16-18 NOVEMBER 2021 (UTC/GMT)

SECOND INTERNATIONAL MOTOR IMPAIRMENT CONFERENCE

ABSTRACT BOOK

With thanks to our Sponsors for 2021

Dear Delegates,

Welcome to the **Second International Motor Impairment Conference – Online 2021**.

The meeting is designed to highlight the various facets of motor impairment. Motor impairment has many elements: weakness and fatigue, sensory impairments, problems with falls and balance, muscle contractures and many more. It is characterised by major deficits in the activity of daily life and it is a progressive accompaniment to aging. The stimulus to study, develop, and promote the topic of motor impairment came from an NHMRC Program grant awarded to Stephen Lord, Rob Herbert, Janet Taylor and me.

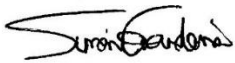
Over the three days we will have 6 sessions of oral presentations covering a wide range of topics associated with aspects of motor impairment, all the way from a fundamental to an effective clinical translation.

To host the meeting we have been helped by underwriting by NeuRA (Neuroscience Research Australia) as well as the Vrije Universiteit, Amsterdam. We have also received generous support for the 2021 and the 2022 conferences from the Journal of Physiology.

We hope you enjoy this online version of the Conference.

In 2022 the ***Third International Motor Impairment Conference*** will be held in Amsterdam.

Sincerely,



Simon Gandevia

On behalf of the organising Committee:

- Mirjam Pijnappels (Vrije Universiteit, Amsterdam)
- Huub Maas (Vrije Universiteit, Amsterdam)
- Simon Gandevia (NeuRA, Australia)
- Annie Butler (NeuRA, Australia)
- Bronwyn Chapman (NeuRA, Australia)

SESSIONS BY SELECTED TIME ZONES

Note orange denotes a different day to rest of world time zones.

SESSION	UTC/GMT	CET	AEDT	CST
A	Tues 16 Nov 8am-10am	Tues 16 Nov 9am-11am	Tues 16 Nov 7pm-9pm	Tues 16 Nov 2am-4am
B	Tues 16 Nov 8pm-10pm	Tues 16 Nov 9pm-11pm	Wed 17 Nov 7am-9am	Tues 16 Nov 2pm-4pm
C	Wed 17 Nov 1am-3am	Wed 17 Nov 2am-4am	Wed 17 Nov 12pm-2pm	Tues 16 Nov 7pm-9pm
D	Wed 17 Nov 8pm-10pm	Wed 17 Nov 9pm-11pm	Thur 18 Nov 7am-9am	Wed 17 Nov 2pm-4pm
E	Thur 18 Nov 3pm-5pm	Thur 18 Nov 4pm-6pm	Fri 19 Nov 2am-4am	Thur 18 Nov 9am-11am
F	Thur 18 Nov 8pm-10pm	Thur 18 Nov 9pm-11pm	Fri 19 Nov 7am-9am	Thur 18 Nov 2pm-4pm

SESSION A: Simon Gandevia (Chairperson)

Prevention of muscle impairment with ageing

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2. @AgeAmsterdam, Department of Human Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam Movement Sciences, The Netherlands.
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The aging process occurs gradually with a high degree of inter and intra-individual differences. As such, within an aging population, significant variation in the prevalence and severity of age related diseases and functional impairment are observed. This variability between individuals is thought to be reflected by their biological age. Human muscle is the largest organ within the body and muscle mass and strength is declining over time. Once a threshold is reached, low muscle mass, strength and function is summarized as sarcopenia, which has been granted an international classification of disease code in 2018. Diagnosing and intervening in declining muscle mass and strength is of upmost importance for maximizing health and functional independency at older age.

Medial gastrocnemius muscle and tendon interaction during gait in typically developing children and children with cerebral palsy

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Pathological changes in the extensibility of the medial gastrocnemius (MG) tissues have been reported in children with spastic cerebral palsy (CP)[1]. Studying the relative length of MG tissues during gait can improve our understanding of their dynamics and, inferably, the control strategies in CP. Method: 3D gait analysis was carried out in 10 children with CP (11±3years, GMFCS I/II:8/2 uni/bilateral:7/3) and seven TD children (13±4years) as they walked at a comfortable walking speed on an instrumented treadmill. Ultrasound images were collected during walking first with the probe on the mid muscle-belly, imaging fascicles and secondly with the probe on the muscle tendon junction (MTJ) to estimate muscle-belly, tendon and muscle-tendon-unit (MTU) length-changes. Fascicle, MTU, muscle-belly and tendon length patterns were averaged over time-normalised gait cycles, and expressed relative to their lengths at initial contact [4]. Results: Children with CP showed reduced length-changes of all tissues compared to TD. Rate of tendon-length change during stance was reduced in CP. In TD, the muscle-belly behaviour did not reflect the fascicle behaviour whereas in CP, muscle-belly and fascicle length patterns were similar. Discussion: Our initial findings of pathological muscle and tendon dynamics during CP gait are in line with a previous study imaging the MTJ [2], but less so with studies relying on modelling to estimate tendon length [3-4]. The similar length pattern between muscle-belly and fascicle in CP may indicate a stiff extracellular matrix. We highlight the importance of collecting experimental data from all three tissues in order to understand the pathology.

1. Kalkman B, Bar-On L, Cenni F, Holmes G, Bass A, Barton G, Maganaris C, Desloovere K, O'Brien T. (2018) Exp Physiol 103:1367–1376
2. Kalsi G, Fry NR, Shortland AP. (2016) J Biomech.49(14):3194–9
3. Barber L, Carty C, Modenese L, Walsh J, Boyd R, Lichtwark G. (2017) Dev Med Child Neurol.59(8):843–51
4.Hösl M, Böhm H, Arampatzis A, Keymer A, Döderlein L. (2017) Clin Biomech. 2016;36:32–9

Clinical feasibility of a simple 3D-Ultrasound protocol for imaging the m. gastrocnemius medialis

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The effects of clinical interventions on the muscle-tendon complex could be evaluated in a non-invasive way by 3D-Ultrasound (3DUS). Two 3DUS protocols for medial gastrocnemius (GM) morphology have been described in the literature: a simple protocol with an overhanging foot (OF) [1] and a more standardized protocol in which the ankle is fixated in a footplate (FP) at a known joint-torque [2]. Aim. Evaluate the clinical feasibility of the OF protocol by testing its intra-rater test-retest reliability and concurrent validity with the FP protocol. Methods. The GM muscle of 16 healthy adults was measured twice using the OF protocol, with a short break in between, and subsequently using the FP protocol at -1, 0 and 1Nm ankle torque. Muscle belly (MBL), fascicle (FL) and tendon lengths (TL), muscle volume (MV) and pennation angle (PA) were extracted from the 3D reconstructions and normalized for either lower-leg-length or body-mass. Results. OF MBL, TL and MV showed high correlations (r=0.88–0.98) and no significant differences with 0Nm FP-protocol. FL and PA had high and moderate correlations (r=0.84; r=0.68) and no significant differences with the -1Nm FP protocol. Reliability of OF-protocol for all variables was good to excellent (ICC=0.82–1) with relative SDD errors of 2-16% for lengths, 11% for MV and 21% for PA. These SDD values are small enough to evaluate the effect of treatments on MBL, TL and MV in children with cerebral palsy (CP) [3]. Evaluation in children with CP will confirm the feasibility of a simple evaluation of GM muscle morphology in clinical practice.

1. Cenni F, Schless S, Bar-On L, Aertbeliën E, Bruyninckx H, Hanssen B & Desloovere K (2018) Computer Methods and Programs in Biomedicine 156, 97-103
2. Weide G, van der Zwaard S, Huijing PA, Jaspers RT & Harlaar J (2017) J. Vis. Exp 129, e55943
3. Walhain F, Desloovere K, Declerck M, van Campenhout A & Bar-On L (2020) Developmental Medicine & Child Neurology 63, 274-286

Rehabilitation of dizziness complaints with a 4-week virtual reality protocol

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In patients with dizziness complaints, a high visual dependency, i.e., reliance on visual information for balance control, appears to be related to severity of symptoms and to hamper recovery. The Military Rehabilitation Center 'Aardenburg' in Doorn aims to reduce visual dependency using a virtual reality protocol. Over the course of 4 weeks, patients undergo twelve therapy sessions of 20 minutes during which they walk on a treadmill surrounded by an immersive screen of which the displayed scenery slowly rotates clockwise and counter clockwise. The first aim of this study was to evaluate if the program reduces visual dependency. The second aim was to assess if dizziness complaints, measured with the Dizziness Handicap Inventory (DHI), decreased. Finally, we aimed to assess if dizziness complaints were related to visual dependency. Visual dependency was quantified as the maximal cross-correlation between the mediolateral center of mass (COM) movement of the patient and the visual perturbations. Thirty-one patients with chronic dizziness complaints were included. Visual dependency significantly decreased during the program. Although the DHI score did not show a significant reduction in the group as a whole, 30% of the patients did show a clinically relevant reduction of dizziness complaints. There was no correlation between visual dependency and dizziness complaints. In conclusion, even though the protocol successfully reduced visual dependency and some patients appeared to benefit, decreases in dizziness complaints were not caused by a decreased visual dependency.

Associations of low-back pain and pain-related cognitions with lumbar movement patterns during repetitive seated reaching

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Development of more effective interventions for low back pain (LBP), requires a robust theoretical framework regarding mechanisms underlying the persistence of LBP. Altered movement patterns, possibly driven by pain-related cognitions, are assumed to drive pain persistence [1], but cogent evidence is missing [2].
AIM: To assess lumbar movement patterns (LMP), in people with and without LBP, and to investigate possible associations with pain-related cognitions.
60 participants were recruited, matched by age and sex (30 back-healthy and 30 with LBP). Pain-related cognitions were assessed by the PCS, PASS and the task-specific EBS. Participants performed a seated repetitive reaching movement (45 times). LMP were assessed by an optical motion capture system recording positions of cluster markers, located on the spinous processes of S1 and T8. LMP were characterized by spatial variability (meanSD) of the lumbar Euler angles: flexion-extension, lateral-bending, axial-rotation, temporal variability (CyclSD) and local dynamic stability (LDE) [2]. Differences in LMP, between people with and without LBP and with high and low levels of pain-related cognitions, were assessed with factorial MANOVA. We found no main effect of LBP on variability and stability, but there was a significant interaction effect of group and EBS. In the LBP-group, participants with high levels of EBS, showed increased MeanSDlateral-bending ($p=0.004$, $\eta 2=0.14$), indicating a large effect.
SIGNIFICANCE: In participants with LBP, spatial variability was predicted by the task-specific EBS, but not by the general measures of pain-related cognitions. These results suggest that a high level of EBS is a driver of increased spatial variability, in participants with LBP.

1. Dieen van JH, Reeves NP, Kawchuk G, Dillen van LR, Hodges PW, Analysis of Motor Control in Patients With Low Back Pain: A Key to Personalized Care?, J Orthop Sport Phys Ther 49 (2019) 380–388
2. G. Christe, G. Crombez, S. Edd, E. Opsommer, B.M. Jolles, J. Favre, Relationship between psychological factors and spinal motor behaviour in low back pain: a systematic review and meta-analysis, Pain. 162 (2021) 672–686
3. M.H. Wildenbeest, H. Kiers, M. Tuijt, J.H. van Dieën, Reliability of measures to characterize lumbar movement patterns, in repeated seated reaching, in a mixed group of participants with and without low-back pain: a test-retest, within- and between session, J. Biomech. 121 (2021) 1–8

Clinical reasoning in physiotherapy assessment for people with neurological disorders-limited evidence for essential domains-a mixed systematic review

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Clinical reasoning as part of neurological assessment enables the physiotherapist to deliver an optimal treatment plan in patients with neurological disorders. There is a lack of consensus in the literature related to what is assessed clinically by physiotherapists in this population. This review aimed to identify essential domains that physiotherapists routinely assess, while exploring the influence of geographical location, experience, health care setting, and type of disorder. Five databases were searched from 1996-2021. All study designs and settings were included. Risk of bias was assessed using appropriate McMaster critical appraisal tools. Data was synthesised based on the Joanna Briggs Institute approach to mixed systematic reviews. Twenty-one studies involving 3,497 participants were included. Studies were rated as medium quality (n=10) and high-quality (n=11). Results showed agreement on five assessment domains: function; postural alignment and symmetry; gait; muscle strength; and balance. Five key themes were identified: clinical reasoning, clinical use of standardised measures, role of the senses, clinician experience and information gathering. Eleven studies reported on clinical reasoning as the main focus of their study or as an included domain. Clinical reasoning was identified as a key theme in this review. Guidance emerging from this review is limited about essential assessment domains. Only four studies adopted all four steps of the WCPT clinical reasoning process. Just over half of the studies reported using standardised measures. Disappointingly the ICF framework was not fully integrated into neurological assessment. Further research is needed to develop a consensus on comprehensive assessment in neurological physiotherapy practice.

Comparison of proprioception and sensorimotor performance in the upper and lower limbs in people with a congenital absence of functional muscle spindles

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Hereditary sensory and autonomic neuropathy type III (HSAN III) is caused by a single-point mutation on chromosome 9q. It features marked gait ataxia that progressively worsens over time, together with sensory disturbances in several domains. We assessed whether proprioceptive disturbances can explain the ataxia: proprioception at the knee and elbow joints was assessed using passive joint angle matching. At the knee HSAN III patients (n=18) performed poorly in judging joint position: the range of absolute errors was very wide and correlated positively to the degree of ataxia (1). However, at the elbow there were no significant differences in mean error in 12 patients and 12 controls (2). Microelectrode recordings from the peroneal (3) and ulnar (4) nerves revealed that functional muscle spindles are absent in the upper and lower limbs, although cutaneous mechanoreceptors appear to be normal. Clearly, the lack of muscle spindles compromised proprioception at the knee but not at the elbow, and we suggest that the HSAN III patients have learned to use proprioceptive signals from the skin around the elbow. Indeed, applying longitudinal strips of elastic tape around the joint to increase tensile strain in the skin improved proprioception at the knee (5) but not the elbow (2). Moreover, applying elastic tape over the hips, knees and ankles improved joint kinematics during walking, but similar taping in the upper limb did not affect reaching and grasping movements. This emphasizes differences in the contributions of muscle spindles to sensorimotor control in the upper and lower limbs.

1. Macefield VG, Norcliffe-Kaufmann LJ, Axelrod F & Kaufmann H (2013) Movement Disorders 28, 823-827
2. Smith LJ, Norcliffe-Kaufmann N, Palma J-A, Kaufmann H & Macefield VG (2020) J Physiol 598, 3521-3529.
3. Macefield VG, Norcliffe-Kaufmann L, Gutiérrez J, Axelrod, F & Kaufmann H. (2011) Brain 134, 3198-3208
4. Smith, LJ, Norcliffe-Kaufmann L, Palma J-A, Kaufmann H & Macefield VG (2018). J Neurophysiol 120, 2788-2795
5. Macefield VG, Norcliffe-Kaufmann LJ, Golding N, Palma JA, Fuente Mora C & Kaufmann H (2016) J Neurophysiol 115, 711-716

SESSION B: Huub Maas (Chairperson)

Discerning and overcoming the biomechanical mechanisms underlying disturbed limb propulsion post-stroke

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Human gait requires coordinated muscle forces to enable stance stability, limb propulsion, and swing limb advancement for safe, smooth, and efficient movement. Following stroke, profound loss of force generating capacity and incoordination can hinder these gait sub-tasks. Limb propulsion, in particular, is required to accelerate the body forward, and is dependent on a combination of ankle plantarflexion force and appropriate limb alignment. Weakness in the ankle plantarflexors after stroke contributes to the presence of asymmetric limb propulsion, with a concomitant increase in the metabolic energy cost of walking. Nevertheless, people following stroke have a robust propulsive reserve that they can engage by increasing the trailing limb posture. This finding suggests that, despite the importance of the ankle plantarflexors for push-off, people post-stroke do not have the capacity to increase their ankle plantarflexion force further. Instead, we propose to use ankle exoskeletons to increase the ankle plantarflexor torque to substitute for, or supplement, the biological torque from the ankle plantarflexors. Early attempts to use ankle exoskeletons have demonstrated mixed results, with greater ankle plantarflexor torque provided, but no decrease in the metabolic cost of walking. Similarly, our early work in the use of distorted visual feedback can produce increases in limb propulsion without conscious awareness.

A study to compare the physiological responses to a single session of 9% FiO2 Acute intermittent hypoxia (AIH) with a single session of 12% FiO2 AIH in able-bodied adults

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Acute Intermittent Hypoxia (AIH) can induce sustained facilitation of motor output in people with spinal cord injury but only if serotonin release is within a narrow dosage window (1). Most human studies use 9% FiO2 AIH although sometimes, with inconsistent outcomes. We aimed to compare the effect of single sessions of 9% FiO2 with 12% FiO2 AIH on the cardiorespiratory response and the excitability of upper and lower limb motor pathways in able-bodied adults. Ten participants completed three sessions of AIH comprising 15 cycles of alternate 1-minute hypoxia and 1-minute normoxia, of 9% AIH, 12% AIH or sham (21% FiO2) in a randomized crossover design. Motor evoked potentials (MEPs, n=30, ~1mV) evoked at rest by transcranial magnetic stimulation and maximal M-waves (Mmax) evoked by peripheral nerve stimulation were measured at baseline and at 0, 20, 40, and 60 minutes post-intervention from the first dorsal interosseous (FDI) and tibialis anterior (TA) muscles. 9% AIH induced the greatest reduction in SpO2 (by 13.0% vs 5.5% and 0.9% in AIH12 and sham, respectively ($p < 0.01$)) and increased in ventilation (by 31% vs 20% and 15% in AIH12 and sham, respectively ($p<0.01$)). MEP amplitudes (%Mmax) did not differ between the sessions for both FDI ($p=0.518$) and TA ($p=0.297$). Despite greater cardiorespiratory changes during 9% AIH, facilitation of the corticospinal tract tested with MEPs did not occur in this study. Further studies are required to explore variability across individuals and other methods to measure motor facilitation in able-bodied adults and people with spinal cord injuries.

1. Navarrete-Opazo A & Mitchell GS (2014). Therapeutic potential of intermittent hypoxia: a matter of dose. Am J Physiol-Regul Integr Comp Physiol 307, 1181-1197

Treatment with electrical stimulation of sensory nerves improves motor function and disability status in persons with Multiple Sclerosis

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4. College of Medicine, King Saud bin Abdulaziz University for Health Sciences, King Abdullah International Medical Research Center, Riyadh, Saudi Arabia

Motor function in individuals with multiple sclerosis (MS) improves immediately when transcutaneous electrical nerve stimulation (TENS) is concurrently applied to limb muscles (1). The purpose of our study was to assess the changes in motor function and disability status elicited by repeated application of TENS to limb muscles of individuals with MS. 15 persons with MS and 11 age-matched healthy controls were evaluated immediately before and after receiving 9 sessions during which TENS was applied over the tibialis anterior and rectus femoris muscles of each leg, and over the median nerve and the thenar eminence of each hand. Each evaluation session involved completing two questionnaires (fatigue and walking limitations) and assessing walking performance (2-min test and 25-ft test), dynamic balance (chair-rise test), manual dexterity (grooved pegboard test), and muscle function of hands and legs (strength and force steadiness). Linear mixed-effects models (2) and paired tests were used analyze the changes in the two groups. The MS group exhibited improvements in the 25-ft test (P=0.001), 2-min test (P=0.002), chair-rise test (P=0.008), grooved pegboard test (P=0.008), and reductions in the self-reported levels of fatigue and walking limitation scores (P=0.02, P=0.008 respectively). In contrast, there were no statistically significant changes in the motor functions for the control group. There were no significant changes in either muscle strength or force steadiness for either group. TENS elicited significant improvements in motor function and self-reported disability status in persons with MS. Some improvements reached clinically meaningful levels.

1. Almuklass AM, Capobianco RA, et al., (2020). Mult Scler Rel Disord 38, 101508
2. Nakagawa S & Schielzeth H (2013) Methods Ecol Evol 4 (2), 133-142

5-HT2 blockade suppresses force development and motor unit discharge during rapid contractions

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Serotonin (5-HT) is a neuromodulator that can regulate the gain of spinal motoneurons when performing muscle contractions. However, the role of 5-HT in modulating human motor unit activity during rapid contractions has yet to be assessed. Nine healthy participants (23.7 ± 2.2 yr) ingested 8 mg of cyproheptadine, a competitive 5-HT2 antagonist, in a repeated-measures, double-blinded, placebo-controlled experiment. Motor unit activity was assessed by high-density surface electromyographic decomposition during rapid dorsiflexions to 30%, 50% and 70% of maximal voluntary contraction (MVC). A second protocol was performed where a fatigue-inducing dorsiflexion was completed prior to undertaking the same 30%, 50% and 70% MVC rapid contractions. Compared to placebo, motor unit discharge rate ($p = 0.017$) and rate of force development ($p = 0.019$) for the unfatigued muscle were both significantly lower for the cyproheptadine condition. Following the fatigue inducing dorsiflexion, cyproheptadine also reduced motor unit discharge rate ($p < 0.001$) and rate of force development ($p = 0.024$), particularly at the highest contraction intensity. Overall, serotonin activity in the central nervous system appears to play a critical role in regulating human motor unit discharge rate during rapid contractions. Our findings support the viewpoint that serotonergic effects on motoneurons are fast acting and are most prominent during contractions that are characterized by large amounts of force development.

Physiological tremor is suppressed in unfatigued and fatigued muscle after administration of the SSRI paroxetine

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2. Child Health Research Centre, University of Queensland, Brisbane, Australia
3. School of Rehabilitation Sciences, Old Dominion University, Norfolk, USA
4. Barwon Health, University Hospital Geelong, Geelong, Australia.

Physiological tremor is an involuntary oscillation specific to the 8-12 Hz bandwidth in force and EMG power spectra. Although there is evidence that neuromodulators, such as serotonin, have the capacity to alter motor output, it is unknown if physiological tremor is altered with enhanced availability of serotonin. A total of 22 healthy individuals participated in this two-way cross-over trial. Measures of physiological tremor were obtained during a session where participants ingested 20 mg of the selective serotonin reuptake inhibitor paroxetine, and a session where a placebo was administered. The peak power of force within 8-12 Hz bandwidth was calculated during the performance of brief unfatigued 10%, 60%, and 100% maximal voluntary contractions (MVCs) of the elbow flexors. The SSRI did not affect the frequency of tremor. However, a main effect of drug was identified for the peak power of force ($p = 0.004$), where paroxetine reduced the amplitude of peak power. Peak power of force within 8-12 Hz bandwidth was also calculated during prolonged sustained MVCs that generated exercise-induced fatigue of the elbow flexors. Once again, the SSRI did not affect the frequency of tremor. However, a main effect of drug was detected for peak power following the fatiguing contractions ($p = 0.002$), where paroxetine reduced the amplitude of peak power. The results of this study indicate serotonin may play a role in physiological tremor and may provide a potential mechanism for treatment of tremor-related movement disorders.

Augmented motor unit discharge rates underlie acute intermittent hypoxia-induced increases in volitional elbow strength in persons with chronic incomplete spinal cord injury

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Acute intermittent hypoxia (AIH) is a therapeutic intervention that utilizes brief reductions of inspired oxygen to stimulate the serotonergic system, a potent neuromodulator of alpha motoneurons. We recently observed AIH-induced changes in torque were associated with increased spatial distribution and amplitude of electromyography (EMG) of the biceps brachii, but mechanisms underlying the altered EMG maps are not clear. Herein, we tried to elucidate AIH-induced increases in strength by decomposing motor unit spike trains from high-density surface EMG during maximal elbow flexion torques, recorded prior to and 60 minutes after AIH. We hypothesized that discharge rates of individual motor units would increase, which would explain some of the observed changes in strength. Seven individuals with chronic iSCI at the cervical level completed AIH and Sham AIH interventions in a randomized order. Participants performed maximal voluntary isometric elbow flexion prior to and 60 minutes after either intervention. AIH consisted of 15 ~60s periods of low oxygen (O2 = 9%) interspersed with 60s periods of normoxia, whereas Sham AIH consisted of repeated exposures to normoxia. After AIH, elbow flexion torque increased by ~63.3% ($p = 0.0078$; $g = 0.58$), whereas there was no change after Sham AIH ($p = 0.69$). Motor units identified both prior to and after AIH increased their discharge rates by ~38% ($p = 0.0015$; $G = 0.86$) following AIH. These findings suggest that excitability and/or the activation of spinal motoneurons are augmented after AIH, providing an underlying mechanism to explain the observed strength increases induced by AIH.

Respiratory muscle reflex control after incomplete cervical spinal cord injury

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In healthy individuals, transient loading of inspiratory muscles with a brief inspiratory occlusion produces a short-latency inhibitory reflex (IR) in the electromyographic (EMG) activity of scalene and diaphragm muscles. It has been argued that this IR plays a protective role in neuromuscular control of the inspiratory muscles to prevent aspiration and airway collapse during sleep(1). In people with sensory complete cervical spinal cord injury (cSCI) American Spinal Injury Association Impairment Scale (AIS) score A, this IR is predominantly absent(2). In this study we investigated the reflex response in participants with incomplete cSCI (AIS score B or C) which has not been previously studied. In 16 participants, we studied the surface electrode EMG recordings of the scalenes and diaphragm to a transient airway occlusion evoking a small change in mouth pressure resembling a physiological occlusion. The IR was present in ten (63%) participants, which was significantly higher than the IR observed in complete cSCI participants in our previous study(2) (14%) ($p=0.032$). The median latency for IR onset across the three muscle sites was 55ms. The median decrease in amplitude relative to the pre-stimulus EMG was 35%. No correlation was observed between presence of the IR and the level (C3-6) or classification (AIS B or C) of injury. This suggests that sensory connections across the reflex site may be necessary to generate the reflex. Inhibitory reflex testing may contribute to the assessment of spared or regenerated neural connections across the injury site and risk of respiratory related morbidity in the cSCI population.

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SESSION C: Janet Taylor (Chairperson)

Population prevalence of motor impairment

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Data on population prevalence provide insight into disease burden. The population prevalence of many diseases is known, but little is known of the population prevalence of motor impairments. This study sought to determine the point prevalence of specific motor impairments (weakness, fatigue, contracture, impaired balance and impaired coordination) in the people 55 years and older residing in New South Wales, Australia in 2018. 55,210 members of the 45 and Up cohort were invited to participate in a follow-up survey that included questions on motor impairment. Responses were received from 20,141 (36%). Calibrated estimates of prevalence of specific motor impairments, and of having at least one motor impairment, were obtained using survey weights based on the known multivariate distributions of age, gender and geographical location (28 regions) in the population. More than one-third of adults aged over 55 residing in NSW had difficulty using their hands, arms or legs. The prevalence of each motor impairment (muscle weakness, fatigue, contracture, impaired balance or impaired coordination) in this population was between 4 and 12%. The prevalence of at least one of these impairments was 21%. The prevalence of at least one impairment in people aged 85 and over was 42%. The prevalence of specific motor impairments in older Australian adults is high - comparable to that of the most prevalent diseases. There may be merit in treating motor impairment as a significant public health problem in its own right.

Assessment of dynamic stretch hyperreflexia during gait in children with spastic cerebral palsy based on fascicle or musculotendon lengthening velocity

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Passive assessment of stretch hyperreflexia may not be representative of its expression during dynamic activities such as gait (1). To quantify dynamic stretch hyperreflexia during gait, previous studies have evaluated muscle activation in relation to modeled musculotendon lengthening (1, 2). However, fascicle lengthening is more directly related to stretch reflex activity (3, 4). We hypothesized that during gait, children with stretch hyperreflexia show enlarged muscle activity in response to fascicle, rather than musculotendon lengthening. 3D-gait analysis including EMG was performed on twelve children with spastic cerebral palsy (CP) and ten typically developing children (TD). Medial gastrocnemius fascicle lengthening was imaged using dynamic ultrasound and musculotendon lengthening simulated using OpenSim. Fascicle and musculotendon lengths were differentiated to obtain lengthening velocities. Peak-EMG and peak-lengthening velocities were identified by experts during swing or early stance phase. Dynamic stretch hyperreflexia was calculated as the ratio between peak-EMG and the preceding peak lengthening velocity and compared between CP and TD using independent t-tests. Dynamic stretch hyperreflexia was significantly higher in CP compared to TD, for both fascicle (3.7 times; $p<0.001$) and musculotendon lengthening (4.7 times; $p<0.01$). This study shows that enlarged muscle activity is present following both fascicle and musculotendon lengthening during gait in children with CP, indicating that either can be used as a measure of dynamic hyperreflexia. However, given the heterogeneity of our patient group, analyses on subject level may reveal intra-individual differences regarding the involvement of the different tissues (muscle, fascicle, tendon) which could provide more insight into dynamic stretch hyperreflexia during gait in CP.

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Novel placement of wearable sensors detects subclinical gait instability in non-disabled people with relapsing-remitting multiple sclerosis in clinical setting using calculated local divergent exponent

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BACKGROUND: The local divergence exponent (LDE) measures dynamic gait stability (coping with step-to-step perturbations) [1]. Lab-based LDE is sensitive to subclinical gait deterioration in people with MS (PwMS) [2]. OBJECTIVE: We examined LDE utilizing wearable sensors during overground walking in a clinical setting to provide known-groups validation and compare sensitivity of sensors placed at sternum and sacrum. METHODS: 51 PwMS (relapsing-remitting, EDSS 0-4) and 23 age-matched healthy controls (HC) walked a 20m walkway (5min), wearing APDM sensors (Oregon, USA). LDE was calculated from 3D acceleration using Matlab (Natick, USA) [3]. One-way ANCOVA assessed group differences, controlling for gait speed. Post hoc pair-wise tests examined differences between disability subgroups. Results: Disability groups (n) were EDSS[0-1](18), EDSS[1.5-2](12), and EDSS[2.5-4](21). When controlling for gait speed, Sternum-VT and Sternum-3D demonstrated significant group effects and large effect sizes (Eta-squared=.144 to .150), while Lumbar-VT and Lumbar-3D demonstrated moderate effect sizes (Eta-squared=.110 to .130). Sternum-AP, but not Lumbar-AP, also showed a moderate effect size (Eta-squared=.115). When comparing HC with the non-disabled group only (EDSS[0-1]), all sternum-derived measures demonstrated significant group effects and moderate to large effect sizes (Eta-squared=.12 to .20), except Sternum-ML, which was rendered insignificant by controlling for gait speed. Lumbar-3D and Lumbar-AP showed large and moderate effect sizes (Eta-squared=.134 and .100, respectively). CONCLUSION: Inertial measures of gait instability distinguished PwMS from HC, even EDSS[0-1], demonstrating potential capacity as a digital biomarker for early gait impairment. Sternum-sensor-derived LDE was more sensitive to group effects. Lumbar-AP discriminated only the non-disabled group from HC, potentially reflecting earliest impairments, later compensated.

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Altered neural control of gait and its association with pain and motor impairment in adults with haemophilic arthropathy

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The dynamic motor control index during walking (Walk-DMC) is a summary metric of neural control [1-3]. We hypothesized that altered neural control is associated with clinical and orthopedic surgical outcomes in people with haemophilic arthropathy (PWHA). The primary aims of this study were to apply the Walk-DMC to assess if people diagnosed with hemophilic arthropathy have an impaired neural control of gait and investigate the association of Walk-DMC with pain and motor impairment. The Walk-DMC was assessed using surface electromyography (EMG) in eleven leg muscles [1-2]. Twenty-two PWHA and 15 healthy subjects walked on a 30 m walkway at 1 m/s. Pain level, degree of knee flexion contracture and the haemophilia joint health score (including range of motion, inflammation and manual muscle testing) were assessed. The Walk-DMC was also assessed in one adult with severe hemophilia before and two years after a total knee replacement (TKR). In thirteen PWHA the Walk-DMC was beyond the normal range. PWHA with an altered neural control had more pain, higher knee flexion contracture, and motor impairment than those with a normal Walk-DMC index. Walk-DMC was moderately associated with pain and motor impairment. Walk-DMC did not return to a normal level following TKR. These results indicate that the altered neural control of gait in PWHA is associated with pain and joint impairment in PWHA. Our results present a first approach about how pain, motor impairment, and orthopedic surgeries may impact the neural control of gait in PWHA.

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People with Multiple Sclerosis show evidence of suboptimal motor cortical output during low-intensity contractions

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Exercise-induced fatigue is a common and frequently disabling symptom in people with multiple sclerosis (PwMS). Although transcranial magnetic stimulation (TMS) has been regularly used to examine central mechanisms that contribute to fatigue, few studies have employed this technique to examine motor cortical output in MS-related fatigue. Nine PwMS (38 ± 7 yr, 6 female) and nine healthy controls (35 ± 6 yr, 4 female) performed an elbow flexion at 15% maximal voluntary contraction (MVC) for 26 min. MVCs were performed every 2 min to determine if maximal force was impaired by the low-intensity contraction. Single-pulse TMS (Magstim 2002) was delivered to the primary motor cortex with a circular coil during each MVC. Superimposed twitches were calculated as the increase in flexion force in response to the TMS pulse. Ratings of perceived exertion (RPE) were obtained before each MVC. In general, MVC progressively declined, superimposed twitches progressively increased, and RPE progressively increased throughout the protocol. Within this framework of fatigue, there was a main effect of group for the amplitude of MVCs ($p = 0.044$) and superimposed twitches ($p = 0.0016$), where MVC was lower and superimposed twitches were greater in MS compared to controls. Overall, the PwMS group fatigued more than healthy individuals. An absence of between-group differences in RPE suggests that this was not mediated by perceptions of fatigue. Instead, the differences in superimposed twitch amplitude suggested that PwMS had suboptimal motor cortical output during the low-intensity contraction compared to the healthy controls.

Anti-muscarinic medication increases TMS-evoked silent period without altering motor evoked potentials during muscle contractions

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Although neurotransmission in motor pathways can be regulated by neuromodulators such as acetylcholine, it is largely unknown how cholinergic activity affects motor circuits in humans during muscle contractions. Ten healthy individuals (23 ± 2 yr) were administered a placebo, or 25 mg promethazine, in 2 testing sessions. Single pulse transcranial magnetic stimulation (TMS) was applied to the motor representation of the elbow flexors to obtain motor evoked potentials (MEPs). MEP area was normalized to Mmax from brachial plexus stimulation. MEPs were obtained during unfatigued isometric elbow flexions of 10%, 25%, 50%, 75%, and 100% of maximal voluntary contraction (MVC). During these contractions, the anti-muscarinic medication had no effect on MEP area ($p = 0.900$). However, the TMS-evoked silent period was increased for the promethazine condition compared to the placebo condition ($p = 0.049$). A follow-up experiment was performed to determine if cholinergic activity affects motor circuits in the presence of muscle fatigue. A maximal isometric elbow flexion was performed until force declined to 60% of baseline MVC. After fatigue was induced, elbow flexions of 10%, 25%, 50%, 75%, and 100% were again assessed. During fatigued contractions, the anti-muscarinic medication had no effect on MEP area ($p = 0.613$). However, the TMS-evoked silent period was increased for the promethazine condition compared to the placebo condition ($p = 0.045$). Given that the cortical silent period is associated with GABAb mediated cortical inhibition, it is likely that anti-muscarinic medication acts on inhibitory rather than excitatory motor cortical circuits regardless of the fatigue state.

Lower limb muscle strength contributions to walking stability in people with Multiple Sclerosis

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Impaired walking is considered the most important functional loss in people with Multiple Sclerosis (MS) [1]. However data on the extent to which weakness in specific lower limb muscle groups contributes to walking impairment in this population are scarce. Stronger evidence is key to the development of effective interventions to improve mobility in people with MS. Our study aimed to describe lower limb muscle strength pattern of people with MS in relation to walking stability. We hypothesized that: (i) hip extensor and ankle plantarflexor weakness would be associated with slower step frequency and irregularity of trunk accelerations in the vertical (VT) and anterior-posterior (AP) planes (higher sample entropy); and (ii) hip abductors weakness would be associated with irregularity (higher sample entropy) and symmetry (smaller harmonic ratios) of trunk accelerations in the medio-lateral (ML) plane. Our sample comprised 33 people with MS (expanded disability status scale 2-6) (19 women, mean (SD) age: 50.6 (12.4) y). Muscle strength was measured bilaterally and accelerations in VT, AP and ML planes were recorded during a 2min-walk test using an inertial sensor fixed at sacrum level. Strength of the hip extensors, but not ankle plantarflexors, was positively correlated with stride frequency, and neither hip or ankle plantarflexor strength was associated with AP and VT irregularity of trunk accelerations. Hip abductor weakness was associated with ML walking instability. Our findings suggest that interventions that focus on strengthening hip extensors and abductors may improve walking impairment by enhancing cadence and ML stability in people with MS.

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SESSION D: Annie Butler (Chairperson)

Estimating maximal muscle electromyographic activity from the relationship between muscle activity and voluntary activation

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Maximal muscle activity recorded using surface electromyography (EMG) is an important neurophysiological measure. It is often used to normalise EMG activity recorded during passive movement or active contractions. However, maximal muscle activity cannot be accurately measured in people with impaired neural drive. In this study, we determined whether maximal muscle activity can be estimated from muscle activity produced during submaximal voluntary activation. Twenty-five able-bodied adults (18 males, mean age 29 yrs, range 19-64 yrs) participated in the study. Participants were seated with the knee flexed 90° and the ankle in 5° of dorsiflexion from neutral. Participants performed isometric voluntary ankle plantarflexion contractions to produce the following target torques, in random order: 1, 5, 10, 15, 25, 50, 75, 90, 95, 100% of maximal voluntary torque. Ankle torque, plantarflexor muscle activity, and voluntary muscle activation measured using twitch interpolation were recorded. In all three muscles tested, there was a strong loge-linear relationship between measures of muscle activation and muscle activity. Linear mixed models were fitted to muscle activation and loge-transformed EMG data. Each 1% increase in muscle activation was associated with a mean increase in muscle activity of 0.027 ln(mV) [95% CI 0.025 to 0.029 ln(mV)] in soleus, 0.025 ln(mV) [0.022 to 0.028 ln(mV)] in medial gastrocnemius, and 0.028 ln(mV) [0.026 to 0.030 ln(mV)] in lateral gastrocnemius. The relationship between voluntary muscle activation and muscle activity can be described using simple mathematical functions, which could be later used to estimate maximal muscle activity to normalise recorded muscle activity.

Effects of age and surface instability on the control of the center of mass

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During standing, posture can be controlled by accelerating the Center of Mass (CoM) through shifting the center of pressure (CoP) within the base of support by applying ankle moments ("CoP mechanism"), or by changing the angular momentum of segments around the CoM, e.g. arm and trunk movement ("counter-rotation mechanism") (1). At both the beginning and the end of the lifespan adequate postural control appears more challenging (2,3). Sixteen pre-pubertal children (6-9y), 17 young adults (18-24y) and eight older adults (65-80y) performed bipedal upright standing trials of 16 seconds on a rigid surface and on three balance boards that could freely move in the frontal plane, varying in height (15-19 cm). Full body kinematics (16 segments, 48 markers) were retrieved. Balance loss only occurred when standing on the highest balance board, twice in one older adult once in one young adult. In children and older adults, the Root Mean Square (RMS) of the CoM accelerations were larger, corresponding to poorer balance performance, probably related to less optimal sensorimotor control compared to young adults (2,3). Next to these performance related outcome measures, we found that across age groups and conditions, the contribution of the CoP mechanism to the total CoM acceleration was much larger than that of the counter-rotation mechanisms, ranging from 94%-113% vs 23%-38%. Deviations in head orientation were small compared to deviations in balance board orientation. We hypothesize that the CoP mechanism is dominant, since the counter-rotation mechanism would conflict with stabilizing the orientation of the head in space (3).

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smart±step: a 12-month randomised controlled trial of cognitive-only and cognitive-motor training for preventing falls in community-dwelling older people

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Training programs that target both cognitive and motor activity involving balance control may provide enhanced value for fall prevention. This assessor blinded randomised controlled trial examined the effectiveness of the smart±step home-based exergame training system, delivered either as cognitive-only training (seated computer training) or cognitive-motor training (standing and stepping on a wireless mat), on preventing falls in community-dwelling older people, compared to a control group (pre-registered: ACTRN12616001325493, statistical analysis plan: https://osf.io/av2mq/). It was hypothesised that both training programs would prevent falls in older people via improvements in physical, cognitive and neural functions. Participants were 769 community dwelling older people aged 65+ years randomised to one of the three groups (cognitive-only training, cognitive-motor training or control). Training participants were asked to undertake two hours of smart±step exergame training per week for 12 months. All reported falls monthly for 12 months. 300 participants attended a 6 month follow up assessment of physical and cognitive performance. The rate of falls was significantly reduced in the motor-cognitive training group compared to control (IRR=0.74, 95%CI=0.56-0.98) and not significantly different between the cognitive training and control groups (IRR=0.86, 95%CI=0.65-1.12). Secondary analyses showed the motor-cognitive training had significantly improved choice stepping reaction times, compared to the control group, with few other training effects on physical and cognitive outcomes. This study has shown that home-based exergaming involving step training can provide safe and efficacious method of preventing falls in older people living in the community, the mechanism of this affect appears to be via improved stepping reaction time.

Electrical stimulation of sensory nerve fibers augments walking endurance in middle-aged adults

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Recent data from our lab showed that walking endurance (6-min walk distance) improved in healthy, middle-aged individuals when TENS was applied continuously to the tibialis anterior and rectus femoris muscles (1). Post-hoc assessments revealed that subjects walked further with TENS during the first four minutes, but less during the final two minutes of the test. This effect was likely mediated by nerve accommodation (2) due to the continuous stimulation. The purpose of our study was to compare the influence of continuous and intermittent TENS applied to leg muscles on performance of the 6-min test of walking endurance by healthy, middle-aged adults. Twenty-seven subjects completed two sessions spaced 3-7 days apart. The first visit involved a Baseline 6-min walk test followed by a Continuous TENS 6-min walk test. The second visit counterbalanced Fast and Slow burst TENS 6-min walk tests in which bursts rates were 5 Hz and 0.5 Hz, respectively. Linear mixed effects models for repeated measures revealed significantly greater distances walked during Continuous, Fast burst, and Slow burst TENS conditions than Baseline for both total 6-min walk distance and distances walked in the last 2 minutes of the tests. Additionally, 6-min distance during both the Fast and Slow burst TENS conditions were significantly greater than that for the Continuous TENS condition. Our data demonstrate that the distance walked in 6 min by healthy, middle-aged adults was increased when supplementary sensory stimulation was applied in bursts during the test of walking endurance.

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Inspiratory muscle performance and anthropometric measures – novel assessments relating to pulmonary function in people with spinal cord injury: a pilot study

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Respiratory compromise is a leading cause of death after spinal cord injury (SCI). Currently, maximal inspiratory pressure (MIP) is the most sensitive and specific predictor of pneumonia for individuals with SCI. However, sustained MIP (SMIP), assessed throughout inspiration, was a better predictor of risk in people with COPD, heart failure, and the critically ill. Further, BMI and abdominal adiposity are related to respiratory function post-SCI. Traditional anthropometric measures may not adequately assess the impact of altered abdominal tone and adiposity on respiratory performance post- SCI. A novel anthropometric measure, the Axillary:Umbilical Ratio (A:U), may more accurately identify the relationship between abdominal maladaptation and RP in persons with SCI. To assess the validity of SMIP and the A:U ratio, 30 participants with SCI (C2-T12, A-D) underwent anthropometric measurements (trunk height, abdominal circumference, axillary circumference, etc.). Respiratory assessment included the inspiratory muscle performance measures MIP, SMIP, and inspiratory duration, and standard pulmonary function tests. The SMIP was significantly related to more respiratory measures than MIP ($P < 0.05$) and the A:U ratio was significantly related to more RP measures than any other anthropometric measure ($P < 0.05$). Additionally, an A:U ratio cutoff point detected individuals with a peak expiratory flow ≥ 80% of their predicted value with a sensitivity and specificity of 85.7% and 91.3%, respectively (area under the curve: 0.92). The strong significant relationships of SMIP and the A:U ratio with respiratory measures suggest their clinical importance in the pulmonary assessment and risk stratification of people with chronic SCI.

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Flexion synergy and laboratory-based methods for quantifying the post-stroke impairment

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Flexion synergy is a trademark movement pattern that emerges following stroke. This abnormal muscle coactivation pattern is driven by volitional shoulder abduction and manifests as flexion across all distal joints (1,2). Several laboratory-based measures have been used to quantify flexion synergy, but few have evidence supporting validity (3). The purpose of the study was to evaluate the criterion validity of six measures in thirty-seven individuals with chronic stroke. The hypothesis was that static measures evaluating flexion synergy in isolation would be less correlated with the criterion measure than dynamic measures evaluating its consequence, loss of independent joint control. The six lab-based metrics included biomechanical and physiological measures of flexion synergy during static and dynamic motor tasks. Fugl-Meyer score was significantly correlated with emergence threshold ($r=0.433$, $p=0.027$), reaching distance at a standardized load ($r=0.405$, $p=0.016$), and synergy-related elbow flexion torque ($r=-0.387$, $p=0.020$). The correlations with biceps EMG during isometric abduction, takeover threshold, and synergy-related flexor EMG at reaching onset were not statistically significant. The moderate significant correlations are considered meaningful since the Fugl-Meyer assesses movement both in and out of flexion synergy while the lab-based measures are focused on movement outside of synergy. The results provide evidence in support of the criterion validity of dynamic measures of flexion synergy's consequence, loss of independent joint control. The kinematic protocols allow for direct high-resolution measurement, which is much needed in targeted therapies and precision medicine. However, secondary elbow flexion torque can alternatively quantify flexion synergy impairment if a dynamic setup is not available.

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Low back pain and associated anxiety may increase the gain but reduce the precision of feedback in control of trunk posture and movement

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Literature reports paradoxical findings regarding the effects of low-back pain (LBP) and related anxiety on trunk motor control (1), as confirmed in our recent work. Compared to controls, patients with LBP showed stronger trunk extensor reflexes and less trunk displacement in response to perturbations and these effects were more pronounced in patients with high pain-related anxiety (2). On the other hand, LBP patients, especially those with high anxiety, showed increased variability of repetitive trunk movements (3). These paradoxical effects may be explained by concomitant increases in the average and variance of muscle spindle firing rates, which result from arousal (4). Such increases would predict higher reflex gains (shown in 2), but a lower coherence between EMG activity and trunk displacement, in patients with LBP and especially those with high anxiety. In addition, while admittance (displacement coherent with the applied perturbations) would be smaller in patients (shown in 2), overall trunk displacement would be less reduced. Here we re-analyzed data from (2) to test these predictions. Instructed to maximally resist continuous unpredictable perturbations, compared to controls, participants with LBP showed lower trunk admittance, but similar root-mean-square trunk displacement, increased reflex gains, and lower coherence between EMG and displacement. This coherence was negatively correlated to pain-related anxiety in participants with LBP. These results support the notion that increases in average and variance of spindle afference result from LBP and related anxiety causing increased reflex gains, but also increased sensory noise, with paradoxical effects on trunk motor control.

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Muscle spindles of the multifidus muscle undergo structural change after intervertebral disc degeneration [in sheep]

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Proprioceptive deficits are common in low back pain. The multifidus muscle undergoes substantial structural change after back injury, but whether muscle spindles are affected is unclear. This study investigated whether muscle spindles of the multifidus muscle are changed by intervertebral disc (IVD) degeneration in a large animal model. IVD degeneration was induced by partial thickness anulus fibrosis lesion to the L3-4 IVD in nine sheep. Multifidus muscle tissue at L4 was harvested at six months after lesion, and from six age-/sex-matched naïve control animals. Muscle spindles were identified in Van Giessen's-stained sections by morphology. The number, location and cross-sectional area (CSA) of spindles, the number, type and CSA of intrafusal fibres, and thickness of the spindle capsule were measured. Immunofluorescence assays examined Collagen I and III expression. Multifidus muscle spindles were located centrally in the muscle and generally near connective tissue. There were no differences in the number or location of muscle spindles after IVD degeneration and only changes in the CSA of nuclear chain fibres. The thickness of connective tissue surrounding the muscle spindle was increased as was the expression of Collagen I and III. Changes to the connective tissue and collagen expression of the muscle spindle capsule are likely to impact their mechanical properties. Changes in capsule stiffness may impact the transmission of length change to muscle spindles and thus transduction of sensory information. This change in muscle spindle structure may explain some of the proprioceptive deficits identified with low back pain.

Intrinsic ankle stiffness relates to body sway size depending on type of measurement in perturbed standing

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Intrinsic stiffness of the ankle joint is too low for complete stabilization of the posture [1,2], and standing individuals are not completely static and present an oscillatory body movement. We demonstrated [3] that intrinsic stiffness inversely correlated to RMS body angular velocity (Pearson's r= -0.54 and -0.56, $p<.05$), and people who swayed less had higher short-range intrinsic stiffness. Postural sway size was also measured as body angle peak-to-peak (p-p) gain as a ratio of footplate rotation, and we showed that the two measurements of postural sway size were unrelated [4], suggesting that the short-term regulation of stability (RMS body angular velocity) and the longer-term regulation of orientation (body angle p-p gain) are controlled by different processes. In this study we investigate the relationship between intrinsic stiffness and body angle p-p gain. Nineteen healthy adults, splinted at hip and knee levels with eyes closed, were tested in conditions of subtle tilts (0.1 Hz sine waveform of 0.2 and 0.4 deg p-p amplitude) applied to the standing platform rotating around the ankles. Brief rotations (140 ms duration, 0.2 and 0.9 deg) were added to measure intrinsic ankle stiffness and a laser-reflex sensor recorded sagittal body angle. We found no correlation between intrinsic stiffness and body angle p-p gain (Pearson's r= -0.36, -0.28, -0.35, -0.35, $p>.05$). The results add knowledge to the relevance of intrinsic ankle stiffness to different measurements of body sway and the different postural control mechanisms that each relates to. Future studies investigating individuals with motor impairments are recommended.

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Plantar pressure during different walking speeds and activities of daily living in people with diabetes at high risk of ulceration

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In evaluating the biomechanical properties of therapeutic footwear, most often in-shoe plantar pressures are obtained during mid-gait steps at preferred speed in a laboratory. We hypothesize that these do not represent plantar pressures or indicate the cumulative stress experienced in daily life. Therefore, we investigated plantar pressure during different walking speeds and activities of daily living in people with diabetes at high risk of ulceration. We assessed in-shoe plantar pressure with the Pedar-X system during three walking speeds: 0.8, 0.6 and 0.4 m/s and seven activities: standing, accelerating, walking at preferred speed, decelerating, Timed Up and Go test (TUG), stair ascending and stair descending. Peak plantar pressure (PPP) and pressure-time integral (PTI) were determined for the hallux, metatarsal 1, metatarsal 2-3 and metatarsal 4-5 region. For statistical analyses we used linear mixed models ($\alpha<0.05$) with Holm-Bonferroni correction. We included 59 feet of 30 participants (5 female, 63.8±9.2 years, 100% IWGDF risk 3). With increasing walking speed, PPP increased and PTI decreased for all regions ($p\leq0.001$). Standing, decelerating, TUG and stair ascending showed lower PPP than walking at preferred speed for most regions ($p\leq0.004$), whereas accelerating and stair descending showed similar PPP. Stair ascending and descending showed higher PTI than walking at preferred speed ($p\leq0.002$), standing showed lower PTI ($p\leq0.001$), while the other activities showed similar PTI. To evaluate biomechanical properties of therapeutic footwear, and to assess cumulative plantar tissue stress in daily life, plantar pressures during different walking speeds and activities of daily living should be taken into account.

The effect of fatigue on trunk stabilization in rowers with and without a history of low back pain

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People with a history of low-back pain (HoLBP) may have impaired trunk stabilization due to slower reflexes responses (1) and/or reduced trunk muscle strength and endurance (2). This study aimed to test the hypotheses that HoLBP and trunk muscle fatigue impairs trunk stabilization in rowers. Twenty active rowers were recruited and stratified into groups with and without a HoLBP. Fatigue was induced by ergometer rowing at 70% of maximum power for 30 minutes. Before and after the fatigue protocol, participants were seated in a rowing position and perturbed 16 times by unexpected frontal plane seat rotations, resembling boat tilts in on-water rowing. Peak frontal plane lumbar angles and moments and trunk muscle reflex latencies and amplitudes were determined and averaged over repeated perturbations. Repeated-measures ANOVA and MANOVA were used to test the effects of HoLBP, fatigue, and their interaction on lumbar angles and moments and on EMG outcomes, respectively. Results showed significantly greater lumbar angles, moments, and reflex amplitudes in rowers with a HoLBP, while no significant effect of HoLBP on reflex latencies was found. No fatigue effects or interaction effects were identified. Results indicate that larger lumbar displacements in rowers with a HoLBP required higher moments to regain balance, which was achieved through higher muscle activation. Such less efficient stabilization may put rowers with HoLBP at a greater risk of recurrent pain. The source of the larger displacement in rowers with a HoLBP remains unknown, although reflex latencies showed a trend towards lower values in this group.

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Changes in muscle-tendon unit length-force characteristics following experimentally induced photothrombotic stroke cannot be explained by changes in muscle belly structure [in rats]*

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BACKGROUND: Stroke is the leading cause of adult disability and majority of survivors experience motor disabilities and sensorimotor deficits, including disrupted motor control and spasticity, which have a negative impact on the quality of life of stroke survivors [1]. The motor disabilities are largely a consequence of muscle weakness due, at least transiently, to an impaired cortico- and reticulospinal control of muscles after a stroke [2], that contribute to spasms [3] and limited fascicle shortening [4].The aim of this study was to assess the effects of experimentally induced stroke on structural and mechanical properties of rat m. flexor carpi ulnaris (FCU). METHODS: Two groups of Young-adult male Sprague-Dawley rats were measured: stroke (n=9) and control (n=7). Photothrombotic stroke was induced in the forelimb region of the primary sensorimotor cortex. Four weeks later, muscle-tendon unit and muscle belly length-force characteristics of the m. flexor carpi ulnaris, mechanical interaction with the neighbouring m. palmaris longus, the number of sarcomeres in series within muscle fibres and the physiological cross-sectional area were measured. RESULTS: Stroke resulted in higher force and stiffness of the m. flexor carpi ulnaris at optimum muscle tendon unit length, but only for the passive conditions. Stroke did not alter the length-force characteristics of m. flexor carpi ulnaris muscle belly, morphological characteristics, and the extent of mechanical interaction with m. palmaris longus muscle. Conclusion: The higher passive force and passive stiffness at the muscle-tendon unit level in the absence of changes in structural and mechanical characteristics of the muscle belly indicates

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Differences in gait stability and acceleration characteristics between healthy young and older females

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Our aim was to evaluate differences in gait acceleration intensity, variability and stability of feet and trunk between older females and young females using inertial sensors. Twenty older females (OF; mean age 68.4, SD 4.1 years) and eighteen young females (YF; mean age 22.3, SD 1.7 years) were asked to walk straight for 100 meters at their preferred speed, while wearing inertial sensors on heels and lower back. We calculated spatiotemporal measures, foot and trunk acceleration characteristics and their variability, as well as trunk stability using the local divergence exponent (LDE). Two-way analysis of variance (including the factors foot and age), Student's t-test, and Mann–Whitney U test were used to compare statistical differences of measures between groups. Cohen's d effects were calculated for each variable. Foot maximum vertical acceleration and amplitude, trunk-foot vertical acceleration attenuation, as well as their variability were significantly smaller in OF than in YF. In contrast, trunk mediolateral acceleration amplitude, maximum vertical acceleration, and amplitude, as well as their variability were significantly larger in OF than in YF. Moreover, OF showed lower stability (i.e., higher LDE values) in mediolateral acceleration, mediolateral and vertical angular velocity of the trunk. Although we measured healthy older females, these participants showed lower vertical foot accelerations with higher vertical trunk acceleration, lower trunk-foot vertical acceleration attenuation, less gait stability, and more variability of the trunk, and hence, were more likely to fall. These findings suggest instrumented gait measurements may help early detection of changes or impairments in gait performance.

Physical impairments as part of the Post Intensive Care Syndrome

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Survival of critically ill patients has dramatically improved, but significant multiple impairments often remain, resulting in long-lasting limitations in daily functioning, participation restrictions and diminished quality of life.
Post Intensive Care Syndrome (PICS) describes these new or worsening impairments in physical, cognitive, or mental health status after critical illness that persist beyond hospitalization.1
Since the COVID-19 pandemic, the recognition of the long-term impact of PICS has increased and the necessity for a personalized rehabilitation trajectory is advocated by health care providers and policy makers.2
In this presentation, the physical impairments of PICS and the consequences of these for survivors of critical illness will be discussed.

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Brain neuroimmune and sensorimotor function in mechanism-based subgroups of individuals with lower back pain

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Recent work has highlighted the involvement of neuroinflammation (glial cell activation) in the sensorimotor cortex (S1/M1) in the maintenance of pain [1]. It is proposed that different neuroinflammatory mechanisms may underlie different clinical pain mechanism categories [2]. How neuroinflammation in S1/M1 varies between pain mechanisms and how this relates to S1/M1 function are not yet clear. This study aimed to: (1) compare evidence of glial activation in S1/M1 between healthy individuals and those with features of different pain mechanisms (nociceptive and nociplastic pain), and (2) evaluate potential relationships between glial activation and measures of sensorimotor function. We hypothesize that individuals withnociplastic pain will present with higher glial activation in S1/M1 compared to individuals with nociceptive pain, and the amount of glial activation will relate to differences in sensorimotor function. PET-fMRI was used to measure the amount of glial activation in functionally defined regions of M1/S1 in healthy and chronic lower back participants (nociceptive and nociplastic pain). Measures of sensorimotor function were made with single and paired-pulse transcranial magnetic stimulation (TMS) and quantitative sensory testing (QST). Sleep, depression, disability, and pain questionnaires were administered to characterize groups. Significantly higher glial activation was present in the lower back cortical representation of M1/S1 for the nociplastic LBP group compared to both nociceptive LBP and healthy groups. In addition, the nociplastic LBP group had decreased corticospinal excitability (measured with recruitment curve) and reduced intra-cortical facilitation. Increased glial activation in M1/S1 was correlated with reduced intra-cortical facilitation, increased intra-cortical inhibition, and higher questionnaire scores.

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Examining exerted force in a music-cued finger tapping task: A multilevel approach

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Rhythmic auditory cueing is increasingly used in movement rehabilitation, and personalizing such interventions is thought to facilitate treatment effectiveness[1]. We expect previous findings on timing accuracy to extend to tapping force. In two studies, 159 healthy young and older adults (70 males; age 18-87; M = 36.19; SD = 21.50) completed finger tapping tasks using 38 different music stimuli, measuring MIDI velocity as an index of tapping force. Participants rated each stimulus, and completed cognitive tasks. A linear mixed model revealed that performance on the Stroop task inversely predicted applied force (estimate = 0.94, SE = 0.31, $p < .01$), as supported by evidence attributing swing variance in walking, resulting in greater energy expenditure, to declines in executive functions[2]. A model assessing musical preference, familiarity, experienced emotional valence and arousal as predictors of tapping force, revealed preference as a modest but significant predictor (estimate = 0.02, SE = 0.01, $p = .02$), in line with previous research associating preference and movement displacement[3]. Participants also tapped significantly harder to music that they perceived as positively valenced (estimate = 0.01, SE = 2.21, $p < .02$), which may be attributed to the motivating effects of music[4]. Surprisingly, no effects of age on tapping force were observed. These preliminary findings support the personalisation of music-cued interventions in movement rehabilitation. Cognition may be more informative than age in determining the suitability of such interventions. Tailoring the music to the patient's preference, and selecting music expressing positive emotions may both increase engagement and motivation.

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Pilot efficacy trial of electrical stimulation cycling exercise for advanced Multiple Sclerosis

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BACKGROUND: Persons with advanced multiple sclerosis (MS) often have significant paralysis and fatigue which severely restricts their activity levels and exercise options. The reduced activity contributes to deconditioning and poor metabolic health. Electrical stimulation (ES) can be used to exercise paralysed muscles. AIMS: The aim of this study was to investigate whether high force ES cycling exercise[1, 2] could exercise paralysed legs to enhance muscle mass, leg strength, and quality of life in patients with advanced MS[3]. METHODS: Eleven participants (Age: 52±9 years, EDSS 7.3±0.6) with progressive MS performed their usual exercise training routines during a 12-week control period, then performed NMES leg cycling exercise three times per week for 12 weeks. Measurements were made before the control period, after the control period, and post ES exercise. Thigh muscle volume changes were calculated using MRI. Questionnaires (MSQOL54, MSIS, & MFIS) were used to determine changes in the impact of MS, quality of life, and perception of leg strength. RESULTS: Thigh muscle volume did not change during the control period (0.5±7.0%) but increased after the NMES cycling intervention (20.5±14.6%; $p<0.001$). Isometric quadriceps strength did not change but participants felt their legs were stronger after the NMES training ($p<0.01$). MSQOL54, MSIS and MFIS displayed small non-significant trends for improvement. CONCLUSION: When ES cycling exercise is adapted to suit persons with multiple sclerosis it can produce noticeable gains in muscle mass. ES may be an effective way of maintaining and preventing disuse atrophy and strength loss in persons with advanced MS.

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AbobotulinumtoxinA-injection in spastic mice improves the gait function and the endurance capacity of the gastrocnemius medialis muscle

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Intramuscular injection with botulinum neurotoxins is used to improve or maintain the joint range of motion in young children with spasticity. Little is known about the effects botulinum neurotoxins on muscle phenotype, force generating capacity and physical performance. We tested long-term gait function, contractile force characteristics, morphology and endurance of the gastrocnemius medialis 9 weeks after a single abobotulinumtoxinA-injection (Dysport®) in the gastrosoleus muscles of wild-type and spastic mice (B6.Cg-Glrbspa/J; a hereditary mutation in the inhibitory glycine receptor) at young age (6-7 days). AbobotulinumtoxinA-injection reduced the force generating capacity of the gastrocnemius medialis by 35% ($p<0.001$), while the length range of active force exertion was unaffected. Muscle mass and physiological cross-sectional area were both 10% lower ($p<0.05$ and $p<0.001$, respectively). AbobotulinumtoxinA-injected muscles had 31% lower numbers of myofibers compared to control ($p<0.0001$), but muscle fiber cross-sectional area was ~24% larger ($p<0.05$). The number of serial sarcomeres was unaffected by abobotulinumtoxinA-injection. The percentage of slow type myofibers in the high oxidative muscle region was 55% higher ($p<0.0001$), but similar in the low oxidative muscle region. Moreover, the succinate dehydrogenase activity was unaltered in abobotulinumtoxinA-injected muscles. These alterations were associated with a 16% improved muscle endurance capacity ($p<0.01$) and with a ~13% higher stride length in gait of spastic mice ($p<0.01$). In conclusion, abobotulinumtoxinA-injection at young age reduces myofiber number, but remaining myofibers show hypertrophy and an unaffected number of serial sarcomeres. AbobotulinumtoxinA-injection has a positive effect on gait and muscular fatigue resistance in mice.

Acute hypoxia impairs recovery of voluntary muscle activation after sustained low-intensity contractions

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Acute hypoxia has been shown to impair voluntary activation (VA) of muscle and alter excitability of the motor pathway during exercise. However, hypoxia related effects on recovery are relatively unknown. The purpose of this study was to determine how severe acute hypoxia alters neural mechanisms of muscle activation during, and following, a sustained fatiguing contraction. Fifteen participants (25 ± 3.2 years, 6 female) attended two sessions where they were exposed to a hypoxia condition (80% SpO2) and a sham condition. After 15 min of exposure, a 10-min isometric elbow flexion at 20% of maximal torque, and a 6 min recovery phase were examined. Transcranial magnetic stimulation (TMS) and motor point stimulation of the biceps brachii were used to assess VA. No hypoxia-related effects were identified for neuromuscular variables during the fatigue task. However, VA assessed by motor point stimulation was lower during hypoxia than sham at the 4th (sham: 89% ± 7%; hypoxia: 80% ± 12%; P = 0.023) and 6th min (sham: 90% ± 7%; hypoxia: 78% ± 11%; P = 0.040) of recovery. Similarly, VA (P = 0.01) and motor evoked potential area (P = 0.002) in response to cortical TMS were 10% and 11% lower during recovery for hypoxia compared to sham, respectively. Although a hypoxic stimulus of 80% SpO2 did not affect neural activity during the fatiguing task, motor cortical output and corticospinal excitability were reduced during recovery in the hypoxic environment.

Physiological and kinematic predictors of trip- and slip-induced falls in people with multiple sclerosis.

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PURPOSE: To identify physiological and kinematic predictors of trip- and slip-induced falls in people with multiple sclerosis (MS). Methods: In this experimental study, 31 participants with MS (50.9 ± 13.1 years) were assessed in demographics, physiological, psychological and lifestyle factors. Participants were also exposed to an unpredictable trip and slip along a 10m walkway where Vicon 3D motion capture was used to record kinematic data during gait and recovery strategies. A fall was defined as more than 30% body weight in harness loading. RESULTS: Fourteen (45.2%) and 19 (61.3%) participants fell due to the trip or/and slip, respectively. Trip fallers had greater trunk angles, lower centre of mass heights and smaller margins of stability during the first recovery step than non-trip fallers ($P<0.05$). Slip fallers had greater slip speeds, slip distances and knee flexion angles during the first recovery step compared to the non-slip fallers ($P<0.05$). Slip fallers were also older and had lower maximum activation in rectus femoris ($P<0.05$). No significant between-group differences were found in clinical measures, gait parameters (i.e. speed, step length, cadence, and toe clearance) or psychosocial factors. DISCUSSION: Neurorehabilitation to help people with MS in dealing with unexpected trips and slips in daily life is required.

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Effects of short and long-term adaptation to a knee joint constraint on shared neural drive of ankle plantar flexors

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The descending drive from the central nervous system (CNS) to synergistic muscles is partly shared [1]. It is unknown how a constraint of the joint range of motion affects this shared neural drive [2]. Our aim was to investigate how an artificial (short-term) and a chronic knee joint constraint (long-term) affect the shared neural drive to ankle plantar flexors during gait. As structural changes in the CNS are found only after a long-term knee joint constraint [2], we hypothesize different effects of an artificial knee joint constraint than of a chronic constraint. Eleven healthy subjects (CG) and eight people with a chronic knee joint constraint walked overground at 1 m/s. The CG also walked with an articulated knee brace limiting knee joint movement to 20°. Muscle activity of plantar flexors was collected through surface electromyography. Shared neural drive was assessed using the ensemble empirical mode decomposition and instantaneous phase dependence of time series in bi-directional causality [3]. The mutual predictability was assessed using the approximate cross-entropy to estimate the intensity of shared neural drive [4]. The artificial knee constraint in the CG resulted in less shared neural drive from biarticular (gastrocnemius) to uniarticular (soleus) plantar flexors. Shared neural drive between plantar flexors bi-directionally was significantly lower in chronic knee constraint compared to CG and artificial knee constraint. In conclusion, short-term adaptation to a knee joint constraint affects the shared neural drive to ankle plantar flexors, but not in the same way as in people with a chronic knee joint constraint.

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Current practice in the assessment of people with neurological disorders: findings from a national survey of Australian physiotherapists

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Currently there are approximately one billion people worldwide affected by a neurological condition. Many of whom are assessed and treated by a physiotherapist in a variety of settings. There is a lack of consensus in the literature related to what is assessed clinically by physiotherapists in people with neurological conditions. A national on-line survey targeting Australian physiotherapists, who currently assess adults with neurological conditions in clinical practice was used to explore assessment practices. The study investigated the influence of health care setting, experience, and therapeutic approach, on neurological assessment. This survey consisting of 39 questions was distributed to physiotherapists through the Australian Physiotherapy Association, Chief Allied Health Officers across Australia and advertised on the National Neurological Physiotherapy Facebook page. In total 389 respondents consented to the survey from all states within Australia. Most respondents were female (85.05%) and aged between 25-30 (33.17%). Preliminary analysis indicates the condition most frequently assessed was Stroke (58.29%) and the most commonly assessed domains by >70 % of respondents were function (89.6%), gait (77.4%), goals (75.9%), falls and safety (75%) and muscle strength (70.3%). There is variability in assessment domains used by physiotherapists across Australia, with common inclusions of function, gait, goal setting, falls and safety, muscle strength. There is little evidence to support what physiotherapists assess in practice, in different settings, in different states within Australia and around the world. Further research is needed to explore this area and develop a consensus around best practice.

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