiting neurite outgrowth. All frequencies induced calcium release from intracellular stores, with frequency-specific changes in gene expression related to apoptosis and neurite outgrowth.In organotypic hindbrain cultures, stimulation with a complex frequency increases axonal reinnervation, while simple frequencies (1Hz and 10Hz) did not. No frequency affected Purkinje cell survival. **Conclusion:** Our results highlight the biological importance of low intensity PMF stimulation either on its own or as a contributor to the effects of rTMS.

ASSESSMENTS OF FUNCTIONAL MOVEMENT ABILITY DO NOT DETECT IMPROVED MOTOR CONTROL AND JOINT KINEMATICS WITH POST-STROKE REHABILITATION

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Introduction: Changes in post-stroke movement ability are traditionally measured with 1-3 repetitions of fractionated movements using multi-domain hierarchically-structured assessment tools or single attribute tests such as active or passive joint range-of-motion. No single assessment tool can be applied across the spectrum of post-stroke impairment without floor and/or ceiling effects. **Methods**: Twelve hemiparetic stroke patients completed a standardised 14-day Wii-based Movement Therapy protocol. Wireless telemetry was used to record joint kinematics at early-, middle-, and late-therapy during the formal therapy sessions. Electrogoniometers were placed across the shoulder, elbow and thenar interphalangeal joints. Continuously recorded data were analysed for movement duration, excursion, velocity and acceleration and compared to more traditional assessments including: active and passive range-of-motion, Wolf Motor Function Test, upper-limb motor subscale of the Fugl-Meyer Assessment and quality of movement subscale of the Motor Activity Log. **Results**: Maximum movement velocity ($p<0.001$), movement acceleration ($p=0.02$) and deceleration ($p=0.004$) improved at the both shoulder and elbow, and joint excursion at the shoulder ($p=0.002$) but not elbow. Thenar signals were unreliable in this configuration and not analysed. Functional movement improved for Wolf Motor Function Test ($p=0.02$) and Fugl-Meyer Assessment ($p=0.01$) and Motor Activity Log ($p<0.001$). Kinematic changes were not correlated with functional assessments but reflected improved motor control at these joints. By the end of therapy patients could appropriately grade motor output and correct movement errors. **Conclusion**: Our data suggest that traditional assessments of motor function do not adequately capture improvements in functional movement ability, motor control or joint kinematics.

HAND FUNCTION IN HEALTHY OLDER ADULTS AT RISK OF PARKINSON'S DISEASE

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Introduction: In healthy adults, abnormal substantia nigra morphology, viewed with transcranial ultrasound, is a significant risk factor for Parkinson's disease. However, little is known about the movement consequences of the abnormality (termed 'hyperechogenicity'). The aim of this study was to investigate hand function in healthy adults with (SN+) and without (SN-) substantia nigra hyperechogenicity. We hypothesised that during object manipulation, SN+ subjects would exhibit increased grip force, impaired temporal coupling of grip force and lift force, and impaired motor learning compared to SN- subjects. **Methods:** 26 healthy older adults (8 SN+ aged 58±8 yrs, 18 SN- aged 57±6 yrs) were asked to grip and lift a light-weight object (342 g) with the dominant hand. Horizontal grip force, vertical lift force, acceleration, and EMG (first dorsal interosseus) were recorded during three trials. **Results:** During the first trial, SN+ subjects exhibited a longer period between grip onset and lift onset (i.e. preload duration) than SN- subjects (P=0.046). SN+ subjects also exerted a greater downward force prior to lift off (P=0.005) and used a greater grip force to lift the object (P=0.022) than SN- subjects. No between group differences were observed in subsequent trials. **Conclusion:** The results indicate that SN+ subjects' exhibit impaired planning for manipulation of new objects. SN+ individuals over-estimate the amount of grip force required, despite a prolonged contact period prior to lifting the object. The pattern of impairment observed in SN+ individuals share similarities to newly diagnosed and not yet medicated Parkinson's disease patients.

MORE IS BETTER:
AN INCREASED NUMBER OF PAIRED CONDITIONING STIMULI ENHANCES SYNAPTIC PLASTICITY IN THE HUMAN CORTICOSPINAL PATHWAY

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Introduction: Spike-timing-dependent-plasticity (STDP) is induced by repeated pairs of pre and postsynaptic stimuli. In humans, repeated pairing of descending volleys in corticospinal neurones with antidromic volleys in motoneurones alters motor responses consistent with STDP at corticospinal-motoneuronal synapses in able-bodied and spinal cord injured subjects (1, 2). We examined whether additional conditioning stimuli induced additional facilitation of responses. **Methods:** Transcranial magnetic stimulation (TMS) over motor cortex elicited volleys in corticospinal axons and electrical stimulation at brachial plexus activated motoneurones antidromically. Stimuli were paired so that presynaptic volleys arrived at synapses just prior to antidromic postsynaptic potentials, at an interval which produced facilitation. Able-bodied subjects (n=10) completed 4 conditioning protocols on 4 days: 50 paired stimuli (0.1 Hz), 100 pairs, two blocks of 50 pairs (15 min apart), and 50 unpaired TMS. Biceps EMG responses to cervicomedullary stimulation (cervicomedullary motor evoked potentials, CMEPs) were recorded before and for one hour after conditioning. **Results:** Areas of CMEPs were compared across protocols. Two-way repeated measures ANOVA showed significant main effects of conditioning protocol ($F_{(3,27)}$=3.61, p=0.026) and time ($F_{(1.9,17.22)}$=3.77, p=0.046) and a significant interaction between conditioning protocol and time ($F_{(21,189)}$=1.682, p=0.036). Contrasts revealed that both the spaced ($F_{(1,9)}$=5.89 , p=0.038) and 100-pair protocol ($F_{(1,9)}$=7.59, p=0.022), but not the 50-pair protocol, induced significant increases in CMEPs in comparison to TMS alone. **Conclusion:** Our data indicate that an increased number of stimulus pairs during conditioning induces more reliable facilitation at corticospinal-motoneuronal synapses.

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DESIGN AND EVALUATION OF RODENT TMS COILS

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Introduction: The mechanisms underlying cortical plasticity induced by focal transcranial magnetic stimulation (TMS) remains unknown. Rodent models can be useful in establishing structural and molecular mechanisms associated with cortical plasticity. However, focal stimulation is not possible in rodents due to large coil to brain size ratios. Here we describe two TMS coils designed for focal rodent stimulation. **Methods**: Two circular coils were designed and constructed with the same windings and dimensions (8 mm outer diameter), but with either a pure iron or air core. Custom biphasic waves were delivered to the coils, and the resulting magnetic field strength measured (XY and Z axes) using a Hall Effect probe. Coil efficacy was tested by stimulating the motor cortex and cervical spinal cord of anaesthetised mice. **Results**: The iron core gave a stronger magnetic field at the expense of decreased focality compared to the air core. Peak magnetic field strength for the air and iron cores were 90mT and 120mT respectively. Half-maximum field occurred at ~1.2mm$_{z\ axis,}$ ~3.5mm$_{xy\ axis}$ (air core) and ~2mm$_{z\ axis}$, ~4mm$_{xy\ axis}$ (iron core). Stimulation to the motor cortex or cervical spinal cord of mice evoked hind limb muscle contractions.
Conclusion: The coils are effective in a rodent model, and provide the opportunity to investigate the mechanisms underlying TMS neuromodulation in an experimental setting.

ARE MOTOR EVOKED POTENTIALS NECESSARY TO PREDICT MOTOR RECOVERY AFTER STROKE?

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Introduction: The PREP algorithm can be used within days after stroke to predict individual recovery of upper limb function at 3 months. PREP (Predict REcovery Potential) involves the sequential use of clinical assessments, motor evoked potentials (MEPs) from transcranial magnetic stimulation (TMS), and diffusion-weighted (DW-) MRI to determine fractional anisotropy (FA) of the posterior limbs of the internal capsules. The positive predictive power of PREP is good, however the use of TMS is a perceived barrier to clinical translation. Our aim was to determine if clinical assessments alone, or tractography of corticospinal (CST) and cortico-rubral pathways (CRP) would improve PREP's positive predictive power, and potentially negate the use of TMS. **Methods**: 57 patients after first ever monohemispheric ischemic stroke were clinically assessed within 72 hours, motor evoked potentials (MEPs) from TMS obtained at 5 days, and DW-MRI obtained within 10 days. Assessments were repeated at 2, 6, 12 and 26 weeks. **Results**: The PREP algorithm rarely overestimates an individual's prognosis. A simple model of proportional recovery could accurately predict impairment outcomes for many patients with MEPs, but it could not resolve uncertainty for those without. In several cases results from tractography were unable to resolve uncertainty related to the presence or absence of MEPs. These results indicate that MEPs provide more salient prediction of recovery of upper limb function than is possible with clinical assessments alone, or with addition of fine-grained analyses from DW-MRI. **Conclusion**: The results confirm the essential role for TMS in predicting motor recovery for individual patients.

THE ROLE OF PRIMARY MOTOR CORTEX INHIBITION DURING MOTOR SKILL LEARNING

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Introduction: Motor learning requires practice over a period of time and depends on brain plasticity. Magnetic resonance spectroscopy studies indicate a reduction of gamma-aminobutyric acid (GABA) concentration in primary motor cortex (M1) that relates to motor learning. Our hypothesis was that a repetitive practice structure would be more strongly associated with putative synaptic and extrasynaptic GABA within M1 compared to an interleaved schedule which is known to engage a wider prefrontal cortical network. **Methods:** Transcranial magnetic stimulation (TMS) was used to assess corticomotor excitability and short intracortical inhibition (SICI) at two interstimulus intervals (ISIs), 1 ms and 2.5 ms. Participants learned a novel sequential pinch-grip task on a computer in either a repetitive (n=12) or interleaved (n=12) practice structure. TMS was delivered after sequence appearance but at least 1 s prior to movement onset on each trial. **Results:** Both practice structures showed equivalent levels of force control at the end of the acquisition session, but the interleaved group made more sequence errors at the start of practice. Repetitive practice elicited a greater reduction of SICI from rest to task, compared to interleaved practice. This release of inhibition was seen independent of ISI. **Conclusion:** Here we present novel findings of a task-related modulation of 1ms SICI associated with motor learning. A repetitive practice structure for motor learning effectively reduces tonic inhibition in primary motor cortex. This may have relevance for rehabilitation after brain injury given that reducing tonic inhibition is associated with enhanced use-dependent plasticity.

ADHD CHILDREN MANIPULATE NEW OBJECTS DIFFERENTLY TO HEALTHY CHILDREN

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Introduction: Children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) have a higher incidence of coordination disorders. However, few studies have examined movement in ADHD children or the role of stimulant medication. The aim of the current study was to investigate hand function in children with ADHD. We hypothesised that children with ADHD exhibit altered movement while gripping and lifting a novel object compared to healthy children. **Methods:** ADHD children with a history of psychostimulant medication use (n=19, aged 12±3 yrs) and healthy age- and gender-matched controls (n=22, aged 12±2 yrs) were asked to grip and lift a test object (342 g) with their dominant hand (pinch grip). Grip force, lift force, and acceleration were measured during the task and no practice was allowed. Maximal pinch grip force was then measured during 3 maximal voluntary pinch contractions (MVCs). **Results:** ADHD children used a significantly smaller grip force to lift the object (20.5±5.1% MVC) compared to controls (29.7±19.1% MVC; P=0.049). However, the groups did not differ in preload duration (time between grip onset and lift onset), temporal coupling between grip force and lift force, rate of force application, or strength (MVC force). **Conclusion:** ADHD children manipulate novel objects with a reduced safety margin for error compared to healthy children. We are currently exploring if the reduced safety margin is associated with ADHD itself or use of psychostimulant medication.

IS HEMISPHERIC BALANCING NECESSARY FOR MOTOR RECOVERY AFTER STROKE?

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Introduction: The prevailing model of motor recovery after stroke is that better recovery is associated with 're-balancing' of asymmetric corticomotor excitability and interhemispheric inhibition between the hemispheres. This model has driven the development of neuromodulation techniques to reduce contralesional excitability and promote recovery. We tested this model by collecting neurophysiological data from patients during the first 6 months post-stroke. **Methods**: TMS was used to elicit MEPs in extensor carpi radialis bilaterally from 46 patients after first ever monohemispheric ischemic stroke. Stimulus response (SR) curves and ipsilateral silent periods (iSPs) were obtained 2, 6, 12 and 26 weeks after stroke. The slope of each SR curve was calculated as a measure of corticomotor excitability. The persistence and depth of iSPs were determined as measures of interhemispheric inhibition. An asymmetry index for RMT and corticomotor excitability was calculated for each time point. **Results**: RMT became more symmetrical over time ($p < 0.001$), due to decreased ipsilesional RMT ($p < 0.001$), with no effect of time on contralesional RMT ($p > 0.5$). Corticomotor excitability became more symmetrical over time ($p = 0.001$), due to increased ipsilesional excitability ($p = 0.008$), with no effect of time on contralesional excitability ($p > 0.2$). There were no effects of time or hemisphere on ipsilateral silent period persistence (both $p > 0.3$) or depth (both $p > 0.1$). **Conclusion**: These findings call into question strategies aimed at suppressing contralesional corticomotor excitability to promote recovery of motor function, particularly in the first few months after stroke.

SYNCHRONIZATION OF FINGER TAPS TO ISOCHRONOUS BEATS: A MAGNETOENCEPHALOGRAPHY STUDY USING DYNAMIC CAUSAL MODELLING

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Introduction: Being able to time motor outputs so that they conform to an external rhythm requires the interaction of a number of brain areas including those involved in the reception of external stimuli, mental timekeeping and in the control of motor output. There is also the need for top-down cognitive control over the process. Both TMS and fMRI studies have provided indirect evidence to support the role of the prefrontal cortex in exerting this top-down influence over lower-level sensory and motor regions during rhythmic timing tasks. We hypothesize that the inferior frontal gyrus is a locus of control that is integral to the control of rhythmic synchronization processes. **Methods:** We use Dynamic Causal Modeling (DCM) of highly time-resolved magnetoencephalographic (MEG) data recorded during a rhythmic unimanual, auditory-paced finger-tapping task in a cohort of healthy adults to extend the current models of neural control of this process to include the inferior frontal gyri. The brain regions examined were organized into a network of excitatory connections between bilateral inferior frontal gyri, (IFG) motor and auditory cortices, cerebellum and basal ganglia. **Results:** Our results show that a DCM that includes IFG is better at explaining the pattern of neural activation during rhythmic synchronization than the canonical (Goldberg, 1985) model. Furthermore, including subcortical sources further enhances model evidence, demonstrating the utility of including so-called 'hidden sources' in DCMs of MEG data. **Conclusion:** DCM of MEG data recorded during rhythmic synchronization provides compelling evidence for an integral role of the IFG in this motor task.

HAS INTERPRETATION OF THE MOTOR ADAPTATION TO PAIN BEEN TOO SIMPLISTIC?

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Introduction: During pain it is proposed the nervous system searches for less painful movement strategies. We investigated whether participants searched for a new, less painful movement strategy during acute experimental pain. **Methods:** In 3 experiments (Exp), participants performed 2 trials of 60 radial-ulnar wrist movements between two target regions. Wrist 3D-motion was recorded. In all experiments variation in flexion-extension angle range during the task was determined in trial 1. For Exp1-trial2, the control condition was repeated. For Exp2-trial2 and Exp3-trial2 wrist extensor muscle pain was induced by electrical stimulation when the wrist crossed neutral. Stimulation intensity was determined by wrist flexion-extension angle. Exp2 – painful stimulation (~5/10) for two-thirds flexion-extension range, and less painful (~1/10) for one-third. Exp3 – painful stimulation (~5/10) for two-thirds flexion-extension range and no pain for one-third. The proportion of movements performed in the less/non-painful flexion-extension angle was recorded. Vector lengths between average wrist-angle of trial1 and wrist-angle for each repetition of trial2 quantified change in wrist-angles relative to baseline. Vectors were summed (*Total vector length*). **Results:** *Total vector length* was greater (Exp2; $p=0.03$) or tended to be greater (Exp3; $p=0.08$) during pain indicating a change in movement strategy. Although the new wrist-angle was perceived as less painful, this did not correspond to the region with less intense stimulation. The less/non-painful region was not used more often in Exp3 ($p=0.90$) and even used less in Exp2 ($P<0.03$). **Conclusion:** A less painful strategy was found, but it was not the solution with complete or near complete pain reduction.

LOW-INTENSITY REPETITIVE TRANSCRANIAL MAGNETIC STIMULATION IMPROVES TOPOGRAPHY IN ABNORMAL VISUAL CORTICAL CIRCUITS AND UPREGULATES BDNF EXPRESSION

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Introduction: Repetitive transcranial magnetic stimulation (rTMS) facilitates plasticity, and shows clinical promise in treating neurological and psychiatric disorders. However, anatomical substrates and molecular mechanisms underlying rTMS effects remain poorly understood. We previously showed rTMS removes abnormal projections in a subcortical visual pathway of ephrin-A2A5$^{-/-}$ mice, a model of abnormal circuitry. However, clinically, rTMS is largely restricted to cortical regions, therefore it is important to establish whether rTMS also affects abnormal cortical projections. **Methods:** We compared rTMS effects on normal (wildtype; WT;n=14) and abnormal (ephrin-A2A5$^{-/-}$;n=16) corticotectal circuits. Mice received rTMS or sham (control) daily for 14 days. To visualize projections, fluorojade and fluororuby were injected into visual cortex. Mice were euthanized, brains cryosectioned, injection site and axon terminal-zone (TZ) locations measured. TZs were quantified as normal or abnormal by comparing actual location to that predicted by injection sites, and ranked within each mouse. We also measured brain derived neurotrophic factor (BDNF) in visual cortex and superior colliculus (SC) after single and multiple stimulations. **Results:** rTMS significantly improved topography in the most disordered TZs in ephrin-A2A5$^{-/-}$ mice, without altering topographically normal TZs in ephrin-A2A5$^{-/-}$ or WT mice. BDNF levels significantly increased after a single stimulation for all groups, but only ephrin-A2A5$^{-/-}$ mice maintained increases in the SC at 14 days. **Conclusion:** Results suggest rTMS upregulates BDNF, maintaining a plastic environment conducive to beneficial reorganisation of abnormal connections. We provide the first direct evidence of cortical reorganisation and increase understanding of mechanisms underlying rTMS effects, an essential step towards optimizing its clinical use.

THE EFFECT OF ACUTE AEROBIC EXERCISE ON EXCITABILITY AND PLASTICITY IN THE MOTOR CORTEX

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Introduction: A single session of exercise is capable of exerting a range of effects on the brain. Many of these effects are likely to involve changes in synaptic plasticity. Synaptic plasticity can be assessed in conscious humans using transcranial magnetic stimulation (TMS). This study aimed to determine whether an acute bout of aerobic exercise would affect TMS-induced synaptic plasticity and whether these effects would be related to brain-derived neurotrophic factor (BDNF) and/or cortisol. **Methods**: The study involved a randomised cross-over design with participants (n=10 males) serving as their own controls. The exercise session consisted of 30-mins of recumbent cycling at 60% of estimated heart rate reserve, while for the control session heart-rate was kept within 5-10 beats of the resting value for 30-mins of slow cycling. Motor evoked potential (MEP) amplitude from the first dorsal interosseous (FDI) muscle was measured before and after cycling, as were salivary cortisol concentrations and plasma BDNF concentration (in n=5). Cortical plasticity was assessed by the increase in MEP amplitude during a 15-min paired-pulse I-wave TMS (ITMS) intervention that was started 10-mins post-cycling. **Results**: There were no significant differences in MEP amplitude within or between sessions. BDNF and cortisol concentrations increased during the exercise but not the control session. There was a non-significant trend for an increase in MEP amplitude during the post-control ITMS session, however this was not the case post-exercise. **Conclusion**: This acute bout of aerobic exercise did not increase cortical plasticity, and may instead have had a post-exercise suppressive effect.

HAND FUNCTION IS ALTERED IN INDIVIDUALS WITH A HISTORY OF ILLICT STIMULANT USE.

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Introduction: Use of illicit stimulant drugs such as ecstasy, methamphetamine, and cocaine are a significant worldwide problem. However, little is known about the effect of these drugs on movement. The aim of the study was to investigate hand function in individuals with a history of illicit stimulant use. We hypothesized that prior use of illicit stimulant drugs is associated with abnormal manipulation of objects. **Methods:** The study involved 24 adults with a history of illicit stimulant use (aged 28±8 yrs; time since last use: 1.7±3.9 yrs) and 2 control groups comprising 24 non-drug users (aged 25±8 yrs) and 9 cannabis users with no history of stimulant use (aged 21±3 yrs). Each subject completed screening tests (lifetime drug history questionnaire, medical history questionnaire, urine drug screen, and neuropsychological assessment) prior to gripping and lifting a light-weight object with the dominant right hand. Grip force, lift force, acceleration, and electromyographic activity (EMG) of the first dorsal interosseus were recorded during 3 trials. **Results:** In trial 1, peak grip force was significantly greater in the stimulant group (12.4±4.7 N) than in the control groups (non-drug: 10.1±4.6 N; cannabis: 8.4±2.1 N, P=0.035). However, peak grip force did not differ between groups in trials 2 and 3. **Conclusion:** The results suggest that individuals with a history of stimulant use overestimate the grip force required to manipulate a novel object but, are able to adapt grip force in subsequent lifts. The results suggest that movement dysfunction may be an unrecognized consequence of illicit stimulant use.

THE ASSOCIATION BETWEEN NECK PAIN AND INJURY AND ERRORS IN LIMB POSITION SENSE AND MOVEMENT; SYSTEMATIC LITERATURE REVIEW.

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Introduction: One of the complications from neck pain and injury, including Whiplash Associated Disorders reported in the literature is clumsiness. Objectives of this review were to (i) collect definitions, (ii) determine frequency of occurrence, (iii) assess the role of the neck in clumsiness/joint position error in the upper and lower limb, and (iv) assess the association between the role of pain signals and abnormal sensory input from the neck in kinesthesia changes. **Methods:** Six electronic databases were systematically searched, followed by a manual search with retrieved paper's titles and abstracts reviewed independently. Selection criteria comprised papers including neck pain/injury/Whiplash Associated Disorder/healthy and extremity joint position sense or kinesthesia. Seventeen papers were retrieved and assessed. Heterogenity in designs of studies prevented pooling of data, so qualitative analysis was undertaken. Risk of bias assessment was carried out independently. **Results:** Proprioceptive inputs from the neck and orbital eye position play an important role in contributing to the internal reference frame of the body. Changes in these inputs result in altered acuity of arm position sense that may be measured as joint position error. **Conclusion:** Future studies are planned to manipulate dorsal neck afferent inputs systematically and in isolation from vestibular and visual inputs, taking into account the effects of gaze to better understand their contribution to upper limb kinesthesia.

EXPERIMENTAL PAIN INFLUENCES THE PERCEPTION OF ACTION CAPABILITIES AND PERFORMANCE OF A MAXIMAL SINGLE LEG HOP

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Introduction: Healthy humans accurately perceive their physical capabilities for tasks such as reaching, stair climbing and jumping. Changes in an individual's state, e.g. anxiety, are associated with altered perception of action capabilities. Motor performance is altered during both acute and chronic pain, but, it is unclear if the individual in pain accurately perceives this change in performance capability. If not, the individual with pain could overestimate their physical capabilities (i.e. if function is reduced but perception in performance capability is not), or they may underestimate their physical capabilities/overestimate the physical cost of performing a task and reduce movement/physical activity. This study aimed to determine the effect of acute experimental pain on perception of action capabilities and performance of a dynamic motor task. **Methods:** Performance estimates and actual performance of maximal single leg hops were recorded for both legs in 13 healthy participants before, during and after an episode of acute pain induced by an injection of hypertonic saline into vastus lateralis muscle of one leg (side counterbalanced between participants). **Results:** Both estimation of performance and actual performance were smaller ($p<0.01$) during pain, than before and after pain. This decrease in estimation and performance during pain was apparent for hops using either leg, but was greater ($p<0.01$) for the painful (-10.8±12.1 cm) than control leg (-5.5±7.9 cm). **Conclusion:** Participants accurately estimated their performance in all conditions for both legs. The results provide evidence that healthy participants have the ability to maintain the relationship between perception and ability during acute pain.

REORGANISATION OF THE PRIMARY MOTOR CORTEX IN AMPUTEES UNDERTAKING PROSTHETIC REHABILITATION

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Introduction: There is some evidence suggesting bilateral reorganisation of the primary motor cortex (M1) occurs following unilateral lower-limb amputation. The objectives of this study were to use transcranial magnetic stimulation (TMS) to determine intracortical excitability of M1 bilaterally in sub-acute unilateral lower-limb amputees completing rehabilitation, and determine if intracortical excitability measures were associated with functional outcomes. **Methods**: Eleven sub-acute amputees admitted for rehabilitation were recruited. TMS was utilised to evoke contralateral MEPs in both the amputated limb (AL) and non-amputated limb (NAL) quadriceps muscles. Short-latency intracortical inhibition (SICI) was assessed in each hemisphere at both the time of prosthetic casting and at discharge. Temporal-spatial gait parameters were assessed using a GAITRite mat at discharge. Step-time variability was the primary gait outcome measure (greater variability indicates poor function). Paired t-tests assessed changes in SICI between sessions for each M1. Linear regression models controlling for age and stump-length assessed relationships between SICI and step-time variability. **Results**: SICI significantly reduced by discharge in M1 ipsilateral to AL ($t_{(10)}$=2.3, p=0.04), but not contralateral to AL (p=0.56). Dis-inhibition of M1 ipsilateral to AL at prosthetic casting was associated with greater step-time variability on the AL (R^2=0.79, p=0.03) and NAL (R^2=0.56, p=0.02). **Conclusion**: Dis-inhibition of M1 ipsilateral to the AL at prosthetic casting may be a predictor of poor functional outcomes. Neurophysiological interventions may be required prior to provision of prosthesis to ensure optimal function at discharge. Further research should be conducted to determine how cortical reorganisation of M1 ipsilateral to the AL affects functional outcomes.

HAND REPRESENTATION VS. OBJECT PERCEPTION: DOES BODY IMAGE CHANGE WITH WHAT WE LIFT?

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Introduction: Accurate proprioceptive information and body representation are required to accomplish even simple tasks, such as lifting a cup. However it is unclear whether the properties of lifted objects affect the internal 'representation' of the hand involved in the task. Specifically, is perceived grasp aperture influenced by the size and weight of lifted objects?
Method: Vision was excluded in all experiments. In experiment 1, subjects reported the perceived weight of lifted canisters that were of different sizes (5.2, 6.6, 10cm width) but of the same weight (0.6kg). In experiment 2, subjects reported perceived grasp aperture while lifting canisters that were of the same size (width 6.6cm) but of varied weights (0.3, 0.6, 0.9, 1.2kg). In experiment 3, subjects reported perceived grasp aperture as they grasped a stationary canister at varied force levels.
Results: When canisters of the same weight but different widths were lifted, perceived weight decreased by 42% from the narrowest to the widest ($p<0.001$). When canisters of the same width but different weights were lifted, perceived grasp aperture decreased ~5% across the range of weights ($p<0.001$). In experiment 3, perceived grasp aperture did not change with the level of grasp force. **Conclusions:** The effect of object properties on hand representation was much smaller than its effect on weight perception. This small effect is not the result of varied grasp forces. Overall, despite a distorted perception of external objects, the central nervous system maintains quite an accurate internal representation of the hand over a range of object weights.

NEURAL CORRELATES OF AGE-RELATED CHANGES IN MOTOR FUNCTION

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Introduction: Our recent research has focused on the role of facilitatory and inhibitory mechanisms in the learning and performance of simple and complex motor tasks. A particular interest of our lab has been how healthy ageing affects motor performance, and how brain activation patterns in simple tasks can change as a function of age. Here we provide an overview of the recent experimental findings.

Methods: A number of motor task paradigms have been employed from bimanual circling, simple reaction time tasks, choice reaction time tasks and Go-NoGo paradigms. Transcranial Magnetic Stimulation (TMS) is used to assess motor cortex excitability and inhibition (both intracortical inhibition and interhemispheric inhibition between motor and premotor regions) during motor preparation and execution. Virtual lesion approaches (short trains of rTMS) are then used to disrupt cortical function and assess causality.

Results: A general finding is that those older adults who are unable to functionally modulate cortical excitability and inhibition are those ones which exhibit the greatest degradation of task performance. Healthy ageing also appears to involve a greater reliance on premotor regions during motor tasks, even during seemingly simple tasks which would not be expected to involve a high degree of cognitive input.

Discussion: We discuss how the recent findings can be applied in the context of motor training and recovery, for example following stroke or traumatic injury.

THETA-BURST STIMULATION TO CEREBELLUM IN CERVICAL DYSTONIA: A SHAM-CONTROLLED CLINICAL TRIAL

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Introduction: There is emerging evidence for involvement of the cerebellum in the pathophysiology of cervical dystonia and the cerebellum may provide a novel target for non-invasive stimulation. This ongoing study aims to assess effects of intermittent theta-burst stimulation (iTBS) of the cerebellum compared to sham stimulation to assess the potential of iTBS as a treatment intervention. Intermittent TBS is followed by motor and cognitive training tasks at each intervention session. **Methods:** Transcranial magnetic stimulation (TMS) is used to assess motor-evoked potentials (MEPs) recorded from the sterno-cleido-mastoid (SCM) and upper trapezius (UT) muscles contralateral and ipsilateral to the direction of head rotation for each participant. Quality of life and dystonia severity are assessed using dystonia specific questionnaires (CDQ24, TWSTRS). Assessments are conducted pre intervention, after five and after ten intervention sessions. Participants are randomised into real or sham TBS groups and both participants and outcome assessors are blinded to group allocation. The intervention, real or sham iTBS, is delivered by an independent investigator at a similar time of the day for ten consecutive working days. **Results:** Eleven participants have completed the trial to date (6 iTBS, 5 sham). Preliminary assessment of MEPs in all participants prior to randomisation revealed greater corticomotor excitability in the contralateral than ipsilateral SCM ($P = 0.014$). There was no difference between sides for the UT ($P = 0.33$). Group comparison does not reveal statistically significant differences at this early stage of the study, although trends for differential effects of iTBS and sham stimulation on MEPs are notable for each muscle. There was no difference between the two groups for overall TWSTRS scores. However, for the pain subsection of the TWSTRS scale there was a reduction in pain after iTBS compared to sham stimulation at both mid ($P = 0.004$) and final assessments ($P = 0.003$). There was a trend toward a lower CDQ24 score, indicating better quality of life, at the mid-way point ($P = 0.08$). **Conclusion:** There is potential for iTBS to provide a novel treatment intervention for people with cervical dystonia. In particular, iTBS may reduce pain associated with cervical dystonia. Our 4 and 12 week follow up assessments will indicate if this improvement is sustained beyond the treatment period.

THE INFLUENCE OF CORTICAL ALPHA OSCILLATORY ACTIVITY ON MOTOR CORTICAL EXCITABILITY AND PLASTICITY INDUCTION

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Introduction: Alpha oscillations (8-12 Hz) might reflect bouts of cortical inhibition. If inhibitory tone is reduced during particular phases of the oscillation, then phase-dependent application of plasticity-inducing protocols, such as theta-burst stimulation (TBS), might lead to less variable, longer-lasting plasticity responses. We have previously shown that motor evoked potentials (MEPs), evoked by single-pulse transcranial magnetic stimulation (TMS), are larger during the down-going than the up-going phase of the endogenous alpha oscillation. Technical difficulties prevent the application of TBS on different phases of the endogenous alpha oscillation, therefore, we used transcranial alternating current stimulation (tACS) to *entrain* the alpha oscillation and applied continuous TBS (cTBS) on the down- and up-going phases of the applied alternating current. **Methods**: tACS (10 Hz sinusoidal) and cTBS were applied simultaneously for 40-seconds, with cTBS bursts triggered on either the down-going or up-going phase of the applied alternating current. MEPs were recorded at baseline and several time-points following tACS-cTBS application. **Results**: Repeated-measures ANOVA showed no significant interaction between phase and time suggesting that application of cTBS on the down-going and up-going phases of the applied alternating current did not differentially affect plasticity responses to cTBS. **Conclusion**: This finding suggests that application of plasticity-inducing protocols on different phases of an entrained alpha oscillation does not lead to less variable plasticity responses. It is possible that [1] 40-seconds of tACS is not sufficient to entrain the alpha oscillation or [2] bouts of cortical inhibition evident with endogenous alpha oscillations are not evident in tACS-entrained oscillations.

DECODING STATIC HAND POSITIONS FROM HUMAN BRAIN ACTIVITY

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Introduction: The brain uses a range of afferent proprioceptive signals to produce accurate movements. However, it is unknown how these signals are integrated and applied. In this study, we investigated how the brain monitors the current position of the hand after passive movements. **Methods**: Participants (n=13) were lying in a magnetic resonance imaging (MRI) camera (3T Philips). They were asked to stay relaxed and attend to the position of their left hand, while it was moved passively into different positions (~20° flexion, ~20° extension, and neutral). The functional MRI data were pre-processed using SPM8. We then applied a multi-voxel pattern analysis (MVPA; LIBSVM implementation) to decode the position of the hand (flexion vs. extension) for the whole brain ($p<0.05$ corrected for multiple comparisons using family-wise error rate, FWE). We also performed small-volume corrections (SVC; $p<0.05$ FWE) in regions of interest derived from the literature (on proprioceptive coding in terms of a kinaesthetic illusion). **Results**: Hand position could be decoded from multiple brain regions. In the contralateral (right) sensorimotor cortex, we found three significant clusters (whole-brain peak at MNI 38 -29 50; SVC peaks at 26 -27 64 and 48 -27 44). Furthermore, we found significant peaks in the right parietal operculum (corresponding to the secondary somatosensory cortex), the supplementary motor area, and the right inferior frontal cluster (Area 44). **Conclusion**: Passive changes in hand position modulate the patterns of cortical activation in several areas, such that the position of the hand can be decoded from activity in these regions.

CORTICAL INHIBITION MEASURED FROM MOTOR AND NON-MOTOR REGIONS USING COMBINED TMS-EEG.

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Introduction: Single-pulse transcranial magnetic stimulation (TMS) evokes multiple cortical potentials (TEPs; P30, N40, N100) in both motor and non-motor regions which can be measured using electroencephalography (EEG). However, the origin of different TEPs remains unclear. We used a paired-pulse long-interval cortical inhibition (LICI) paradigm to assess whether the N100 TEP reflects a cortical inhibitory mechanism. **Methods:** Electromyography (EMG) was recorded from the first dorsal interosseous muscle and EEG was recorded from the scalp. In experiment 1, single and paired (inter-stimulus interval=100 ms; LICI) TMS was given over the motor cortex (n=8). Conditioning intensities (100%, 120%,140% resting motor threshold; RMT) and test intensities (110%, 125%, 140% RMT) were varied between stimulation blocks. Motor evoked potential (MEP) and TEP LICI strength were compared with the slope of the conditioning pulse N100. In experiment 2, single and paired (ISI=100ms) TMS was given over dorsolateral prefrontal cortex (DLPFC; n=30). TEP LICI strength was compared with N100 slope from single-pulse TMS across participants. TEP LICI strength was also correlated with working memory performance. **Results:** Over motor cortex, increasing conditioning intensities increased LICI and increasing test intensities decreased LICI of MEPs and P30 TEPs. The slope of the N100 evoked by the conditioning stimulus correlated with both MEP and P30 LICI strength. Over DLPFC, the slope of the N100 correlated with LICI of N40 across participants. LICI of N100 also positively correlated with working memory performance. **Conclusions:** The N100 represents the mechanism responsible for LICI in both motor and non-motor regions, possibly $GABA_B$-mediated inhibitory neurotransmission.

EXPERIMENTAL KNEE PAIN AND MAXIMAL VOLUNTARY ACTIVATION OF KNEE EXTENSOR MUSCLES

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Introduction: Reduced knee strength has been reported after pain was experimentally induced by injection of hypertonic saline into rectus femoris muscle or the infrapatellar fat pad of healthy individuals. However, recent observations of elbow flexion tasks have failed to demonstrate reduced voluntary activation during painful contractions. To investigate whether the effects of pain on neural drive to a muscle may be voluntarily overcome, we assessed subjects who were familiar with hypertonic saline injections. **Methods**: Maximal isometric knee extensions were performed before, during and after the effects of an injection of hypertonic saline (5%) into the infrapatellar fat pad. Supramaximal electrical stimuli were delivered during and ~4s after contractions using large surface electrodes over the quadriceps muscles. Participants rated pain intensity from 0 to 10 before and during each contraction. Electromyography was recorded from knee extensor and flexor, and hip extensor muscles. **Results**: Preliminary findings (n=4) suggest negligible effects of knee pain on both maximal voluntary force and voluntary activation (~2% change on average). Pain intensity was consistently lower during contractions (0.8) than immediately before (3.5). Increased activity of contralateral knee flexor and hip extensor muscles was observed in some subjects (n=2). **Conclusion**: Although limited in sample size, the current findings indicate that with sufficient encouragement participants with positive pain beliefs are able to generate equivalent force during transient experimental pain, demonstrating no reduction in voluntary activation. A group of naïve subjects will be further assessed. Experimental models to induce pain that is not reduced during contractions may yield different results.

MODULATION OF THE INPUT-OUTPUT PROPERTIES OF THE HUMAN CORTICOSPINAL TRACT FOLLOWING CONTINUOUS THETA BURST STIMULATION OF THE MOTOR CORTEX

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Introduction: The long-term depression-like reduction in corticospinal excitability induced by continuous theta burst stimulation (cTBS) of the human motor cortex can vary considerably between individuals and between studies. This may be related to the methods used to probe excitability changes following cTBS. Whereas most studies use single-pulse transcranial magnetic stimulation (TMS) at single, intermediate test intensities to evoke motor evoked potentials (MEPs) with amplitudes that lie within the linear portion of the sigmoidal input-output curve, it is unclear whether this method is optimal for detecting cTBS-induced after-effects. Therefore, we constructed input-output curves before and following cTBS to determine the range of test intensities that are most sensitive to the effects of cTBS. **Methods:** Single-pulse TMS was applied to the left motor cortex and MEPs were recorded from the right first dorsal interosseous muscle. To construct input-output curves, eight TMS pulses were applied at ten different stimulus intensities between 90% and 180% of resting motor threshold (RMT) in a pseudo-randomised order. Curves were measured five times: twice at baseline and at 0, 15, and 30 min following cTBS. **Results:** There was no effect of cTBS on MEPs evoked using near-threshold stimulus intensities, nor was there a change in MEPs at intermediate stimulus intensities above threshold. However, MEPs evoked using intensities between 150% and 180% RMT (corresponding to the upper end of the sigmoidal input-output curve) were depressed following cTBS. **Conclusion:** These results suggest that test intensities higher than those conventionally used may be required to detect cTBS-induced changes in corticospinal excitability.

AGE-RELATED CHANGES IN PRE- AND POST-SYNAPTIC INTRACORTICAL INHIBITION IN A HUMAN HAND MUSCLE

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Introduction: Previous research has observed changes in short- (SICI) and long-interval intracortical inhibition (LICI) within old adults, but age-related changes in the interaction between these paradigms have not been assessed. SICI-LICI interactions are thought to reflect presynaptic inhibition in motor cortex, which is abnormal in some neurological conditions. The current study therefore investigated age-related changes in the presynaptic modulation of SICI by LICI.

Methods: In 15 young (22.5 ± 3.5 years) and 9 old (74.1 ± 1.5 years) adults, paired-pulse transcranial magnetic stimulation (TMS) was used to measure SICI (2 ms interstimulus interval; ISI) and LICI (100 and 150 ms ISI) in resting first dorsal interosseous muscle, whereas triple-pulse TMS was used to investigate SICI when primed by LICI.

Results: For SICI, no difference was found between young and old subjects. For LICI, measurements using a 100 ms ISI were consistent between groups, whereas those using a 150 ms ISI were significantly reduced in older subjects. For both age groups, SICI was reduced when primed by LICI at both 100 ms and 150 ms. However, old adults showed less reduction in SICI when primed by LICI using a 100 ms ISI compared with young subjects.

Conclusion: Our results support age-related reductions in $GABA_B$ mediated intracortical inhibition within primary motor cortex. Furthermore, these changes are timing dependent, providing further evidence for the independence of LICI when assessed at 100 ms and 150 ms. Age-related changes in SICI-LICI interactions suggest that motor cortex presynaptic inhibition may be altered with healthy ageing.

Identifying walking induced motor fatigue in people with Multiple Sclerosis.

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Introduction: Neurophysiological studies have identified central and peripheral causes of activity-dependent motor fatigue in Multiple Sclerosis (MS). The aim of our research was to identify and measure objective signs of motor fatigue induced by walking that can be used in a clinical setting. **Methods:** Thirty-four people with moderately disabling MS participated in 2 assessment sessions. Each session involved one of two 6-minute conditions: (1) seated rest and (2) six-minute walk test (6MWT). Fatigue, standing postural sway, lower limb strength, simple and choice reaction time and gait were all comprehensively assessed before and after each 6-minute condition. A matched sample of 10 healthy controls also completed the 6MWT protocol.

Results: The 6MWT resulted in a significant increase in perceived fatigue, postural sway, simple and choice reaction time, and reductions in knee extensor and ankle dorsiflexor strength. There were no changes in healthy control subjects. A number of kinematic, kinetic and spatiotemporal gait variables also changed with fatigue.

Conclusion: We have identified a number of fatigue related motor impairments impacting safe mobility in people with MS. We will discuss some clinically useful physiological measures that capture fatigue related motor impairments induced by walking. These have important implications for mobility, fatigue and falls risk.

CAN AEROBIC EXERCISE PROMOTE MOTOR CORTICAL NEUROPLASTICITY?

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Introduction: Regular physical activity is associated with enhanced plasticity in the motor cortex, but does a single session of aerobic exercise promote neuroplasticity? **Methods:** We performed a randomised, within-participant experimental study. Twenty-five (16 F) healthy, moderately active adults completed three experimental sessions during which they cycled on a stationary bike at a workload equivalent to 57% (low intensity, 30 mins), 77% age-predicted maximal heart rate (moderate intensity, 15 minutes), and a seated control condition. Cortical excitability was examined each session using transcranial magnetic stimulation to elicit motor evoked potentials in the right first dorsal interosseus muscle. Levels of serum brain-derived neurotrophic factor and cortisol were assessed throughout the experiments. Neuroplasticity within the primary motor cortex was then examined using a continuous Theta Burst Stimulation paradigm. **Results:** Exercise did not alter cortical excitability. Following continuous Theta Burst Stimulation, there was a transient inhibition of motor evoked potentials during control and low intensity conditions but this was only significantly different following the low intensity state ($p = 0.02$). Moderate intensity exercise alone increased serum cortisol levels, but brain-derived neurotrophic factor levels did not increase across any condition. **Conclusion:** Low intensity lower limb cycling promoted the neuroplastic response to continuous Theta Burst Stimulation within the hand area of the motor cortex of healthy adults. These findings suggest that light exercise may be used to prime the brain, or promote widespread changes in the motor cortex and enhance the effectiveness of motor learning or recovery following brain damage.

MOTOR CONTROL STRATEGIES ASSOCIATED WITH POSTURAL REACTIONS TO EXTERNAL PERTURBATIONS IN PEOPLE POST-STROKE

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Introduction: Ankle plantarflexor muscles are essential for balance in standing. This research aims to describe how impairment of plantarflexors after stroke impacts the motor response to external perturbations in standing. **Methods**: Participants post-stroke and age-matched controls stood with feet on separate force-platforms during 2 external-perturbation paradigms; 1) anteriorly-directed loads of 2% body weight (BW) which were either investigator- or participant-triggered and, 2) loads of 1% BW applied every 20-30sec until a total of 5% BW was maintained. High-density surface electromyography (EMG) of the plantarflexors (soleus (SOL), medial (MG) and lateral (LG) gastrocnemius), electrodermal activity (EDA; measurement of physiological arousal) and anterio-posterior center of pressure (AP-CP) measurements were taken. **Results**: Participants post-stroke demonstrated significantly higher anticipatory plantarflexor EMG amplitude and EDA levels than controls and maintained higher EDA levels during self-triggered perturbations, whereas controls were lower. AP-CP excursion was lower post-perturbation in people post-stroke than controls. While there was no difference between legs of controls; post-stroke, the non-paretic MG and LG were significantly more correlated with the AP-CP compared to the paretic at low loads (1-2%BW), but not with higher loads (3-5%BW). **Conclusions**: Higher levels of physiological arousal post-stroke, accompanied more anticipatory plantarflexor activation and decreased CP excursion suggesting a bracing strategy. With increasing levels of perturbation, the correlation of the EMG with the CP excursion increased in the paretic leg to become more similar to the non-paretic leg, suggesting a benefit to increasing the challenge of balancing tasks in rehabilitation.

REAL-TIME CONTINUOUS ESTIMATES OF MANIPULATION FORCE PARAMETERS DERIVED FROM MONKEY FINGERTIP AFFERENT RESPONSES

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Introduction: Dexterous manipulation of objects essentially relies on sensory information about object properties and manipulative forces. However, it has not been demonstrated how sensory information could be extracted from the responses of fingertip tactile afferents in a real-time fashion without knowledge of stimulus onset times or combinations of different concurrent stimulus parameters used. **Methods**: To achieve this, a multiple regression model was developed to concurrently estimate instantaneous normal force (1.8, 2.2 and 2.5 N) and torque magnitude (0, 2.0 and 3.5 mNm) applied to the monkey fingertips. The regression model inputs were sliding 200 ms time windows of binned spike counts from each tactile afferent. Leave-one-out cross validation was used to measure model performance. **Results**: Using responses from 58 SA-I and 25 FA-I afferents as model inputs, the mean estimate error for normal force was -0.0029 N (SD 0.1323), and the torque magnitude mean estimate error was 0.0015 mNm (SD 0.3768). Using responses of only 58 SA-I afferents as model inputs, the mean normal force estimate error was -0.0035 N (SD 0.1542), and the mean estimate error for torque magnitude was -0.0029 mNm (SD 0.4092). There was no significant difference in estimate error (one-way ANOVA, $p>0.05$) using responses of both afferent types compared to using responses of only SA-I afferents indicating that FA-I afferent contribution in this model was negligible. **Conclusion**: This study demonstrated that decoding of tactile afferent responses could be achieved in real-time with no a priori information about stimulus onset time and presence of multiple stimulus parameters.

MEASURING DEXTERITY IN PODIATRISTS: A COMPARISON OF NOVICE AND EXPERIENCED PODIATRISTS

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Background

Podiatry is a profession requiring high levels of dexterity. There are numerous methods of evaluating dexterity; few have been used to specifically evaluate the Podiatric profession. The intention of this study was to use a number of dexterity tests to evaluate whether they could discriminate between novice Podiatry students and experienced Podiatrists

Methodology

Novice students without any scalpel experience were recruited from two Universities together with Podiatrists with a minimum of two years clinical experience. Professional musicians or anyone with a condition affecting hand function were excluded.

Participants were required to complete a battery of dexterity related tests including the grooved pegboard test, tremor, finger-tapping, a visuomotor tracking task, grip-lift task, pinch grip strength, grip strength and a test of sensory discrimination.

Results

From the battery, four test outcomes showed a significant difference; this was consistent for both dominant and non-dominant hands and included the Grooved Pegboard test ($F(1) = 6.175$, $p=.015$ and $F(1) = 6.211$, $p=.014$), Preload duration from the Grip-lift task ($F(1) = 12.568$, $p=.001$and $F(1) = 11.41$, $p=.001$) , Pinch grip strength ($F(1) = 4.393$, $p=.039$ and $F(1) = 8.144$, $p=.005$) and Grip strength ($F(1) = 8.061$, $p=.005$ and $F(1) = 7.068$, $p=.009$). From these tests, the two strength tests were subject to gender effects.

Conclusion

Dexterity tests such as the Grooved Pegboard test and a Grip-lift task may be suitable to distinguish between novice students and expert Podiatrists, be useful in assessing dextrous ability and improvements in that ability and provide the first piece of evidence of task-related training for dexterity within the podiatry field.

KNEE JOINT TAPING IMPROVES PROPRIOCEPTIVE ACUITY AT THE KNEE AND IMPROVES GAIT IN HUMANS DEVOID OF MUSCLE SPINDLES

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Introduction: Hereditary sensory and autonomic neuropathy type III features disturbed proprioception and a marked ataxic gait; joint angle matching error is positively correlated with the degree of ataxia. We recently showed that these patients lack functional muscle spindle afferents but preserved large-diameter cutaneous afferents, suggesting that patients with better proprioception may be relying on proprioceptive cues provided by tactile afferents. We tested the hypothesis that enhancing cutaneous sensory feedback by stretching the skin at the knee joint using unidirectional elasticity tape (kinesiology tape) could improve proprioceptive accuracy and gait. **Methods:** Proprioceptive acuity at the knee joint was measured in 18 patients with HSAN III and 14 age-matched control subjects during passive dorsiflexion and plantarflexion of the knee joint with and without taping. Knee joint positions relative to one another were recorded on digital inclinometers. Tape was applied bilaterally to the knees in an X-shaped pattern. **Results:** Patients with HSAN III performed poorly on the joint angle-matching test (mean joint matching error±SE 8.6±1.1°, controls 3.0±0.3°). With taping, proprioceptive accuracy was significantly better (mean error: 5.7±0.9°), improving 36% compared to the pre-taping condition. Gait analysis revealed that the average stride width, calculated as the maximal distance between ankles during each step, decreased significantly with taping (23.7±1.5 cm) when compared to pre-taping (29.1±1.3 cm). **Conclusion:** We conclude that taping improves both proprioceptive acuity and decreases the wide-based ataxic gait associated with HSAN III, presumably via enhanced sensory feedback from preserved cutaneous afferents sensitive to tensile strain in the skin.

TRANSCRANIAL BRAIN STIMULATION IN POST-STROKE SWALLOWING REHABILITATION

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Introduction: Swallowing disorders (dysphagia) affect up to 70% of stroke patients and can severely impact physical, nutritional and social well-being. Increasingly, the potential of non-invasive brain stimulation techniques, such as repetitive transcranial magnetic stimulation (rTMS) or transcranial direct current stimulation (tDCS) is being explored to maximise swallowing rehabilitation outcomes. Using a systematic approach, we evaluated the volume and quality of this research. **Methods:** Databases including MEDLINE, AMED, Scopus and Science Direct were searched for relevant articles and their reference lists consulted for further studies. The quality of the scientific design of each included study was critically appraised using a modified McMaster University appraisal tool and a Level of Evidence score (I-IV) based on NHMRC criteria was assigned. The research question was: "In patients with dysphagia following stroke, can transcranial brain stimulation improve measures of swallowing function?" **Results:** Eight studies were appraised [rTMS (4), tDCS (3) and paired associative stimulation (1)]. Scores for methodological quality ranged from 12.5/20 to 17.5/20. Six studies provided Level II evidence, one study provided Level IIIa evidence and one study provided Level IV evidence to support the rehabilitative potential of the studied technique. **Conclusion:** Emerging evidence supports the potential usefulness of non-invasive brain stimulation as an adjunct to swallowing rehabilitation. However, empirical support is limited due to the small number of studies evaluating each of the various stimulation paradigms. Additional high-quality studies are required in order to determine the safety and efficacy of brain stimulation paradigms in assisting recovery of swallowing function following stroke.