Book of Abstracts

The International Motor Impairment Conference 2025

The International
Motor Impairment Conference
8-10 October 2025

NeuRA Discover — Conquer — Cure

Amsterdam Movement Sciences
VU Vrije Universiteit Amsterdam
Amsterdam UMC

Faculty of Behavioral and Movement Sciences

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Keynote / Invited Speakers / Oral Presentations

Keynote 1 (K1)

Motor Impairment: where are we now?

Simon Gandevia
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This conference was founded in 2018 on the belief that impairment of motor function occurs across multiple diseases and domains such as ageing. It is broadly defined and likely very common. In the quest to understand and ameliorate motor impairments the field needs quality research rather than mere quantity. I will cover several issues. First, a commentary on the ubiquitous problem of p-values. They provide a delusion about the likely reproducibility of results when the p-value is around 0.05 – the usual threshold for 'significance'. Such a value has only a 50% chance of replication. There are other ways in which our statistical beliefs are manipulated by our apparent results. Second, it is often tempting to assume that a correlation signifies a cause. This is exemplified by the seemingly strong link between results of proprioception tests and tests of practical function in patient groups. Our recent review of this link in stroke, multiple sclerosis and Parkinson's disease shows otherwise (Robertson et al, 2025). Third, in chronic spinal cord injury, another motor impairment, the view from small poorly controlled studies suggests that transcutaneous spinal cord stimulation would enhance the ability of locomotor training to improve walking. Not so according to robust results from our randomised, sham-controlled, triple-blinded, fully-powered trial (Bye et al, 2025). Finally, we need strategies to improve the reliability of our clinical research, reduce research 'waste', and maximise the benefits of what we do.

Session 1: Muscle and Tendon Impairments - Invited speaker presentation (S1-1)

What can magnetic resonance imaging tell us about muscle structure, function and metabolism and their relationship with motor impairment?

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Andrew Blamire

Abstract

Magnetic resonance imaging (MRI) is well known as a diagnostic tool providing high-definition detail of human anatomy, both within the central nervous and musculoskeletal systems. The true power of MRI rests with the capacity to link scan contrast to an array of underlying tissue characteristics, from microstructure to metabolism and function as well as gross anatomy. As a non-invasive technology MRI provide an important tool to follow disease progression and response to intervention. Recent developments pioneered by my group include the ability to image and quantify individual motor units, to study fasciculation, to measure muscle contractile characteristics and their response after fatiguing exercise and to follow progression of muscle loss in degenerative conditions. This presentation will overview the use of MRI in the muscular system, introducing our new techniques and consider the insights which they can provide into muscle ageing and disease pathophysiology across a range of clinical conditions including healthy ageing, mitochondrial disease and neuromuscular diseases (dysferlinopathy, spinal muscular atrophy and amyotrophic lateral sclerosis).

Session 1: Muscle and Tendon Impairments - abstract presentation (S1-2)

SYSTEMIC UPREGULATED INFLAMMATORY CYTOKINE IL-6 IN ESTABLISHED RHEUMATOID ARTHRITIS IS ASSOCIATED WITH ALTERED MUSCLE MITOCHONDRIAL RESPIRATION AND ROS PRODUCTION

Yaro Meijer[1], Winston van Druten[2], Lisse Geurink[2], Felicia Tröger[1], Esmee van den Berg[2], Aiarpi Ezdoglian[1], Sebina Jakupovic[1], Martin van der Esch[3], Rob C.I. Wüst[2], Richard T. Jaspers[2], Conny van der Laken[1], **Maarten M. Steinz**[1,2]

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Background
Despite effective treatment of joint inflammation, muscle dysfunction persists in rheumatoid arthritis (RA), reducing muscle strength up to 75% in established-RA. Interleukin-6 (IL-6), a pleiotropic cytokine, remains chronically elevated in established-RA even under first-line anti-TNF-α therapy. The IL-6 effects on muscle mitochondria at RA-relevant pathophysiological concentrations are unclear, yet may be critical to develop therapies restoring muscle function.

Purpose
Investigate the effects of IL-6 at RA-relevant concentrations on mitochondrial respiration, ROS production, and gene expression in human muscle *in-vitro*.

Methods
Healthy control and established-RA serum IL-6 concentrations were determined with multiplex. Primary human muscle cells were differentiated into myotubes and exposed to IL-6 (0–160 pg/ml) or established-RA serum. Mitochondrial respiration (basal, leak, ATP-linked, maximal) was assessed by Seahorse respirometry, ROS-production by MitoSox imaging, and gene expression by qPCR.

Results
Serum IL-6 concentrations were elevated in anti-TNF-α-treated established-RA patients (35.84±18.67 pg/ml) vs. controls (1.23±0.27 pg/ml). IL-6 at 10–20 pg/ml increased maximal muscle cell respiration (40%, 37%) and leak respiration (25% at 10–40 pg/ml). At 20 pg/ml, IL-6 raised ROS by 16% after 72h, also in the presence of anti-TNF-α. It also reduced mitochondrial complex IV gene expression: NDUFA4 (−23%) and COX4I1 (−32%). Similar reductions occurred with established-RA serum: NDUFA4 (−45%), COX4I1 (−41%). *$p<0.05$ for all results.

Conclusions
Serum IL-6 remains ~35× higher in established-RA despite anti-TNF-α therapy, impairing muscle mitochondrial function and gene expression by *in-vitro* exposure. Findings suggest a

pathophysiological link between IL-6 and mitochondrial dysfunction in established-RA, which remains to be established through further translational studies.

Muscle and bone growth in the lower legs of typically developing children and children with cerebral palsy: a longitudinal imaging study

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Longitudinal data on skeletal muscle growth in children are scarce, so little is known about developmental trajectories of skeletal muscle size, the relative timing of muscle and skeletal growth, and how cerebral palsy (CP) affects growth. Extending a cross-sectional muscle growth study (1), here we present longitudinal imaging data of 252 children (66 with CP) aged 5-18 years. Using deep learning for accurate, automated segmentation of lower leg muscles and bones from mDixon MRI scans, we measured the volumes of ten individual leg muscles and tibia lengths on 2-3 occasions over, on average, three years. The measurements were used to estimate age- and sex-specific reference curves for growth velocities of muscle volumes and tibia length. Peak adolescent growth velocity in total lower leg muscle volume was higher and occurred later in typically developing boys (155 cm^3/yr at 14.2 years) than in girls (117 cm^3/yr at 12.1 years), and occurred 1.9 and 1.8 years after peak tibia length velocity in boys and girls, respectively. In children with CP, median muscle growth velocities were ~41% smaller and tibia length velocities were ~11% smaller than in age- and sex-matched typically developing children. This study shows how advances in MRI imaging and automated analysis methods enable large-scale and detailed research on typical childhood growth, as well as child- and muscle-specific analyses of the effects of neuromuscular disease on muscle and bone growth. The findings may be used to optimise timing and selection of muscles to target for interventions in children with CP.

1. Bolsterlee B, Chow BVY, Yu J, Davies S, Morgan C, Rae CD, Warton DI, Novak I, Lancaster A, Popovic GC, Rizzo RRN, Rizzo CY, Ball IK, Herbert RD (2025). PNAS 122, e2416660122.

Session 1: Muscle and Tendon Impairments - abstract presentation (S1-4)

Gastrocnemius medialis muscle morphology and function after lengthening surgery in children and youth with cerebral palsy

Van den Heuvel G [1, 2], Mooijekind B [1, 2, 3], Van der Krogt MM [1, 2], Witbreuk MMEH [4], Schallig W [5], Weide G [2, 6], Jaspers RT [2, 6], Bar-On L [3], Buizer AI [1, 2, 7]

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Plantarflexion contracture is a common deformity in children with cerebral palsy (CP). Surgical gastrocsoleus aponeurotic lengthening can improve ankle Range Of Motion (ROM). Effects on muscle morphology are not yet known. We assessed the effects of gastrocsoleus lengthening on gastrocnemius medialis (GM) morphology and ankle ROM during gait in CP. We hypothesized postoperative increases in ankle ROM due to tendon elongation.

Nine individuals with CP (12-19 years) were assessed before and one year after gastrocsoleus surgery. All had a 3D ultrasound of the GM[1], and seven participants also underwent 3D clinical gait analysis with multi-segment foot model[2]. Outcomes were compared using a Wilcoxon signed rank test.

After surgery, tendon length normalized by tibia length increased by 14%, (*median [min:max]*), (0.056 [-0.008:0.143], p=.01), while normalized fascicle length decreased by 13%, (-0.021 [-0.078:-0.006]). Muscle volume normalized to body mass increased non-significantly by 10%, (0.179 [-0.477:0.339], p=.26). The Physiological Cross-Sectional Area (PCSA=volume/fascicle length) increased by 15%, (4.27cm^2 [1.48:10.75cm^2], p=.03). Large variation in gait pattern changes after surgery was observed. The passive resting ankle dorsiflexion angle increased by 17° [6-26°] (p=.01), Ankle ROM during gait was decreased by -3.99° [-1.62:-10.44°] (p=.02) due to reduced maximum dorsiflexion (N=2), reduced maximum plantarflexion (N=4), or reduction of both maximum dorsiflexion and plantarflexion (N=1).

Despite large variation in effects of surgery between individuals, gastrocsoleus lengthening increases passive ankle dorsiflexion by elongating the Achilles tendon, while fascicles shorten and PCSA increases. The observed reduction in active ankle ROM could be related to fascicle shortening.

1. Weide G, Van der Zwaard S, Huijing PA, Jaspers RT & Harlaar J (2017) J Vis Exp 129, e55943

2. Van den Heuvel G, Buizer AI, Quirijnen L, Witbreuk MM, Van der Krogt MM & Schallig W (2025) Gait Posture 117, 115-120

Functional power training increases calf muscle volume in children with spastic paresis

Mooijekind B [1,2,3], Bar-On L [2], van Vulpen L [4], Van den Broeck C [2], Jaspers RT [5], Weide [5], van der Krogt MM [1,3], Buizer AI [1,3,6]

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Children with spastic paresis (SP) often experience muscle weakness and shortening, limiting walking capacity. Functional training improves walking and running capacity (1), but its effects on muscle morphology remain unclear. We investigated how training impacts gastrocnemius medialis (GM) morphology in children with SP. We hypothesized that GM volume and physiological cross-sectional area (PCSA) would increase, potentially lengthening the muscle belly due to the GM pennate structure.

Twenty-two ambulatory children with SP participated in a twelve-week functional power training program. In a double baseline study design, GM morphology, i.e. muscle belly, tendon, fascicle length, muscle volume, and PCSA (volume/fascicle length), was assessed twelve weeks before (T0), just before (T1), and after training completion (T2) using 3D ultrasound (2). Isometric GM strength and running speed were assessed at T1 and T2. Morphological changes between usual care (T1–T0), training (T2–T1), and isometric strength and running speed (T1 vs T2) were compared with paired t-tests.

GM volume increased by 5.3±5.3mL after functional power training ($p<0.001$) compared to usual care. PCSA did not change between T0 and T1, but was 13% larger at T2 (10.4±4.8cm) compared to T1 (11.6±4.8cm). However, changes in PCSA or other GM length variables did not differ between usual care and training. After training, isometric plantar flexor strength increased by 19% and running speed by 15% (all $p<0.001$).

Functional power training increases GM volume, without altering GM length in children with spastic paresis. The increase in volume may contribute to the functional progress after functional power training.

[1] van Vulpen (2017) Neurorehabil. Neural Repair. 31, 827-841

[2] Weide (2017). J. Vis. Exp. 129, e55943

Session 2: Balance & Gait Impairments – Invited speaker presentation (S2-1)

Mobility as the 6th vital sign in the Decade of Healthy Aging

Dr. Marla Beauchamp, PT, PhD
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Abstract

Mobility has been coined the 'sixth vital sign' because of its ability to predict health outcomes in later adulthood. The World Health Organization defines mobility as movement in all forms, powered by the body or a vehicle. It encompasses both simple movements, such as standing up, and more complex activities, like walking or driving. While numerous measures have been developed to assess mobility, challenges arise from inconsistent definitions and lack of standardized terminology. To address this, we proposed a unified mobility measurement framework that considers three facets of mobility: perceived mobility ("can do"), locomotor capacity ("could do"), and actual mobility ("do do"). The latter aspect, actual mobility, has received less attention until recently. Wearable devices provide a unique opportunity to track the actual real-world mobility of older adults within their homes and communities. In this presentation, we will discuss results from the McMaster Monitoring My Mobility (MacM3) study, a cohort of over 1,500 community-dwelling older adults who are being followed every 4 months for 2 years using wearable technology. The study provides detailed data on all three mobility aspects and examines their relationships with key health outcomes, demonstrating the value of mobility vital sign tracking for promoting healthy aging.

New Technologies for Fall Prevention

Lord SR [1]

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This talk will present findings from recent research that has used new technologies to enhance our understanding of fall risk and facilitate fall prevention interventions. It will initially outline the utility of wrist-worn sensors for predicting falls and associated conditions such as frailty, as well as describe the role of stepping and gait adaptability tasks as models for fall risk. In terms of interventions, this presentation will summarise the findings of several randomised controlled trials of e-health, exergame and virtual reality interventions. It will explore mechanisms underlying training effects on improved stepping performance, present the findings of a large randomised controlled trial that found exergame step training can reduce falls by 26% and describe recent work that has incorporated reactive and voluntary stepping into virtual reality treadmill training. It will conclude with practical suggestions for how these interventions can be incorporated into clinic settings.

Perception and Intentionality of Gait Adaptations Following Exercise-Induced Muscle Fatigue In Older Adults

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Exercise-induced muscle fatigue can affect older people's gait and hence their fall risk. However, non-homogeneous gait adaptations have been shown (1), questioning whether these are caused by a direct effect of fatigue or by compensatory strategies to account for (perception of) fatigue. This study aimed to determine if older adults, when their gait changes as a result of exercise-induced muscle fatigue, perceive gait alterations, and whether these alterations are (un)intentional.

We conducted a convergent mixed-methods study with eighteen healthy older adults (>65 year, 13 females). Participants performed a paradigm of twenty repetitive sit-to-stand exercises, alternated by in-between 15-m walking trails until fatigued. Gait parameters were measured using THEIA Markerless motion capture. Directly after the increasingly fatiguing walking trails, participants were interviewed on perception of gait adaptations. Gait parameters were analysed on individual level using independent samples tests. Further analysis focussed on whether older adults' perceived gait adaptations were congruent with objective gait parameter data, and if adaptations were (un)intentional.

In most individuals, gait speed, step length, and anterior-posterior margin of stability significantly changed with exercise-induced fatigue. Participants most frequently perceived slower gait speed and decreased stability. Furthermore, only a few adaptations were intentional. Convergent analysis showed that the majority of participants did not accurately perceive the alterations in gait.

Although gait changes when fatigued, and older adults do perceive adaptations, they do not seem to congruently match their perception with actual changes. This misalignment could play a role and should be addressed in older adults' risk for falling when fatigued.

1. Voorn, Oomen, Buczny, Bossen, Visser & Pijnappels (2025) EURAPA 22:4

Balance impairment in older adults: ageing or neuromuscular deconditioning?

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Ageing is a multifactorial process, often accompanied by sedentary behaviour, especially in highly developed countries. This study aims to determine whether age-related balance impairments are a direct result of ageing itself, or if they are primarily caused by a sedentary lifestyle and the resulting neuromuscular deconditioning.

We tested standing balance in four groups of 10 participants: young sedentary (21.8±3.52years, 1.65±0.09m, 66.1±11.9kg), young exercisers (23.4±6.24years, 1.68±0.13m, 65.2±9.86kg), older sedentary (75.3±5.9years, 1.65±0.09m, 71.0±13.4kg), older exercisers (73.6±5.04years, 1.71±0.06m, 74.6±12.4kg). Participants' sway was recorded for 30s under 8 conditions, altering visual input (eyes open/closed), standing surface (rigid/foam), and stance width (self-selected/feet together).

Under un-perturbed conditions (self-selected standing, rigid surface, eyes open), no difference was found between groups. As the sensory challenges were introduced, with eyes closed sedentary participants showed 5.34mm larger medio-lateral sway than exercisers (p=0.010). With feet together, older participants showed larger sway than younger participants (5.37mm antero-posterior, p=0.022; 9.01mm medio-lateral, p=0.003). When sensory perturbations were combined, older participants showed larger sway. On the foam surface with eyes closed, older groups showed larger sway, older exercisers showed larger sway than younger sedentary participants, and younger exercisers showed lower sway than younger sedentary participants.

Across both age groups, exercisers showed reduced sway. However, older exercisers did not outperform younger sedentary participants. These results suggest that while a sedentary lifestyle and resulting neuromuscular deconditioning contribute to balance impairments, they do not fully account for them. Intrinsic, age-related factors also play a significant role.

Is perception of postural instability impaired in people with Parkinson's disease?

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Background: For people with Parkinson's disease (PwPD), backward postural instability is common and debilitating. Their reactive stepping responses to balance perturbations are often insufficient, increasing fall risk. We investigated whether instability perception in PwPD, i.e., the brain's estimation of a perturbation's impact on stability, might explain this inadequate response. We hypothesized that the midfrontal EEG response during reactive balance control, previously associated with the perturbation's impact on stability [1,2], would be attenuated in PwPD compared to healthy age-matched controls (HC)

Methods: High-density EEG and kinematic data were recorded while PwPD (n=11) and HC (n=15) received 90 low-intensity, forward balance perturbations. The low intensity ensured that all participants could rely on a feet-in-place strategy to recover balance. We extracted source-level midfrontal N1 and theta (3-8 Hz) responses following the perturbation. In addition, we extracted biomechanical outcomes, including the instantaneous and minimal margin of stability (MoS). We analysed single-trial data using linear mixed-effects (LME) models.

Results: PwPD showed lower MoS at the theta peak latency (-2.12 cm) but no between-group differences in theta peak power or minimal MoS were found. Theta power was negatively correlated with MoS. PwPD exhibited reduced theta power at comparable instability levels for both instantaneous and minimal MoS.

Conclusion: Reduced midfrontal response may reflect an impaired perception of instability, potentially contributing to impaired balance in PwPD. Future research should explore midfrontal dynamics during more destabilizing tasks to further investigate backward stepping deficits in this population.

References

1. Solis-Escalante et al., Eur. J. Neurosci., 54(12), 2021

2. Stokkermans et al., Cereb Cortex, 33(7), 2023

Cannabis intoxication acutely increases sway during quiet standing: A double-blinded, placebo-controlled crossover study on Δ9-tetrahydrocannabinol and cannabidiol

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Despite 200+ million people using cannabis annually, little is known about its impact on human movement. The primary intoxicant in cannabis, Δ9-tetrahydrocannabinol (THC), impairs cognitive motor function[1], whereas another key compound, cannabidiol (CBD), may lessen the THC-induced high. Standing balance is impaired for chronic cannabis users[2], but the acute effects of THC and CBD on balance are unknown. In this study, we hypothesized: 1) THC would increase postural sway, characterized by centre of pressure path length (COP_{PL}), compared to placebo (PLA); 2) co-administration of THC+CBD would attenuate the THC-induced increase of COP_{PL}; and 3) CBD alone would not influence COP_{PL}. Across four visits, seven (two female) infrequent cannabis users completed an easy (vision, non-compliant surface) and challenging (no vision, compliant surface) 3-min quiet stance trial on a force plate before (Pre) and after (Post) ingesting: THC (10mg), THC+CBD (10mg each), CBD (10mg), or PLA (vitamin E). Linear mixed-effects models were used to compare PLA Post data to those of other interventions, with Pre included as a covariate. Post-hoc Holm-Bonferroni corrected paired t-tests were used to compare THC and THC+CBD. No differences were observed between interventions during the easy posture ($p \geq 0.121$). For the challenging posture, compared to PLA, COP_{PL} increased by 53% following ingestion of THC ($p=0.039$) and by 90% following THC+CBD ($p=0.001$), with no difference between THC and THC+CBD ($p=0.419$). Quiet stance was unaltered by CBD ($p=0.250$). Overall, this work indicates that THC impairs standing balance if posture is sufficiently challenged, and CBD does not attenuate this effect.

1. Crean, R.D., Crane N.A., & Mason, B.J. (2011). J Addict Med 5, 1-8
2. Bolbecker, A. R., Apthorp, D., Martin, A. S., Tahayori, B., Moravec, L., Gomez, K. L., O'Donnell, B. F., Newman, S. D., & Hetrick, W. P. (2018). Drug Alcohol Depend 190, 54-61

Free-living gait assessment in Parkinson's disease with contextualization via computer vision

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Free-living gait assessment for fall risk in Parkinson's disease (PD) often relies on inertial measurement units (IMUs) to quantify spatio-temporal gait characteristics. However, that method alone lacks critical contextual data which may lead to an overestimation of fall risk from gait characteristics due to random environmental factors e.g., obstacles. This study integrates IMU with wearable eye-tracking video glasses and AI-driven computer vision (CV) to enhance free-living gait assessment by providing contextual (environment) and behavioural (gaze) insights for a more informed fall risk assessment. Ten participants with PD wore a waist-mounted IMU and eye-tracking video glasses for a 3-hour free-living assessment. IMU data (100Hz, ±8g) were processed with validated algorithms to derive gait characteristics (e.g., step time variability). Video data were analysed using a validated fine-tuned YOLOv8 model trained on 4,800 annotated home-environment images. IMU data alone suggested several high fall-risk bouts, evidenced by elevated step time variability (e.g., 0.20s) compared to other bouts with low variability (e.g., 0.01s). However, when examined with AI contextual data, these high-risk bouts were explained by natural adaptive responses to environmental challenges e.g., navigating stairs, avoiding pets, or avoiding obstacles. Eye-tracking (gaze) data confirmed a natural response as participants focused on e.g., hazards, obstacles or other people, reducing the perceived number of high-risk events. Ongoing research is recruiting more participants with PD and growing the generalisability of the model to validate this method in larger cohorts and refine workflows to unify gait and contextual data for robust risk profiling.

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Session 3: Sensory Impairments – Invited speaker presentation (S3-1)

What can assist the adoption of novel interventions, technologies and evidence in rehabilitation? Examples from stroke and diabetic foot care pathways

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Abstract:

Using examples of stroke rehabilitation and diabetic foot care clinical contexts, this talk will explore ingredients of research that is poised to optimise the likelihood of mobilising knowledge generated through research into clinical action and improved service user outcomes. Research questions include: What are the roles of partnership and whole systems thinking in the earliest stages of mechanisms focussed research? How do we balance goals for discovery and design of the most ambitious treatments, what is practically possible in public care systems and what matters to people who could stand to benefit from improved treatment approaches? What might our role be in better mobilising evidence base of sensori-motor impairments?

Applying multidimensional plantar pressure analyses to evaluate the offloading effectiveness of custom-made footwear in people with diabetes and loss of protective sensation

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Custom-made footwear is a key recommendation to reduce the risk of foot ulceration in people with diabetes and loss of protective sensation caused by peripheral neuropathy. The DIASSIST optimization method, which is based on scientific evidence, clinical expertise, and pressure-data-driven footwear design (1), might be used to pressure-optimize this footwear. Our aim was to investigate the offloading effectiveness of the DIASSIST optimization method using multiple peak pressure parameters.

A total 126 participants with diabetes, peripheral neuropathy, a recently healed foot ulcer or (partial) foot amputation, who possessed custom-made footwear were included in the DIASSIST randomized controlled trial. In-shoe plantar pressures were measured, from which scalar and multidimensional pressure parameters were calculated (2). Footwear of participants in the intervention arm were pressure-optimized following the DIASSIST optimization method. Differences between intervention and control group and between pre- and post-modifications for the intervention group were assessed with t-tests and statistical parametric mapping.

Footwear in the intervention group was significantly improved compared to control and compared with pre-modifications. For both comparisons, all scalar parameters improved significantly ($p<0.05$), except the pressure-time integral for the intervention vs. control comparison. Improvements in pressure were found during 42-85% of the stance phase and in the metatarsal area of the foot ($p<0.05$).

To conclude, the DIASSIST optimization method significantly improved the pressure-relieving properties of custom-made footwear. In the absence of sensory feedback, multidimensional pressure analyses provide a detailed alternative feedback method to identify spatiotemporal peak pressures, enabling targeted modifications and thereby enhancing personalization of custom-made footwear.

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Reliability and feasibility of static and dynamic balance assessments using a pressure platform in patients with diabetic neuropathy

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Introduction: Diabetic neuropathy (DNP) has been associated with impaired postural balance, which increases the risk of falling and has a negative impact on quality of live and living independently.[1,2] Conventionally, force platforms have been used to evaluate postural balance. However, their application in clinical (podiatry) practice remains limited. A pressure platform may be a valuable alternative device for assessing postural balance.

Objectives: The objective of this study was to evaluate the reliability and feasibility of static and dynamic balance assessments using a pressure platform in patients with DNP, and assess the impact of protocol variations on reliability.

Method: Cross-sectional study among patients with DNP (n=58). We recorded six static center of pressure parameters, during eyes open and closed, at 30 and 60 seconds, and 15 dynamic balance parameters each during two test sessions. Reliability within session (intra-session) and between sessions (inter-session) was assessed using intraclass correlation coefficients (ICCs), and standard errors of measurement (SEMs). We considered an ICC ≥0.7 as acceptable.

Results: Two measurements were sufficient to obtain reliable static intra-session measures, and three for inter-session measures. Higher ICCs were found for eyes closed versus eyes open, regardless of sample duration. Five steps were required to obtain reliable scores for 14 out of 15 dynamic balance parameters (93.3%) within and between sessions. However, some dynamic parameters show high SEMs, up to 68.5% of the (low) median.

Conclusion: A pressure platform can reliably obtain a wide range of static and dynamic balance parameters in patients with DNP in a clinical setting.

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Characterising signatures of atypical dementia: gait differences between Posterior Cortical Atrophy, Alzheimer's and Lewy body disease

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Diminished walking and mobility are life- and health-limiting consequences of dementia. Common dementia subtypes – such as Alzheimer's (AD) and Lewy body disease (LBD) – can be distinguished by measuring walking patterns (1), with potential utility as a biomarker for differential diagnosis. The most common atypical AD clinical phenotype – posterior cortical atrophy (PCA) – results in early visuomotor and mobility difficulties (2) but whether walking patterns are distinct from other dementia subtypes is unclear.
We measured walking at a self-selected pace in 18 people with PCA and compared to people with typical-AD (n=36), LBD (dementia with Lewy bodies [n=30] or Parkinson's disease dementia [n=15]), or no clinical diagnosis (Control; n=29). We computed walking metrics representing pace, variability, rhythm, asymmetry, and postural control using gold-standard motion-capture techniques. People with PCA were on average younger than the other groups but matched with typical-AD and LBD groups for mini-mental state examination (MMSE) score. We hypothesised that PCA would be slower and more variable than typical-AD, and intermediate between typical-AD and LBD groups in walking abnormality. Statistical models adjusted for age, sex, and height.
People with PCA walked slower, with shorter steps, and greater stance time variability, step velocity variability, step length variability, and step width compared with typical-AD and Controls.
People with PCA walked with greater stance time variability and step length variability than LBD.
We demonstrate that walking patterns can distinguish PCA from other dementia subtypes. Current PCA diagnostic criteria ignore gait disorder, but our findings suggest gait abnormality in PCA comparable to, or greater than, LBD.

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Disruptions in Sensorimotor Integration: Unraveling Abnormal Corticomuscular and Intermuscular Coherence in Childhood Dystonia

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Motor impairment is a common cause of disability across neurological conditions, including childhood dystonia. This movement disorder involves involuntary, sustained muscle contractions and impaired voluntary control, yet the precise neural mechanisms remain poorly understood (1). Corticomuscular (CMC) and intermuscular coherence (IMC) are neurophysiological metrics that assess synchronization between cortical and muscular activity, providing insight into sensorimotor integration during movement (2). We hypothesize that children with dystonia show altered coherence, particularly in the beta (15–30 Hz) and gamma (30–45 Hz) bands, indicating impaired corticospinal connectivity and disrupted motor coordination. To investigate this, we conducted a systematic review of studies using CMC and IMC in pediatric dystonia. Results revealed considerable variability in task paradigms, signal processing methods, and coherence analysis, underscoring the need for methodological standardization. To complement the review, we conducted a pilot study using a robotic arm called the Haptic Master. Healthy adults performed 256 reaching trials under visual and force perturbations while EEG and EMG were recorded. Perturbations were introduced via visual rotation (±15°) or force displacement (±15° or ±30°). Behavioral metrics included reaction time (RT) and endpoint error. RTs increased significantly under both visual (M = 1.292 s, SD = 0.206) and force perturbations (M = 1.398 s, SD = 0.251), and accuracy decreased under both conditions ($p < .001$). These findings suggest that coherence measures, combined with behaviorally sensitive reaching tasks, may offer a robust framework to evaluate sensorimotor function. This approach may support improved diagnostics and interventions in childhood dystonia and other motor impairments.

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Associations Between Persisting Primitive Reflexes, Fundamental Motor Skills and Cognitive Functions in Preschool Children: a Cross-Sectional Study

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Introduction: Primitive reflexes (PRs) are involuntary motor responses crucial in early neurodevelopment (1). While typically integrated within the first year of life, their persistence—termed persisting primitive reflexes (PPRs)—has been linked to developmental delays, particularly in populations with neurodevelopmental disorders (2). However, their predictive role in neurotypical children remains underexplored. This study hypothesised that individual PPRs are associated with performance in motor and cognitive domains in preschool-aged children.

Methods: Seventy-seven neurotypical children (aged 4–6) were assessed on five PRs (ATNR, STNR, TLR, Landau, Moro), fundamental movement skills (TGMD-2), and cognitive functions (IDS-P/IDS battery). Multiple regression analyses were used to evaluate the predictive value of individual PPRs while controlling for age, sex, and parental factors.

Results: The Moro reflex emerged as a significant negative predictor of both locomotion and object manipulation scores. In the cognitive domain, the Landau reflex was a significant negative predictor of performance in phonological memory and visual perception subtests. These associations remained significant after adjusting for relevant covariates.

Conclusion: Our findings suggest that residual PPRs, even in neurotypical children, may influence both motor coordination and selected cognitive processes. These baseline results highlight the importance of including reflex assessment in early developmental screenings to identify subtle delays and potentially guide early intervention.

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Unlocking vestibular stimulation as a rehabilitation approach: an application of sensory reweighting

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Sensory signals from the visual, vestibular, and proprioceptive systems are integrated based on their reliability to stabilize the trunk's upright posture, in a process known as 'sensory reweighting' [1]. Individuals with low back pain rely less on lumbar proprioceptive signals for postural control during standing [2]. This study aimed to test whether prolonged stochastic electrical vestibular stimulation (EVS) could decrease the weighting of vestibular signals and increase the weighting of lumbar proprioception for trunk stabilization during walking in healthy individuals.

Eleven healthy young participants walked on a treadmill at 2.8 km/h for 70 minutes with eyes open. Stochastic EVS (2 to 25 Hz) was applied continuously for 50 minutes. Muscle vibration (80 Hz) was applied on the left paraspinal muscle at the L2 level, in series of fifteen 1-second vibrations with 2-second intervals. Vibration series were applied at 0, 30 and 50 minutes during EVS, and 10 minutes before and after EVS.

The weighting of lumbar proprioception was assessed by the muscle vibration induced mediolateral displacement of a cluster marker at the sixth thoracic level. Vestibular contribution was evaluated by the coherence and gain between the EVS signal and mediolateral ground reaction force (GRF). Generalized linear models were fitted to identify changes in sensory weighting over time.

EVS-GRF coherence and gain significantly decreased over time, while the response magnitude to muscle vibration increased. These findings suggests that prolonged EVS can downweigh the vestibular signal while upweighting lumbar proprioception. This may unlock EVS as a novel rehabilitation approach for proprioception impairments.

Word count: 250 words

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The influence of body orientation on length judgements.

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Introduction:
Perceiving the size of an object requires the combination of various sources of sensory information. Recent literature suggests that body orientation plays a crucial role in such function (1), implying potential consequences in neurological conditions characterised by altered body sensory information (2).

Objectives:
In this exploratory study, we aimed to explore within-participant and group-level effects of body orientation on visual and haptic estimations. Moreover, we intended to investigate whether the reported effect on visuo-haptic size matching was consistent with the effects identified on visual and/or haptic estimations.

Methods:
We used a within-participant design combining an experiment using visuo-haptic size matching with two experiments that assessed the visual and haptic size-percept using free magnitude estimation. All experiments were performed in a virtual reality environment using HTC Vive Pro Eye.
We modelled random-effect regression lines to the percepts; we reported and interpreted means and confidence intervals built on the slopes for three different body orientations.

Results:
Confidence interval overlaps indicated no significant group-level effects. Within-participant effects could not be consistently linked to changes in body orientation. Visuo-haptic matching produced smaller mismatches than free magnitude estimations, with a direction opposite to that reported in the reference literature (1).

Conclusion:
Our findings suggest that conclusions about perceived object size are highly sensitive to experimental design details. Standardisation is essential before applying such paradigms to more variable populations, such as patients with neurological conditions. Future research should clarify how various sensory cues contribute to perception and how these contributions may change in clinical populations.

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Metabolic cost of vestibular-driven variability during standing balance

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Older adults often exhibit increased postural sway (1), which not only destabilizes balance but also elevates energetic demands, contributing to fatigue and greater fall risk. Yet the explicit metabolic cost of variability during standing remains unclear. Here, we investigated this relationship by perturbing vestibular input with electrical vestibular stimulation (EVS) in healthy young adults (N = 20). Participants stood quietly with eyes closed across seven conditions varying in EVS frequency (0-20 Hz), amplitude (0-3 mA), and external support, while whole-body sway, electromyography, ground-reaction forces, and energy expenditure (indirect calorimetry) were measured. Our results reveal that when participants were externally supported during low-frequency EVS (0–4 Hz), or when exposed to high-frequency EVS (5–20 Hz) that reliably evoked vestibular-driven muscle activity but without sway, energy expenditure was indistinguishable from equivalent conditions without EVS. In contrast, when standing freely, low-frequency EVS (0-4 Hz) induced sway and significantly elevated metabolic cost, with effects scaling with sway amplitude. When participants voluntarily reproduced matched sway trajectories, the energetic increase was similar, showing that both reflexive and voluntary variability carry equivalent costs. These results demonstrate that sway variability itself, rather than vestibular activity or vestibular-driven muscle recruitment alone, is the primary determinant of the metabolic cost of standing. This insight highlights a potential mechanism by which increased sway in aging or disease elevates the energetic burden of balance and contributes to mobility decline.

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Session 4: Cardiovascular & Respiratory function Impairments – Invited speaker presentation (S4-1)

Exploring O2 cascade from the ambient air to mitochondria in health and disease

Simone Porcelli

University of Pavia, Italy

Aerobic capacity—driven by efficient oxygen (O_2) delivery and utilization—is a cornerstone of physical function and a powerful predictor of morbidity and quality of life. This presentation will explore the O_2 cascade, from pulmonary uptake to mitochondrial consumption, through the lens of both systemic physiology and neuromuscular limitations. We will highlight how disruptions in this cascade contribute to motor impairments in disuse, aging population and chronic disease. Key innovations in non-invasive assessment techniques will be discussed, including the use of near-infrared spectroscopy (NIRS) to quantify skeletal muscle oxidative capacity and O_2 diffusion. By integrating insights from translational human studies, this presentation aims to advance our understanding of neuromuscular limitations to movement and guide future interventions to preserve or restore aerobic function in clinical populations.

Exercise limitation in long COVID and ME/CFS: convective, diffusive, and mitochondrial impairments in the oxygen cascade

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Long COVID and myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) are debilitating diseases which share many characteristics. A defining feature of both symptoms is a reduction in exercise capacity relative to the patients' pre-illness baseline. However, in both cases, the mechanisms underpinning this reduction in exercise capacity remain unclear. In this presentation, I will outline the evidence for impairments at each step in the oxygen transport and utilization cascade in these conditions, from atmosphere to muscle mitochondria. In particular, I will highlight a re-analysis of the results of invasive cardiopulmonary exercise tests which demonstrates a quantitatively large deficit in the muscle diffusing capacity for oxygen in both conditions. These data dovetail with work performed by our group over the last ~3-4 years which has demonstrated significant impairments in skeletal muscle mitochondrial function, capillary endothelial alterations, and accumulation of extracellular matrix. These histological and ultrastructural alterations can explain the physiologically-measured deficits in muscle diffusing capacity and thereby explain, in part, the reduced exercise capacity that is emblematic of long COVID and ME/CFS. Crucially, these findings highlight interventions that target skeletal muscle as promising interventions to alleviate exercise intolerance in long COVID and ME/CFS.

INTERNATIONAL MOTOR IMPAIRMENT CONFERENCE 2025

Balancing Safety and Efficacy in Aerobic Exercise Prescription: Alternatives to CPET in Neurological and Orthopedic Rehabilitation

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Aerobic exercise is a cornerstone of rehabilitation for patients with motor impairments resulting from neurological, cardiovascular, or orthopedic conditions. Higher levels of physical fitness are consistently associated with improved functional recovery, greater independence in daily activities, and enhanced quality of life.
A major challenge in this context is prescribing exercise intensity that is both safe and sufficiently effective. Undertraining may fail to induce meaningful adaptations, whereas overtraining carries risks of adverse events. While the cardiopulmonary exercise test (CPET) remains the gold standard for determining individualized training thresholds, its widespread use in rehabilitation practice is limited by cost, equipment requirements, and the need for specialized expertise.
Alternative approaches for exercise prescription, such as the Talk Test, the Steep Ramp Test, heart rate–based methods, and perceived exertion scales (e.g., Borg RPE), offer more feasible options in clinical practice. However, these methods differ in validity, reliability, and applicability across patient populations, particularly in frail or medically complex individuals.
This lecture will provide an overview of available alternatives to CPET for prescribing aerobic exercise in patients with motor impairments. The advantages and limitations of different methods will be discussed from both scientific and clinical perspectives, with a focus on balancing safety and efficacy in rehabilitation. By addressing these considerations, the lecture aims to contribute to more tailored and pragmatic strategies for aerobic exercise prescription

Session 5: Brain Impairments – Invited speaker presentation (S5-1)

The impact of brain impairments in MS on functional mobility performance, and rehabilitation strategies

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Abstract:
MS is characterised by demyelination and progressive accelerated brain atrophy, and rehabilitation strategies are advocated, already short after diagnosis. Hallmark symptoms include reduced motor or cognitive capacity, but also fatigue and fatigability in the motor and cognitive domain. The presentation will discuss examples of reduced performance, assessment options, effectiveness of rehabilitation strategies and related insights in neural structure and dynamics. Also, attentional control of movements as walking and strategies such as auditory-motor coupling will be elaborated.

Session 5: Brain Impairments – Abstract presentation (S5-2)

Sustained Benefits of a Multi-Domain Lifestyle Intervention in Multiple Sclerosis (LIMS): A 24-Month Follow-Up

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Introduction: Multiple sclerosis (MS) often results in physical, cognitive, and psychological impairments, significantly impacting life. A s current disease-modifying therapies fall short in halting disease progression, there is a growing interest in the potential of modifiable lifestyle factors to improve outcomes.

Objectives/aims: To examine the long-term effects of a multi-domain lifestyle intervention, promoting a Mediterranean diet, physical activity, stress management, and sleep, on MS.

Methods: In the LIMS study, 500 people with MS (age 47±10; 85% female) participated in a 3-month lifestyle program with 21 months follow-up. Patient-reported outcome measures were collected at 3-month run-in, baseline, post-intervention, and at 3-, 6-, 12-, 18-, and 24-months follow-up. The primary outcome was MS-related impact on daily functioning (MSIS-29). Secondary outcomes included quality of life, general health, and MS-specific symptoms. Longitudinal changes were analyzed using mixed-effects models.

Results: Participants showed significant improvements in the MSIS-29 physical (β =–2.62, 95%CI: –3.58; –1.65) and psychological subscale (β =–3.50, 95%CI: –4.65; –2.36). Psychological improvements persisted up to 24 months (β = –3.10, 95%CI: –4.29; –1.91), while physical improvements only remained significant at 6- and 18-months follow-up. Sustained benefits were also seen in mental quality of life, fatigue, depression anxiety, and anthropometrics at 24 months.

Conclusion: A multi-domain lifestyle intervention reduced the psychological impact of MS and improved mental quality of life, fatigue, mood, and general health over 24 months. Physical improvements were less durable. These findings support lifestyle interventions as valuable adjuncts to conventional MS management.

Is gait harmony after stroke influenced by motor impairment or walking speed?

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Gait ratios (GRs), which relate durations of gait cycle phases (GR0:stride/stance; GR1:stance/swing; GR2:swing/double support) assess gait harmony[1]. After stroke, GRs are expected to be deviated from the golden ratio (1.618), but it remains unclear whether these deviations stem from slower speeds, motor impairments, or time since stroke (TSS). Given post-stroke gait asymmetries, GRs are anticipated to deviate initially and improve with recovery.
GRs were calculated from retrospective data of 46 individuals post-stroke (mean TSS 26 ± 37 months) walking at self-selected speed on a self-paced treadmill. For a subset of 20 participants, GRs were compared to age- and gender-matched healthy controls walking at matched walking speed.
Follow-up data were available for a subgroup (N=16) to assess changes in GRs over time.
All GR values significantly deviated from the golden ratio ($p<0.001$), with paretic side GRs differing significantly from the non-paretic side ($p<0.001$). GRs were strongly correlated with speed (GR0 $r=0.768$; GR1 $r=-0.764$; GR2 $r=0.751$; all $p<0.001$), moderately with TSS (GR0 $r=0.374$, $p=0.010$; GR1 $r=-0.396$, $p=0.006$; GR2 $r=0.411$, $p=0.005$) but not with lower limb impairment. After five weeks, GR2 improved significantly on both paretic ($p=0.015$) and non-paretic sides ($p<0.001$); GR0 and GR1 changed only on the non-paretic side (both $p<0.001$). Compared to matched healthy controls, only the paretic sides (GR0 $p=0.020$; GR1 $p=0.035$) showed significant differences.
Deviations in persons after stroke seem to be mostly affected by walking speed. Only at the paretic side, GRs differ from healthy controls walking at matched speeds. Partial recovery of GRs is observed over time.

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Toward Real-World Gait Monitoring: Association Between Anterior-Posterior Acceleration Impulse and Propulsion Force Impulse in Healthy and Post-Stroke Individuals.

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Background Gait propulsion is a critical target in post-stroke gait rehabilitation (1), but difficult to measure outside the lab (2). This study evaluated whether anterior-posterior acceleration impulse from a lumbar-mounted inertial measurement unit can serve as a surrogate measure for propulsion force impulse during walking.

Methods Seventeen healthy and thirteen chronic stroke individuals completed 2-minute self-paced treadmill walking trials. Step-by-step AP acceleration impulse, derived from a single IMU at the lower back, was compared to propulsion force impulse from treadmill ground reaction forces. Associations (R^2) and error (RMSE) were evaluated at group and within-subject levels using linear mixed models. Effects of temporal smoothing over 3- and 5-step windows were also examined.

Results Group-level associations were significant but modest (marginal R^2: healthy = 0.318; paretic leg = 0.151; nonparetic leg = 0.050), with corresponding RMSE values of 0.061, 0.073, and 0.064 N·s/kg. Within-subject median [IQR] R^2 were 0.420 [0.337–0.483] for healthy individuals, 0.190 [0.021–0.518] for the paretic leg, and 0.033 [0.020–0.251] for the nonparetic leg, and RMSE values were 0.022 [0.020–0.025], 0.030 [0.023–0.035], 0.038 [0.027–0.042], respectively. Temporal smoothing did not significantly affect R^2 but substantially reduced RMSE, improving accuracy in post-stroke individuals to levels comparable with healthy individuals.

Conclusion These findings suggest that AP acceleration impulse has limited value for between-subject and group-level evaluations. However, it shows more promise as a within-subject surrogate for propulsion force impulse, especially when combined with temporal smoothing, which may support real-world gait monitoring after stroke.

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Effects of Postural Change and Executive Function tasks on Cerebral Blood Supply and Cortical Oxygenation in Older People and Parkinson's Disease.

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Introduction: Decreased cognitive function has been associated with reduced cerebral blood flow in Parkinson's disease (PD) and older people [1,2] which may partly occur due to orthostatic hypotension (OH) [1]. Alterations in autonomic function may also affect cortical oxygenation during cognitive and standing balance tasks. This study assessed whether alterations in cortical oxygenation during performance of a cognitive task differed between PD and older people with and without OH under different postural conditions.

Method: 20 PD (14 with OH; 65 yrs; Hoehn & Yahr 1.4; disease duration 3yrs) and 22 older people (13 with OH; 62yrs) undertook an executive function task (serial seven subtraction-SST) under four postural conditions: supine, seated, supported upright (passive standing) and quiet stance (active standing). Three 30s blocks of the SST were undertaken separated by 70s rest. fNIRS recorded oxygenated (O_2HB) and deoxygenated (HHb) hemoglobin over left and right dorsolateral prefrontal cortex (DLPFC). Continuous measures of heart rate, respiration, blood pressure and middle cerebral artery blood flow (MCBF) velocity were recorded.

Results: All groups had similar performance on the SST. For all groups O_2HB increased over left and right DLPFC during the SST for each of the four postural conditions. These increases were smaller for the PD groups. For the right DLPFC the O_2Hb changes were less during passive and active standing compared to supine. Heart rate was higher during passive and active standing for all groups and increased for all groups during the SST. Blood pressure (systolic, diastolic) increased during the SST but this was smaller for the PD groups. MCBF velocity was lower during passive and active standing but increased during the SST for all groups for all postures.

Conclusion: Reduced cortical oxygenation for the PD groups during the SST task while in the passive and active standing conditions was associated with lower blood pressure changes and decreased MCBF velocity despite increased heart rate.

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