ABSTRACTS

Academy of Neurologic Physical Therapy
Platform Presentations
Do Exoskeleton Training and FES Ameliorate Muscle Atrophy Following Acute SCI?

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ABSTRACT BODY:

Purpose/Hypothesis: After spinal cord injury (SCI), muscular atrophy occurs rapidly, with a concomitant expression of muscular fat infiltration (MFI), particularly in the lower extremities. Cross-sectional areas of lower extremity muscles may decrease up to 30-45% in the first six weeks after injury. Gait training interventions such as body weight supported treadmill training, functional electrical stimulation (FES), and robotic exoskeletons have shown to influence muscle architecture in persons with chronic (status post > 1 year) SCI, but the isolated or combined effects in the acute stage are unknown. Accordingly, the aim of this preliminary investigation was to evaluate the combined effects of exoskeleton and FES training on muscle architecture during over-ground gait training in persons with acute SCI. Measuring these muscle architectural changes using magnetic resonance imaging (MRI), it was hypothesized that FES and exoskeleton gait training in persons with acute SCI would result in a decrease in lower extremity muscle atrophy and MFI.

Number of Subjects: Six participants with SCI (mean age 32 years old, average time to begin the study 26.4 days post injury), five with motor complete injuries and one with a motor incomplete injury, all cervical or thoracic level. Sixteen lower extremity muscles were analyzed per participant (eight each side), for a total of 96 muscles.

Materials and Methods: This study used a prospective cohort cross-over design in an academic hospital setting. Three participants received three weeks of over-ground robotic exoskeleton gait training with FES applied to bilateral quadriceps, hamstrings, tibialis anterior, and gastrocnemius musculature, followed by a three-week control period of standard inpatient therapy. The other three participants completed the control period first, then the intervention. MRI data of the lower extremity muscles were collected on three occasions (prior to beginning, then after the first three week period, and at the end). Imaging data were processed to measure muscle volumes and MFI. For the 16 muscles, percent change scores were calculated for both the control time period and for the intervention time period. Because the same muscle’s percent change was being compared, intervention versus control, a paired t-test was used. An independent samples t-test was used to compare muscle volume percent changes for the muscles stimulated with FES versus muscles not stimulated with FES. MFI statistical analyses were conducted and completed in the same manner as muscle volumes.

Results: Muscle volumes demonstrated a significantly higher percent change during the intervention period compared to the control period (p < .01). MFI demonstrated a trend towards lower percent change during the intervention period compared to the control period (p = 0.06). No statistically significant difference was found for muscles stimulated with FES versus muscles not stimulated with FES, in terms of volume percent change (p = 0.15) or MFI percent change (p = 0.14).

Conclusions: Overground gait training with a robotic exoskeleton may retard the expected reductions of lower extremity muscle volume that occurs following SCI. This preliminary study was likely under-powered to detect significant changes related to the FES intervention. Clinical Relevance: Prevention of reductions in lower extremity muscle volumes may feature as another indication for selecting an overground robotic exoskeleton intervention for patients with acute spinal cord injury.
Background and Purpose: Simultaneous epidural spinal stimulation with intensive exercise has been effective in improving locomotor function in people with chronic spinal cord injury (SCI) (Angeli 2018; Wagner 2018). Recent data from our group have demonstrated that non-invasive skin surface (transcutaneous) spinal cord stimulation (tSCS) with high overlapping frequency integrated with intensive physical therapy (PT) in an individual with chronic incomplete tetraplegia results in immediate and lasting improvements in the targeted arm and hand functions (Inanici 2018). The use of tSCS alone has also proved modestly effective in inducing locomotor pattern after incomplete SCI (Gerasimenko 2015). Therefore, we hypothesize that tSCS combined with intensive locomotor training will amplify the neuroplastic benefits of tSCS. The purpose of this study is to highlight the effects of tSCS on locomotor function in an individual with chronic incomplete SCI when implemented with intensive PT focused on locomotion training.

Case Description: A 64-year-old male with C4, AIS D SCI from four years prior participated in the study. The study protocol included four months of intervention consisting of intensive PT (A), and tSCS with intensive PT (B) periods in an A-B-A-B sequence. During locomotor training, tSCS was applied to the cervical and lumbosacral spinal segments. The stimulator delivered 10-60 mA 30Hz biphasic pulses with 10 kilohertz overlapping frequency during the B period. The PT program consisted of intensive overground and treadmill walking with regular therapeutic exercises.

Outcomes: At baseline, the subject required moderate physical assist for walking with a platform walker. By post-treatment phase, intensive exercise with tSCS enabled stepping with a quad cane requiring standby assist, increased walking speed and distance in 6MWT, and improved Berg Balance Scale score beyond the minimum clinically important difference. Improvement of 6MWT distance was greater during the PT + stimulation phases compared with phases of PT intervention only. Additional effects included improvements in motor score in upper and lower extremities (UEMS and LEMS), increased sensation, and improved bladder function throughout the intervention phases. These gains in lower and upper extremities, and bladder function were maintained 14 weeks at follow-up.

Discussion: High frequency tSCS combined with intensive PT over 16 weeks evinced functional improvements in locomotor function, sensation, and bladder function in a case with incomplete tetraplegia. These gains were maintained at 14 weeks follow-up with no intervention. The application of tSCS with intent to improve UE and LE function has been investigated individually, but recently the effects of tSCS have included gains in both UE and LE function when intervention was only LE-focused (Gad 2019). Improvement in UE function after cervical incomplete SCI may be elicited with tSCS + PT intervention despite lack of specific training to the upper extremities. This study highlights the potential systemic therapeutic benefits of tSCS as a useful modality to enhance functional independence in individuals with incomplete cervical SCI.
Can Early MRI Measures Predict Who Will Walk Outside One Year after Spinal Cord Injury?

**ABSTRACT BODY:**

**Purpose/Hypothesis:** Following spinal cord injury (SCI), American Spinal Injury Association Impairment Scale (AIS) grades and clinical examination are used to categorize patients based on current motor and sensory function. Magnetic resonance imaging (MRI) measures of spinal cord damage can be used in conjunction with physical examination to prognosticate future improvements in neurological status and motor function after SCI. The extent of spinal cord damage, measured as the length of intramedullary edema using T2-weighted MRI, is a strong predictor of future AIS grade conversion and useful for predicting future motor scores.

While AIS grades and motor scores provide a simple clinical perspective of motor output after SCI, functional walking (outside in the community) is a more complex task requiring a multitude of sensory-motor demands. Predicting functional ambulation is important because the rehabilitation team may prescribe different therapies and different equipment in accordance with realistic walking goals. Whether or not MRI measures predict the ability to walk outside in the community one year after SCI is currently unknown.

Accordingly, the purpose of this study was to establish the potential of early measures of intramedullary edema length to predict a self-reported ability to walk outside one year after SCI.

**Number of Subjects:** 138 participants with cervical spinal cord injury, data acquired from the local SCI Model Systems Database.

**Materials and Methods:** This study used a double-blinded retrospective design in both a university research and SCI academic hospital setting. 138 participants with SCI received MRI of the spinal cord during their inpatient hospital stay. Using the midsagittal T2-weighted image, intramedullary edema length was quantified. One year after SCI, per the local SCI Model Systems follow-up, each participant answered yes/no to the question, “Are you able to walk (with or without mobility aid) for one street block outside?” A Pearson (point-bi-serial) correlation was used to establish the relationship between edema length and the primary outcome measure – outdoor walking at one year follow-up. A receiver operating characteristic curve was created from the data to determine predictive value and a cutoff score for edema length.

**Results:** 42 individuals reported they could walk one street block outside, while 96 could not. Edema length had a significant negative linear correlation with outdoor walking ($R = -0.26, P < 0.01$). Maximizing both sensitivity and specificity, the edema length of 13.1 mm was selected as the cutoff score.

**Conclusions:** Edema length, measured using a midsagittal T2-weighted image during the acute hospital stay, had a fair association with self-reported outdoor walking ability one year after spinal cord injury. A measured edema length of less than 13.1 mm was associated with the ability to perform outdoor walking.

**Clinical Relevance:** Following spinal cord injury, intramedullary edema length may be useful, in conjunction with clinical examination, to predict who will be able to walk outside in the community one year after SCI.
Purpose/Hypothesis: Spinal cord injury (SCI) can result in significant loss of sensorimotor function, although preservation of volitional strength below the lesion may be sufficient to allow recovery of independent ambulation. Strategies to improve walking capacity vary substantially, however. Traditional interventions often target impairments underlying locomotor dysfunction, such as balance, strength and aerobic capacity. More recent studies suggest providing task-specific (i.e., walking) training, primarily at higher cardiovascular intensities, may be necessary to maximize walking function. No studies have attempted to assess the relative efficacy of providing task-specific vs non-specific training in incomplete SCI when controlling for other training parameters. The purpose of this study was to assess the role of training specificity on locomotor function in patients with incomplete SCI.

Number of Subjects: Sixteen ambulatory individuals with chronic motor incomplete SCI with self-selected gait speeds (SSS) < 1.0 m/s.

Materials and Methods: Using a cross-over, randomized trial design, participants received up to 20 1-hr sessions of task-specific stepping or non-specific training over 6 weeks. Task-specific training consisted of variable stepping tasks performed overground, on a treadmill and on stairs for up to 40 minutes per session, with goals to achieve higher intensity using cardiovascular or subjective measures (70-80% heart rate [HR] reserve). Non-specific training consisted of strengthening, balance, and aerobic (recumbent stepping) exercises with goals to achieve 70-80% HR reserve. Primary outcomes included fastest possible gait speed (FS) and peak treadmill speed during graded exercise testing. Secondary measures included SSS and 6 minute walk test, and measures of strength, balance, transfers and performance during recumbent stepping tests. Data were analyzed using a 3-way repeated measures ANOVA (a=0.05), with focus on time X intervention and time X order X intervention interactions.

Results: Changes following task-specific vs non-specific training resulted in significant differences in gains for FS (0.14±0.19 vs 0.01±0.08, p<0.05), peak treadmill speed (0.20±0.14 vs 0.0±0.20) and 6MWT (48±32 vs 2.6±28). No differences were observed for other secondary outcomes, with the exception of the recumbent stepping test favoring non-specific training. Preliminary analyses reveal no differences in training frequency, duration, or intensity.

Conclusions: The results suggest task-specific (walking) practice may be critical to improving walking function, and non-specific practice improved only selected tasks that were practiced, but did not transfer to gains in walking function.

Clinical Relevance: These data reinforce the importance of task-specific training to improve walking function following chronic neurological injury.
Purpose/Hypothesis: The average wheelchair user performs 15-20 transfers per day. Previous studies have demonstrated that among individuals who are able to independently transfer, more than half demonstrate significant deficits in their transfer skills. Performing suboptimal transfers has been linked to poorer biomechanics and increased pain and pathology of the upper limbs. Thus, it is vital that wheelchair users are taught and maintain appropriate technique over time. Although transfer training has traditionally been provided by clinicians in-person, the lack of adequately trained clinicians, environmental and transportation barriers, and financial costs associated with increased training have resulted in only 42% of wheelchair users citing that they learned their essential mobility skills from a health care professional. Additionally, about 50% of people report consulting online resources before a health care professional. Therefore, web-based training may provide a unique outlet for training wheelchair users as well as healthcare providers in order to decrease future injury risk and increase long-term community participation and quality of life outcomes. The purpose of this study was to assess the efficacy, implementation, and provide resources for a web-based transfer training module for wheelchair users and clinicians.

Number of Subjects: 71, 117 for randomized clinical trial to date

Materials and Methods: We assessed the efficacy of a web-based transfer training module in improving transfer skills among wheelchair users compared to in-person training and a waitlist control group. Individuals transferred to a mat table before and after completing an one hour web-based module or in-person training, as well as an additional transfer after a 1-2 day delay. Each transfer was scored using the Transfer Assessment Instrument 3.0 (TAI). Work is also ongoing through a randomized control trial to implement web-based transfer training to a larger population of wheelchair users across the country with a 6 month follow-up period to ensure that transfer skills are maintained longer-term.

Results: TAI scores were similar at among all groups at baseline. Both training groups had significantly higher TAI scores after the intervention compared to both the baseline scores and the waitlist control group (p<.01). Both training groups also maintained their skills after the follow-up period. Preliminary results of the randomized control trial, as well as the public availability of the web-based transfer training module will also be discussed.

Conclusions: Results indicate that web-based training provides an improvement in transfer technique similar to traditional in-person training, and may be a more accessible mechanism for providing training.

Clinical Relevance: A web-based transfer training module has demonstrated to be beneficial in improving transfer technique and the publicly module will be presented as an available resource for wheelchair users and clinicians.
TITLE: Gait Speed Is Associated with 30-Day Readmission and Post-Discharge Home Health Utilization after Inpatient Rehabilitation.

CURRENT SECTION: Neurology
CURRENT SUB-CATEGORY: General
AUTHORS: Danica Rae Dummer, Christopher S. Noren, Robin L. Marcus

ABSTRACT BODY:
Purpose/Hypothesis: Although the use of functional measures has increased in the inpatient setting, their use to guide treatment is limited. Gait speed (GS) has been referred to as the “sixth vital sign” and is related to physical function, health status, and mortality.\(^1\) GS is also related to readmission in patients with myocardial infarction\(^2,3\) and COPD\(^4\) however limited research is available looking at 30-day readmission and GS in the inpatient rehabilitation (rehab) population. Further, GS has been shown to be related to discharge home vs. skilled nursing facility in patients with acute stroke however the use of home health services related to GS has not been reported.\(^5\) The purpose of this investigation was to determine the association between GS and 30-day readmission and post-discharge use of home health. We hypothesized that GS would be significantly associated with 30-day readmission and home health use after a rehab stay.

Number of Subjects: 859

Materials and Methods: Four-meter GS was collected on ambulatory patients during physical therapy sessions from Jan 2016-July 2019 at a single academic inpatient rehabilitation hospital. The primary outcome was 30-day readmission and the utilization of home health services. The primary predictor was GS (meters/second). Additional variables included in the model were age, sex, Charlson Comorbidity Index, MS-DRG Weight and admit functional mobility. To determine the relationship of GS on home health usage and readmission, multiple logistic and linear regression was used.

Results: After controlling for age (58.9±17.2 years), sex (58.1% male), Charlson Comorbidity Index (4.4±3.3), initial Activity Measure for Post-acute Care “6-clicks” Basic Mobility short form (AM-PAC) score (16.2±3.5) and MS-DRG weight (1.2±0.4) in the model, GS was significantly associated with 30-day readmission. 743 patients did not readmit and had a mean GS of 0.68 m/s (±0.3), 116 patients readmitted and had a mean GS of 0.54 (±0.2). Readmission was associated with a 0.12 m/s decrease in GS during the rehab stay (95%CI=−0.17, -0.07, \(p<.0001\)). Additionally, compared to patients that are Cross Street & Normal WS ambulators (>1.2 m/s)\(^1\), patients that are Household Ambulators (<0.4 m/s)\(^1\) and Limited Community Ambulators (0.4-0.8 m/s)\(^1\) are respectively 7.2 and 3.8 times more likely to discharge home with home health services after a rehab stay (95%CI 2.3,22.9 \(p=.001\) and 1.3,11.6, \(p=.017\)).

Conclusions: Patients readmitted within 30 days after a rehab stay had significantly slower GS than those who were not readmitted. While both groups walked slower than age-matched norms\(^6\), those who experienced a readmission (mean GS=0.54 m/s) walked at a speed that has been shown to be associated with an increased risk of hospitalization (<0.60 m/s).\(^1\) This study provides further discrimination between patients walking at slower GS after discharge from rehab. Further, patients with slower GS were more likely to discharge home with home health services.

Clinical Relevance: Gait speed during a rehab stay may be an important variable to consider during discharge planning to decrease the risk of readmission and optimize post-discharge service utilization for optimal outcomes.
TITLE: Are Neurologic Physical Therapists across the Continuum of Care Using Outcome Measures?
CURRENT SECTION: Neurology
CURRENT SUB-CATEGORY: Practice Issues
AUTHORS: Elizabeth Marie Brewer, Marissa Francis Lyon

ABSTRACT BODY:

Purpose/Hypothesis: Use of outcome measures (OMs) is considered an aspect of evidence-based practice in physical therapy. Although OMs have proven to be beneficial, barriers to use have been identified including insufficient time, lack of administrative support, inefficient access, educational gaps, and no mandate supporting evidence-based practice. These barriers decrease the frequency of use of outcome measures. This project has two purposes: 1. Determine how frequently neurologic physical therapists (PTs) across the continuum of care at one metropolitan health system use OMs during the initial evaluation. 2. Examine the use of OMs before and after varying knowledge translation (KT) efforts.

Number of Subjects: Initial evaluations varied by timepoint and location from 61-253. Evaluations were analyzed from 8 acute care, 38 inpatient, and 35 outpatient neurologic PTs.

Materials and Methods: Initial evaluations from Memorial Hermann acute care neurologic physical therapy (AC), TIRR inpatient (IP), and TIRR Kirby Glen outpatient (OP) were reviewed from three one-month time points from August 2016 to November 2017. OMs were categorized by World Health Organization International Classification of Functioning, Disability, and Health (ICF) level. Fields completed for each OM in the electronic medical record were determined through an aggregate data warehouse report. Fields were coded to represent each OM and a count of OMs from each ICF level for each timepoint was determined. OM use was expressed as a frequency for OM use at each ICF level for each timepoint.

Results: Across all settings, OMs at the body structures and functions level were used more frequently than at the activity or participation levels. A greater variety of outcome measures were performed at OP vs IP/AC and in IP vs AC. At AC and IP, a greater variety of OMs were used after KT efforts. Outcome measures at the activity and participation levels were used more frequently in the OP setting as compared to IP and AC. At AC there was a significant increase in use of activity level OMs from 0.46% to 11.86% prior to formal KT, which occurred as a clinician prepared for the NCS and prepared the KT initiative for the facility. After the KT effort there was a non-significant increase to 15.42%. At IP, OM use at the activity level increased from 14.47% to 35.53% after a formal requirement to use outcome measures was implemented. Participation level measures were used at 0.00% in AC and IP at all three timepoints and at 8.20% at OP during the last timepoint. At OP, KT efforts occurred prior to the first timepoint and use of activity level OMs ranged from 50.72% to 78.79%.

Conclusions: OM use varies across setting and increases after KT efforts. Neurologic PTs are using OMs at the body structures and functions level more often than at the activity and participation levels.

Clinical Relevance: Recent publications, including a clinical practice guideline, convey the importance of using OMs. Despite increases in OM use, there is a need for further KT efforts to continue to encourage PTs to use OMs during initial evaluations.
TITLE: Long-Term Wellness Services Improves Physical Activity and Quality of Life in Persons with Neurologic Disorders

CURRENT SECTION: Neurology
CURRENT SUB-CATEGORY: General
AUTHORS: Stephanie A. Miller, Sharon Baggett, Nora Ellen Foster, Celine Siahmakoun

ABSTRACT BODY:

Purpose/Hypothesis: Few options are available beyond traditional outpatient rehabilitation for long-term therapy and guided exercise for patients with neurologic dysfunction. The purpose of this study was to evaluate physical activity and health-related quality of life outcomes over six months with regular participation in an activity-based therapy and wellness program.

Number of Subjects: Forty-seven participants were enrolled in this prospective, longitudinal study. [30 (70%) males; mean (SD) age = 44.5 (19.2); median (IQR) days post injury = 414 (1215); spinal cord injury/spinal disorders n = 28; acquired brain injury/stroke n = 12; traumatic brain injury n = 7].

Materials and Methods: Participants individually received activity-based therapy by a physical therapist and/or guided exercise with an exercise physiologist at least weekly for 6 months. The program specializes in long-term, affordable treatment for individuals living with and recovering from neurologic injury after insurance for traditional services is expended. The Berg balance scale (BBS), modified functional reach test (MFR), activities-specific balance confidence scale (ABC), and the comfortable 10-meter walk test (10MWT) were completed at initial evaluation and at 3 and 6 months after evaluation. Eight subscales of the Quality of Life in Neurological Disorders (Neuro-QoL) were completed at initial evaluation and 6 months later. Inferential statistics and Cohen’s $d$ effects sizes were used to assess within group change over time.

Results: Significant improvements were found with the BBS ($X^2=7.5; p=.02$), ABC ($X^2=10.9; p<.01$) and 10MWT ($X^2=13.4; p<.01$). Modified functional reach increased a median of 2-4cm over time, but this was not a significant change ($X^2=4.8; p<.09$). All subscales of the Neuro-QoL demonstrated improvements except lower extremity function. Neuro-QoL subscales of emotional and behavioral dyscontrol ($Z=1.9; p=.05$), cognitive function ($t=2.3; p=.05$) and satisfaction with social roles ($Z=2.0; p=.05$) significantly improved over time. Effect sizes for change across time for all variables were moderate to large (Cohen’s $d=.43$-$1.54$).

Conclusions: At a time point in recovery when traditional therapeutic services are typically discontinued due to depleted insurance funds and/or lack of progress, this group of participants demonstrated consistent improvements across all physical activity and health-related quality of life measures. Regular engagement in ongoing therapy and/or guided exercise provided a means for this group with neurologic disorders to continue to enhance their physical function, independence and perceptions of quality of life. Future studies should take into consideration amount and type of therapy services for comparison.

Clinical Relevance: Physical therapists can play an important role in providing ongoing therapy and wellness services for persons living with neurological disorders. Adopting a model with long-term services for people with chronic neurologic disorders that innovatively utilizes various revenue sources in order to offset insurance will be crucial in the provision of these services as part of the continuum of care.
TITLE: Belief, Confidence, Motivation to Use the Upper Limb in Daily Life Early after Stroke
CURRENT SECTION: Neurology
CURRENT SUB-CATEGORY: Stroke SIG
AUTHORS: Kimberly J Waddell, Michael J. Strube, Rachel G Tabak, Deborah Haire-Joshu, Catherine Eckels Lang

ABSTRACT BODY:

Purpose/Hypothesis: Upper limb (UL) performance, or use, in daily life is complex and likely influenced by many factors. While the recovery trajectory of UL impairment post-stroke is well documented, little is known about the recovery trajectory of sensor-measured UL performance in daily life early after stroke. Likewise psychosocial factors such as belief that paretic UL recovery is possible and confidence and motivation to use the paretic UL in everyday tasks are unexplored early after stroke. Data are needed about the potential moderating role of these factors on UL performance in daily life during the time period when rehabilitation services are provided.

The purposes of this hypothesis-generating study were to: 1) examine the recovery trajectory of UL performance in daily life; 2) characterize belief, confidence, and motivation to use the paretic UL in daily life, and self-perceived barriers to UL recovery; and 3) explore the potential moderating role of these factors on UL performance over the first 12 weeks post-stroke.

Number of Subjects: 30
Materials and Methods: This was a longitudinal, prospective cohort study quantifying UL performance and related psychosocial factors early after stroke. UL performance was quantified via bilateral, wrist-worn accelerometers over five assessment sessions for 24-hours. Belief, confidence, and motivation to use the paretic UL, and self-perceived barriers to UL recovery were quantified at the same time points via survey and analyzed using descriptive statistics. Change in four accelerometer variables and the moderating role of psychosocial factors was tested using hierarchical linear modeling. The relationship between self-perceived barriers and UL performance was tested via Spearman rank-order correlation analysis. Further analyses explored relationships between clinical measures of UL capacity, depressive symptomatology, cognition and psychosocial factors.

Results: UL performance improved over the first 12-weeks after stroke. Belief, confidence, and motivation to use the paretic UL were high over the same time period, with little variation. Belief, confidence, and motivation did not moderate UL performance over time. There was a negative relationship between UL performance and self-perceived barriers to UL recovery at week 2 which declined over time. No relationships between clinical measures and psychosocial factors were found at weeks 2 or 12.

Conclusions: Sensor measured UL performance can improve early after stroke. Levels of belief, confidence, and motivation were higher than expected and appear consistent over this same time period. The lack of correlations between psychosocial factors and clinical measures suggests belief, confidence, and motivation may not be vulnerable to functional status early after stroke.

Clinical Relevance: Early after stroke, rehabilitation interventions may not need to directly target belief, confidence, and motivation but may instead focus on reducing self-perceived barriers to UL recovery.
ABSTRACT BODY:
Purpose/Hypothesis: Recovery of arm function after stroke remains a problem for many stroke survivors and novel interventions with long-term benefit are needed. This study consisted of a randomized, sham-controlled pilot investigation to evaluate the long-term effects on safety, feasibility and potential efficacy of Vagus Nerve Stimulation (VNS) paired with rehabilitation for upper limb motor recovery.
Number of Subjects: Seventeen participants with chronic ischemic stroke and moderate to severe upper limb impairment were enrolled.
Materials and Methods: All participants were implanted with a VNS device and then randomized to Active VNS (n=8; rehabilitation paired with VNS) or Control VNS (n=9; rehabilitation without VNS). Participants in both groups received 6-weeks of high-repetition and task-specific in-clinic rehabilitation for the upper limb. Each movement repetition was associated with a brief burst of Active or Control VNS triggered by the therapist, but participants and therapists were blinded to group allocation. In-clinic therapy was followed by therapist-prescribed, individualized, daily, 30-min, home exercise program with self-triggered VNS (Kimberley 2019). As previously reported (Kimberley et al., 2018), the average Fugl-Meyer Upper Extremity (FMA-UE) increased by 9.5 points from baseline with Active VNS compared to 3.8 points in Control VNS group (difference, 5.7 points; CI, −1.4 to 11.5; p=0.055) at 3 months. After the 3-month follow-up from the randomized portion of the study, the Control VNS group crossed-over to receive 6-weeks of rehabilitation paired with Active VNS. Participants in both groups continued their home exercise program with self-triggered VNS for 1 year with additional long-term testing. Here, we report 1-year follow-up results from the pilot study.
Results: There were no VNS-treatment related serious adverse events during the long-term therapy. Stimulation-related adverse events were mild and events possibly related to stimulation included hoarseness and hiccups. No subject withdrew due to adverse events. Two Control VNS subjects discontinued prior to receiving the full crossover VNS. One subject had substantial benefit from rehab-only while the second subject lived a significant distance from the site and decided to dropout to avoid continued travel. One year after starting home-based therapy, the average FMA-UE score for the Active VNS group improved by 10.8 points (n=8, CI, 4.49, 17.26, p=0.005) from initial baseline. FMA-UE in the VNS Control group, after cross-crossover to VNS, improved by 7.2 points (n=7, CI, -0.9, 15.5, p=0.07) from initial baseline. On average, at one year, 11/15 participants (73%) showed a clinically meaningful improvement in FMA-UE (≥ 6-point change) after receiving Active VNS.
Conclusions: VNS combined with rehabilitation provides long-term benefits to individuals with chronic stroke and warrants further investigation.
Clinical Relevance: Impaired arm function after stroke presents a significant burden for large numbers of people and the chronicity is associated with poor quality of life and disability. VNS paired with rehabilitation, a therapy based on neuroplastic principles, may address this unmet need by providing long-term self-directed treatment in the person’s home.
TITLE: Factors Associated with Improved Walking Speed over the First Six Months Post Stroke
CURRENT SECTION: Neurology
CURRENT SUB-CATEGORY: Stroke SIG
AUTHORS: Stephanie A. Miller, Eric Dugan, Elizabeth Moore
ABSTRACT BODY:

Purpose/Hypothesis:
Recovery of walking is a primary goal for many people after stroke. Predicting improvement in walking speed early after stroke could enhance the rehabilitation process. The purpose of this study was to examine factors that are associated with improvement in walking speed over the first six months post stroke within the contemporary healthcare environment.

Number of Subjects:
Fifty individuals within one month of ischemic stroke (19 males; 27 with left hemiparesis; mean age 57.2 SD 14.1; median days post stroke 15.0 IQR 13.0; lower extremity Fugl-Meyer score 25.0 IQR 5.0) participated in this prospective longitudinal study.

Materials and Methods:
Testing was completed within one month (baseline) and at three and six months post stroke. During each testing session, participants completed the comfortable 10-m walk test (CWT). At baseline the Berg balance scale (BBS), lower extremity subsection of the Fugl-Meyer Assessment (FMA), demographics, health history and preferred assistive device were recorded. A linear mixed methods analysis was conducted to examine change over time in walking speed taking into account covariates of age, gender, side of hemiparesis, co-morbidities, use of assistive device, BBS and FMA at baseline.

Results:
Walking speed significantly improved over time (F=42.5; p<.01) with significant increases in walking speed from baseline to 3-months (change estimate = 0.28m/s; p<.01) and baseline to 6-months (change estimate = 0.33m/s; p<.01). Only age, BBS and use of an assistive device at baseline significantly contributed to change in walking speed overtime (p<.01). Every one-point increase in the BBS or one-year increase in age predicted a 0.01m/s increase in walking speed. Use of an assistive device at baseline was associated with decreased gait speed (0.29m/s; p<.01).

Conclusions:
Walking speed increased over the first six months post stroke in this sample with acute stroke. Better balance and not using an assistive device within the first month after stroke predicted greater improvements in walking speed, confirming reports from previous retrospective and cross sectional studies. Few studies have examined predictors of change over time from a prospective, longitudinal perspective. Advancing age was also associated with improvements in walking speed, perhaps due to the younger sample. While gender, side of hemiparesis, co-morbidities and motor impairment were not associated with change in walking speed, factors such as cognition and site of lesion should be considered in future work.

Clinical Relevance:
Assessment of balance with the highly recommended BBS and determination of need for an assistive device within the first month of stroke, prior to discharge from rehabilitation, can be used to predict improvement in walking speed three and six months after stroke.
Purpose/Hypothesis: It is well understood that reduced levels of physical activity (PA) after stroke are associated with increased risk for cardiovascular disease and recurrent stroke. Evidence has shown that individuals post-stroke are less physically active than healthy age-matched counterparts. Recent work has attempted to understand factors associated with reduced PA levels post-stroke but have been limited in terms of issues related to low sample size and models that ultimately explain a small percentage of the variance associated with post-stroke PA. To date, studies have analyzed predominantly mobility and psychological factors with minimal investigation of the environmental domain, despite evidence of this domain being an important factor in the older adult population. Measures such as the Walk Score (WS) and Area Deprivation Index (ADI) are available that include social and physical environmental constructs that have yet to be investigated related to post-stroke PA. The WS is an assessment of walkability of a neighborhood and measures the proximity of an address to nearby amenities, such as grocery stores and parks. Similarly, the ADI has been shown to be a valid indicator of neighborhood disadvantage and consists of a composite index of numerous socioeconomic factors. The purpose of this study was to better understand the role of social and physical environmental factors in explaining walking activity after stroke.

Number of Subjects: 249

Materials and Methods: Individuals >6 months post-stroke, ages 21-85, with a comfortable gait speed between 0.3-1.0 m/s and who averaged <8,000 steps/per day were included. Steps per day was the primary measure for quantifying walking activity and was collected during all waking hours using the FitBit™. A minimum of 3 days of step data was recorded. Constructs of the social and physical environmental domain included work status, living situation, WS, and ADI. Work status and living situation were categorized based on level of employment and amount of support within the home, respectively. Regression was used to examine the influence of social and physical environmental constructs on walking activity post-stroke.

Results: The social and physical environmental constructs of work status, living situation, WS, and ADI explained 4.5% (p=.035) of the variance in walking activity in individuals post-stroke.

Conclusions: While significant, social and physical environmental constructs explained only a small percentage of the variance in walking activity in chronic stroke survivors. The results from this study confirm the need to develop more comprehensive models and alternative analytical approaches for understanding walking activity in individuals post-stroke.

Clinical Relevance: As stroke is a leading cause of disability worldwide, it is becoming increasingly important to understand factors associated with post-stroke walking activity. While constructs of the social and physical environmental domain may play a role, development of more sophisticated analytical approaches are needed to broaden our understanding of these factors related to walking activity in chronic stroke survivors.
TITLE: Contributions of Stepping Intensity and Variability to Mobility in Individuals Post-Stroke: A Randomized Clinical Trial

CURRENT SECTION: Neurology

CURRENT SUB-CATEGORY: Stroke SIG

AUTHORS: Christopher Edward Henderson, Abbey Plawecki, Emily G. Lucas, Jennifer Kristine Lotter, Molly Elizabeth Holthus, Gabrille Brazg, Meghan M. Fahey, Jane Lou Woodward, Marzieh Ardestani, Elliot Roth, Thomas George Hornby

ABSTRACT BODY:

Purpose/Hypothesis: The amount of stepping practice provided during rehabilitation post-stroke can influence locomotor recovery and reflects one aspect of exercise “dose” that can affect the efficacy of specific interventions. Emerging data suggest that markedly increasing the intensity and variability of stepping practice may also be critical, although such strategies are discouraged during traditional rehabilitation. The purpose of this study was to determine the individual and combined contributions of intensity and variability of stepping practice to improving walking speed and distance in individuals post-stroke. We hypothesized that high intensity stepping training in variable contexts would result in greater gains in outcomes as compared to high-intensity walking with limited variability, or low intensity training of variable stepping tasks.

Number of Subjects: 97 individuals with chronic stroke

Materials and Methods: Participants were randomized to receive ≤ 30 sessions of high intensity (70-80% age predicted HR reserve) stepping of variable, difficult tasks (high-variable) or only forward walking (high-forward), or to low intensity (30-40% HR reserve) stepping in variable contexts. Primary outcomes were the 10MWT and 6MWT, with secondary measures including the FGA, 5xSTS, ABC, and spatiotemporal gait parameters. Data were analyzed using a 3-way repeated measures ANOVA with post-hoc ANOVAs when significant interaction effects were identified. Adverse events were categorized by training intensity and analyzed using χ² analyses.

Results: All walking outcomes were significantly greater following either high intensity vs low-variable training (all p<0.001). Additional gains in spatiotemporal symmetry were observed with high-intensity training, and FGA and ABC increased only following high-variable training, particularly in those with more severe impairments. Average HRs achieved during high-intensity training were 61-67% of age predicted HR reserve, but 108-111% of observed HRs achieved during initial testing, with no serious adverse events or significant differences in minor adverse events between groups (p=0.73).

Conclusions: Stepping training at high-intensities with or without practice of variable stepping tasks elicits gains in walking function and gait symmetry as compared to low-intensity activities. Changes in balance and balance confidence suggest a possible benefit of providing high intensity training in variable contexts. Despite non-significant differences in adverse events, future studies should further identify the potential risks for this population. The relative contributions of volume, intensity and variability may be important, and future studies are needed to further define optimal training parameters.

Clinical Relevance: Selection of effective and safe physical therapy interventions is essential to maximize locomotor function for individuals following stroke.
Treating Spatiotemporal Gait Asymmetry Post-Stroke Does Not Influence Balance, Quality of Life, or Physical Activity

Purpose/Hypothesis: Prior observational cross-sectional analyses have suggested a significant relationship between spatiotemporal gait asymmetry and gait efficiency, balance, endurance, quality of life, and physical activity in people with chronic stroke.1-4 Our purpose was therefore to determine if targeted training to change spatiotemporal gait symmetry will concomitantly improve these outcome measures. We hypothesized that individuals with a greater reduction in spatiotemporal gait asymmetry after training will exhibit greater improvements across all outcome measures purported to be influenced by spatiotemporal gait asymmetry.

Number of Subjects: 48 participants with chronic stroke, gait speed <1.0 m/s, and spatiotemporal gait asymmetry.

Materials and Methods: This study represents secondary outcome measures from a prior RCT in which participants were randomized to one of three groups: error augmentation, error minimization, or conventional treadmill training (i.e., control).5 Training to reduce step length asymmetry (N=26) or stance time asymmetry (N=22) consisted of 18 sessions of up to 20 minutes of treadmill walking followed by 15 minutes of overground gait training per session.5 Measures of balance (Berg, 4SST), daily step count, endurance (6MWT), metabolic cost, quality of life (SIS) and overground spatiotemporal asymmetries were collected one week prior to and following training. We performed separate analyses for those who trained for spatial vs temporal asymmetry. The effect of time (pre/post) was examined for all measures and correlational analyses evaluated the potential relationships between changes in spatiotemporal asymmetry and all other measures.

Results: Individuals who trained to improve step length asymmetry exhibited significant improvements in step length asymmetry, gait speed, Berg, 4SST, 6MWT distance, metabolic cost of walking, and SIS-mobility. Those who trained to improve stance time asymmetry significantly improved gait speed, Berg, 4SST, 6MWT, SIS-mobility, and SIS-Global recovery scores. Despite these changes, improvements in step length asymmetry were only related to improved gait speed (p=0.040; r=-0.45) and 6MWT distance (p=0.025; r=-0.49). Improvements in stance time asymmetry were only related to improved metabolic cost of transport (p=0.031; r=0.558).

Conclusions: Despite significant improvements in many important metrics, most changes did not appear to arise from improved spatiotemporal asymmetry. Furthermore, the improvements in gait function observed in the lab setting did not appear to translate to increased community mobility (daily step counts).

Clinical Relevance: Targeting spatiotemporal gait asymmetry can yield significant improvements in many gait-related measures, but the focus of the intervention may not have been the contributing factor in many of the observed changes.
Does Cognition Predict Ability to Learn and Retain a Novel Walking Pattern in Individuals Post-Stroke?

Purpose/Hypothesis: Locomotor learning is essential for developing effective rehabilitation after stroke; however, there is significant variability in post-stroke locomotor learning ability. We currently do not understand sources of variability in locomotor learning. Demographics and physical impairments do not identify stroke survivors who can and cannot perform well on locomotor learning tasks. Research in healthy older adults suggests that cognition relates to upper extremity motor learning; yet, cognition has been ignored in post-stroke locomotor learning, despite the prevalence of cognitive deficits after stroke. Thus, our purpose was to determine if a relationship exists between locomotor learning and cognition in stroke survivors. We hypothesized that cognition will explain a significant portion of variability in an explicit locomotor learning task after accounting for age and physical impairment (i.e. self-selected walking speed; SSWS).

Number of Subjects: Twenty-four chronic stroke survivors (66.29 ± 8.57 yrs, 11 F) who could walk without physical assistance participated to date.

Materials and Methods: Subjects performed a treadmill locomotor learning task with Baseline and Learning phases. During Baseline, we calculated step length (SL) and identified the leg with the shorter SL (SSL). During Learning, a bar graph with a target line displayed real time information about subjects’ SL. Subjects were asked to match the bars to the target line during Learning; however, distortion was added to the SSL bar resulting in subjects learning a new walking pattern. The measure of learning was Absolute Error (AE), which was the absolute difference between the target SL of the SSL and the SL of SSL at the end of Learning. Subjects then completed the 10 meter walk test and the NIH Toolbox - Cognitive Battery. This battery assesses major domains of cognition and produces a Fluid Cognition Composite Score (FCCS), a global index of cognitive abilities. A sequential regression model with AE as the outcome was performed with 3 blocks of predictors: 1) age, 2) SSWS, and 3) FCCS.

Results: Subjects learned a walking pattern that was different than Baseline (p<0.001); however, there was substantial individual variability. Age and SSWS were not significant predictors of AE (p=0.11, R²=0.11; p=0.51, ∆R²=0.018, R²=0.13, respectively). After accounting for age and SSWS, FCCS was a significant predictor of AE during locomotor leaning (p=0.03, ∆R²=0.18, R²=0.31).

Conclusions: A global index of cognition explained significant variance in locomotor learning beyond that explained by age and SSWS. This suggests that stroke survivors with higher cognitive test scores learned an explicit locomotor task more successfully (i.e., with fewer errors) than those with lower cognitive test scores abilities.

Clinical Relevance: Understanding the relationship between cognition and locomotor learning will allow clinicians to personalize post-stroke interventions. For example, because individuals with lower FCS scores do not learn as well through explicit tasks, clinicians may consider interventions that are less explicit.
How Computational Modeling Can Advance Neurorehabilitation: Insights from Studies of Individuals with Chronic Stroke

Purpose: The purpose of this presentation is to provide researchers with a high-level introduction to the application and benefits of computational modeling for neurorehabilitation research.

Description: Computational modeling involves formalizing, in mathematical terms, hypotheses and theories regarding the behavior of complex systems. Across all sciences, computational models have been remarkably successful in enhancing our understanding of a wide range of phenomena, from the behavior of ion channels within neurons to the physics of flight. In the field of motor learning, the pairing of carefully designed behavioral studies and computational modeling has led to breakthrough advances in our understanding of multiple motor learning processes in neurologically normal individuals, including error-based, reinforcement, and use-dependent learning.

Currently, there is increasing recognition within the neurorehabilitation community of the pivotal role computational models play in understanding the mechanisms underlying sensorimotor rehabilitation. Specifically, researchers have developed models of learning in individuals with stroke that have been used to understand and predict improvements in functional arm movements, shifts in brain activation patterns, and changes in Fugl-Meyer scores following regimens of physical or robot-assisted therapy. Combined, these studies highlight how computational models provide a theoretical framework for understanding motor learning impairments, identify potential targets for rehabilitation, and predict the efficacy of different intervention strategies on stroke recovery.

While there is a strong rationale for computational modeling in neurorehabilitation, there is a clear divide between researchers with quantitative backgrounds, for whom the appeal of computational models is readily appreciated, and researchers from biological and clinical backgrounds, who have not had exposure to modeling studies or feel ill-prepared to tackle them. Recent work has underscored the importance of introducing more clinical researchers to the techniques, intuitions, and relevance of computational modeling to make this powerful set of tools more broadly accessible.

Summary of Use: For this platform, computational modeling of behavioral data collected from 31 individuals with chronic stroke will be discussed. The purpose of this recently published work was to investigate the efficacy of exercise priming on motor learning during a well-studied locomotor adaptation paradigm. The computational models and simulation techniques utilized in this study shed light on the processes underlying both learning and 24-hour retention. All computer code and data used during this discussion will be made publicly available.

Importance to Members: This platform is designed to provide a practical introduction to researchers on how computational techniques may complement and bolster their current research programs.
TITLE: Expanding Vestibular Spatial Perception
CURRENT SECTION: Neurology
CURRENT SUB-CATEGORY: Vestibular SIG
AUTHORS: Eric R. Anson, Yoav Gimmon, Michael C Schubert

ABSTRACT BODY:
Purpose/Hypothesis: Spatial orientation perception is highly influenced by vestibular afferent signals. Individuals with vestibular disease often report persistent sensations of abnormal self-motion (chronic dizziness), and perform worse on spatial perception and navigation tasks than healthy adults. The mainstay of vestibular rehabilitation emphasizes bottom-up behavioral modification via reflex adaptation, multisensory integration, and/or habituation. We hypothesized that a top-down approach based on verbal feedback will modify self-motion perception, specifically vestibular spatial orientation.

Number of Subjects: Healthy young adults participated in experiment 1 (EXP1) [n = 15, mean age 31.2 (SD = 7.96)] and experiment 2 (EXP2) [n = 9, mean age 30.9 (10.7)].

Materials and Methods: EXP1: Subjects experienced 100 passive whole body rotations (10 blocks of 10 rotations) non-uniformly distributed randomly ordered (45, 90, 135, or 180 degrees) while blindfolded and listening to white noise. After each rotation, subjects verbally reported the perceived rotation size, but received no feedback regarding accuracy. Perceptual gain (PG) was calculated (perceived rotation size / actual rotation size).

EXP2: Subjects experienced 120 uniformly distributed randomly ordered passive whole body rotations (60, 90, 120, 150, or 180 degrees) while blindfolded and listening to white noise. As in EXP1, subjects verbally reported the perceived rotation size. No feedback was provided after rotations 1-20 (pretest) or 101-120 (posttest); verbal feedback to bias (increase) perceived rotation size was provided after rotations 21-100. PG was calculated as in EXP1. Mixed model analyses determined whether PG differed across rotation size or rotation block in EXP1. Repeated measures ANOVA determined whether posttest PG significantly differed from pretest PG.

Results: EXP1: PG for vestibular spatial orientation significantly declined with increasing rotation amplitude (F(3,59) = 18.22, p < 0.001). Average PG was stable across all blocks (F(9,149) = 1.52, p < 0.208).

EXP2: PG for vestibular spatial orientation significantly increased in the direction biased by the verbal feedback when comparing posttest to pretest (F(1,40) = 175.49, p < 0.001). Pairwise comparisons show that PG significantly increased for all rotation sizes (p’s < 0.001).

Conclusions: These results indicate vestibular perception of spatial orientation is modifiable in healthy adults. Additionally, vestibular perception of spatial orientation is stable across repetitions for healthy adults in the absence of modifying feedback. These experiments provide the groundwork for development of novel treatments for perceptual impairments in chronic dizziness.

Clinical Relevance: A perceptual re-training paradigm based on verbal feedback may have clinical applications for individuals with chronic dizziness.
Purpose/Hypothesis: The prevalence of anxiety and depression is higher among persons with vestibular disorders than the general population. Anxiety and depression among persons with vestibular disorders is associated with higher perceived handicap, poorer quality of life, and longer recovery time. The aim of this study was to determine the effect of baseline anxiety and depression levels on activity and participation-level function at 3-month follow-up among persons with vestibular disorders. We hypothesize there will be lower levels of activity and participation-level functioning among those with vestibular disorders who have abnormal versus normal levels of anxiety and depression.

Number of Subjects: 295 patients were recruited from a tertiary care balance center and vestibular rehabilitation clinics.

Materials and Methods: All subjects completed the Hospital Anxiety and Depression Scale (HADS) and the Vestibular Activities and Participation Measure (VAP) at baseline. 205 out of 295 subjects (69%) completed the 3-month follow up assessment including the VAP and Global Rating of Change (GROC). The relationship between the measures at baseline and at 3 months were examined using Spearman’s correlation coefficients. Each HADS sub-scale was categorized into 3 groups based on score: normal (0-7), borderline abnormal (8-10), and abnormal (11-21) levels of anxiety and depression. One-way analysis of variance was used to test for differences in the VAP and GROC scores among the HADS patient groupings at 3 months.

Results: The mean baseline HADS anxiety sub-scale score (HADS-A) was 7.2 (SD=4.4) and depression sub-scale score (HADS-D) was 5.6 (SD=4.0). The mean baseline and 3 month VAP scores were 1.1 (SD=0.8) and 0.76 (SD=0.8) indicating mild difficulty with activity and participation function at baseline, which improved over 3 months. Mean GROC at 3 months was 3.4 (3.3) indicating subjects felt somewhat better compared to baseline. The HADS-A and HADS-D scores had moderate positive correlations with the baseline VAP score (ρ=0.42, 0.62, p<.01). The HADS-A and HADS-D scores had small to moderate positive correlations with the VAP (ρ=0.35, 0.50, p<.01) and small negative correlations with GROC (ρ=-0.15, -0.25, p<.05) at 3 months. There were significant differences in 3-month VAP scores among normal, borderline abnormal, and abnormal patient groups on the HADS-A [F(2,202)=14.6, p<.001] and between normal and abnormal groups on HADS-D [F(2,202)=19.3, p<.001].

Conclusions: Levels of anxiety and depression measured by the HADS are associated with lower levels of activity and participation-level functioning and less self-reported change in function at 3 months among persons with vestibular disorders. Those with borderline abnormal and abnormal levels of anxiety and depression had significantly worse scores on the VAP at 3 months than those with normal levels of anxiety and depression.

Clinical Relevance: Determining the presence of anxiety and depression may assist in determining the prognosis, the plan of care, and in goal-setting when treating persons with vestibular disorders.
Purpose/Hypothesis: A loss of balance after a stroke from either an externally induced perturbation or during a voluntary movement, can be recovered by a protective step. The purpose of this study was to characterize the stepping behaviors during induced perturbations and voluntary steps in fallers and non-fallers in community-dwelling individuals with chronic stroke.

Number of Subjects: 30 individuals >6 months post-stroke

Materials and Methods: Participants were exposed to externally induced lateral waist-pull perturbations and voluntary steps. A balance tolerance limit (BTL) was established for the induced steps, which was the magnitude that balance recovery transitioned from a single to multiple steps. Step initiation time, step velocity, first global step length, and step clearance were calculated for all steps. BTL and step type were determined for the induced steps. Clinical measures included the Community Balance & Mobility Scale (CB&M), abductor hip torque, and foot cutaneous sensation. Participants were classified as fallers if they reported a fall in the prior six months. Group comparisons were performed with a multivariate analysis of variance for the step parameters for the waist-pull perturbation (at BTL and one above BTL) and voluntary steps on the paretic and non-paretic leg.

Results: There were 12 fallers and 18 non-fallers. Fallers had a lower score on the CB&M ($P=0.042$), reduced paretic abductor torque ($P=0.004$), and impaired paretic foot cutaneous sensation ($P=0.05$). The threshold for transitioning from single to multiple steps was reduced for fallers compared to non-fallers ($P=0.002$). Fallers took more medial steps than non-fallers ($P=0.006$) though these differences disappeared above BTL. Fallers had a reduced non-paretic first step length ($P=0.043$) and clearance ($P=0.026$) compared to non-fallers at BTL and above BTL. No between-group differences were found in step parameters when the paretic leg took the first step. Above BTL, fallers took longer to initiate a step with the paretic ($P=0.032$) and non-paretic leg ($P=0.047$). Few differences were found in the voluntary step. Fallers took longer to initiate a step with the paretic leg than non-fallers ($P=0.045$).

Conclusions: Fallers took multiple steps at a lower perturbation magnitude, using a medial step. With larger perturbation magnitudes fallers are slower to initiate a step regardless of the leg used as the first step. A delayed step initiation of the paretic leg during the voluntary movements with no other differences may indicate that when given enough time to plan, fallers can generate an appropriate motor output.

Clinical Relevance: A high fall rate after stroke necessitates effective fall prevention strategies. Given that more differences were found between fallers and non-fallers during the externally induced perturbations, fall prevention should include externally generated balance perturbations along with voluntary movements.
ABSTRACT BODY:

Purpose/Hypothesis: The dysfunctions related to hereditary degenerative cerebellar diseases (HDCD) cause substantial limitation to functional mobility and negative impact on individual independence. However, the increased impairment and limitations that follow the progression of HDCD are not well characterized. Furthermore, which signs can explain the loss of mobility and the risk of falls in these individuals are not known. The understanding of these outcomes may facilitate the comprehension of functional prognosis and may help to guide rehabilitation interventions, promoting the independence of individuals with HDCD. The present study aimed to characterize the factors associated with functional mobility and falls in individuals with HDCD. Specifically, the present study investigated the hypothesis that factors related to the loss of functional mobility and falls for these individuals can be assessed in the earlier stages of the HDCD.

Number of Subjects: 60

Materials and Methods: Individuals with spinocerebellar ataxia diagnosis were categorized into different degrees of impairments according to the Scale for the Assessment and Rating of Ataxia (SARA). Aspects of the body function, activity, and participation were also assessed. Multiple linear regression models were conducted to investigate the main factors related to functional mobility and falls in individuals with HDCD. For functional mobility, individuals were assigned into three groups according to their mobility status: independent, walking with assistant devices and restricted to a wheelchair. Regarding falls, individuals were divided into two groups characterized by the number of falls in the last year: fallers and non-fallers. Groups comparisons were conducted using One-way ANOVA.

Results: The BEST-test is the main outcome measure that explains the loss of mobility in individuals with HDCD ($\beta_0 = 3.34$, $\beta_1 = -0.030$; CI 95% $-0.035$, $-0.024$). Of all BEST-test items, only the limit of stability was not different among the independent group and the walking with assistant devices group ($p = 0.184$), and among the wheelchair group and the walking with assistance devices group ($p = 0.161$). Regarding falls, SARA is the outcome measure most associated with the history of falling.

Conclusions: Balance and severity of ataxia are respectively associated with functional mobility and falls in individuals with HDCD and should be carefully assessed. Future longitudinal studies may be conducted to identify what are the main predictors that compromise these outcomes over the progression of the disease.

Clinical Relevance: Balance and severity of ataxia are factors respectively associated with functional mobility and falls in individuals with HDCD and must be carefully assessed and focused on the physiotherapy interventions in this population. This knowledge brings new insights to understand the progression of the disease and to guide new proposals to change the natural disease history.
Purpose/Hypothesis: Gait and balance limitations in persons with multiple sclerosis (PwMS) are common,1,2 contribute to the high prevalence of falls1 and to healthcare costs,3 and create considerable negative effects on function and quality of life. Recommendations to address gait and balance limitations include rehabilitation, exercise, mobility assistive technology, and medications.4,5 Despite these recommendations, there is growing but limited information on implementation and barriers and facilitators6,7 to follow through on recommendations by PwMS and providers. The purpose of this study is to narrow the gap by describing and exploring barriers and facilitators to the engagement of PwMS in gait- and balance-enhancing behaviors (specifically exercise and mobility assistive technology) after out-patient (OP) physical therapy from both the perspective of PwMS and physical therapists (PT).

Number of Subjects: Seven dyads participated (matched PwMS – PT pairs, n=12 as one PT participated three times). Six of the seven PwMS were female with relapsing remitting disease; four were meeting exercise guidelines,5 disease steps scores were between 3 – 6. Three of the four PTs were female, worked in a hospital based out-patient physical therapy clinic associated with a MS center, and were MS or neurology certified.

Materials and Methods: A qualitative multi-method case series was used. Purposeful quota sampling maximized variability. Dependability and credibility were enhanced via an audit trail, reflective memos, regular team meetings, and thick descriptions. PwMS completed a phone survey, a follow up in-person interview, and standardized questionnaires. PTs completed an in-person interview. PT medical records were reviewed. Data were collected 2 – 8 weeks following discharge. Content and constant comparison analyses were used for thematic development and triangulation across data sources.

Results: The four primary themes impacting engagement in gait and balance-enhancing behaviors for both exercise and mobility assistive technology after OP physical therapy were 1) Importance and confidence: Believing in behavior and in self, 2) Support: Support from others and supporting self, 3) Resilience: Bouncing back and rising above, and 4) Weighing factors: Facilitators must outweigh barriers. While there was strong agreement in overarching themes by PwMS and PTs, unique roles and perspectives resulted in differences in confidence levels and specific barriers and facilitators.

Conclusions: This enhanced understanding through four primary themes impacting engagement in gait and balance-enhancing behaviors may aid in optimizing the PwMS – PT experience and ultimately gait and balance outcomes following physical therapy.

Clinical Relevance: PT can play an important role in supporting PwMS by helping maximizing facilitators and reducing barriers through discussion of key themes, addressing individual needs, connecting to supports outside of PT, and reflecting on personal beliefs and skill sets.
TITLE: Clinical Utility of the Single-Leg Calf Raise Test in People with Multiple Sclerosis
CURRENT SECTION: Neurology
CURRENT SUB-CATEGORY: Degenerative Diseases SIG
AUTHORS: Paul W. Kline, Cory Lynn Christiansen, Emily R Hager, Mark McLaughlin Manago
ABSTRACT BODY:

Purpose/Hypothesis: Ankle plantarflexor muscle function is a driver of functional mobility and a target for intervention in patients with multiple sclerosis (MS). However, clinical assessment of plantarflexor muscle function can be challenging as manual muscle testing and hand-held dynamometry have limited validity, and electromechanical dynamometry may not be feasible. As such, plantarflexor muscle function is commonly measured clinically by evaluating muscle endurance using a single-leg calf raise test. While a reliable measure, it is unclear how the calf raise test relates to muscle strength and functional mobility. The purpose of this study was to determine the concurrent validity of the calf raise test with peak plantarflexion strength assessed by electromechanical dynamometry, and compare the relationship of both measures to functional mobility.

Number of Subjects: Twenty-one people with MS (16 F, age: 49±12 years, BMI: 24.6±5.3 kg/m², Expanded Disability Status Scale range: 1.5-5.5).

Materials and Methods: Plantarflexor endurance was measured using a calf raise test in which the participant performs as many single-leg calf raises as possible until: knee or hip compensation, unable to achieve heel rise of ≥5 cm, or cadence reduced to <40 repetitions per minute. Peak plantarflexor muscle strength was measured using an electromechanical dynamometer with the participant in supine, hip and knee flexed, and ankle in 0° dorsiflexion. Functional measures of walking endurance (2-minute walk test – 2MWT), gait speed (Timed 25-foot walk – T25FW), and stair climbing ability (Stair Climbing Test – SCT) were also assessed. Relationships between endurance, peak strength, and functional measures were assessed using Pearson’s correlations.

Results: There was no significant correlation between the calf raise test and peak plantarflexion strength when evaluated using the entire sample (n=42, r=.08, p=.626). However, when including only limbs with less than 20 calf raises, there was a significant positive correlation with peak strength (n=24, r=.63, p=.001). For the entire sample, the calf raise test was significantly correlated with 2MWT (r=.40, p=.008), T25FW (r=.34, p=.03), and SCT (r=.41, p=.008) whereas peak strength was significantly correlated with only SCT (r=.41, p=.008).

Conclusions: In people with MS who performed less than 20 calf raises, the calf raise test had acceptable concurrent validity with peak plantarflexion strength and therefore may be a useful test for clinical practice. Additionally, the calf-raise test had significant correlations with each functional test suggesting that this test captures meaningful functional constructs for people with MS.

Clinical Relevance: Although the calf raise test is a measure of endurance, it may be a valid assessment of plantarflexor strength in people with MS, particularly in those who performed less than 20 calf raises. The calf raise test also may be a better indicator of functional mobility than peak strength and therefore useful for clinical practice.
Purpose/Hypothesis: Sleep complaints are among the most common non-motor manifestations of Parkinson disease (PD). People with mild PD demonstrate decreased physical activity (PA) quantity and intensity compared to healthy older adults (HOA). Although research has shown a bidirectional relationship between sleep and PA in HOA, the interaction of sleep deficits and diminished PA has not been well characterized in the PD population. The purpose of this study was to examine the association between objectively measured nighttime sleep and PA variables for subjects with early PD and HOA.

Number of Subjects: Thirty participants with early PD and 30 HOA were recruited from the local community. Eligibility criteria were: (1) a score of 26 or greater on the Montreal Cognitive Assessment Scale; (2) ability to walk a block without an assistive device; (3) no surgery in the past 3 months; (4) no restrictions on daily PA; and (5) no diagnosis of a neurologic condition (other than PD for the PD group). A diagnosis of PD by a physician was required for the PD group.

Materials and Methods: Participants wore a Fitbit Charge HR continuously for 14 days and nights. Sleep and PA variables were derived using the device’s standard algorithm. T-tests and Wilcoxon Rank-Sum tests compared average PA (steps and PA intensity) and sleep variables (sleep time per night, number of wakenings, naps, and nighttime interrupted sleep) between PD and HOA groups. Age-adjusted linear regression models were fit for the association between minutes of nighttime sleep and PA variables (significance level α=0.01 to correct for multiple comparisons).

Results: There were no significant differences in age, education, or number of comorbidities between groups. Participants with PD achieved 49% fewer steps per day than the HOA group (p=0.003), had significantly fewer PA minutes at all intensity levels, and 32% higher sedentary time (p<0.001). The PD group slept 75 fewer minutes per night; 18% less than HOA (p=0.003). The PD group had over three times more nights with interrupted sleep (p=0.03). Average number of wakenings per night was not significantly different between groups. Both groups demonstrated similar significant associations between lower nighttime sleep and higher sedentary time (p<0.01).

Conclusions: Commercially available activity monitors provide objective confirmation of reduced PA and sleep in people with PD. Greater amounts of sleep were associated with lower sedentary time for both groups, suggesting that interventions to improve sleep may have similar effects in reducing sedentary behavior in people with PD and HOA. Further work will need to determine the causal direction of the relationship between sleep and PA in people with PD.

Clinical Relevance: A relationship between sleep and PA in PD suggests that improved sleep may be critical to optimize interventions that aim to reduce sedentary behavior and increase PA in the PD population. The presence of reduced sleep and PA even in the early stages of PD suggests that interventions targeting improved sleep and PA should occur early after PD diagnosis.
Effects of a 6-Week Cognitively Challenging Agility Exercise Program in People with Parkinson’s Disease

Purpose/Hypothesis: Falls in people with Parkinson’s disease (PD) have a multifactorial causation, and gait and balance impairments are a major contributor to this important problem. In PD, gait and balance impairments have been associated with cognitive deficits so it may be helpful to integrate cognitive challenges into mobility rehabilitation. We hypothesized that the 6-week small group exercise program of Agility Boot Camp with Cognitive Challenges (ABC-C) will improve clinical, perceived, and objective measures of balance and gait, as well as brain connectivity in people with PD. Since our previous studies showed excessive connectivity between the SMA and PPN, we also investigated whether it can be improved with ABC-C.

Number of Subjects: 94 people with PD (age 68±7, MDS-UPDRS III: 42±12; mean±SD), of which 40 had Freezing of Gait

Materials and Methods: In this cross-over design, participants completed 6-weeks of ABC-C exercise program and 6-weeks of Education classes (placebo), with the order of interventions randomized. Progressive exercise sessions of 90 minutes 3x per week with 3-6 subjects were headed by an exercise trainer supervised by a physical therapists. Outcome measures (Off medication) included clinical (mini-BESTest and MDS-UPDRS III, and the MDS-UPDRS sub-score of Postural Instability and Gait Disorder [PIGD]), perceived condition (PDQ-39 ADL, MDS-UPDRS II), objective measures of balance and gait (inertial-sensors), and cognitive function (SCOPA-COG). To evaluate the change in outcome measures, we calculated each of the differences before and after intervention and used a linear mixed-model that included fixed effects, education versus exercise, order (exercise or education first), and period; and random effects, such as subjects. Resting state functional MRI evaluated connectivity between the PPN and SMA in a subset of 13 freezers both before and after the interventions.

Results: Among clinical measures, the PIGD score improved after the ABC-C program but not after education (p=0.002), while the MDS-UPDRS III and total mini-BESTest did not change (p=0.09, p=0.08, resp). Perceived functional independence showed a significant improvement (PDQ39, p=0.001, and MDS-UPDRS II, p=0.01). Among the objective measures of gait and balance, the following spatio-temporal gait parameters: gait speed, stride length, foot strike angle, and arm swing range of motion, significantly improved after the ABC-C program but not after education (p<0.00001). Postural sway while standing eyes open on foam improved after the ABC-C program but not after education (p=0.03), while postural responses to a Push and Release test did not change. Executive function measured with the SCOPA-COG showed a tendency to improve after the ABC-C program (p=0.06), and showed a very significant improvement only in those participants with longer disease duration (p=0.009). Lastly, the dual-task cost on gait speed significantly improved after ABC-C program but not after education (p=0.001). Brain connectivity between the brainstem locomotor center (PPN) and the supplementary motor cortex (SMA) was reduced (improved) after exercise but not after education.

Conclusions: A 6-week cognitively challenging exercise program significantly improved specific characteristics of gait and balance in a large group of patients with PD. The outcomes that improved the most with exercise were the objective measures of balance and gait. When correcting for multiple comparisons, spatio-temporal parameters of gait, dual-task cost of gait, perceived functional independence, and PIGD were the most sensitive to change after exercise compared to after education. Several characteristics of subjects at baseline, such as worse disease duration, worse FoG and worse cognitive status resulted in more improvements with the ABC-C program. Brain connectivity can be improved with the ABC-C program.

Clinical Relevance: An Agility Boot Camp with Cognitive Challenges can improve balance, gait and cognitive function, as well as brain cortical connectivity in people with PD, especially those with more severe disease, freezing of gait and cognitive impairments. Objective measures of balance and gait should be used to evaluate the success of rehabilitation intervention for gait and balance.