Abstracts

CSM 2015 Neurology Section
PLATFORM Presentations
TITLE: Interhemispheric Supplemental Motor Area Tract-Specific Measures are Associated with Dual-Task Walking Variability in Multiple Sclerosis

AUTHORS/INSTITUTIONS: N.E. Fritz, Physical Medicine & Rehabilitation, Kennedy Krieger Institute, Johns Hopkins School of Medicine, Baltimore, Maryland, UNITED STATES|A.D. Kloos, M. Fiumedora, D.A. Kegelmeyer, Physical Therapy, The Ohio State University, Columbus, Ohio, UNITED STATES|D.S. Nichols-Larsen, Health & Rehabilitation Sciences, The Ohio State University, Columbus, Ohio, UNITED STATES|

ABSTRACT BODY:

Purpose/Hypothesis: Individuals with Relapsing Remitting Multiple Sclerosis (RRMS) commonly experience declines in walking ability, cognitive function, and dual-task (DT) performance (e.g., performing a motor and a cognitive task simultaneously). The supplemental motor area (SMA) is active during complex motor tasks and cognitive DTs, but its relationship to clinical measures of motor-cognitive DT has not been explored. Diffusion tensor imaging (DTI) is a tool to investigate white matter pathways. The objective of this study was to examine the relationship between clinical measures of DT performance and measures of diffusivity in the interhemispheric SMA tract.

Number of Subjects: 18 female volunteers with RRMS (mean ± SD age: 45.5 ± 8.2; symptom duration: 12.3 ± 6.7; and median (range) EDSS: 2.2(1.5-4) participated in a mobility assessment and a DTI scan.

Materials/Methods: Mobility measures included the Walking While Talking Test (WWTT), TUG-Cognitive, and forward dual-task walking (DTW) with serial-3 subtraction on the GAITRite electronic walkway. Spatiotemporal measures and coefficients of variation (CV) were calculated. DTI images were acquired on a Siemans 3T scanner in the axial plane with diffusion gradients in 64 directions. Probabilistic tractography was used to model the SMA interhemispheric tract using FMIRB’s Diffusion Toolbox, and measures of diffusivity (Fractional Anisotropy, Mean Diffusivity, Radial Diffusivity, and Axial Diffusivity (AD)) were calculated. Spearman correlation analyses were performed using SPSS version 19 to examine relationships between DTI measures and DT ability.

Results: Of the tract-specific measures of diffusivity, AD demonstrated the strongest relationships with measures of DT. AD coincides with the fiber tract axis and animal work suggests that AD may be specific to axonal degeneration. AD was significantly related to DTW variability: stance time CV (r=0.621; p=0.006); double support time CV (r=0.548; p=0.018); step length CV (r=0.487; p=0.040); step time CV (r=0.519; p=0.027) and swing time CV (r=0.533; p=0.023). AD was also trending toward significance in DTW velocity (r= -0.428; p=0.077) and the WWTT (r= 0.432; p=0.074).

Conclusions: This study correlated DTI with clinical outcome measures to gain a better understanding of the neural connectivity that underlies DT performance in individuals with RRMS. Our data identifies a significant relationship between AD of the interhemispheric SMA tract and DTW variability. Data collection is ongoing and future analyses will examine the relationships between other DTW variables and measures of diffusivity as well as the predictive value of these imaging measures using regression models.

Clinical Relevance: DTI may be a useful adjunct to clinical measures to predict DT performance and provide important information about recovery patterns in MS. Functional recovery can be challenging to objectively report in neurodegenerative diseases like MS, and use of DTI could show microstructural improvements and suggest improved connectivity.
Upper Extremity Performance Improves Following Video Game Delivery of Constraint-Induced Movement Therapy in a Pilot Study

A. Borstad, Division of Physical Therapy, The Ohio State University, Columbus, Ohio, UNITED STATES; L.P. Lowes, Nationwide Children's Hospital, Columbus, Ohio, UNITED STATES; L. Marx, Holzer Health System, Gallipolis, Ohio, UNITED STATES; L. Worthen-Chaudhari, K. Phillips, L. Gauthier, Physical Medicine and Rehabilitation, The Ohio State University, Columbus, Ohio, UNITED STATES; D. Maung, R. Crawfis, Computer Science and Engineering, The Ohio State University, Columbus, Ohio, UNITED STATES; J. Jaffe, College of Arts and Sciences, The Ohio State University, Columbus, Ohio, UNITED STATES; R. McPherson, Electrical and Computer Engineering, The Ohio State University, Columbus, Ohio, UNITED STATES.

Purpose/Hypothesis: Constraint-induced movement therapy (CI therapy) is an effective treatment for the improvement of upper extremity function in individuals with hemiparesis, yet many individuals lack access to CI therapy or any outpatient rehabilitation. The purpose of this research was to develop an affordable home-based model of constraint-induced movement therapy in which motor practice is delivered through a custom 3D video game and establish the feasibility and initial efficacy of this intervention.

Number of Subjects: Twelve community-dwelling individuals with hemiparesis as a result of stroke (n=11) or traumatic brain injury, with mild to moderate deficits in upper extremity function.

Materials/Methods: A custom 3D video game for upper extremity rehabilitation was developed using the Microsoft Kinect®. CI therapy was delivered using a home-based therapist-as-consultant model. Twice weekly in-home consultation sessions were provided throughout the two-week intervention. Participants were encouraged to play the game for a target of 30 hours. Game content emphasized high-repetition, and self-assessment of daily arm use through a gamified Motor Activity Log. Participants agreed to wear a restraint mitt on the less affected hand for 10 hours per day to promote use of the more affected hand for daily activities. Motor function was assessed by blinded testers immediately prior to and following treatment via the Wolf Motor Function Test (WMFT). Arm use was assessed via tri-axial accelerometry (ratio of more-affected to less-affected arm accelerometer counts). Other measures included the Patient Health Questionnaire and the Brief Kinesthesia Test.

Results: Participants played for an average of 17.92 hours, accumulating an average of 23,587 movement repetitions. Dose was consistent as evidenced by the correlation between hours played and movement repetitions (r=0.9, p<0.001). As a whole, participants showed clinically meaningful improvements in motor function (mean change in WMFT rate metric = 13.62). Six individuals scored in the 90th percentile or higher of WMFT changes reported by Taub and colleagues. Five individuals demonstrated increased arm use based on accelerometry. There was no significant relationship found between depression and duration of game play. No relationship was observed between improvement on the WMFT and duration of game play, number of motor repetitions, kinesthetic impairment, handedness, or hemisphere affected.

Conclusions: This in-home therapist-as-consultant model of CI therapy is feasible, delivers a high dose and had initial efficacy in this pilot study. Randomized comparative-effectiveness trials are needed.

Clinical Relevance: A custom CI therapy game could serve as an engaging platform for providing intensive rehabilitation to underserved individuals with hemiparesis.
TITLE: Combining Magnetization Transfer Ratio Magnetic Resonance Imaging and Quantitative Measures of Walking Improves the Identification of Fallers in Multiple Sclerosis

AUTHORS/INSTITUTIONS: N.E. Fritz, K. Zackowski, Physical Medicine & Rehabilitation, Kennedy Krieger Institute, Johns Hopkins School of Medicine, Baltimore, Maryland, UNITED STATES|R.R. Marasigan, J. Keller, C. Chiang, Motion Analysis Laboratory, Kennedy Krieger Institute, Baltimore, Maryland, UNITED STATES|C.K. Jones, Kirby Center for Functional Imaging, Kennedy Krieger Institute, Baltimore, Maryland, UNITED STATES|A. Eloyan, Biostatistics, Johns Hopkins School of Public Health, Baltimore, Maryland, UNITED STATES|P.A. Calabresi, Neurology, Johns Hopkins School of Medicine, Baltimore, Maryland, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: Multiple sclerosis (MS) is a progressive demyelinating disease affecting the central nervous system. Balance and walking are frequently impaired in individuals with MS, resulting in accidental falls and injury. Falls in MS have been associated with higher Expanded Disability Status Scale (EDSS) scores and poor balance. Magnetic resonance imaging (MRI) is a common clinical tool for monitoring disease progression. An exploration of infratentorial lesions in individuals with known balance dysfunction showed that falls were positively associated with lesion volume in the middle cerebellar peduncle and brainstem. However, the relationship of walking and falls to tract specific MRI measures and quantitative clinical measures of strength and sensation has not been explored in MS. The objective of this study was to examine the relationship and predictive value of clinical measures and tract specific brain MRI measures sensitive to myelin (magnetization transfer ratio (MTR)) and axonal integrity (fractional anisotropy (FA)) in the corticospinal tract (CST) to quantitative measures of walking and fall status (faller v. non-faller).

Number of Subjects: 23 individuals with relapsing-remitting MS (mean ± SD age: 49.1 ± 11.5 years; 12 females; EDSS: 3.9 ± 1.5; symptom duration: 14.1 ± 10.2 years; 10 fallers) participated in the study.

Materials/Methods: All participants underwent a 3T brain MRI including diffusion tensor imaging (DTI) and MTR, as well as clinical tests of walking, strength, sensation and a falls history. Region of interest selection for the CST was performed in DTIStudio. Spearman Correlation and Forward Stepwise Logistic Regression were used to assess the relationships of walking and MRI measures on fall status.

Results: Walking velocity, Timed Up and Go (TUG) and Timed 25 Foot Walk performance were significantly associated with CST FA (r=-0.4879; p=0.0248; r=-0.6117; p=0.0054; r=0.5447; p=0.0107, respectively) and MTR (r=-0.4331; p=0.0441; r=-0.4744; p=0.0257; r=0.4704; p=0.0272, respectively). Interestingly, a model including CST MTR and TUG explained >47% of the variance in fall status (R²=0.4739; MTR p-value=0.071; TUG p-value=0.040) and accurately distinguished fallers from non-fallers with a cross-validation error of 23%. Inclusion of DTI, strength and sensation measures did not improve the model.

Conclusions: These preliminary results suggest that tract specific MTR may be useful in relating brain pathology to walking performance and fall status in MS. This data is part of an ongoing study; thus, additional subjects and brain volume MRI variables will be added which may improve identification of significant associations between MRI measures and clinical measures of walking and falls in MS.

Clinical Relevance: Use of structural imaging may provide additional information about walking performance and fall status in MS and holds potential to improve fall prediction that may lead to better identification of fallers.
Purpose: Scientific evidence from fields of motor learning, neuroscience, and the psychological science of behavior change has important implications for neurorehabilitation and rehabilitation, in general. We present the set of principles informed by advances in these fields that guided the investigational intervention, Accelerated Skill Acquisition Program (ASAP) in the recent multi-site phase III randomized controlled trial, Interdisciplinary Comprehensive Arm Rehabilitation Evaluation (ICARE).

Description: The ASAP involves a set of nonexclusive principles organized around three overlapping essential elements—skill acquisition (movement and self-management), impairment mitigation, and motivational enhancement (intrinsic drive). Activities to increase skills, capacity, and motivation are centered around the vehicle of specific tasks chosen by the participant. Key principles include: a) ensure challenging and meaningful practice, b) address important (interfering) changeable impairments, c) enhance motor capacity through overload and specificity, d) preserve natural goal-directedness in movement organization, e) avoid artificial task break-downs when possible, f) ensure active participant involvement and opportunities for self-direction, g) balance immediate and future needs, and h) drive task-specific self-confidence high through performance accomplishments. Among the key strategies are to: determine the point at which the participant's movement performance breaks down (challenge threshold), identify the impairments that interfere with efficient skilled movement, establish the level of intensity for task practice, and consider activity and task progressions. Other components include: frequent measurement of progress in skill, capacity, and confidence, encouraging self-directed activity in the natural environment beyond the therapy setting through formalized and participant-centered action plans, and enabling participant problem identification and solution generation.

Summary of Use: Our collective implementation experience suggests several important distinctions from conventional practice, including challenging and intense practice, as well as a strong emphasis on collaboration and participant-directed therapy with the therapist assuming a consultative and coaching role. For example, the therapist interacts to protect the participant's fundamental psychological needs by support for autonomy (choice and collaboration), eschewing controlling language, and authoritative direction in session activities. One strength of a principle-based approach, in contrast to a protocol-driven regimen, is the ability to take advantage of "teachable moments" as they emerge during the therapy session. This flexibility can be challenging for inexperienced clinicians, but exciting for those seeking new challenges in their practice and high quality interactions with their clients.

Importance to Members: Our expectation is that the ASAP principles could apply across a diverse spectrum of rehabilitative interventions, settings, and disabling clinical conditions.
TITLE: Single session of cortical stimulation-enhanced gait training improves post-stroke lower limb corticomotor excitability

AUTHORS/INSTITUTIONS: N. Kanekar, S. Madhavan, University of Illinois at Chicago, Chicago, Illinois, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: Non-invasive brain stimulation, particularly transcranial direct current stimulation (tDCS), is emerging as a promising tool for use as an adjuvant to enhance neuroplastic changes and improve function in people with stroke (1-3). We recently showed that anodal tDCS enhances paretic ankle motor performance in patients with chronic stroke (4). The aim of this study was to investigate in people with chronic stroke, whether a single session of high intensity gait training combined with cortical priming [via tDCS enhanced ankle motor training] results in improved corticomotor control of the paretic lower limb compared to gait training alone.

Number of Subjects: 4 individuals (3 females, 1 male; mean age: 66.75 ± 5.85 years; mean height: 1.64 ± 0.12 m; mean weight: 73.95 ± 11.72 kg) with chronic stroke (mean stroke duration: 10.5 ± 9.53 years; stroke type: 3 ischemic and 1 hemorrhagic; paretic side: 2 right, 2 left) participated in the study. 8 additional participants are currently enrolled.

Materials/Methods: All the subjects participated in two sessions (randomized and 1 week apart) of high intensity speed dependent gait training (5). The control session consisted of 40 minutes (5 minutes warm-up – 30 minutes walking – 5 minutes cool down) of treadmill walking with the subjects fitted in a safety harness with no body weight support. During the cortical priming session, prior to the treadmill walking, subjects performed a visuomotor tracking task with their paretic ankle for 15 minutes while receiving facilitatory anodal tDCS over their lesioned motor cortex. For each session, pre and post cortical excitability measures were obtained for bilateral tibialis anterior (TA) muscles using single pulse transcranial magnetic stimulation.

Results: Preliminary results demonstrated a 114% increase in the amplitude of the motor evoked potential (MEP) for the paretic TA and a 10% decrease in the MEP amplitude for the non-paretic TA following the cortical priming-enhanced gait training session as compared to the control session. The MEP area normalized against the background modulus showed a 126% increase in magnitude for the paretic TA following the cortical priming-enhanced gait training session as compared to the control session. The cortical silent period was 12ms or 18% longer for the paretic TA and 6 ms or 26% shorter for the non-paretic TA following the cortical priming-enhanced gait training session as compared to the control session.

Conclusions: This is the first study to show that a single session of cortical stimulation-enhanced gait training combined increases corticomotor control of the paretic lower limb as compared to gait training alone.

Clinical Relevance: This study lays an important background demonstrating the feasibility and effectiveness of stimulation enhanced gait training in rehabilitation of individuals with stroke.
TITLE: Virtual reality-based therapy for the treatment of balance deficits in patients receiving inpatient rehabilitation for traumatic brain injury

AUTHORS/INSTITUTIONS: D.R. O'Dell, K. Hays, A. Natale, Physical Therapy, Craig Hospital, Englewood, Colorado, UNITED STATES|J.P. Cuthbert, K. Staniszewski, D. Gerber, Research, Craig Hospital, Englewood, Colorado, UNITED STATES|

ABSTRACT BODY:

Purpose/Hypothesis: There is limited evidence for the treatment of diminished balance for people with traumatic brain injury (TBI); however, research in populations with neurological deficits similar to TBI has demonstrated that virtual reality (VR) can be an effective modality for improving balance. The purpose of this pilot study was to evaluate the feasibility and safety of utilizing a commercially available virtual reality gaming system as a treatment intervention for balance training in individuals with TBI.

Number of Subjects: Twenty subjects with TBI requiring inpatient balance rehabilitation.

Materials/Methods: Participants consenting and exhibiting a minimum of 15/56 on the Berg Balance Scale (BBS) were randomized into one of two treatment conditions: Extra Standard Balance Care (ESC) or VR-based balance therapy utilizing the Nintendo Wii (VRT). All participants received a standard therapy program as per the therapeutic guidelines established at Craig Hospital and 15 minutes of balance-focused physical therapy delivered by a licensed physical therapist at the end of the rehabilitation day through either ESC or VRT, 4 times per week, for 4 weeks. Study outcomes were measured at baseline and at the end of 2 and 4 weeks of therapy. Outcomes included: Physical Activity Enjoyment Scale (PACES), BBS, Functional Gait Assessment (FGA) and adverse events. T-tests, chi-square test, and linear mixed effects repeated measures were utilized to assess outcome scores.

Results: Participants in the ESC group had slightly higher enjoyment, as measured by the PACES, at mid-intervention while those receiving the virtual reality-based balance intervention were found to have higher enjoyment at study completion, though neither difference was found to be significant (p=0.59, 0.34, respectively). Both groups demonstrated significantly improved balance over the course of the study on the BBS and FGA, though no significant between groups differences were noted (p=0.70; p = 0.73, respectively). No adverse events occurred during the course of the study for any participant.

Conclusions: This study provides a modest level of evidence to support using commercially available VR gaming systems for the treatment of balance deficits in patients with TBI receiving inpatient rehabilitation. Additional research of these types of interventions for the treatment of balance deficits is warranted. This study led to a randomized controlled trial currently running at Craig Hospital for community dwelling individuals with TBI comparing a home exercise program and a VR program performed in the home.

Clinical Relevance: The use of VR systems in rehabilitation is safe and can be as effective as standard balance programs if appropriately designed. A VR based balance retraining program may be more engaging for some individuals to participate in compared to standard balance activities for balance retraining.
Purpose: Chronic balance deficits are commonly reported after traumatic brain injury (TBI); yet, there is limited evidence for the treatment of diminished balance for this population. Research in similar populations has shown that virtual reality (VR) can be an effective adjunct modality to improve balance. A pilot randomized controlled trial (RCT) conducted at Craig Hospital showed that the use of a commercially available VR gaming system for inpatients with TBI was safe, as effective as additional standard balance care, and enjoyed by participants more than traditional balance activities. Based on this information, a large scale RCT was developed to assess the efficacy of a home-based VR Physical Therapy (PT) program for community dwelling individuals with TBI reporting balance deficits. The purpose of this presentation is to explore the rationale for the use of outcome measure scores to develop specific balance programs used in this RCT.

Description: Thirty six protocols were developed as part of the current trial. Eighteen protocols use a commercially available VR system, and eighteen are non-VR home balance programs. Each protocol is designed to address system deficits (measured by the Balance Evaluation Systems Test (BEST)) and functional balance (measured by the Community Balance and Mobility Scale (CBAM)). BEST subscale scores are used to select activities that will challenge the systems with the greatest underlying deficits, while CBAM scores are utilized to determine the difficulty of the program. This presentation will focus on the clinical rationale used in the development of these protocols and how these can be applied in a clinical setting.

Summary of Use: The concept of using balance assessment scores to select VR-based balance rehabilitation games is generalizable to the clinic setting. Off-the-shelf VR games target various underlying balance systems and require different skill sets for successful participation. By having a working knowledge of the balance systems most impaired in an individual and the available game options, clinicians can tailor a specific program for the clinic or home setting. This program can target specific impairments and accommodate an individual's personal preferences and interests.

Importance to Members: The use of commercially available VR systems in rehabilitation is growing rapidly. Selecting appropriate games to treat specific balance deficits can be an overwhelming task for clinicians. The concept of using scores on standardized balance tests to guide game choices based on difficulty and affected balance systems can assist clinicians in determining what games to select, and can assist patients in achieving the best possible outcomes for their balance by creating an enjoyable treatment environment which may improve compliance.
ABSTRACT BODY:

**Background & Purpose**: Arm and hand recovery after stroke remains one of the most challenging targets for rehabilitation, with over 65% of individuals unable to incorporate their paretic limbs in everyday activities 6 months after stroke. The purpose of this case example with supplemental video clips is to illustrate implementation of the principles of the Accelerated Skill Acquisition Program (ASAP), originally designed to address arm recovery needs of these individuals in the outpatient setting.

**Case Description**: The participant in this case is a 60-year-old right-hand dominant man who sustained a right basal ganglia hemorrhagic stroke resulting in left upper extremity motor deficits, including limitations in reaching, grasp and release of objects, and dexterity (baseline Fugl-Meyer score = 43/66). He was randomized 24 days after stroke to the investigational treatment arm, ASAP, of the phase III multi-site Interdisciplinary Comprehensive Arm Recovery Evaluation (ICARE) RCT. Administered during 30 1-hour visits distributed across 10 weeks (3 x/week), ASAP integrates progressive task-oriented training with participant-centered strategies to facilitate the translation of skilled functional improvements into the home and community environment. Self-selected therapeutic activities were centered on the participant’s vocation of painting and associated functions. Tasks were used as vehicles to address the overlapping components of skill (motor learning and self-management), capacity (impairment mitigation) and motivation (intrinsic drive). Motor capacity was enhanced through practice of painting-related exercises at his challenge threshold for the activity with progression as skilled behavior developed. The participant identified lynchpin impairments of shoulder strength and dexterity to improve his ability to use a paintbrush at or above shoulder height. The therapist facilitated the participant’s problem-solving using non-controlling language to support his self-management skills while promoting his intrinsic motivation. Participant self-efficacy was fostered by provision of positive feedback during successful completion of challenging tasks.

**Outcomes**: While full results of the ICARE trial await the final release of the findings, this participant experienced substantial improvements in his upper extremity function over the course of the 30 sessions, from initial inability to grasp a paintbrush to the capability to paint an entire wall (blue) with his more affected and non-dominant hand. His confidence for this task rose from 1/10 (“not confident at all to paint a wall”) to 10/10 (“very confident”). Therapeutic gains were seen in his problem-solving, self-management, and health protective behavior, and in his confidence for social participation as caregiver for his family and return to work.

**Discussion**: This case is an example of the potential optimization of motor recovery through an integrated skill-based, capacity-building, and motivational (social-cognitive) intervention designed and implemented within the framework of ASAP.
TITLE: Increased central activation during eccentric contractions is associated with increased spinal excitability during muscle lengthening in individuals with spinal cord injury

AUTHORS/INSTITUTIONS: H.E. Kim, Graduate Program in Neuroscience, University of Illinois at Chicago, Chicago, Illinois, UNITED STATES|D.M. Corcos, Department of Physical Therapy, University of Illinois, Chicago, Illinois, UNITED STATES|T. Hornby, Department of Physical Therapy & Human Movement Sciences, Northwestern University, Chicago, Illinois, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: Recent data demonstrate individuals with incomplete spinal cord injury (SCI) generate greater neural drive to the knee extensors during eccentric maximal voluntary contractions (MVCs) as compared to isometric or concentric MVCs (1). This pattern of central activation directly contrasts findings of reduced eccentric activation observed in neurologically unimpaired control subjects (2, 3). Others have suggested that inhibition of Ia-α motoneuron transmission during muscle lengthening, as determined by H-reflex testing, may contribute to deficits in eccentric activation in unimpaired individuals (4, 5). Significantly, stretch reflex excitability may be increased in many individuals with chronic SCI and contribute to altered muscle activation strategies. The aims of the current study, therefore, are to assess muscle activation and modulation of H-reflexes during isometric, shortening, and lengthening actions of the plantarflexors in subjects with SCI and controls. We hypothesize that subjects with SCI will demonstrate greater muscle activation during eccentric versus isometric or concentric MVCs, and that this pattern of activation will be associated with enhanced Ia-α motoneuron transmission during muscle lengthening.

Number of Subjects: 5 males with incomplete SCI, 4 males without neurologic injury

Materials/Methods: Subjects sat in the testing chair of an isokinetic dynamometer with the tested knee flexed 30 deg. For anisometric testing, the ankle moved through a 30 deg range (-5 - +25 deg plantarflexion) at 20 deg/s. Position, torque, and surface electromyography (EMG) signals were recorded during all trials. For all tests, stimulation to the posterior tibial nerve was delivered at a constant reference angle of 10 deg plantarflexion. Central activation was evaluated by delivering a supramaximal doublet during MVCs and calculating the ratio of peak voluntary torque to peak superimposed torque (6). Spinal modulation was assessed by comparing maximal H reflex amplitudes (Hmax) across all conditions.

Results: For subjects with SCI, central activation ratios are higher during eccentric MVCs (0.78 ± 0.13) than isometric (0.64 ± 0.17) or concentric (0.55 ± 0.29) MVCs. Consistent with previous data, controls demonstrate an inhibition of Hmax during passive muscle lengthening (41.2 ± 13.6% of isometric values). Subjects with SCI demonstrated lengthening Hmax values that were more than double that of controls (84.5 ± 12.4% of isometric values).

Conclusions: Contrasting patterns of muscle activation between subjects with SCI and controls may be related to differences in modulation of Ia-α motoneuron transmission during muscle lengthening.

Clinical Relevance: Increased understanding of the neural activation strategies utilized by individuals with SCI during eccentric contractions may hasten development of more targeted interventions for improving strength and function.
TITLE: Comparison of an Intermittent vs. Continuous Walking Program in Persons with Multiple Sclerosis Using the 6 Minute Walk Test: A Randomized Crossover Pilot Study

AUTHORS/INSTITUTIONS: H. Karpatkin, S. DiCarrado, B. Dungan, J. Potrezba, E. Huallpa, Physical therapy, Hunter College, City University of New York, Brooklyn, New York, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: Difficulty with gait is one of the most common complaints of persons with MS (pwMS) and can be due to many causes, including neurogenic fatigue. Neurogenic fatigue is one of the most common MS symptoms, and can prevent pwMS from walking longer distances, thus limiting their ability to improve gait endurance. Intermittent walking, a technique where persons take breaks during walking rather than walking continuously may allow for pwMS to walk longer distances due to less accrual of fatigue. Previous studies have shown that intermittent walking results in greater distance walked and less fatigue in persons with MS than continuous walking. However, the effectiveness of intermittent walking as a training program relative to continuous walking has not been examined. The purpose of this pilot study was to investigate whether a program of intermittent walking will result in a greater improvement in gait endurance in pwMS than a continuous walking program.

Number of Subjects: 9 subjects with a diagnosis of clinically definite MS.

Materials/Methods: A randomized crossover design was used. Subjects were randomized into intermittent (INT) and continuous (CONT) groups. All subjects performed a baseline 6-minute walk test (6MWT) following which, they performed a training regime of eight 6-minute walks over a 4-week period, followed by a 6MWT posttest. Subjects in the INT group trained with three 2-minute walks interspersed with 2-minute seated rests, while the CONT group trained 6 minutes continuously. Subjects then underwent a 4-week detraining period, followed by another 4-week walking period where they performed whatever type of training they did not perform originally, with 6MWT’s performed before and after the eight training bouts. To determine whether the subjects found one type of training more fatiguing than the other, a Visual Analog Fatigue Scale (VAFS) was used to measure subjective perception of fatigue for both walking conditions.

Results: 9 subjects (6 female and 3 male, mean age 52.9 +/- 12.6) completed the study. Mean disease severity as measured by the Expanded Disability Status Scale (EDSS) was 3.4, indicating a mild to moderate disability. Intermittent training resulted in a significant (F (1,8) = 9.634, p< .015.) improvement in 6MWT distance (143.01’) relative to continuous training, which resulted in a decrease of 59.2’. Subjective perceptions of fatigue as measured by the VAFS while walking were not significantly different for the two walking conditions.

Conclusions: Despite the small sample size, intermittent gait training was clearly superior to continuous gait training in improving 6MWT performance.

Clinical Relevance: Gait endurance in pwMS may be better improved with gait training that emphasizes intermittent rests as opposed to walking continuously.
TITLE: Self-efficacy mediates the relationship between balance/walking performance, activity, and participation after stroke

AUTHORS/INSTITUTIONS: M.A. French, M.F. Moore, Department of Physical Therapy, University of Delaware, Newark, Delaware, UNITED STATES | R. Pohlig, Biostatistics Core Facility, University of Delaware, Newark, Delaware, UNITED STATES | D. Reisman, Biomechanics and Movement Science, University of Delaware, Newark, Delaware, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: Many outcome measures (OM) have been categorized using the World Health Organization International Classification of Function model (ICF) as tools to evaluate activity and/or participation after stroke. Some measures evaluate an individual’s ability to perform functional tasks, while other measures assess the individual’s belief in his/her ability to perform these functional tasks. The relationship between these different types of measures of activity and participation remain unclear. Thus, the purpose of this study was to explore the relationships between various types of OM and activity and participation in people with stroke.

Number of Subjects: Subjects >3 months post-stroke, who were able to ambulate without the assistance of another person, had no other neurologic conditions, and were not limited by pain were included in the study.

Materials/Methods: Subjects (n=59) participated in a clinical evaluation including self-selected walking speed (SSWS), 6 minute walk test (6MWT), Timed “Up and Go” Test (TUG), Berg Balance Scale (BBS), Functional Gait Assessment (FGA), Walk 12, Activity-specific Balance Confidence Scale (ABC), Step Activity Monitoring (SAM), and Stroke Impact Scale-Participation (SIS-P). Following the ICF model, SAM was used as a measure of activity and SIS-P as a measure of participation. An Exploratory Factor Analysis (EFA) was performed including all measures but SAM and SIS-P. Due to non-normality, the EFA was performed on the Spearman Correlation Matrix using Maximum Likelihood extraction and Direct Oblimin rotation. Two factors were extracted. The first, which we termed performance based (PB), included SSWS, 6MWT, TUG, BBS, and FGA. The second factor included Walk-12, ABC, and FGA, which we labeled self-efficacy (SE). Factor scores were calculated using the Regression Method after standardizing the variables. Subsequently, a Path Analysis was performed testing the role of SE as a mediator in the relationships of PB to both SAM and SIS-P.

Results: Using the Baron and Kenny method for mediation, all four criteria were satisfied. It was found that SE mediates the relationship of PB and SAM as well as PB and SIS-P. In the mediation model, PB significantly predicts SE (β =.47, p < .001), but does not significantly predict SAM or SIS-P (p’s > .05) directly. SE significantly predicts both SAM (β =.62, p < .001) and SIS-P (β =.48, p < .001). The Indirect Effects of PB on both outcomes were significant, SAM (β =.30, p < .001) and SIS-P (β =.23, p < .001).

Conclusions: These results suggest that SE mediates the relationship between PB and activity and participation after stroke, reinforcing the idea that improving activity and participation is more complicated than only targeting performance.

Clinical Relevance: Based on these findings, clinicians should administer SE and PB measures to get the most accurate view of patients after stroke. Treatment sessions should incorporate strategies to improve SE with patients following stroke.
TITLE: Biomechanical Gait Characteristics of Unsuccessful Foot Clearance During Swing in Individuals With Chronic Stroke

AUTHORS/INSTITUTIONS: J. Burpee, M. Lewek, UNC-Chapel Hill, Chapel Hill, North Carolina, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: Individuals with hemiparesis due to chronic stroke commonly display motor impairments that result in altered biomechanical characteristics of gait. These abnormalities may increase the risk of falls and injury during ambulation. Lower extremity gait impairments have been previously described compared to the non-paretic limb or healthy control subjects. Unfortunately, the biomechanical parameters underlying instances of unsuccessful foot clearance (i.e., trips) during the swing phase of gait have yet to be examined. The purpose of this study was to examine the paretic lower extremity temporal, kinematic, and kinetic characteristics during gait cycle’s involving trips in individuals with chronic stroke.

Number of Subjects: 26 subjects with chronic stroke (age: 56±12 years; time post-stroke: 60±76 months; paretic side: 15R / 11L; overground gait speed: 0.68±0.27m/s) who were able to ambulate without physical assistance, typically walked without an AFO, and unintentionally had the paretic foot make contact with the ground during paretic swing phase of a training session.

Materials/Methods: Gait data were obtained during a 20 minute gait training session on a dual-belt ‘instrumented’ treadmill. Force plate data were examined to identify naturally occurring trips during the swing phase of the paretic limb. Instances of successful foot swing immediately prior to each trip were also identified (non-trips). Temporal (double support time), kinematic (hip, knee, and ankle angles), and kinetic (propulsive impulse and hip, knee, and ankle moments) measures of the paretic limb occurring during late stance, toe-off, and swing were collected for each trip and non-trip step. Data were compared between trip and non-trip steps using paired samples t-tests. An α=0.004 was used to adjust for multiple comparisons. Pearson correlations determined relationships between variables.

Results: In the paretic limb, the ankle angle at toe off (p=0.003), knee flexion velocity at toe off (p<0.001), and peak knee extension moment during terminal stance (p<0.001) were significantly different between trips and non-trip steps. During trips, ankle plantarflexion at toe-off was 1.1° greater, knee flexion velocity was reduced by 17.6°/sec, and peak knee extension moment was increased by 0.01Nm/kg*m. Knee flexion velocity at toe-off correlated significantly (p<0.05) with the other significant parameters.

Conclusions: Biomechanical differences in the parameters between instances of successful and unsuccessful foot clearance are relatively small, but create a longer limb during swing.

Clinical Relevance: Although small, the multi-joint biomechanical changes occurring in the paretic limb during unsuccessful foot clearance result in a functionally longer limb. It appears to take only minor changes in the movement of the paretic limb to result in a trip. Thus, interventions targeting multiple joints in the paretic limb may be needed to reduce the risk of trips following stroke.
Purpose/Hypothesis: Stroke is the leading cause of disability in the US. Foot drop, a major sequela associated with stroke, contributes to locomotor impairments. Robot-assisted repetitive task practice is one approach that has been shown to improve lower extremity function and locomotion in stroke survivors. Robotic training, however, is typically confined to large clinics or research laboratories. The purpose of the current study was to investigate the effectiveness of home-based robot-assisted ankle rehabilitation at improving strength, locomotion, and quality of life in chronic stroke survivors.

Number of Subjects: Seven stroke survivors (6 male) with an average time since injury of 66.9 months.

Materials/Methods: In this single group repeated measures design individuals completed three 60-minute home-based robot-assisted training sessions (Foot MentorTM, Kinetic Muscles Inc.) per week for 12 weeks (36 total). Isometric dorsiflexion strength and locomotor function (Velocity and 6MWT Distance) were assessed at baseline, after the 12 week intervention, and at the end of a 4 week follow-up period. Use and performance data from the robotic device were monitored remotely and feedback was given weekly via telephone.

Results: All 7 participants adhered to the intervention protocol with no reports of adverse events. Quantification of dorsiflexion force revealed mean increases of 28.5% post intervention and 18.9% at the four week follow up. Six of the seven participants demonstrated increases in force post intervention, with 5/7 maintaining increases at the 4 week follow up. Effect size calculations revealed these increases to be substantial (ES=0.87 at post-treatment and 0.78 at four-week follow-up). Quantification of walking speed revealed mean increases of 17.8% post intervention and 15.5% at the 4 week follow up. All seven participants demonstrated increases in walking speed both post intervention and at the 4 week follow up. Six of the seven participants demonstrated increases greater than .1 m/s. Effect size calculations revealed these increases to be substantial (ES=2.35 at post-treatment and 1.90 at four-week follow-up).

Quantification of walking distance during the 6 minute walk test revealed increases of 9.6% post intervention and 7.2% at the 4 week follow up (Table 2). All seven participants demonstrated increases post intervention with 4 maintaining these increases at the 4 week follow up. Effect size calculations revealed these increases to be substantial (effect size (ES)=1.6 at post treatment and ES=0.90 at four-week follow-up).

Conclusions: Home-based robot-assisted ankle rehabilitation improves strength and locomotor function in chronic stroke survivors.

Clinical Relevance: In the changing landscape of health care it is important to investigate alternative methods for delivering physical therapy. Home-based robotic interventions are one such methodology falling under the heading of telerehabilitation. The results presented here provide preliminary evidence supporting the use of home-based robotics for the treatment of distal lower extremity dysfunction in chronic stroke survivors.
TITLE: VALIDITY OF AN INTERACTIVE FUNCTIONAL REACH TEST (I-FRT) PERFORMED USING THE MICROSOFT KINECT® SENSOR

AUTHORS/INSTITUTIONS: A. Diamond, V. Brodith, D. Wyatt, A. Pavlov, V. Pardo, S. Galen, Physical Therapy Program, Wayne State University, Detroit, Michigan, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: Video games such as the Microsoft Kinect® are increasingly used by Physical Therapists as an adjunct to therapy aimed at improving balance performance and mobility. (1-2) The limitation of "off the shelf" video games is that they do not provide performance measures that are clinically relevant. We have now developed software called the Interactive Functional Reach Test (I-FRT) that enables the Microsoft Kinect® Sensor to assess a patient’s balance. The aim of this study was to test the concurrent validity of the I-FRT by using a 3D motion capture system as a criterion reference. The secondary aim was to establish the feasibility of performing the I-FRT in adults with mild balance impairments.

Number of Subjects: 20 healthy adults and 10 adults with mild balance impairments

Materials/Methods: The 3D position of the subject’s wrist and upper extremity were simultaneously tracked using the IFRT software and an Optotrak Certus 3D motion-capture system, while the subjects performed a FRT. Subjects completed a total of 9 FRT trials with the Microsoft Kinect® Sensor placed at a distance of 2.0m (3 trials), 2.5m (3 trials) and 3.0m (3 trials) from the subject. The absolute measurement error was calculated for each FRT trial and an interclass correlation (ICC) was performed to establish the agreement between the two systems. In addition adults with mild balance impairments provided qualitative feedback on performing an I-FRT using the NASA-task load index tool.

Results: The absolute errors in FRT measurement as measured by the IFRT software for the three Microsoft Kinect® Sensor positions 2.0 m, 2.5 m and 3.0 m were 6.01 ± 4.47 cm, 4.92 ± 4.13 cm and 4.82 ± 4.31 cm respectively. Statistical analysis using ICC showed moderate to good agreement between the two measurement systems. The greatest agreement between the two measurement systems was found with the Microsoft Kinect® Sensor placed at a distance of 2.5m (ICC2,k=.786, p<.001) from the subject. The qualitative feedback provided by adults with mild balance impairments indicated that performing the I-FRT placed a low to moderate level mental and physical demand on the subject.

Conclusions: This preliminary study showed that the IFRT software provided the best estimate of FRT measures with the Microsoft Kinect® Sensor placed at a distance of 2.5m. The measurement errors were consistent with previous studies(3) that have validated the Kinect for assessing human movement. This study has demonstrated the potential of the I-FRT software to provide a clinically relevant measure that can be embedded into the gaming platform with an ability to assess clients/patients’ balance performance.

Clinical Relevance: The Microsoft Kinect® Sensor in combination with the I-FRT software provides a low cost and user friendly clinical measure that helps to assess the patient’s balance performance. The recent introduction of the Xbox One sensor which has a higher resolution than the current Microsoft Kinect® Sensor has the potential to reduce the measurement errors further.
TITLE: Daily arm use measured by a triaxial accelerometer in individuals with impairment from chronic stroke: a pilot investigation

AUTHORS/INSTITUTIONS: M. Finley, Krannert School of Physical Therapy, University of Indianapolis, Indianapolis, Indiana, UNITED STATES|A. Karduna, Department of Human Physiology, University of Oregon, Eugene, Oregon, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: The incidence of stroke is widespread in the United States, affecting 7 million people. Despite therapeutic efforts, upper extremity weakness and motor control deficits exist in both limbs. However, there is a dearth of objective measures that quantify upper extremity movement quantity and quality in this population. Therefore, the purpose of this study was to utilize a triaxial accelerometer to examine characteristics of typical bilateral, daily upper extremity use in persons with impairment from chronic stroke.

Number of Subjects: Thirteen individuals with upper extremity impairment from chronic stroke participated in this study (mean age = 62±8yrs, onset since stroke = 8.4±4.6years)

Materials/Methods: Fugl-Meyer Upper Extremity Assessment (FMA, max score = 66) was obtained prior to attaching an MSR® 145 mini data logger to each upper extremity, at the level of the deltoid tuberosity. The sensor was activated for duration of 3.5-5.5 hours with data processed per previous studies. Outcomes of static parameters (percent time above threshold elevation angles 30°, 60° 90°) were determined. Dynamic parameters were percentiles of arm velocity, jerk time and subcomponents (static, slow, fast) movement patterns. Paired t-tests (p=0.05) were used to compare between paretic and less affected limb of all participants. Pearson correlations assessed relationships (moderate r =0.3 to 0.5, high r >0.5) among movement variables and impairment level based on FMA category (severe <30 n=6; mild-moderate >30, n=7) by limb.

Results: Mean FMA was 33±18.4 (range 11-58). The paretic limb was found to have 31% lower percent time above 30° (p<0.01), 19.5% lower jerk time (p=0.02) with 13% reduced slow movement subcomponent (p=0.01) and 26.5% less fast movement subcomponent (p=0.02). The paretic limb also demonstrated 13.1% greater static time (p=0.01) compared to the less affected limb. Velocity at 99th (p<0.01), 90th (p<0.01) and 10th (p<0.01) percentiles were lower for the paretic limb. Moderate to high correlations were found in the less affected limb for both impairment groups (severe and mild-moderate) for elevation angles, velocity percentiles, jerk, static and slow subcomponent to FMA score. The mild-moderate group paretic limb had high correlations in movement angles (30°, 60°, 90°) and velocity percentiles (1st, 10th) with the severe group paretic limb showing moderate relationship to arm elevation at 60° and 90° and velocity (10th).

Conclusions: Quantifiable interlimb differences in daily arm use and movement quality have been found in individuals with chronic impairment from stroke. FMA was found to have a moderate-high relationship with movement quantity for less affected and paretic limbs in both severe and mild-moderate impairment.

Clinical Relevance: The MSR® 145 is a valid tool for assessing in-vivo, real-time upper extremity activity, with capability for providing triaxial output providing needed objective measures on real-world activity in persons with impairment from chronic stroke.
TITLE: Stepping strategies for lateral balance recovery during unexpected lateral perturbations and lateral voluntary stepping in persons post-stroke

AUTHORS/INSTITUTIONS: V. Gray, S. McCombe Waller, M. Rogers, University of Maryland Baltimore, Baltimore, Maryland, UNITED STATES|M. Fujimoto, Ritsumeikan University, Kusatsu, JAPAN

ABSTRACT BODY:

Purpose/Hypothesis : Falls after stroke commonly occur as weight is transferred laterally, and are equally probable after unexpected balance disturbances as for voluntary movements. Voluntary stepping is initiated with either the paretic or non-paretic leg, however the limb use during unexpected lateral perturbations is unclear. The purpose of this study was to Investigate the paretic and nonparetic stepping strategies used in response to an unexpected lateral perturbation compared to voluntary lateral steps in persons with chronic stroke.

Number of Subjects : Six community dwelling individuals (4 right; 2 left paretic), >6 months post-stroke participated in the study (mean age = 62±7 years). The mean Community Balance & Mobility score was 33±13 /96 and Chedoke McMaster Stroke Assessment for the motor recovery of the leg+foot was 7±1 /14.

Materials/Methods : Participants performed 6 trials of randomly-ordered unexpected lateral waist-pull perturbations (2 directions x 3 repetitions), and 10 voluntary lateral steps in response to a light cue. Step type and characteristics were determined from an ankle marker using 3D motion analysis. Stepping responses with the limb passively unloaded by the lateral waist-pull (contralateral side of the pull direction) were analyzed. Student’s t-tests were used to compare the voluntary and induced paretic and nonparetic step. Significance was set at p<0.05.

Results : For all waist-pulls, first steps were initiated with the paretic leg in 17% of the trials and with the nonparetic leg in 83% of trials. The main initial step types occurred with the passively unloaded leg for crossover (front, back) or medial steps. Pulls to the nonparetic side resulted in a single step by the paretic leg only 20% of the time, otherwise multiple steps occurred. Compared with voluntary crossover steps of the paretic leg, induced crossover steps showed a reduced step length (by 63%;p<0.05) and step height (by 66%;p<0.05). For paretic-side waist-pulls, a single nonparetic leg recovery step occurred in 33% of the trials. The nonparetic leg step length was reduced (by 36.7%;p<0.05) compared to voluntary steps. The onset time of the first step was similar for the paretic (487ms) and nonparetic leg (521ms) during the waist-pull trials. Compared to induced steps, voluntary steps were initiated later for both the paretic (1142ms;p<0.05) and nonparetic steps (1007ms;p<0.05).

Conclusions : There is a reliance on the nonparetic leg to recover lateral balance when pulled unexpectedly to the paretic side. Induced steps initiated with the paretic leg have a shorter step length and height than voluntary steps, and nonparetic leg steps have a shorter step length. Thus, regardless of the side of the stepping leg, multiple steps were used to recover lateral balance, demonstrating the nonparetic leg first step may be as inefficient in recovering lateral balance as the paretic limb.

Clinical Relevance : The present results can be used to guide therapeutic targets for improving lateral balance stability through protective stepping following stroke.
TITLE: Withdrawal of Anti-Parkinson’s Medication Suppresses Central Activation of the Quadriceps in People with Parkinson’s Disease-Related Fatigue

AUTHORS/INSTITUTIONS: A.J. Threlkeld, D. Katsavelis, N.B. Huben, T.L. Grindstaff, D. Givens, Physical Therapy, Creighton University, Omaha, Nebraska, UNITED STATES| J.M. Bertoni, Neurology, University of Nebraska Medical Center, Omaha, Nebraska, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: The purpose of this study was to assess quadriceps muscle performance of people with PD-fatigue whilst ON and OFF anti-Parkinson’s medication (APMed) compared to healthy younger and older control subjects. Excessive fatigue is a major cause of disability and activity limitation in people with Parkinson’s disease (PD). Additionally, withdrawal of APMed has been reported to reduce muscle contractile force in people with PD. The underlying mechanisms of PD-fatigue, the response to APMed and the superimposed effects of aging are poorly understood.

Number of Subjects: Sixteen PD-fatigue (13M, 3F; age=65.8±6yrs; BMI=28.7±4; Parkinson’s Fatigue Scale=10.9±2), 20 younger unimpaired (14M, 6F; age=24.0±2yrs; BMI=23.9±3) and 15 older unimpaired (13M, 2F; age=65.3±7yrs; BMI=27.7±3) volunteers were assessed.

Materials/Methods: Subjects with PD-fatigue were tested twice (minimum of 4 days apart), ON and OFF APMed. Superimposed electrical stimulation was applied to the quadriceps to determine percent voluntary activation via twitch interpolation before (PRE), after (POST) fatigue and 2min after POST (REC). Fatigue was induced by repetitive isometric knee extension contractions. Fatigue was defined as a 35% reduction in peak maximum voluntary isometric torque. A mixed model analysis of variance (ANOVA), with groups as the between subjects variable and time (PRE, POST, REC) as the within subjects variable was performed in SPSS. Post hoc analysis was performed using Tukey HSD and pair-wise t-test for the ON and OFF APMed groups at an alpha level of 0.05.

Results: In comparison to the ON state, APMed withdrawal produced a significant decrease (7-11%) in percent voluntary activation of the quadriceps throughout the testing periods. The OFF state produced significantly lower values of central activation in comparison to any other group at all three timepoints (p<0.05). There was no significant difference in central activation between ON state versus the control groups (younger and older). In addition, there was a main effect of time period with PRE voluntary activation values being significantly higher than both POST and REC.

Conclusions: Although torques were reduced, subjects with APMed withdrawal followed the same voluntary activation pattern as their control counterparts at the PRE, POST and REC timepoints. The reduction in central activation in the OFF state across the three tested periods implies a strong dopamine-dependent central component in people with PD-fatigue. In conclusion, APMed impacts overall quadriceps voluntary activation, improving muscle performance in people with PD-fatigue.

Clinical Relevance: Based on our current analysis, clinicians should choose interventions that address the central contribution to fatigue in people with PD.
TITLE: Acute and post-acute assessment of postural control and cognitive efficiency following concussion.

AUTHORS/INSTITUTIONS: L.A. King, F.B. Horak, Neurology, Oregon Health Sciences University, Portland, Oregon, UNITED STATES|J. Chesnutt, Sports Medicine, Oregon Health & Science University, Portland, Oregon, UNITED STATES|J. Chapman, Neurology, Washington, DC Veterans Affairs Medical Center, Washington DC, District of Columbia, UNITED STATES|J. Wilhelm, Rehabilitation, Oregon Health Sciences University, Portland, Oregon, UNITED STATES|

ABSTRACT BODY:

Purpose/Hypothesis: To determine: 1.) if impaired postural control was detectable in the acute and post-acute period after concussion, 2.) the timeframe of recovery of postural control and 3.) if recovery timeframe for postural control was similar to that of cognition. We hypothesized that impaired postural control would persist in a subset of people and would be unrelated to cognitive functioning after concussion.

Number of Subjects: Eleven athletes (age 20±1; 9 men, 2 women) who had sustained sports-related concussion and 17 age-matched students athletes with no history of concussion participated in the study.

Materials/Methods: After concussion, participants were serially tested on postural control at approximately days 2, 5, 9, and 14. Cognition was assessed at baseline (pre-season) and approximately days 2, 5, and 9. To assess balance, two dimensional sway area during the Instrumented Balance Error Scoring Scale (IBESS) test from one inertial sensor on the belt was used. Sway area was averaged over three 20-second trials (feet together, single limb stance and tandem on firm surface; eyes closed). Cognition was estimated using the ImPACT screening tool (preliminary data are based on the Cognitive Efficiency Index).

Results: The IBESS revealed differences (p= 0.047) in postural control between acutely concussed (2 days post-injury) and controls. At 2 days post-injury, our case group was divided between those with normal (54%) and abnormal (45%) balance. Preliminary results indicated that 40% remained abnormal 9 days after injury, 20% at 16 days and 1 person at day 23. Of note, at day 5, 80% of the athletes with abnormal balance had returned to baseline cognitive efficiency and were returned to play. Cognitive recovery post-injury was not consistently associated with balance scores. The Cognitive Efficiency Index from ImPACT did not correlate with balance measures at any of the post-injury measurement times (Day 2: r=0.09; p=0.79; Day 5: r=0.45, p=0.19 and Day 9 r= 0.10, p=0.78).

Conclusions: Athletes with abnormal postural control and prolonged return to normal balance had minimal overlap with the individuals who had prolonged return to cognitive baseline measure. Different neural pathways may recover at different rates after concussion warranting objective evaluation of both domains.

Clinical Relevance: Sensitive assessment of postural control after concussion is warranted because abnormalities may persist in a subset of people. Postural control measures did not correlate with cognitive scores so both domains should be assessed prior to return to play.
TITLE: Baseline Balance Predicts Gait Speed Improvement following Gait Training in Chronic Stroke

AUTHORS/INSTITUTIONS: M. Lewek, UNC-Chapel Hill, Chapel Hill, North Carolina, UNITED STATES|C. Husted, UNC Health Care, Chapel Hill, North Carolina, UNITED STATES|

ABSTRACT BODY:
Purpose/Hypothesis: Recent evidence suggests that greater balance may be associated with gait speed improvements following training, regardless of specific intervention among patients following acute stroke. Given the presence of postural instability, patients may be less willing to alter aspects of their gait that would result in increased gait speed. Thus, the purpose of this study is to determine if baseline balance also predicts an individual’s ability to increase gait speed following gait training in chronic stroke. It was hypothesized that those that do not demonstrate an improvement in gait speed following training would demonstrate poorer balance at baseline.

Number of Subjects: 27 subjects with chronic stroke (17M/10F, 60±11 years old, 44±34 months post stroke) in an ongoing trial

Materials/Methods: Subjects were randomized into one of three treadmill training groups: control (n=8), error minimization (n=10), or error augmentation (n=9) as part of a larger single blinded randomized control trial addressing either stance time or step length asymmetry. Subjects completed 18 training sessions that consisted of ambulation on a dual-belt treadmill followed by overground gait training. A harness was used for safety, and a handrail and appropriate assistive devices were used as needed. Prior to and one week following completion of training, gait and balance outcome measures [overground comfortable gait speed, Berg Balance Scale (BBS), Four Square Step Test (4SST), and Functional Gait Assessment (FGA)] were performed. A Wilcoxon rank sum test (for the BBS and FGA) and independent samples t-test (for 4SST) were used to determine differences in balance between the responders that demonstrated improvement in gait speed from pre to post training (≥0.15 m/s; n=10) and the non-responders that demonstrated no improvement (<0.15 m/s; n=17).

Results: The non-responders displayed more impaired balance at baseline compared to those who responded to training and increased their gait speed ≥0.15 m/s. For the BBS, the responders demonstrated higher scores (p=0.05) with an average of 46.4±7.5 points versus the non-responders average score of 39.6±9.1. The responders had lower 4SST times (p=0.06) than those that did not improve their gait speed. The average time for responders was 33±24 seconds versus 62±43 seconds for the non-responders. There was no significant difference in balance for the FGA (p=0.22) with the responders having a score of 12±3 and the non-responders scoring 10±3 points.

Conclusions: Both the responders and non-responders displayed impaired balance. However, those that increased their gait speed following training had greater baseline balance than the non-responders.

Clinical Relevance: Following chronic stroke, baseline balance may predict an individual’s ability to increase gait speed since those with more impaired balance are less likely to practice independently and/or attempt new movement patterns that might increase gait speed. For this group of individuals, interventions that specifically target balance may be beneficial in conjunction with gait training to improve speed.
Purpose/Hypothesis: Imbalance following concussion often results from abnormal sensory integration between visual, somatosensory and vestibular inputs. Subtle postural control and mobility deficits may impact performance, safety, and readiness to return to duty (RTD) or play following concussion/mild traumatic brain injury (mTBI) and go undetected by standard clinical balance and gait tests. The purpose of this report is to describe findings from an instrumented 30 second stand and 7 meter walk with a 180 degree turn for the ability to distinguish healthy control (HC), “duty ready” Soldiers from Soldiers undergoing rehabilitation for persistent deficits following mTBI.

Number of Subjects: A convenience sample of 34 healthy (23 male, age 26.9 ± 5.1 years) Soldiers and 30 active duty (all male; age 28.7 ± 6.7 years) Soldiers receiving treatment for persistent post-concussive symptoms at a military TBI care center.

Materials/Methods: The Instrumented Stand and Walk (ISAW) test (Mobility Lab, APDM INC, Portland OR) uses small, wireless Opal™ movement monitors which contain 3D angular rate sensor, 3D accelerometer and gyroscope. Monitors were affixed to the lumbar area and lateral ankles to quantify sway, gait, and rotational kinematics. A commercial algorithm was used to analyze all movements to include the initiation and completion of turns. Three trials of the ISAW were completed. Median values from three-replication sets were compared between groups for the sway and gait parameters using a two-sided t-test; p-values <0.05 are reported.

Results: Measures of sway during quiet stance and gait at a self-selected, “comfortable” walking pace were not significantly different between groups. Instrumented measures of turning revealed significant between group differences. Soldiers with post-concussive deficits demonstrated longer turn durations (HC: 1.58 ± 0.29 seconds; mTBI: 1.90 ± 0.37 seconds, p<.001); increased step numbers to complete a turn (HC: 3.51 ± 0.56; mTBI: 4.07 ± 0.87 steps, p<.004), and decreased peak rotational velocities during turns (HC: 225.73 ± 45.49°/s; mTBI: 192.10 ± 35.33°/s, p<.003).

Conclusions: These findings support the utility of the ISAW to detect subtle sensorimotor deficits in Soldiers with persistent post-concussive deficits during a 180 degree turn which involved rapid peak rotational movements. Analysis of sway and gait kinematics did not reveal significant between groups differences.

Clinical Relevance: Based on this preliminary analysis, instrumented assessment with inertial sensors shows promise as a means to detect subtle post-concussive differences where standard clinical measures of mobility and balance may be insufficient in highly trained military personnel. This type of instrumented assessment in combination with other functional metrics may more fully characterize readiness to RTD or play.
Purpose/Hypothesis: In both children and adults with hemiplegia, high effort motor tasks in the lower extremities can result in involuntary upper extremity movements, referred to as associated reactions. Associated reactions are thought to be the result of an increased reliance on brainstem pathways, specifically reticulospinal or vestibulospinal tracts. The purpose of this study was to quantify upper extremity muscle activity in response to the generation of varying levels of knee torques to gain insight into how brainstem pathways are recruited in pediatric and adult hemiplegia. We hypothesize that associated reactions will be linked to lower extremity effort level, as more demanding tasks exhaust the remaining corticospinal resources and require the additional recruitment of brainstem pathways.

Number of Subjects: 2 individuals with pediatric hemiplegia; 2 individuals with adult hemiplegia; 1 control participant

Materials/Methods: Participants performed knee flexion and extension maximum voluntary isometric torques while seated using the Biodex system to measure knee torque. Participants then performed submaximal knee flexion and extension torques at 25, 40, 55, 70, and 85% of maximum voluntary torque. Visual feedback of torque was given, and participants were instructed to relax their arms during the task. Surface EMG activity was recorded bilaterally from shoulder, elbow, and forearm muscles in the upper extremity as well as knee flexors and extensors, and normalized to maximum voluntary activity.

Results: The control participant demonstrated muscle activation in the upper extremities only when performing maximum contractions, and not at submaximal levels. In all individuals with hemiplegia, EMG activity was present at submaximal levels and correlated with lower extremity torque. Upper extremity activity was elicited with both knee flexion and extension. Minimal activation was found in the nonparetic upper extremity. Associated reactions were also elicited while generating knee torques with the nonparetic leg, though to a lesser extent.

Conclusions: Associated reactions are present in both pediatric and adult hemiplegia and are modulated by lower extremity effort level. This supports the hypothesis that associated reactions arise when the task exceeds the capabilities of the damaged corticospinal system and brainstem pathways are recruited.

Clinical Relevance: Associated reactions can greatly impair interlimb coordination, affecting balance during gait and the ability to do functional tasks such as carry a tray while walking. Understanding the mechanisms responsible for associated reactions will allow for more targeted interventions. Additionally, improving our basic science knowledge of how brainstem pathways are utilized in both pediatric and adult hemiplegia will increase our understanding of motor control impairments in these populations.
TITLE: Characteristics of subjects who exhibit avoidance behavior due to a fear of falling in Parkinson's disease

AUTHORS/INSTITUTIONS: M.R. Landers, M. Lopker, M. Newman, P. Johnson, University of Nevada, Las Vegas, Las Vegas, Nevada, UNITED STATES|R. Gourlie, Select Physical Therapy, Las Vegas, Nevada, UNITED STATES|S. Sorensen, Alta Health Services, Clearfield, Utah, UNITED STATES|R. Vong, Desert Valley Therapy, Las Vegas, Nevada, UNITED STATES

ABSTRACT BODY:

Purpose/Hypothesis: The purpose of this study was to compare individuals with Parkinson’s disease (PD) exhibiting fear of falling avoidance behavior to those with no fear of falling avoidance behavior. Because avoidance behavior can have deleterious downstream consequences, it is important to determine what potentially mitigable physical and psychological factors are associated with it.

Number of Subjects: Fifty-nine community dwelling individuals (age=72.0 years, SD=9.4; males=45, females=14) with PD (Hoehn and Yahr Scale stage median=2.5, mode=3.0) were classified into two groups using the Fear of Falls Avoidance Behavior Questionnaire (FFABQ): avoiders (n=27, ≥20 FFABQ), and non-avoiders (n=32, <20 on the FFABQ).

Materials/Methods: Avoiders and non-avoiders were compared using five domains: demographics (age, gender, socioeconomic status (SES), education), PD-specific symptoms (Parkinson’s Unified Parkinson’s Disease Rating Scale (MDS-UPDRS), Hoehn and Yahr Scale, Parkinson’s Disease Questionnaire (PDQ-39)), balance and falls (fall history, Berg Balance Scale (BBS), Activities Specific Balance Scale (ABC)), strength and conditioning (2-minute step test (2MST), 30 second Sit to Stand Test (30STS), Timed UP and Go Test (TUGT), ActivPAL physical activity monitor data), and psychological factors (Zung Anxiety Scale (ZAS), Beck Depression Inventory (BDI), Falls Efficacy Scale (FES), Catastrophizing About Falls Scale (CAFS), Impact of Events Scale (IES), and Consequences of Falling Questionnaire (CoFQ)).

Results: There were no differences between avoiders and non-avoiders in age, gender, SES, education, year of diagnosis, and fall history, including injurious falls (ps≥0.182). Avoiders had worse scores on the MDS-UPDRS (sections I-III, ps≤0.009) and the PDQ (mobility, ADLs, emotion, stigma, cognition, and bodily discomfort subscales, ps≤0.015). Avoiders also exhibited poorer balance performance (BBS, p=0.002), less balance confidence (ABC, p<0.001; FES, p=0.022), decreased strength (30STS, p=0.048), and spent less time stepping during the day (p=0.018). Avoiders reported higher depression (BDI, p=0.010), anxiety (ZAS, p=0.025), and catastrophization (CAFS, p=0.001; CoFQ, p<0.001).

Conclusions: Fear of falling avoidance behavior is common in PD and does not appear to be related to current fall history. Additionally, individuals with PD who report avoidance behavior have more involved PD symptoms, poorer balance, less strength and conditioning, and have greater psychological distress, including depression, anxiety, and catastrophization. While these findings suggest that avoidance behavior has both physical and psychological dimensions, the cause-effect relationship cannot be determined.

Clinical Relevance: Fear of falling avoidance behavior is associated with several physical factors that can be addressed by physical therapists; however, there are also several psychological factors that may benefit from psychology-based therapies.
TITLE: Ipsilesional VOR Gain Adaptation - Advancing Gaze Stability Training

AUTHORS/INSTITUTIONS: M.C. Schubert, Otolaryngology Head and Neck Surgery, Johns Hopkins University, Baltimore, Maryland, UNITED STATES|A. Migliaccio, Neuroscience Research Australia, Sydney, New South Wales, AUSTRALIA|

ABSTRACT BODY:

Purpose/Hypothesis: We hypothesized: I. The gain of the human vestibulo-ocular reflex (VOR) could be increased for head rotations to one side only in healthy subjects in an incompletely darkened room; II. We could increase the VOR gain on one side without affecting the contralateral response; III. We could adapt the ipsilesional VOR gain in patients with vestibular hypofunction.

Number of Subjects: 9 healthy subjects and 7 patients with vestibular hypofunction.

Materials/Methods: We used the scleral search coil method to record eye and head velocity. We built a portable device that senses horizontal angular head velocity and generates a visual target, with a gain that can be adjusted asymmetrically and incrementally (i.e. VOR gain = 1.3, 1.4, 1.5 during rightward and always 1.0 during leftward head impulse rotations). The incremental laser target displays an image that is always lit and moves at a percentage of the head velocity. All subjects performed ~300 active head impulses, divided into 10 epochs of 30 head impulses (15 to each side, alternating) with 30 to 60 sec rest periods between epochs. For each epoch of 30 impulses, the 15 impulses towards the adapting side include a target that incrementally increases; for the 15 impulses away from the adapting side, subjects viewed either no target or a stationary target (Aims I and II).

Results: Aim I: In healthy controls, the VOR gain increased towards the adapting side from 0.92±0.18 to 1.11±0.22 (+22.7±20.2 %) during active head impulses and from 0.91±0.15 to 1.01±0.17 (+11.3±7.5 %) during passive head impulses. However, the VOR gain towards the non-adapting side also increased by 8%. Aim II: In healthy controls, rotations towards the adapting side increased by 26.1 ± 23.4% during active head impulses and by 14.6 ± 13.0% during passive head impulses. In contrast, there were no significant increases for rotations towards the non-adapting side. Aim III: Although we show a large change in VOR gain adaptation in patients towards the ipsilesional side (pre-adaptation VOR gain 0.59 ± 0.22; post-adaptation VOR gain 0.75 ± 0.30; an increase of 29.2 ± 21.0%), this 0.17 ± 0.14 increase was not significant (p = 0.17).

Conclusions: This study shows that unilateral vestibular adaptation is possible in humans with and without a healthy VOR (Aims I-III). To prevent VOR adaptation on the opposite side, a stationary visual target must be present for contralateral rotations (Aim II). The magnitude of unilateral adaptation in patient subjects is less consistent.

Clinical Relevance: The VOR gain enhancement measured in our study occurred in an incompletely darkened room, suggesting incremental adaptation can improve the VOR gain in the light—a critical component for rehabilitation. Our study is an important step towards developing a practical technique that can be implemented via a portable head-mounted device for patients with vestibular hypofunction.
**TITLE:** Fall Reduction and Functional Improvement with Balance-Based Torso-Weighting in People with Multiple Sclerosis

**AUTHORS/INSTITUTIONS:** G.L. Widener, K. Horn, C. Gibson-Horn, Physical Therapy, Samuel Merritt University, Oakland, California, UNITED STATES|D.D. Allen, Graduate Program in Physical Therapy, University of California-San Francisco/San Francisco State University, San Francisco, California, UNITED STATES

**ABSTRACT BODY:**

**Purpose/Hypothesis:** People with multiple sclerosis (MS) fall frequently. Balance-based torso-weighting (BBTW) can improve gait speed and increase time spent in single-limb support while walking. However, the association between BBTW and falls has not yet been examined in MS. Our purpose was to investigate the effects of BBTW on function, balance and fall frequency during sensory organization tests (SOT) in people with MS (PwMS) and healthy controls (HC). We hypothesized that BBTW would improve function and reduce falls people with MS compared to healthy controls (HC).

**Number of Subjects:** 60 PwMS with self-identified gait and balance difficulties (Disease Steps 1-4) and 10 healthy controls that were bin-matched for age and sex.

**Materials/Methods:** All participants completed the SOT on the SMART EquiTest® BalanceMaster, the Timed Up and Go test (TUG), 25 Foot Timed Walk (25FTW) and the Dynamic Gait Index (DGI). Both the TUG and 25FTW were completed twice, scores averaged. All clinical tests were completed one time, once without weights (NW) and a second time following the strategic placement of light-weights (WT) using the BBTW method. The testing protocol generally lasted 3-5 hours during a single session for PwMS (2-3 hours for HC), and participants completed additional impairment testing of the lower extremities following the clinical testing. A mandatory rest break followed BBTW assessment and weighting with additional breaks provided as needed. For the SOT, participants underwent 3 trials each for 6 conditions, resulting in a composite score (CS) and the number of trials that ended in a fall. A fall during the SOT was defined as touching the surround, taking a step, or being caught by an overhead harness. Dependent t-tests compared PwMS and HC in NW and WT conditions, and independent t-test compared MS to HC with alpha set at 0.05.

**Results:** A statistically significant change occurred in mean (SD) CS from NW to WT conditions, 50.5 (14.6) to 59.7 (14.5), respectively in PwMS (P<0.001). No change in CS occurred NW to WT in HC, 73.9 (6.0) and 75.2 (9.5), respectively (P=0.626). The minimal detectable change for CS is 8 percentage points. 34 PwMS (55%) and 3 HC (30%) increased their CS by at least 8 percentage points. Fall occurrence was significantly reduced during WT condition in PwMS (P<0.001), but not in HC (P=0.484). Both TUG and DGI scores were significantly improved in PwMS, respectively (P<0.001 and P=0.035) but not in HC (P=.273 and P=.213, respectively). Gait speed was not significantly different in either group but was different between HC and PwMS for NW and WT (P=.016 and P=.039, respectively).

**Conclusions:** A significant decline in fall number and increase in CS occurred with WT condition for PwMS during the single testing session. These changes were not seen in HC. The functional tests of gait (DGI and TUG) also improved with BBTW in PwMS.

**Clinical Relevance:** While further research is needed, BBTW shows promise as an intervention that may lead to fall reduction and improved function when worn by PwMS.