Multiple Sclerosis and Related Disorders xxx (xxxx) xxx

Contents lists available at ScienceDirect

Multiple Sclerosis and Related Disorders

journal homepage: www.elsevier.com/locate/msard

12th Annual International Symposium of Gait and Balance in Multiple Sclerosis. Neural Control of Mobility in MS: Process to Practice

The Effectiveness of Reactive Step Training in People with Multiple Sclerosis

Andrew S. Monaghan [1], Jessica L. Trevino [1], Jordan S. Barajas [1], Daniel S. Peterson [1,2]

[1] *College of Health Solutions, Arizona State University, Phoenix, AZ, USA*
[2] *Phoenix VA Health Care Center, Phoenix, AZ, USA*

Background and Purpose: Falls are poorly controlled in people with Multiple Sclerosis (PwMS). Reactive stepping after a loss of balance has been associated with falls and is altered in PwMS. However, there is limited data regarding whether reactive step training improves steps in PwMS. We aimed to determine whether reactive stepping improved following two weeks of reactive step training in PwMS.

Methods: To date, 16 PwMS participated in an 18-week multiple baseline study. Participants attended 2 baseline assessments (B1 and B2) before training, a 2-week, 6-session training protocol, and 2 post-training assessments (P1 and P2) to assess acute (P1) and retained (P2-8 weeks post-training) effects. Each assessment consisted of 3 backward reactive step trials. Training consisted of 32 stepping trials in the forward, backward, left, and right directions. Outcomes included the anterior-posterior margin of stability (MOS), step length, and step latency during backward stepping. Repeated measures ANOVAs were assessed training (B2 - P1; n = 16) and retention (B2 – P2; n = 8) effects. Performance change and effect sizes (η^{2}- partial eta-squared, 0.01 small, 0.06 medium, 0.14 large) were interpreted as data collection is ongoing.

Results: In this interim analysis, immediately after training, participants demonstrated quicker (-45 ms, η^2= 0.15) and larger steps (+2.5 cm, η^2= 0.09), with a larger MOS (+3 cm, η^2= 0.12) than before training. Despite only 8 participants completing the 8-week follow-up thus far, improvements in MOS (+ 3cm, η^2= 0.11), step length (+7 cm, η^2= 0.20), and step latency (-10 ms, η^2= 0.03) were retained 2 months after training compared to B2.

Discussion: These interim findings suggest that reactive step training may be an effective approach to improve reactive balance in PwMS. Given the importance of reactive stepping for fall prevention, this work may impact rehabilitative care and reduce fall-risk for PwMS.

doi: 10.1016/j.msard.2023.104632

The Transcallosal Highway: The ipsilateral silent period as a neural biomarker for impaired corpus callosum communication in multiple sclerosis

Jordan S. Acosta [1], Andrew C. Hagen [1], Brett W. Fling [1,2]

[1] *Department of Health and Exercise Science, Colorado State University, Fort Collins, CO, USA*
[2] *Molecular, Cellular, & Integrative Neuroscience Program, Colorado State University, Fort Collins, CO, USA*

Multiple sclerosis is a neurodegenerative disease that damages myelin sheath within the central nervous system. This axonal demyelination impacts communication between the brain's hemispheres in persons with multiple sclerosis (PwMS). Changes in transcallosal communication impairs the coordination of movements requiring precise temporal and spatial components such as lower extremity function during gait. These bilateral movements require constant communication across the corpus callosum to excite and inhibit specific muscle groups. The ipsilateral silent period (iSP) is an indirect marker of the magnitude for transcallosal inhibition. We hypothesize that the iSP may also serve as a neural biomarker for transcallosal impairments originating from the more affected hemisphere and highlight underlying mechanisms for gait asymmetries in PwMS. Our ongoing study utilizes transcranial magnetic stimulation to assess the inhibitory capacity between the brain's hemispheres (i.e., iSPs). A focal magnetic pulse is delivered to the first dorsal interosseous resulting in a suppression of muscle activity, thus reflecting inhibitory transcallosal communication. There is a lack of research analyzing directionality data between the more and less affected hemisphere in PwMS. Therefore, we evaluate outcome metrics dependent upon the individual's more affected hemisphere. Twenty-three PwMS completed the ongoing protocol and inhibitory metrics such as depth iSP% average, duration, depth iSP% max, transcallosal conduction time, and onset latency were collected. No statistically significant differences have been found between the two hemispheres in PwMS. However, beyond directionality data, our study is investigating gait coordination with overall inhibitory capacity. Walking coordination is quantified using a metric called phase coordination index (PCI). A greater PCI value reflects poorer gait coordination. We hypothesize those who demonstrate better gait coordination (lower PCI values), will have a greater iSP. These findings will determine the potential of iSPs as a neural biomarker to address gait asymmetries and stratify participants into individualized mobility rehabilitation protocols.

doi: 10.1016/j.msard.2023.104633

https://doi.org/10.1016/j.msard.2023.104623
2211-0348

Improvement in Participant-Perceived Benefits with Long-Term Torso Weighting in Multiple Sclerosis: A Randomized Controlled Trial

Melissa S. Schoell [1], Diane D. Allen [1], Gail L. Widener [2]

[1] *University of California San Francisco/ San Francisco State University*
[2] *Samuel Merritt University; San Francisco, CA, USA*

Background: In prior research, people with multiple sclerosis (MS) and gait and balance limitations improved in standing stability, gait parameters, and fatigability after wearing custom-placed balance-based torso-weights (BBTW) for 2-4 hours daily for 2 weeks. Participant-perceived benefits were mixed, perhaps because of short intervention duration.

Purpose: Examine the effect of torso weights compared to no weights or sham weights over four 4-week periods.

Methods: Eleven participants with MS experienced all three conditions with the order of sham versus torso-weighted conditions randomized: no weights, torso/sham-weights, sham/torso-weights, torso-weights. Weighting involved applying light (or sham) weights to a vest-like garment in strategic positions to improve reactive response to manual perturbations. Participants and assessors were blinded to active condition. Gait parameters, Sensory Organization Testing (SOT), and self-reported outcome measures were assessed at baseline and after each 1-month period. Self-report measures included the Activities-Specific Balance Confidence Scale (ABC), Movement Ability Measure Computer-Adaptive Test (MAM-CAT), Modified Fatigue Impact Scale (MFIS), Multiple Sclerosis Walking Scale (MSWS-12), and the Multiple Sclerosis Impact Scale (MSIS-29). Changes in measures were compared after each time period using one-tailed t-tests with a p-value of 0.10.

Results: Statistically significant improvements included better scores after torso-weights compared to no weights in current movement ability (MAM-CAT now), MSIS physical and psychological subscales, and stride width. Other measures trended in the expected direction but did not reach significance. Differences between sham and torso-weight conditions did not reach significance. The interaction between weight order and weight condition was significant only for SOT, with larger improvements for the sham-first vs. weight-first group.

Discussion: Final torso-weighting resulted in participant-perceived benefits over the no-weight condition. Unexpectedly, scores following sham and torso-weighting periods did not differ, perhaps affected by significant baseline differences between the sham-first and weight-first groups despite randomization. Larger samples may clarify participants' benefits from this promising intervention.

doi: 10.1016/j.msard.2023.104634

Ultrasound Measures of Muscle Morphology in Multiple Sclerosis and its Relation to Patient Characteristics, Muscle Performance and Functional Mobility

Katie Boncella [1,2,4], Mark M. Mañago, PT, PhD [2], Bryant A. Seamon, PT, DPT, PhD [3,4,7], Mitchel T. Wallin, MD [5], Heidi Maloni, PhD [6], Brian Hoover, MS [4,7], Marc R. Blackman, MD [7], Michael O. Harris-Love, PT, DSc [1,2,3,4,7]

[1] *Department of Physical Medicine and Rehabilitation, University of Colorado Anschutz Medical Campus, Aurora, CO, United States*
[2] *VA Research Service, Rocky Mountain Regional VA Medical Center, Aurora, CO, United States*
[3] *Department of Rehabilitation Sciences, Medical University of South Carolina, Charleston, SC, United States*
[4] *Muscle Morphology, Mechanics and Performance Lab, University of Colorado Anschutz Medical Campus, Aurora, CO, United States*
[5] *Neurology Service, Washington DC VA Medical Center, Washington, DC, United States*
[6] *Geriatric Service, Washington DC VA Medical Center, Washington, DC, United States*
[7] *Research Service, Washington DC VA Medical Center, Washington, DC, United States*

Multiple sclerosis (MS) is an inflammatory disease impacting the central nervous system affecting approximately 2.5 million people worldwide. Morphological changes in muscle tissue, such as muscle size and quality, may result from weakness due to decreased mobility. This study aimed to investigate asymmetries in lower limb muscle morphology via sonography in people with MS and to quantify relationships of muscle morphology measures with individual patient characteristics, muscle performance, and functional mobility.

Twenty-nine Veterans with MS (52% female, 79% African-American, 48.6 ± 11.2 years old, Expanded Disability Status Scale: 3.6 ± 1.4) underwent measurement of ultrasound-measured rectus femoris (RF) muscle morphology (thickness and echo intensity), muscle performance (knee extension strength and power), and functional mobility (Timed 25-Foot Walk, 5-Times Sit-to-Stand). The more-involved limb was identified with weaker knee extension strength. Differences between more and less-involved limb were quantified using a t-test for all muscle morphology and performance outcomes. Relationships between muscle morphology, patient characteristics, performance, and functional mobility were quantified using bivariate and multivariate analysis.

The more-involved limb had significantly less RF thickness ($p<0.001$) than the less-involved limb, but echo intensity was not different between limbs ($p=0.147$). The more-involved RF thickness was significantly associated with age, muscle strength, power, and gait speed, while echo intensity was associated with only muscle strength and power. Normalized RF thickness has a positive association with knee extension torque at 60 deg/sec and 180 deg/sec ($p=0.003$,$p=0.003$) and gait speed ($p=0.024$), whereas the corrected echo intensity values had negative associations at 60 deg/sec and 180 deg/sec ($p=0.013$,$p=0.006$).

Asymmetrical differences between RF thickness measured by ultrasound are consistent with muscle strength and power asymmetries. Deficiencies in the morphology of the RF were associated with patient characteristics, knee extension muscle performance, and functional mobility. Ultrasound is an important clinical assessment tool used to identify muscle morphology asymmetries in MS.

doi: 10.1016/j.msard.2023.104635

Validation of the Self-Assessed Dynamic Gait Index in People with Multiple Sclerosis

Vicky Chen [1,2], Andrea Hildebrand [1,3], Mark Manago [4,5], Andrea Serdar [6], Michelle Cameron [1,2]

[1] *Department of Neurology, VA Portland Health Care System, Portland, OR, United States*
[2] *Department of Neurology, Oregon Health & Science University, Portland, OR, United States*
[3] *Biostatistics & Design Program, Oregon Health & Science University, Portland, OR, United States*
[4] *Physical Therapy Program, Department of Physical Medicine Rehabilitation, School of Medicine, University of Colorado Denver, Aurora, CO, United States*
[5] *Rocky Mountain Regional VA Medical Center, Aurora, CO, United States*
[6] *OP Rehabilitation, Oregon Health & Science University, Portland, OR, United States*

Background and Purpose: The Dynamic Gait Index (DGI) is a validated clinical measure of walking ability in people with multiple sclerosis (MS). There is need for a self-assessed version of the DGI that can be conducted remotely and that demonstrates concurrent validity with the

original DGI in people with MS. We therefore developed a self-assessed Dynamic Gait Index (sDGI). The purpose of this study is to evaluate the relationship between the sDGI, clinically-assessed DGI, and falls in people with MS with gait impairment.

Methods: We will enroll 50 ambulatory people with MS with gait impairment. Participants will complete the sDGI (online questionnaire) and then, within 4-weeks, the DGI (in-person evaluation by a physical therapist). Other outcome measures include: modified Telephone Interview for Cognitive Status (TICS-M) and self-reported fall history in the past 3 months. We will calculate concordance between the sDGI and DGI, and use linear regression to determine if concordance is impacted by cognition. The ability of the sDGI to identify fallers will be evaluated using the receiver operating characteristic curve.

Results: At time of submission, 41 participants are enrolled, 31 have completed the study. Anticipated date of study completion is March 2023. Full study results will be presented at the meeting.

Discussion: The sDGI has potential to be used by physicians, physical therapists, and others to remotely assess walking ability and identify fallers in people with MS. Information from this study will determine how self-assessment of walking ability compares with clinically-assessed walking ability in people with MS. Our study will also determine if cognition impacts the validity of the sDGI. If concordance between sDGI and DGI is lower in those with worse cognitive performance, users of the sDGI might exercise greater caution using this measure to approximate DGI and predict fall risk in individuals with cognitive impairment.

doi: 10.1016/j.msard.2023.104636

Spatio-Temporal Gait Parameters to Distinguish Multiple Sclerosis Disability during Dual- Task Walk

Matthew Stucke [1,*], Melissa Schoell [1,*], Desiree Torrecampo [1], Katayani In [1], Julia DePaoli [1], Jaeleene Wijangco [2], Kyra Henderson [2], Kanishka Koshal [2], Shane Poole [2], Valerie J Block [1,2,^], Riley Bove [2,^]

[1] *Department of Physical Therapy and Rehabilitation Science, University of California at San Francisco, San Francisco, CA, USA*
[2] *UCSF Weill Institute for Neuroscience, University of California at San Francisco, CA, USA*

* Co-First authors.
^ Co-Last authors.

Background: Differences in gait between people with multiple sclerosis (PwMS) and controls are well documented and effective in distinguishing between disability levels based on the Expanded Disability Severity Scale (EDSS) during preferred walking (PrW). However, clinically measured PrW does not consider higher cognitive demand required to perform more complex motor tasks in everyday living (e.g., conversing while walking). A dual-task walk (DTW) mimics this cognitive load, thus offering greater ecological validity when distinguishing between disability levels in PwMS.

Purpose: To evaluate the utility of spatio-temporal gait parameters during a DTW to distinguish between mild and moderate disability in PwMS.

Methods: Gait velocity, stride velocity, step width, step length and mean gait variability index were measured in a convenience sample of 44 PwMS (36=mild MS: EDSS 0 to 3.5, 7=moderate MS: EDSS 4.0 to 6.0) during PrW and DTW using a Protokinetic Zeno Walkway. Subjects were dichotomized into mild or moderate disability groups. Variable selection was performed using stepwise linear regression, including all gait metrics and covariates (sex, age, height, type of multiple sclerosis: relapsing or progressive, and disease duration). Logistic regressions were performed separately for PrW and DTW.

Results: During PrW, greater step length (cm) was associated with mild disability (R^2=0.39, ChiSquare=14.72, p<0.001). During DTW, both stride width (ChiSquare=4.69, p=0.03) and step length (ChiSquare=5.16, p=0.02) were associated with disability (R^2=0.38): people with moderate disability demonstrated increased step width and decreased step length.

Discussion: Results highlight the need to investigate differences in gait during DTW in addition to PrW in PwMS with different disability levels. However, generalizability is limited due to disproportionate sample sizes of disability groups. Still, DTW protocols may provide supplemental information for monitoring disability among PwMS, which can inform clinicians of the effectiveness of gait interventions or disease progression.

doi: 10.1016/j.msard.2023.104637

Fear of falling and concern about falling in individuals with relapsing-remitting MS and progressive MS

Taylor N. Takla [1,2,3], Patricia N. Matsuda [4], Tracy E. Herring [5], Ana M. Daugherty [1,6,7], Nora E. Fritz [1,2,8,9]

[1] *Neuroimaging and Neurorehabilitation Laboratory, Wayne State University*
[2] *Translational Neuroscience Program, Wayne State University*
[3] *Department of Psychiatry and Behavioral Neurosciences, Wayne State School of Medicine*
[4] *Department of Rehabilitation Medicine, Division of Physical Therapy, University of Washington*
[5] *Department of Rehabilitation Medicine, University of Washington*
[6] *Department of Psychology, Wayne State University, Detroit, MI, USA*
[7] *Institute of Gerontology, Wayne State University, Detroit, MI, USA*
[8] *Department of Health Care Sciences, Wayne State University*
[9] *Department of Neurology, Wayne State University*

Background and Purpose: Falls and fear of falling (FOF) in multiple sclerosis (MS) are highly prevalent issues. Previously, FOF and concern about falling (CAF) have been used interchangeably; however, persons with MS report that FOF is different than CAF. Therefore, our objective was to examine prevalence and relations of FOF and CAF to function in relapsing-remitting MS (RRMS) and progressive MS (PMS).

Methods: In an online survey, 1025 participants with MS indicated their FOF (yes/no) and CAF (yes/no), rated how they felt on a scale of no concern (0) to fearful (4) during 28 activities (the CF-Fall), and completed physical, cognitive, and psychological measures. Pearson's correlations were used to examine relations among the CF-Fall with other measures. In persons endorsing FOF and CAF, independent t-tests were used to compare functioning between subtypes.

Results: Overall, 60.2% of subjects reported that FOF and CAF are different constructs and 47.2% reported FOF (yes/no) and 64.6% reported CAF (yes/no). PMS reported greater FOF (59.1%) and CAF (80.1%) than RRMS (41.6% and 57.0%, respectively). Avoidance behavior ($r = .82$, $p < .001$), walking impairment ($r = .83$, $p < .001$), physical function ($r = -.84$, $p < .001$), and lower extremity function ($r = -.85$, $p < .001$) were most correlated to the CF-Fall. People with PMS endorsing FOF and CAF demonstrated greater FOF on the CF-Fall, greater avoidance behavior, poorer walking ability, physical function, life-space mobility, lower extremity function, but greater cognitive function than RRMS (all, $p < .001$).

Discussion: These findings underscore the disparity between FOF and CAF, emphasize the importance of evaluating FOF and CAF in MS subtypes separately, as rates for the whole sample may underestimate the prevalence in PMS, and highlight non-motor factors contributing to FOF and CAF. Future work should focus on interventions that incorporate motor, cognitive, and psychological components to address FOF and CAF.

doi: 10.1016/j.msard.2023.104638

Splitting the Difference: Split-Belt Treadmill Training Improves Spatial and Temporal Gait Symmetry in People with Multiple Sclerosis

Andrew C. Hagen, Jordan S. Acosta, Brett W. Fling

Multiple sclerosis (MS) is a neurodegenerative disease affecting two million people worldwide. This disease is characterized by degradation of the myelin sheath resulting in impaired neural communication throughout the body. As a result, most people with MS (PwMS) experience significant mobility impairments. Gait asymmetries between the two legs are prevalent leading to an increased risk of falls, musculoskeletal injury, and decreased quality of life. Recent work indicates that split-belt treadmill training, where the speed of each leg is controlled independently, can decrease gait asymmetries for other neurodegenerative impairments. In this study, 26 PwMS have undergone split-belt treadmill training, with the faster paced belt moving under the more affected limb. Phase coordination index (PCI), which measures temporal coordination to assess stepping accuracy and consistency, and limb excursion asymmetry (LEA), which measures spatial coordination by quantifying sagittal displacement from toe off to heel strike of the ipsilateral leg, are the primary outcome measures used to assess gait symmetry in the current study. Previous work has identified an average PCI for PwMS population to be 5.19%, thus we grouped participants based on their baseline PCI value as either 1) above (poor baseline symmetry) or 2) below (good baseline symmetry) the previously recorded MS mean PCI of 5.19%, predicting that participants with a baseline PCI greater than 5.19% would show a greater response to split-belt treadmill training. Preliminary results show a mean PCI change of -1.31% (SE=0.65) for the poor baseline symmetry group and a mean PCI change of 0.92% (SE: 0.32) (p=0.0062). Among participants with poor baseline symmetry, the mean LEA change is -13.02mm (SE: 5.25) compared to a mean LEA change of 0.83mm (SE=3.35) for participants with good baseline symmetry (p=0.037). These findings suggest that PwMS retain the ability for gait adaptation, and provide the template for a novel, targeted mobility intervention.

doi: 10.1016/j.msard.2023.104639

Effects of a 6-week virtual reality treadmill training on frailty in people with multiple sclerosis

Tobia Zanotto, PhD [1,2], Irina Galperin, MPT [3,4], Danya Pradeep Kumar, PhD [5], Sharon G Lynch, MD [6], Hannes Devos, PhD [2,5], Jeffrey M Hausdorff, PhD [3,7,8], Jacob J Sosnoff, PhD [2,5]

[1] *Department of Occupational Therapy Education, School of Health Professions, University of Kansas Medical Center, Kansas City, KS, United States*
[2] *Mobility Core, University of Kansas Center for Community Access, Rehabilitation Research, Education and Service, Kansas City, KS, United States*
[3] *Center for the Study of Movement, Cognition and Mobility, Neurological Institute, Tel Aviv Sourasky Medical Center, Tel Aviv, Israel*
[4] *Department of Neurology, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel*
[5] *Department of Physical Therapy, Rehabilitation Science, and Athletic Training, School of Health Professions, University of Kansas Medical Center, Kansas City, KS, United States*
[6] *Department of Neurology, School of Medicine, University of Kansas Medical Center, Kansas City, KS, United States*
[7] *Department of Physical Therapy, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel*
[8] *Rush Alzheimer's Disease Center and Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, IL, United States*

Background and Purpose: Up to two thirds of people with multiple sclerosis (pwMS) are frail. Frailty within MS is associated with adverse clinical outcomes such as falls, independently of age, gender, and disability levels. Consequently, there is a critical need to identify strategies to counteract frailty in pwMS. Since MS affects both motor and cognitive function, cognitive-motor rehabilitation is a potentially viable strategy to reduce frailty in pwMS. Therefore, the purpose of this study was to examine the effects of a cognitive-motor rehabilitation intervention consisting of virtual reality treadmill training (VRTT) compared to treadmill training (TT) alone, on frailty in pwMS.

Methods: Fifty-three people with relapsing-remitting MS [age=50.8 years (SD=9.2); 77.4% female; expanded disability status scale (EDSS) range=2.0-6.0] were randomized to VRTT (n=25) or to TT alone (n=28). Both groups trained three times per week for six weeks. Frailty was evaluated through the deficit accumulation model before and after the intervention using standard validated procedures. A 40-item frailty index was taken as the main study outcome.

Results: Forty-five participants, 23 in the experimental group and 22 in the control group, completed the intervention and the pre- and post-training frailty assessments. Per-protocol repeated measures ANOVAs revealed that frailty index scores improved in both groups (time effect: $p<0.001$, $\eta^2=0.262$). The frailty index decreased from 0.29±0.13 to 0.27±0.12 in the TT alone group, and from 0.31±0.15 to 0.26±0.15 in the VRTT group. However, group by time interactions were not significant ($p=0.119$, $\eta^2=0.055$).

Discussion: The current study provided evidence that treadmill training with or without virtual reality may be a viable strategy to reduce frailty in pwMS. Interestingly, VRTT tended to have a greater effect in terms of frailty reduction (Δ~0.05) compared to TT alone (Δ~0.02) as indicated by a clinically meaningful change, defined as a reduction greater than 0.03 in frailty index score.

doi: 10.1016/j.msard.2023.104640

Neuromotor and functional assessment of the non-progressive to progressive transition in multiple sclerosis: a multiple case study

Stephanie Jones [1,2], Sumire D. Sato [2,3], Richard Van Emmerik [2]

[1] *Smith College, Northampton, MA*
[2] *University of Massachusetts, Amherst, MA*
[3] *University of Florida, Gainesville, FL*

Background: The search for sensitive outcome measures that discriminate among subtypes of multiple sclerosis (MS) is important for targeting appropriate treatment and assessing the efficacy of intervention. Even more elusive are measures that can identify and track disease progression. Longitudinal studies targeted at assessing functional and neuromotor measures over time may enable us to characterize the natural history of the transition from non-progressive to progressive forms.

Methods: In this multiple case study, we examined functional and neuromotor measures from three individuals who were part of a large-scale longitudinal study (N=93), and for whom we captured the transition to progressive MS. All participants were tested at 3 timepoints (approximately every 12 months) across 5 domains: patient-reported (Fatigue Severity Score, Visual Analog Fatigue Scale, Activities Balance Confidence Scale, Godin Leisure Time Questionnaire), mobility function (Timed 25 Foot Walk, Timed Up and Go), sensation (vibration sensitivity thresholds of foot and hand), proprioception (ankle- and elbow- position matching, and a multi-joint finger matching task) and motor (rapid foot and hand tapping). Only descriptive data will be reported.

Results: One participant transitioned between the first and second visits, while two transitioned between the second and third. Across most outcome measures there was rarely a linear change identified.

Particularly for the participants for which transition occurred between visits 2 and 3, the second visit (just prior to their diagnosis of progressive MS) often demonstrated an inflection point of either worsening or improvement of neuromotor measures followed by a reversal towards their baseline levels. Foot vibration sensitivity demonstrated worsening that appeared to mirror means of the larger cohort, although there was a ceiling effect.

Discussion: These data underscore the need for robust longitudinal studies with frequent assessments to characterize how neuromotor and functional measures change prior to, during and following the transition from non-progressive to progressive MS.

doi: 10.1016/j.msard.2023.104641

Pilates vs Alternative Exercise on Cognition and Respiratory Function in Patients with Multiple Sclerosis: A Systematic Review and Meta-Analysis

Claire Maurel, Julia DePaoli, Valerie Block, Diane D. Allen

University of California San Francisco/ San Francisco State University; San Francisco, CA, USA

Background: People with Multiple Sclerosis (PwMS) report a variety of cognitive and motor dysfunctions that may improve with exercise. Pilates exercises have improved physical function and quality of life in many populations, including PwMS. Pilates' mind-body training principles and breathing techniques may also improve cognition and respiratory function, but evidence is lacking.

Purpose: Examine evidence of the effects of Pilates compared to alternative exercise on cognition and respiratory function in PwMS.

Methods: Two reviewers independently searched PubMed, CINAHL, and SportDiscus through January 2023 for intervention studies comparing the effects of Pilates and alternative exercise for PwMS. Studies were included if participants were adults, had Expanded Disability Status Scale score of ≤6, and cognition or respiratory function were assessed. Means and SDs for both outcomes were extracted. Effect sizes (ES) and 95% confidence intervals (CI) were calculated within and between groups. ES were combined across studies using random effects models when the Q heterogeneity statistic was significant and fixed effect models otherwise.

Results: Four studies of low to moderate quality met inclusion criteria. Cognition was assessed through the Paced Auditory Serial Addition Test, or Brief International Cognitive Assessment of MS. Respiratory function was assessed through Maximal Inspiratory Pressure and Maximal Expiratory Pressure. Meta-analyses revealed Pilates had a statistically significant effect within-groups on cognition [ES = 0.63 (0.22 – 1.04)] and respiratory function [ES = 0.53 (0.03 – 1.03)], and between-groups [ES = 0.68 (0.34 – 1.02)] on cognition. Data were insufficient to analyze respiratory function between groups.

Discussion: Pilates moderately improves cognition and respiratory function from pre- to post-intervention and is superior to alternative interventions in improving cognition. Limitations of this study included small sample size and overlapping research groups potentially affecting generalizability and potential for bias. Further research is needed to support Pilates as an effective tool to manage multiple impairments in PwMS.

doi: 10.1016/j.msard.2023.104642

Neural Substrates of Mobility and Postural Impairments in People with Multiple Sclerosis

Chris M. Patrick [1,2], Brett W. Fling [1,2]

[1] *Department of Health and Exercise Science, Colorado State University, Fort Collins, CO, USA*

[2] *Molecular, Cellular, & Integrative Neuroscience Program, Colorado State University, Fort Collins, CO, USA*

Background & Purpose: Damage to the central nervous system is a primary corollary of multiple sclerosis (MS) and commonly results in mobility and balance impairments, placing people with MS at greater risk for experiencing a fall, thereby decreasing independence and quality of life. To date, research has largely focused on the role of the corticospinal tract in mobility and balance impairments seen in people with MS. However, evidence from lesion studies in animals suggests that the reticulospinal tract (RST), a bilateral motor neuron pathway originating in the brainstem, is critical for gross motor movements such as posture and locomotion.

Methods: We collected behavioral data in the form of the Mini-Balance Evaluation Systems Test from 25 MS and 25 neurotypical participants to assess gait and mobility. We then used transcranial magnetic stimulation and electromyography recordings from the tibialis anterior on both legs to assess neural communication via the RST. Lastly, we used diffusion tensor imaging as an anatomic measure of neural structure to determine if there are white matter differences in the RST.

Results: To date our analysis has only been performed on the behavioral data, showing that people with MS score lower on all sections of the Mini-Balance Evaluation Systems Test. By the time of this conference, we will have preliminary evidence from both of our other measures to share.

Discussion: Recent literature suggests that acute neural adaptations to resistance training may be mediated by the RST. Several studies have found that resistance training in people with MS increases muscle strength and functional capacity. However, the underlying neural adaptions have yet to be fully determined. Our results will highlight the RST as a key contributor to mobility deficits in people with MS and suggest that stimulation of the RST such as with resistance training could promote better balance and mobility.

doi: 10.1016/j.msard.2023.104643

Backward Walking Training Induces Structural Changes in the Superior Cerebellar Peduncle: A Pilot Myelin Water Imaging Study

M Abbawi [1], JA Stanley [2,3], B Yu [1], E Myers [1], NE Fritz [1,2,4,5]

[1] *Neuroimaging and Neurorehabilitation Laboratory, Wayne State University*
[2] *Translational Neuroscience Program, Wayne State University*
[3] *Department of Psychiatry and Behavioral Neurosciences, Wayne State University*
[4] *Department of Health Care Sciences, Wayne State University*
[5] *Department of Neurology, Wayne State University*

Background and Purpose: Multiple sclerosis (MS) is a complex neurodegenerative disease that is identifiable by the loss of myelin in the central nervous system (CNS), leading to motor decline. Our lab has shown that backward walking (BW) speed in addition to MRI measures may improve fall prediction for persons with MS (pwMS). Myelin Water Imaging (MWI), a novel technique for assessing the myelin microstructure, has not been examined in relation to BW. This study examines the impact of an 8-week BW training program on the superior cerebellar peduncle (SCP) utilizing MWI, as well as the relation of the change in the SCP to the change in function.

Methods: Eight individuals with relapsing-remitting MS participated in this pilot study. Participants completed functional tests and a 3T MRI before and after the 8-week intervention, consisting of treadmill and overground BW 1x/week and home exercises 2x/week. Falls were monitored for 6 months after the intervention. The MWI metrics, which included the Myelin Water Fraction (MWF) reflecting myelin content and the geomT2IEW reflecting axon size/packing density, were estimated from the SCP. T-tests were used to examine differences in SCP

pre/post and Spearman correlations were used to examine relations among changes in SCP and changes in function. Due to the pilot nature of this study, effect sizes and rho values were prioritized.

Results: MWF and geomT2IEW values increased after training, with effect sizes of -0.16 and -0.53, respectively. The change in geomT2IEW was strongly correlated with improvements in balance measured with wearable sensors (r=0.61), BW speed (r=0.79), forward walking speed (r=0.52) and prospective falls at 6 months (r=0.46).

Discussion: Our pilot data suggests that BW training induces both structural (SCP) and functional (balance, gait, falls) changes over 8 weeks and shows potential for future larger-scale studies exploring efficacy.

doi: 10.1016/j.msard.2023.104644

Utilizing the ISway to Identify and Compare Balance Domain Deficits in People with Multiple Sclerosis

Patrick G. Monaghan, MS [1], Andrew S. Monaghan, MS [2], Andrew Hooyman, Ph.D. [3], Brett W. Fling, Ph.D. [4], Jessie M. Huisinga, Ph.D. [5], Daniel S. Peterson, Ph.D. [2,6]

[1] *School of Kinesiology, Auburn University, Auburn, AL, USA*
[2] *College of Health Solutions, Arizona State University, Phoenix, AZ, USA*
[3] *School of Biological and Health Systems Engineering, Arizona State University, Tempe, AZ, USA*
[4] *Department of Health and Exercise Science, Colorado State University, Fort Collins, CO, USA*
[5] *Department of Physical Therapy and Rehabilitation Science, University of Kansas Medical Center, KS, USA*
[6] *Phoenix VA Health Care Center, Phoenix, AZ, USA*

Background and Purpose: Balance impairments are a common symptom in people with Multiple Sclerosis (PwMS). The instrumented sway (ISway) is a reliable clinical balance assessment; however, this approach yields a vast range of outcomes that may hinder interpretation and delivery of evidence-based care. Identifying balance domains that are both altered in PwMS and clinically relevant would help isolate treatment targets. Therefore, we sought to develop a multiple sclerosis (MS)-specific model of balance and examine differences between 1) PwMS and neurotypical controls and 2) PwMS with (MS-F) and without a fall history (MS-NF).

Methods: 118 people with relapsing-remitting MS (MS-F = 39; MS-NF = 79) and 46 age-matched neurotypical controls completed the ISway balance assessment. 22 sway measures obtained from the ISway were entered into an exploratory factor analysis (EFA) to identify underlying balance domains. The model-derived balance domains were compared between 1) PwMS and age-matched, neurotypical controls and 2) MS-F and MS-NF.

Results: 3 distinct balance domains were identified: 1) sway amplitude and velocity, 2) sway frequency and jerk mediolateral (ML), and 3) sway frequency and jerk anteroposterior (AP), explaining 81.66% of balance variance. PwMS exhibited worse performance (i.e., greater amplitude and velocity of sway) in the sway velocity and amplitude domain compared to age-matched neurotypical controls (p = .003). MS-F exhibited worse performance in the sway velocity and amplitude domain compared to MS-NF (p = 0.046). The AP and ML sway frequency and jerk domains were not different between PwMS and neurotypical controls nor between MS-F and MS-NF.

Discussion: PwMS exhibited deficits within the sway amplitude and velocity domain compared to neurotypical controls, with a similar effect observed between MS-F and MS-NF. Recognizing balance domains altered in PwMS and related to falls may be useful for efficient and strategic balance assessment and rehabilitation.

doi: 10.1016/j.msard.2023.104645

Impaired Voluntary Activation of an Ankle Dorsiflexor Muscle Predicts Walking Capacity in Multiple Sclerosis

Mitra Rouhani [1], Sandra Hunter [1], Marie K. Hoeger Bement [1], Ahmed Z. Obeidat [2], Kathleen M. Zackowski [3], Alexander V. Ng [1]

[1] *Marquette University, Milwaukee, WI*
[2] *Medical College of Wisconsin, Milwaukee, WI*
[3] *National Multiple Sclerosis Society, New York, NY*

Background and Purpose: Walking impairments are highly prevalent in people with Multiple Sclerosis (pwMS) and are related to factors including motor deficits and balance. Reductions in voluntary activation (VA) (i.e., reduced neural drive known as central fatigability) is a key contributor to motor deficits during fatiguing tasks in pwMS; however, the relationship between central fatigability and walking function is poorly understood. The purpose of this study was to determine associations between reductions in VA after a fatiguing task and walking capacity (WC) in pwMS and controls.

Methods: 19 pwMS (female=9) and 10 age-matched controls (female=6) participated. PwMS were sub-grouped for disease severity into those mildly affected (n=11, female=5, EDSS=2.5-4.0) and moderately affected (n=8, female=4, EDSS= 4.5-6.5). Twitch interpolation during a maximal voluntary contraction quantified VA of the tibialis anterior muscle before and immediately after a fatiguing time-to-task failure isometric task performed at 50% of maximal strength. The 6-minute walk test determined baseline WC. Values are mean ± SD.

Results: Moderately affected pwMS showed greater central fatigability after the fatiguing task compared with mildly affected pwMS (p=0.01), and controls (p=0.07) (moderately affected= 23.5% ± 24.9, mildly affected= 0.3% ± 5.4, controls= 6.4% ± 14.4). Both groups of pwMS showed lower WC than controls (moderately affected= 299.5m ± 75.2, mildly affected= 527.7m ± 68.9, controls= 613.7m ± 88.9, p<0.001). Further analyses revealed an association between central fatigability and WC, but only in the moderately affected pwMS (R^2= 0.7, standardized estimate= -0.8, t=-3.8, p=0.009).

Discussion: Impaired neural drive of the ankle dorsiflexor muscles is a predictor of WC in pwMS who experience greater disease severity. Thus, mechanisms for limitation in walking function may be different based on disease severity in pwMS and this knowledge may assist in optimizing rehabilitation strategies to improve walking function in pwMS.

doi: 10.1016/j.msard.2023.104646

Acute Intermittent Hypoxia and UE Strength and Function changes in Multiple Sclerosis: A Case Report

Wesley A. Thornton [1], Mark Mañago [1,2,3], Andrew Quesada Tan [4], Andrew C. Smith [1]

[1] *Physical Therapy Program, Department of Physical Medicine and Rehabilitation, University of Colorado, Aurora, CO*
[2] *Department of Neurology, School of Medicine, University of Colorado, Aurora, CO*
[3] *Geriatric Research Education and Clinical Center, VA Eastern Colorado Healthcare System, Denver, CO*
[4] *Department of Integrated Physiology, University of Colorado, Boulder, CO*

Background/Purpose: Recovery of upper extremity (UE) function is a priority for individuals with multiple sclerosis (MS) whose disease sequalae often results in loss of UE strength and motor control. Acute Intermittent Hypoxia (AIH) is a novel intervention where an individual breathes bouts of air with low oxygen (~9% O_2) to set off a cascade of cellular events that may induce neuroplasticity and improve motor function. This intervention has shown promising effects in individuals with motor incomplete spinal cord injury (iSCI), even after a single bout. The purpose of this case report was to assess the ability of a single-bout

AIH protocol to improve UE strength and function in an individual with chronic, relapsing-remitting MS.

Methods: A 30-year-old, right-handed female with a 10-year history of MS (Expanded Disability Status Scale score 3.0), who presented with LUE weakness and increased LUE tone participated in two treatment sessions. In the first session, she received a sham intervention where she was delivered normal room air, through the hypoxia generator for the entire treatment. The following week she received AIH. The 9-Hole Peg Test (9HPT) and Hand-held dynamometry (HHD) were performed immediately before and after the intervention

Results: Following the single bout of AIH, compared to baseline, left shoulder abduction strength increased 8% immediately after treatment and 21% at the 30-minute assessment. Left wrist extension strength increased 26% and 30%, respectively. Left shoulder flexion and elbow extension did not change. Comparatively, right shoulder abduction strength increased 27% and 7%. Right wrist extension strength increased 12% and 1%. Functionally, the participant's 9HPT time decreased from 44.88 to 41.41 seconds on her left but increased from 15.69 to 16.06 seconds on her right.

Discussion: AIH treatment was well tolerated by our participant and a single bout of AIH resulted in positive changes in UE strength and function on her more involved side. These results are promising, and further research is required to further assess safety, feasibility, and potential efficacy of AIH in people with MS.

doi: 10.1016/j.msard.2023.104647

A Novel Functional Electrical Stimulation Device Plus Telerehabilitation Improves Walking in People with Multiple Sclerosis: A Case Series

EJ Gann [1], VJ Block [1,2], D.D. Allen [1]

[1] *Department of Physical Therapy and Rehabilitation Science, University of California at San Francisco*
[2] *Department of Neurology, University of California at San Francisco*

E-mail address: Elliot.gann@cuanschutz.edu

Background and purpose: Foot drop in people with multiple sclerosis (PwMS) commonly leads to decreased mobility and quality of life (QOL). Functional electrical stimulation (FES) of the peroneal nerve can improve gait but access to wearable FES devices is limited by cost and burden of in-person visits for device optimization. Therefore, the purpose of this case series was to assess the effectiveness and feasibility of a telehealth-monitored FES device.

Methods: Ten PwMS (50.2 years [SD 11.3]; 2 males) with moderate disability (median EDSS 4.75; IQR 3.75 – 5.75) were provided an EvoWalk FES device. Participants were prescribed an 8-week wear-schedule. A wearable accelerometer (ActiGraph) recorded daily step count at week 0 and 8. For week 0 activity levels, the EvoWalk was donned but not activated, and settings were progressed over three bi-weekly telehealth sessions. Effectiveness was assessed by Timed-25 Foot Walk (T25FW), 2-Minute Walk test (2MWT), Timed-Up and Go (TUG), and self-report of walking, fatigue, and QOL collected in-person at baseline and study end. Feasibility was assessed by percentage of telehealth visits completed and participant-reported satisfaction.

Results: All (100%) telehealth visits were completed with high levels of satisfaction reported, mean score 4.7/5 (SD .51). ActiGraph data were available for 3 participants: average daily step count pre (2,996; SD 1,235) was lower than post (3,930: SD 1,157) EvoWalk use. At study completion, use of FES resulted in a larger orthotic effect in gait speed for T25FW (-14.2%), TUG (-17.0%) and distance on the 2MWT (14.6%). Post-trial self-report measures showed improvements in subjective walking (-15.6%), QOL (-13.6%) and fatigue (-7.5%).

Discussion: Telehealth was safe and feasible for progressing FES intervention. Gait speed, walking distance, and QOL improved following the intervention. Using telerehabilitation to monitor FES intervention may simultaneously improve access and reduce patient burden. Future research should include follow-up to assess long-term effects

doi: 10.1016/j.msard.2023.104648

Gait Deviations Identified During the Six-Minute Walk Test Using Inertial Measurement Units in Patients with Multiple Sclerosis

Shawn L. Hanlon, Mark M Mañago, Eliza A. Biondi, Emily Hager, Cory L. Christiansen

University of Colorado, Anschutz Medical Campus and Geriatric Research Education and Clinical Center, VA Eastern Colorado Healthcare System, Denver, CO

PURPOSE: Gait deviations are common in patients with multiple sclerosis (MS) and can increase the risk of falls and potential for musculoskeletal pain. This study evaluated relationships between fatigue-induced changes in lower extremity kinematics and spatiotemporal measures during a Six-Minute Walk Test (6MWT).

METHODS: Baseline data from 29 participants ((age 49±12 years, 21F, Expanded Disability Status Scale 1-5.0) with MS completed the 6MWT. Gait parameters were recorded continuously via inertial measurement units (Xsens MVN, Enschede, Netherlands). Peak joint angles (knee flexion, hip adduction, trunk angular displacement) and spatiotemporal measures (gait speed, stance time, stride length) were calculated and analyzed for each walking stride during the first and last minute of the test. Pearson correlations were used to evaluate 1) relationships between the Distance Walked Index (DWI, difference in distance between first and last minute) and changes in involved ($_i$) and uninvolved ($_u$) limb peak joint angles and 2) relationships between changes in gait parameters, spatiotemporal measures, and 6MWT DWI. Paired t-tests evaluated differences in peak joint angles between the first and last minute of the 6MWT.

RESULTS: Participants demonstrated a 7.0% decline on the DWI (4.3 ± 6.4m reduction in walking distance) and gait speed declined by 8.5% (0.07 ± 0.11 m/s) between the first and last minute of the 6MWT. A weak, negative correlation was observed between change in frontal trunk angular displacement and DWI (R= -.501, p= .009). There were no changes in stance time$_i$ or stance time$_u$. Stride length decreased on both limbs over time (Mean Difference (MD)$_i$: 3.2cm, p <.001; MD$_u$: 3.2cm, p<.001). Within-limb peak knee flexion angle decreased on both limbs over time (MD$_i$: -6.7±14.1°, p=.021; MD$_u$: -8.11±14.7°, p=.008).

CONCLUSION: Gait deviations presented as decreased stride length and bilateral reduced peak knee flexion angle during the 6MWT. Greater DWI was associated with reduced trunk angular displacement. Interventions targeting hip and knee joint-specific dysfunction may be advantageous for mitigating gait deviations in patients with MS.

doi: 10.1016/j.msard.2023.104649

Association of Daily Physical Activity with Cervical Spinal Cord Areas in Multiple Sclerosis

Valerie J Block, PT, DPTSc [1,2], Shuiting Cheng, MS [1], Jeremy Juwono [1], Richard Cuneo, MD [1], Gina Kirkish, MS [1], Amber M Alexander [1], Mahir Khan, MS [1], Amit Akula [1], Eduardo Caverzasi, MD [1,3], Nico Papinutto, PhD [1], William A Stern, RT(MR) [1], Mark J Pletcher, MD [4,5], Greg M Marcus, MD [4], Jeffrey E Olgin, MD [4], Stephen L Hauser, MD [1], Jeffrey M Gelfand, MD, MAS [1], Riley Bove, MD, MSc [1], Bruce AC Cree, MD, PhD, MAS [1,*], Roland G Henry, PhD [1,6,*]

[1] *Weill Institute for the Neurosciences, University of California, San Francisco (UCSF), San Francisco, CA, United States*
[2] *University of California San Francisco, Department of Physical Therapy and Rehabilitation Science, San Francisco, USA*
[3] *University of Padua, Italy*
[4] *Department of Medicine, UCSF*
[5] *Department of Epidemiology, UCSF*
[6] *Department of Radiology, University of California San Francisco, San Francisco, USA*

* Co-last Authors

Background and purpose: Remote activity monitoring has the potential to evaluate real-world motor function and disability outside of the clinic. The relationships of daily physical activity with spinal cord white matter and grey matter areas, MS disability, and leg function are unknown. Our purpose was to evaluate the association of remotely captured ambulatory activity with structural central nervous system pathology via quantitative magnetic imaging, in people with multiple sclerosis (MS).

Methods: Fifty adults with progressive or relapsing MS with motor disability who could walk at least 2 minutes, were assessed using clinical, patient-reported, and quantitative brain and spinal cord MRI measures. Fitbit Flex2, worn on the non-dominant wrist, remotely assessed activity over 30 consecutive days. Univariate and multivariate analyses were performed to assess correlations between remote physical activity and other disability metrics.

Results: The mean age of the cohort was 53.3 years and the median EDSS was 4.0. Average daily step counts (STEPS) were highly correlated with EDSS and walking measures (i.e., Timed 25-foot Walk, Timed up and Go tests, and subjective 12- item MS Walking Scale). Greater STEPS correlated with greater C2-C3 spinal cord grey matter areas (rho=0.39, p=0.04), total cord area (rho=0.35, p=0.04), and brain volume (rho=0.32, p=0.04).

Discussion: These results provide preliminary evidence that spinal cord grey matter area is a neuroanatomical substrate associated with STEPS. STEPS could serve as a proxy to alert clinicians and researchers to possible changes in structural nervous system pathology. Longitudinal observations are needed to determine directionality and value of STEPS as a proxy for generalized brain and cord volume loss. These results have potential implications for structural and functional modification of disease progression via therapeutic interventions aimed at altering STEPS.

doi: 10.1016/j.msard.2023.104650

Enhancing Mobility in Persons with Footdrop in Multiple Sclerosis through Functional Electrical Stimulation

James Fang [1], Danya Pradeep Kumar [1], Elie Celnikier [2], Makenna Snyder [1], Emilia Potts [1], Jacob Sosnoff [1]

[1] *University of Kansas Medical Center*
[2] *Evolution Devices, Inc.*

Background: Footdrop is a significant problem in individuals living with multiple sclerosis (MS), leading to falls and reduced quality of life. Functional electrical stimulation (FES) is a common treatment for footdrop. Technological advances are leading to the development of the next generation of FES devices, such as the non-invasive EvoWalk (Evolution Devices, Inc). Prior to widespread use the accuracy of the device's gait detection needs to be validated.

Aim: To validate EvoWalk's gait analysis accuracy based on ground truths from a pressure-based walkway gait analysis system and examine the improvement in gait with FES in pwMS.

Method: Individuals living with MS, unilateral footdrop and capable of walking 10m with or without an assistive device were eligible. Participants performed a series of walking and stair-climbing tasks while wearing the EvoWalk device with and without FES stimulation active on the affected leg. Data was simultaneously recorded on the EvoWalk device, and the Zeno pressure-based walkway gait analysis system.

Results: Data from two pwMS with unilateral footdrop and one healthy control was analyzed. Compared to the pressure-based walkway system, EvoWalk yielded an average heel-strike and toe-off onset detection differences of 32.7ms (SE=15.3, 95% CI = [2.72,62.7]) and 59.1ms (SE=36.4, 95% CI = [0,130.4]), respectively. Also, in one pwMS, swing-time improved by 11.83% when the stimulation was active. Due to technical issues, we were unable to compare the stimulation results for the other pwMS and stimulation was inactive for the control participant.

Discussion: The wearable FES device tested here was accurate in detecting gait events and has some benefit to gait parameters. Further research concerning the device is warranted.

doi: 10.1016/j.msard.2023.104651

White Matter Correlates of Reactive Stepping in People with Multiple Sclerosis

Andrew S. Monaghan [1], Jessica L. Trevino [1], Jordan S. Barajas [1], Daniel S. Peterson [1,2]

[1] *College of Health Solutions, Arizona State University, Phoenix, AZ, USA*
[2] *Phoenix VA Health Care Center, Phoenix, AZ, USA*

Background and Purpose: Reactive steps are rapid protective responses after balance challenges. People with MS (PwMS) demonstrate impaired stepping, which can increase fall-risk, and these deficits may be caused by white matter (WM) loss. However, the specific neural mechanisms contributing to reactive stepping in PwMS are poorly understood. We aimed to determine WM correlates of reactive stepping and responsiveness to step training.

Methods: 14 PwMS participated in an 18-week multiple-baseline study. Participants attended 2 baseline assessments (B1 and B2) before training, a 2-week, 6-session training protocol, and a post-training assessment (P1). Each assessment consisted of 3 backward reactive step trials. Training consisted of 32 stepping trials. Outcomes included the anterior-posterior margin of stability (MOS), step length, and step latency. Tract-Based Spatial Statistics (TBSS) was performed to investigate the WM microstructure by correlating fractional anisotropy (FA), mean diffusivity (MD), and radial diffusivity (RD) with baseline reactive step performance (B1) and immediate responsiveness to training (P1).

Results: The FA of the right superior longitudinal fasciculus (R-SLF) was associated with baseline step length (p=0.048) and MOS (p=0.048). Corpus Callosum (p=0.047) and right anterior corona radiata (R-ACR) (p=0.047) FA were also related to baseline MOS during backward stepping. FA of the corticospinal tract was also associated with baseline step length (p=0.048). The FA (p=0.047) and the MD (trending- p=0.082) of the L-ACR were also related to step length. No significant associations were found between WM and training responsiveness, but a trend showed an association between the right uncinate fasciculus and a change in step latency (p=0.072).

Discussion: We identified several WM loci associated with baseline stepping involved in the rapid integration of sensory information and the execution of motor responses. A better understanding of the neural control of reactive stepping may lead to developing more effective rehabilitation strategies and ultimately reducing fall-risk in PwMS.

doi: 10.1016/j.msard.2023.104652

MOVEMENT-SPECIFIC CHANGES IN ENERGY EXPENDITURE FOR PERSONS WITH MILD MULTIPLE SCLEROSIS

Robert Courter [1,2], Enrique Alvarez [3], Roger Enoka [1], Alaa Ahmed [2]

[1] *Departments of Integrative Physiology, University of Colorado, Boulder, CO, USA*
[2] *Departments of Mechanical Engineering, University of Colorado, Boulder, CO USA*
[3] *Department of Neurology, University of Colorado Anschutz Medical Campus, Aurora, CO*

E-mail address: roco4819@colorado.edu

Background and Purpose: In healthy adults and animals, movement speeds are often chosen to reduce the energy expended; thus, is MS-related slowness of walking and arm reaching linked to increased effort costs? Here, we hypothesized that the costs of walking would be higher in MS due to gait-related impairments such as spasticity, balance deficits, or worsened fitness; whereas the costs of seated reaching would be no different due to its divorce from the sensorimotor covariates associated with elevated walking costs and low cardiorespiratory demand.

Methods: Participants with MS (pwMS) (n=13) and age- and sex-matched controls (HCs) (n=11) first performed a battery of assessments. On two separate days, metabolic rates were measured via indirect calorimetry while participants walked on a treadmill at five speeds (0.6 up to 1.60m/s) and while performing out-and-back reaching movements with the dominant arm at five speeds (approx. 0.1 up to 0.8m/s).

Results: Neither age, height, nor weight differed between pwMS and HCs. The only metrics that differed between groups were the time to walk 25 feet (slower for pwMS) and fatigue ratings (higher for pwMS).

Net metabolic rate (normalized to body mass) increased with walking speed ($p<2e-16$) and was ~20.54% higher for pwMS at any speed than HCs ($p=0.0185$). However, the net rate (normalized to arm mass) was no different between pwMS and HCs at any speed ($p=0.911$). Elastic net regression techniques reinforced these findings: selecting MS-status as an important predictor of walking metabolic rate, while excluding this variable for predicting reaching rate, even when controlling for many additional factors.

Discussion: Individuals with MS who have high mobility and low disability may require more energy expenditure to walk, but not for seated reaching movements. Our results suggest that movement slowness occurring with MS is not altogether a consequence of energy conservation. Instead, other mechanisms such as fitness, perceived effort, or reward sensitivity should be investigated for improving mobility.

doi: 10.1016/j.msard.2023.104653