TITLE: Afferent Stimulation Provided by Glove Electrode during Task-specific Arm Exercise Following Stroke

AUTHORS/INSTITUTIONS: J.E. Sullivan, L.D. Hedman, D. Hurley, Department of Physical Therapy and Human Movement Sciences, Northwestern University, Chicago, IL;

ABSTRACT BODY:
Purpose/Hypothesis: The purpose of this study was to determine if home-based sensory amplitude electrical stimulation (SES) delivered via glove electrode during task-specific arm exercise would result in a greater reduction in impairment and improvement in function in the hemiparetic arm of chronic stroke survivors compared with sham stimulation during task specific exercise. We postulated that increases in sensory traffic obtained with SES would enhance practice effectiveness and result in better outcomes at the body structure/function and activity levels.

Number of Subjects: 38 subjects with arm paresis following chronic (> 6 month) stroke. Participants included 27 males, 11 females; mean age 60.63 years (37-88); mean time post stroke 7.29 years (range 1-29); 21 subjects had left hemiparesis; 17 had right-side involvement.

Materials/Methods: Participants were randomly assigned to either an SES (n = 20) or sham stimulation (n = 18) group. A blinded examiner administered the following outcome measures prior to and following the 4-week intervention: Tardieu Scale of spasticity (TSS), Fugl-Meyer Motor Assessment (FMA), Nottingham Stereognosis Assessment (NSA), Perceptual Threshold Touch using Electrical Stimulation (PTT-ES), Arm Motor Ability Test (AMAT), Motor Activity Log-14 (MAL-14), and the Stroke Impact Scale-16 (SIS-16). Subjects in both groups engaged in individually designed, task-based repetitive arm exercises at home for 30 minutes, twice daily, 5 days/week for 4 weeks (40 sessions). During exercise, all subjects wore a glove electrode. Subjects in the SES group received sub-motor amplitude SES via glove electrode while subjects in the sham group received sham stimulation during exercise. The data was analyzed using Mann Whitney U Tests.

Results: Sham and SES groups were not significantly different in pre-test FMA score, age, gender, side of involvement or dominance. Total practice time (as recorded by stimulator compliance meter) was not significantly different between groups. Practice time was not associated with a change in outcome measures. There were no statistically significant differences between the change scores for the sham and SES groups on all outcome measures. There was a statistically significant difference between the pre and post-test scores within the SES group for FMA (p = .035) and AMAT median time (p = .003), but not for the sham group. There was a moderate correlation between the pre-test FMA scores and FMA change scores (.402, p = .006) and MAL change scores (.598, p= 0). There was a moderate significant correlation between pre-test FMA and MAL change scores in the SES group (.538, p =.01).

Conclusions: Subjects who receive SES delivered via glove electrode during home-based, task-specific exercise experienced changes at the body structure function and activity levels in their impaired arms. These changes were associated with baseline motor capacity.

Clinical Relevance: SES provided by a glove electrode may provide a method to enhance the effectiveness of task-specific arm activities in chronic stroke.
ABSTRACT BODY:

**Purpose/Hypothesis:** Describe the variation in time spent and type of transfer training for patients with traumatic spinal cord injury (SCI).

**Number of Subjects:** 600 patients in a practice-based evidence, observational, cohort design

**Materials/Methods:** Physical Therapists providing regular care to patients with SCI documented the content of each physical therapy (PT) sessions using portable electronic devices featuring customized software. Session type (group vs. individual), session activities, and time spent on each activity were documented. Patient and injury characteristics were obtained via chart review. Level and completeness of SCI were determined using the International Standards of Neurological Classification of SCI. Total minutes of treatment per week were calculated. Inter-group comparisons of patient characteristics and treatment time were made using Chi-square tests and ANOVA.

**Results:** The majority of patients (589/600, 98%) participated in PT sessions involving transfer training during inpatient rehabilitation. Wide variation was found in time spent on transfer training (mean 55 minutes per week, interquartile range 28-70). Therapists provided transfer training to/from 21 surface types. Transfer board transfers were practiced most frequently (5,689 sessions with 440 patients.) Pop-over transfers also were practiced regularly (2,404 sessions with 439 patients.) The majority of pop-over training sessions were completed without a board (2158 versus 246 sessions with a board). The mean number of sessions per patient for transfer board training was 12.9, 7.1 for pop-over transfer without a board, and 1.8 for pop-over transfers with a board. Patient with an AIS A, B or C level of impairment practiced transfers more frequently than patients with AIS D (approximately 20 sessions per patient versus 12 sessions per patient). The types of transfers practiced most often with patients with C1-4 AIS A, B, C were transfer board transfers (1,011 sessions) and dependent transfers using a lift (940). Patients with low tetraplegia AIS A, B, C practiced dependent transfers with lift (528 sessions) and pop-over without board (350) most often. For patients with paraplegia, transfer board transfers (2,368 sessions) were the most common and for patients with AIS D, sit-to-stand transfers were practiced most frequently (326 sessions).

**Conclusions:** Wide variations in time spent and devices used for transfer training demonstrate the absence of a common standard of care and the need to determine the most effective transfer types to practice to prepare a patient with varying levels of SCI injury for a safe discharge.

**Clinical Relevance:** Transfer training is a crucial part of the plan of care for each patient with SCI. These findings form a foundation for analysis for transfer progression for patients with similar levels of injury.

Support: NIDRR grant #H133A060103
TITLE: Novel Locomotor Training Improves Gait Performance, Activity, and Participation in Individuals with Chronic Stroke

AUTHORS/INSTITUTIONS: T.M. Kesar, D. Reisman, M. Roos, R. Perumal, S. Binder-Macleod, Physical Therapy, University of Delaware, Newark, DE; W.B. Farquhar, Health, Nutrition, and Exercise Science, University of Delaware, Newark, DE;

ABSTRACT BODY:

Purpose/Hypothesis: Gait deficits persist even after rehabilitation in persons post-stroke and can lead to increased risks for falls and decreased community ambulation. Recently, decreased forward propulsion during terminal stance has been shown to be a critical gait deficit correlated with slow walking speed, asymmetry, and inactivity post-stroke. We hypothesized that an intervention that improved forward propulsion would have beneficial effects on gait function and activity after stroke. We developed a novel gait rehabilitation intervention combining functional electrical stimulation (FES) of ankle dorsi- and plantar-flexor muscles and Fast treadmill walking (FastFES) that uses principles from motor learning, biomechanics, and applied physiology. The purpose of this study was to test the effects of FastFES gait training on body structure and function, activity, and participation in persons post-stroke.

Number of Subjects: 12 individuals with chronic post-stroke hemiparesis (5 males, Age 63±8 years, time post-stroke 56±44 months)

Materials/Methods: Each subject participated in 12-weeks (3 sessions/week) of gait training. Each training session comprised ~30-minutes of fast walking. Based on principles of motor learning and task specificity of training, each session included walking practice with and without FES, and both treadmill and overground walking. Training speeds were based on participant’s maximal walking speed and progressed every 4 weeks. Pre- and post-training measures of body structure and function included gait kinematics & kinetics, oxygen consumption, and lower extremity portion of the Fugl-Meyer. Measures of activity included walking speed, endurance, timed up and go score, and tests of dynamic balance. The Stroke Impact Scale participation domain score was used to measure participation. Paired t-tests were used to compare pre- and post-training measures.

Results: As hypothesized, after training, forward propulsion increased by 4.3±1.8%. In addition, FastFES gait training resulted in improvements in all measures of body structure and function, activity, and participation (p<0.05). For example, overground walking speed by 0.18±0.02 mps, and 6-minute walk test distance by 89.4±22.8 m. Most changes exceeded known minimal detectable change values for persons post-stroke and the level of change reported by other gait training studies of similar duration in persons post-stroke.

Conclusions: Our results show that poor paretic leg propulsion can be improved through the combination of fast walking training and plantar-flexor muscle FES and support previous work suggesting the relationship between paretic leg propulsion and function post-stroke.

Clinical Relevance: Our findings suggest that addressing forward propulsion during gait rehabilitation post-stroke may be important for improving walking function and participation. One method that appears effective is the combination of fast walking and plantarflexor muscle FES.
Purpose/Hypothesis: The aim of this study was to determine the short-term effects of a community-based dance program for individuals with Parkinson Disease (PD) on motor and non-motor symptoms, activities of daily living, physical activity levels, participation, and quality of life.

Number of Subjects: Sixty-two subjects with idiopathic PD.

Materials/Methods: Participants were randomly assigned to a community-based Argentine Tango dance program or a control group that received no intervention. Participants were assessed off anti-Parkinson medication by a blinded rater at baseline and after three months of intervention. We measured disease severity using the Movement Disorders Society-Unified Parkinson Disease Rating Scale I-IV (MDS-UPDRS I-IV), upper extremity function was assessed using the Nine Hole Peg Test (9HPT), lower extremity function using the Five Times Sit to Stand (FTSTS) test, and balance using the Mini-BEST test. We determine gait velocity for forward (FWD), dual task (DTW), and backward (BCK) walking using a GAITRite computerized walkway. Finally, we assessed participation, quality of life, freezing of gait and physical activity using the Activity Card Sort, Parkinson Disease Questionnaire-39, Freezing of Gait Questionnaire, and Physical Activity Scale for the Elderly, respectively. Repeated measures ANOVAs with group (Tango or Control) and time (baseline, 3-month) were used to assess the effects of the intervention (p ≤ 0.05), with Tukey posthoc tests as appropriate.

Results: There were significant interactions between group and time for activities of daily living (UPDRS-II), motor symptoms (UPDRS-III), 9HPT, FTSTS, mini-BEST test, DTW and BCK. The Tango group improved significantly from baseline, and was significantly different from baseline and 3-month Control group performance, for the following measures: UPDRS-III, Mini-BEST test, and DTW (p <0.05). The Control group declined from baseline while the Tango group had no change compared to baseline in the following areas: UPDRS-II, and BCK (p<0.05). There were no significant changes in freezing of gait, quality of life, self-reported physical activity levels, or participation in either group and no differences between groups.

Conclusions: The effects of this community-based tango class are comparable to those reported previously for institution-based tango classes; however, this is the first time such improvements have been shown for individuals tested off of anti-Parkinson medication. Across all measures, those who were exercising maintained or improved performance, while those in the control group showed a decline in performance on several measures.

Clinical Relevance: It is important that physical therapists are aware of this form of group exercise therapy for people with PD. The short-term results presented here show that community-based dance may reduce severity of PD motor symptoms as well as improve balance and walking in challenging situations. This is the first phase of a 12-month study and we expect differences between the exercise and control groups to become even larger over the course of the year-long intervention.
TITLE: Locomotor interlimb coordination adaptability is slowed after stroke.

AUTHORS/INSTITUTIONS: C.L. Malecka, D. Reisman, Physical Therapy, University of Delaware, Newark, DE;

ABSTRACT BODY:

Purpose/Hypothesis: Previous studies have shown that both healthy human adults and individuals who have had a stroke demonstrate a characteristic pattern of step length adaptation during a single bout of split-belt treadmill walking (Reisman et al. 2004, Reisman et al. 2007). This paradigm, therefore, is useful for investigating the capacity of individuals who have had a stroke to alter their movement patterns in response to changing environmental demands. In this study, we investigate the rate of decay of the adapted step length pattern following split-belt treadmill walking in both neurologically intact adults and in those post-stroke. We hypothesized that individuals who have had a stroke would demonstrate a slower decay of the adapted compared to neurologically intact age-matched participants.

Number of Subjects: In an ongoing study, 6 individuals who have had a stroke and 6 age-matched neurologically intact subjects have been tested while walking on a split-belt treadmill with the ViconNexus motion capture system.

Materials/Methods: The following paradigm was used: baseline walking (belts tied slow-2min; tied fast-1min), adaptation phase (belts split in a 2:1 speed ratio-10min), post-adaptation phase (belts tied slow x5 min.) For the subjects who have had a stroke, the fast belt speed was chosen as their fastest speed, and set in a configuration such that the after-effect would induce symmetry. The neurologically intact subjects’ speeds matched their age-matched counterpart. Step length was calculated stride-by-stride as the sagittal distance from one heel marker to the contralateral heel marker at initial contact. Rate of decay of the adapted pattern was determined by calculating the number of strides required to return to a subject’s baseline step length ratio (5 consecutive strides +/-1SD) after both belts have been returned to the slow speed.

Results: Four of six individuals who have had a stroke did not return to baseline over the entire period of post-adaptation. In those cases the time for decay is the maximum number of strides in the post-adaptation period. On average, it took the individuals who have had a stroke 131.8 +/-18.2 strides to return to their baseline step length pattern, as compared to the neurologically intact subjects who required 80.2 +/-26.0 strides.

Conclusions: The results support our hypothesis and suggest that individuals who have had a stroke are slower to alter their movement patterns in response to changing environmental demands. The fact that this slowed response was observed during a return to their baseline, habitual walking pattern, rather than during the acquisition of a novel pattern makes our findings even more powerful.

Clinical Relevance: This demonstrates that when individuals who have had a stroke are asked to change their motor patterns from familiar to unfamiliar ones, the slow response observed here is likely to be even more pronounced. This has implications for therapeutic activities and session structure for therapists working with this patient population, as well as for the movement flexibility required for community ambulation after a stroke.
TITLE: Specificity of Exercise for People in Early and Mid-Stage Parkinson Disease

AUTHORS/INSTITUTIONS: M. Schenkman, Physical Therapy Program, Dept of Physical Medicine and Rehabilitation, University of Colorado, Aurora, CO; A.E. Barón, Biostatistics and Informatics, Colorado , University of Colorado, Aurora, CO; D.A. Hall, Neurological Sciences, Rush University, Chicago, IL; R. Schwartz, W.M. Kohrt, Geriatric Medicine, University of Colorado, Aurora, CO;

ABSTRACT BODY:

Purpose/Hypothesis: Exercise interventions for people with Parkinson disease (PD) have demonstrated improvements in functional activities, gait, balance, and underlying impairments. A number of exercise strategies have been investigated, with a variety of outcome measures. Yet to be established is which interventions are most effective. Our purpose was to examine specificity of exercise for individuals in early and mid-stage PD. We hypothesized that, when compared with usual care (CON), 1) flexibility, balance and functional exercise (FBF) would result in greater improvements on measures related to flexibility and balance; 2) aerobic endurance exercise (AE) would result in greater improvements on measures related to gait and endurance; and 3) both FBF and AE would result in greater improvements of UDPRS ADL.

Number of Subjects: 121 participants in early and mid-stage PD

Materials/Methods: Data are from planned secondary analyses of a 16-month randomized, controlled trial. The sample was 63% male; mean age (SD) was 64.8 (10.4). Participants were randomly assigned to 3 treatment groups: FBF, AE, or CON. Those in the FBF and AE groups participated in supervised exercise 3X/wk for 16 wks. The FBF participants received one-on-one flexibility training for 2 mo. and group balance and functional training for 2 months. The AE participants exercised at 65-80% of maximal heart rate for 4 mo. in a group exercise facility under direct supervision. The CON participants were instructed to exercise at home using the American Parkinson Foundation Exercise program and participated in group exercise 1X/mo. Outcomes included measures of balance and gait (5-m walk time and steps, 360 turn time and steps, and 6-minute walk [6MW]); spinal flexibility (functional axial rotation [FAR]); and overall functional ability (UPDRS ADL score). A mixed model with main effects for wave (baseline, 4 months), stratification variables used in randomization (sex and Hoehn and Yahr stage), and interaction terms between exercise group and wave was used to estimate the intervention effect for each dependent variable, with α = 0.05 for all tests.

Results: 105 participants (87.5%) completed the 4-mo. study. The FBF group improved more than the CON group on FAR, p = 0.044; 360 turn time, p = 0.010; and UPDRS ADL, p = 0.037. The AE group tended to improve more than the CON group on 5-m walk time, p = 0.022; 5-m walk steps, p = 0.058; and 360 turn time, p = 0.052. Improvements in 6MW approached significance (p=0.057) compared with CON for combined FBF and AE.

Conclusions: Findings support the hypotheses regarding the specificity of exercise. The efficacy of the exercise strategies to generate meaningful functional changes in PD will be established when the primary, 10-month data from the trial are analyzed.

Clinical Relevance: Based on this preliminary analysis, clinicians may consider the underlying impairments that most contribute to activity restriction when designing physical interventions for specific patients.
TITLE: Walking economy and gait function in early and mid-stages of Parkinson’s disease

AUTHORS/INSTITUTIONS: C.L. Christiansen, M. Schenkman, Physical Medicine & Rehabilitation, University of Colorado, Aurora, CO; A.E. Barón, Biostatistics and Informatics, University of Colorado, Aurora, CO; W.M. Kohrt, Medicine, University of Colorado, Aurora, CO;

ABSTRACT BODY:

Purpose/Hypothesis: The purpose of this study was to determine whether walking economy and walking endurance are worse for patients in mid-stages of Parkinson’s disease (PD) compared to early stages. It was hypothesized that more progressed disease severity would be associated with worse walking economy and endurance.

Number of Subjects: 105 (men:64, women:41)

Materials/Methods: Participants were classified at Hoehn and Yahr (HY) stages 1 to 3 (64.8 ± 10.6 yr; mean ± SD). Both HY stage and Unified Parkinson’s Disease Rating Scale motor (UPDRSm) scores were used to quantify disease severity. Participants were divided into two HY groups: stages 1-2 (n=61) and 2.5-3 (n=44). Three groupings were used for UPDRSm scores: 0-15 (n=22), 15.5-30 (n=57), and 30.5-60 (n=26). Walking economy was determined by measuring net rate of oxygen consumption (VO2) at 2.5 mph treadmill walking speed. Walking endurance was measured as distance traveled during a standardized 6-minute walk (6MW). Linear regression was used to evaluate effects of disease stage on VO2 and 6MW. Sex, body mass index (BMI), and age were included as covariates for both outcomes.

Results: There were no significant differences in VO2 (ml/min/kg) between disease stages for either the HY (8.7 ± 1.3 (stages 1-2), 9.1 ± 1.6 (stages 2.5-3); p=0.35) or UPDRSm (8.6 ± 1.2 (scores 0-15), 8.8 ± 1.5 (scores 15.5-30), 8.9 ± 1.8 (scores 30.5-60); p=0.50). 6MW distances (m) were shorter at higher ratings of disease severity considering both the HY (559.6 ± 80.4 (stages 1-2), 460.1 ± 114.0 (stages 2.5-3); p<0.001) and the UPDRSm (568.6 ± 52.6 (scores 0-15), 520.5 ± 101.1 (scores 15.5-30), 469.4 ± 134.3 (scores 30.5-60); p=0.05). All results are presented as mean ± SD.

Conclusions: It has been previously shown that people with PD have impaired walking economy (i.e., higher levels of energy expenditure) during treadmill walking compared with healthy individuals of similar age. Findings of this current study suggest that walking economy does not significantly worsen across early and mid-stages of disease severity, although the trend was for mean VO2 values to increase. In contrast, poorer walking endurance, as measured by the 6MW, was found in mid- compared to early stages. These findings suggest that reduced walking economy is accounted for by factors beyond those measured with common clinical disease severity rating scales. Additionally, decline in walking endurance is not paralleled by changes in walking economy.

Clinical Relevance: Walking economy uniquely captures a functional characteristic for people in early to mid-stages of PD, different from what is measured by the HY and UPDRSm scales. Differences between stages in 6MWT in the absence of VO2 differences indicate that these two measures capture separate aspects of walking function. Further research is needed to determine the mechanisms and functional ramifications related to impaired walking economy for people with PD.
Purpose/Hypothesis: Describe associations of patient and injury characteristics with time spent in physical therapy (PT) activities.

Number of Subjects: 600 patients in a practice-based evidence, observational, cohort design

Materials/Methods: Physical Therapists providing regular care to patients with SCI documented the content of each physical therapy (PT) session using portable electronic devices featuring customized software. Session type (group vs. individual), session activities, and time spent on each activity were documented. Patient and injury characteristics were obtained via chart review. Level and completeness of SCI were determined using the International Standards of Neurological Classification of SCI. Total minutes of treatment per week were calculated. Inter-group comparisons of patient characteristics and treatment time were made using Chi-square tests and ANOVA. Ordinary least squares regression models were used to predict time spent in PT activities. The semi-partial R² value signifies the percent contribution that the predictor variable adds to the total R² for the model.

Results: Statistically significant differences in time spent on specific PT activities were seen among injury groups. Regression models for common PT activities, in which at least 30% of patients participated, had an R² value of greater than 0.20. Injury group (paraplegia, AIS A, B, C - semi-partial R²=0.15) was the strongest predictor of time spent in manual wheelchair mobility training (R²=0.41); these patients spent 46.8 more minutes per week on that activity. For every additional FIM motor score point, patients spent 0.5 minutes more per week on manual wheelchair skills. Older age, longer time from injury to rehabilitation admission, race-black, and sports related injury also were associated with less time spent in manual wheelchair mobility training. Patient and injury characteristics also explain much of the variability spent on transfer training (R²=0.36); injury group explains almost all of the variation (semi-partial R²=0.31). Approximately 25% of the variation in time spent on PT activities of bed mobility and range of motion can be explained by patient and injury characteristics; again injury group and FIM score predict most of the variation.

Conclusions: Injury groups are strong predictors of time spent in PT activities and patients with higher FIM motor scores on admission to rehabilitation spend more time on manual wheelchair mobility and less time on transfers, bed mobility, and stretching. Other predictors, e.g., severity of comorbidities, race, etiology of injury, and ventilator use at rehabilitation admission also are significant predictors of time spent.

Clinical Relevance: Awareness of the influences of patient and injury characteristics on time spent on PT activities can assist in development of appropriate care plans for optimal achievement of inpatient goals, and provide a framework for payers and case managers in determining the appropriateness of treatment.
TITLE: Comparative Analysis of Balance Measures in Parkinson Disease  
AUTHORS/INSTITUTIONS: A. Leddy, B. Crowner, G.M. Earhart, Program in Physical Therapy, Washington University in St. Louis School of Medicine, St. Louis, MO;  
ABSTRACT BODY:  
Purpose/Hypothesis: Balance impairments are common for individuals with Parkinson disease (PD), contributing to a higher risk of falling. The current reference standard for clinically assessing balance impairments and fall risk is the Berg Balance Scale (BBS), which has been shown to have a ceiling effect, possibly missing some individuals with impairments. The Functional Gait Assessment (FGA), Balance Evaluation Systems Test (BESTest), and the Mini-BESTest, a shortened version of the BESTest, have been proposed as more challenging alternative measures of balance for these individuals.  

The purpose of this study was to evaluate the reliability and validity of the FGA, BESTest, and Mini-BESTest, as well as their ability to discriminate between fallers and non-fallers, in individuals with PD.  
We hypothesized that all 3 tests would be reliable and valid, with the BESTest being the most accurate at identifying fallers since it is a more comprehensive test.  

Number of Subjects: 80 individuals with idiopathic Parkinson disease Hoehn & Yahr (H&Y) stages I-IV  
Materials/Methods: The BBS, FGA, BESTest, and Mini-BESTest were administered to participants on their normal medication regimen. Intraclass Correlations (ICC 2,1) were used for inter-rater (n=15) and test-retest reliability (n=24), and Spearman’s Correlation was used for concurrent validity. Receiver operating characteristic plots were used for sensitivity, specificity, and cutoff values for discriminating between fallers and non-fallers (n=80). A faller was defined as someone who fell 2+ times in the prior 6 months.  
Results: The BBS had a ceiling effect, while the FGA, BESTest, and Mini-BESTest were normally distributed. Inter-rater reliability was ≥0.92 for all 4 tests. Test-retest reliability was 0.80, 0.90, 0.91, and 0.92 for the BBS, FGA, BESTest, and Mini-BESTest, respectively. Concurrent validity was high for all tests compared to the BBS (r=0.78-0.88). Cutoff scores chosen for individuals with PD were 47/56 for the BBS, 15/30 for the FGA, 69% (75/108) for the BESTest, and 22/35 for the Mini-BESTest. The Mini-BESTest had the highest sensitivity and highest overall accuracy in identifying fallers.  
Conclusions: The Mini-BESTest might be the most clinically useful of these balance tests for assessing both fall risk and balance impairments. The FGA, BESTest, and Mini-BESTest were reliable and valid measures of balance impairments across the disease spectrum (H&Y stages I-IV). The Mini-BESTest was most discriminative between fallers and non-fallers, though all tests were acceptable. Future work should examine the sensitivity of the Mini-BESTest to measuring changes in balance over time.  
Clinical Relevance: It is important to have accurate and efficient measurement tools to assess balance impairments in clinic and research settings. Earlier and more accurate identification of balance impairments in individuals with PD might allow earlier and more appropriate interventions.  

This research was supported by the Davis Phinney Foundation and NIH grant TL1 RR024995.
TITLE: Group Therapy Utilization in Inpatient Rehabilitation for Acute Spinal Cord Injury

AUTHORS/INSTITUTIONS: J.M. Zanca, Department of Rehabilitation Medicine, Mount Sinai School of Medicine, New York, NY; A. Natale, J. Nicolosi, Craig Hospital, Englewood, CO;

ABSTRACT BODY:

Purpose/Hypothesis: To describe the nature and extent of group therapy utilization in inpatient rehabilitation for spinal cord injury (SCI).

Number of Subjects: 600 patients with acute traumatic SCI who were enrolled in the first year of the SCIRehab project, a 5-year, 6-center collaborative study of inpatient rehabilitation for SCI.

Materials/Methods: Physical Therapists providing usual care to patients with SCI documented the content of each physical therapy (PT) session using portable electronic devices featuring customized software. Session type (group vs. individual), session activities, and time spent on each activity were documented. Patient and injury characteristics were obtained via chart review. Level and completeness of SCI were determined using the International Standards of Neurological Classification of SCI. Total minutes of treatment per week were calculated. Inter-group comparisons of patient characteristics and treatment time were made using Chi-square tests and ANOVA.

Results: The vast majority of patients (549 of 600, 91.5%) participated in at least one group PT session during inpatient rehabilitation. On average, nearly one-quarter of therapy time was spent in group sessions (23%, mean 101.1 minutes/week). Time spent in group activities varied greatly among patients (interquartile range 25.5-144.6, median 69.2 minutes/week). Among all patients, the most common group PT activities were strengthening (43% of mean group minutes/week), manual wheelchair mobility (17%), gait training (8%), endurance (7%), and range of motion/stretching (5%), making up 80% of all time spent in group sessions. Among all injury level/AIS subgroups, strengthening was the most common group PT activity (range 38-50% of mean minutes/week). Patients with high and low tetraplegia spent the highest percentage of group therapy time (other than time spent on strengthening) on power wheelchair mobility (15%, and 7% of mean minutes per week, respectively), while patients with paraplegia spent the most time on manual wheelchair mobility (29% of mean minutes/week). Patients with AIS D injuries spent 25% of their group therapy time on gait training.

Conclusions: While the majority of inpatient PT is provided in individual sessions, most patients also participate in group therapy and group sessions contribute significantly to total therapy time. Variation in time spent in group PT activities among injury subgroups fits with typical therapeutic goals and functional expectations for these groups, and suggests that patient needs associated with the nature and severity of injury are a major driver of treatment selection within group PT sessions.

Clinical Relevance: Group therapy can be a valuable tool to increase delivery of rehabilitation services to patients with SCI while managing cost of care. Greater understanding of group PT use in SCI rehabilitation will be important in evaluating appropriate utilization of group PT and the potential impact of policy changes that pertain to the perceived value of group PT relative to individual PT.
TITLE: Effects of a novel gaming device on upper extremity impairment and function in persons with chronic stroke: A case series

AUTHORS/INSTITUTIONS: M. Henss, S. Himmler, K. Lapota, D. Stillwell, M. Finley, S.A. Combs, Krannert School of Physical Therapy, University of Indianapolis, Indianapolis, IN;

ABSTRACT BODY:

Background & Purpose: Recent research has shown that interventions including higher numbers of repetitions improve upper extremity outcomes more so than general therapeutic exercises for persons with chronic stroke. A novel gaming device known as the Hand Dance Pro(TM) incorporates high repetitions of goal-oriented unimanual and bimanual reaching coordinated to music, with immediate performance feedback. The aim of this case series was to determine the effectiveness of Hand Dance Pro(TM) on the impairments and activity limitations associated with upper extremity deficits in persons with chronic stroke.

Case Description: Nine individuals (5.5 ± 3 years post-stroke) completed 18 sessions with the Hand Dance Pro(TM). Each session consisted primarily of unimanual reaching with the paretic arm for 15, 2-minute songs, with one minute rest breaks after each song while seated with a trunk restraint. A standardized progression algorithm was used to advance song stages by increasing number of repetitions, speed of movement and bimanual reaching requirements. Outcome measures, taken pre-intervention and immediately post-intervention included the Fugl-Meyer Upper Extremity Motor Assessment (FM), Wolf Motor Function Test (WMFT), Stroke Impact Scale (SIS), and 3-dimensional kinematic analysis (3D). Kinematics of the paretic upper extremity were acquired using the Motion Monitor(TM) during reaching to targets aligned on the side of the paretic limb (ipsilateral) and aligned with the nonparetic limb, crossing the body (contralateral).

Outcomes: Participants were categorized by impairment level based on their original FM score (mild, moderate, and severe). Gains in clinical outcomes (FM, WMFT, SIS) were found primarily in those participants with moderate and severe impairments. Those with mild impairments likely demonstrated a ceiling effect across outcomes. Across impairment levels, ipsilateral reaching kinematics demonstrated faster mean speed (7 of 9 participants) and peak speed (5 of 9 participants) with improved movement smoothness (5 of 9 participants) post intervention. Contralateral reaching kinematics demonstrated faster mean speed (6 of 9 participants) and peak speed (6 of 9 participants) with improved movement smoothness (4 of 9 participants) post intervention.

Discussion: For most of the participants in this case series, improvements were seen in stroke related impairments and functional activities after a novel six week gaming intervention for the upper extremity. The participants with more involved upper extremity impairments demonstrated greater improvements. The results of this study indicated the need for future research on gaming based interventions that progressively increase repetitions and complexity of tasks for persons with chronic stroke.
TITLE: Comparison of wrist and elbow stabilization to improve muscle activation following pinch reconstruction in tetraplegia.

AUTHORS/INSTITUTIONS: M. Johanson, V.R. Hentz, Rehabilitation R&D Center, VA Palo Alto Health Care System, Palo Alto, CA; W. Murray, Biomedical Engineering, Northwestern University, Chicago, IL;

ABSTRACT BODY:

Purpose/Hypothesis: Individuals with tetraplegia may receive tendon transfer surgery to restore grasp and pinch function. These procedures involve re-routing the brachioradialis (Br) and the extensor carpi radialis longus (ECRL) tendons volar to the flexion-extension axis of the wrist, leaving the extensor carpi radialis brevis (ECRB) muscle to provide antagonist wrist extension strength. The purpose of this study was to determine if externally stabilizing the wrist would improve the ability to activate the transferred Br and resulting pinch force, similar to the effect observed by stabilizing the elbow.

Number of Subjects: The subjects included 7 men and 1 woman age 29.6-54.7 years with injury levels C6-8, 7 with complete and 1 with incomplete injuries. All had previous tendon transfer surgeries: 8/8 had transfer of the Br to flexor pollicis longus to restore pinch, 7/8 also had transfer of ECRL to to flexor digitorum profundus restore grasp. The mean time since surgery was 7 years (sd. 8 years).

Materials/Methods: A single factor repeated measures study design was used to determine the effect of 3 support conditions on muscle activation and lateral pinch force magnitude. Muscle activation was recorded from Br and ECRB (fine-wire electrodes) and from biceps and triceps muscles (surface electrodes). Pinch strength was quantified with a force sensor and custom grip. Measurements were recorded in 3 support conditions; with the arm self-supported (SS), with elbow stabilization (ES), and with elbow and wrist stabilization (E+W). Subjects were instructed to perform maximum pinch effort and maintain 60° of elbow flexion in each of the support conditions. Pairwise differences were tested using Wilcoxon signed-rank tests (p≤.02).

Results: Pinch force magnitude significantly increased in both ES (35N sd 29) and E+W (39N sd 32), compared to the SS condition (27N sd 29). However, when E+W support was compared to ES alone, there were no significant differences in pinch strength or Br activation. None of the subjects activated the Br during pinch to the same level recorded during resisted elbow flexion, even with both the wrist and elbow stabilized. The non-transferred biceps, triceps, and ECRB were not significantly different across support conditions, but exhibited a coordinated pattern of activation.

Conclusions: The Br has potential for greater activation postoperatively. Stabilizing the elbow had the greatest effect on Br activation emphasizing the need for elbow extension strength. Added wrist support did not improve pinch force indicating ECRB provided sufficient antagonist power to keep the wrist from falling into flexion during strong pinch and grasp even after multiple tendon transfers.

Clinical Relevance: One important determinant of post-operative pinch force is how effectively the patient can activate the transferred Br during pinch effort. Postoperative rehabilitation effort should focus on elbow extension strength and stability. Tasks that improve muscle coordination between flexor and extensor muscle groups should be included in re-education protocols.
TITLE: Characterizing high velocity angular vestibulo ocular reflex (aVOR) function in Service Members post blast exposure.

AUTHORS/INSTITUTIONS: M. Scherer, Physical Therapy and Rehabilitation Science, University of Maryland, Baltimore, Baltimore, MD; M. Schubert, Otolaryngology Head and Neck Surgery, Johns Hopkins School of Medicine, Baltimore, MD;

ABSTRACT BODY:

Purpose/Hypothesis: Blasts are the most common mechanism of injury in modern warfare. Traumatic Brain Injury (TBI) and dizziness are common sequelae associated with blast exposure, however little is known about their underlying cause. Data suggest Service Members (SMs) with post-blast complaints of dizziness may have vestibular dysfunction. It has also been suggested that symptoms of dizziness experienced during running may be related to pitch plane gaze instability. The purpose of this study was to prospectively assay the vestibular systems of blast-exposed SMs with TBI and assess their symptoms while running.

Number of Subjects: N = 24

Materials/Methods: SMs recovering from TBI sustained in Iraq or Afghanistan were prospectively assigned to one of two groups based on presence or absence of symptoms of dizziness. Wireless monocular scleral search coil and rate sensor were used to characterize yaw and pitch plane angular vestibulo-ocular reflex (aVOR) gain. Visual analog scale (VAS) was used to monitor subject severity of vestibular symptoms during an exertional treadmill protocol. Each subject was assessed using standard vestibular function tests.

Results: The aVOR during yaw head impulses in the symptomatic group were lower for active impulses (Ga symptomatic = .794 + .15, Ga asymptomatic = .867 + .18) but not passive rotations (Ga symptomatic = .781 + .14, Ga asymptomatic = .745 + .18) (p= 0.0005). For pitch head rotations, aVOR gains were lower in the symptomatic group (active Ga = 0.915 + .24, passive Ga = 0.878 + .22) than the asymptomatic group (Ga = 1.03 + .27, passive pitch Ga = 0.97 + .23) (p= 0.004). VAS was worse for severity of vertigo, oscillopsia, motion intolerance, and dysequilibrium during and after treadmill testing relative to baseline (p < 0.05). Rotational chair and ENG revealed 6/9 (66%) symptomatic subjects had findings consistent with vestibular pathology compared with 1/7(14%) in the asymptomatic group. Oculomotor anomalies were apparent from 6/9 ENG examinations in the symptomatic group, compared with 4/9 (44%) in the symptomatic group.

Conclusions: Our findings suggest highly variable injury profiles in blast-exposed SMs including deficient as well as elevated aVOR responses. Our data demonstrate that some symptomatic SMs have diminished capability to generate compensatory eye movement responses during high velocity, actively generated head movements, which are typically greater than those during passive head rotations. This may suggest disruption of efference copy signals to brainstem vestibular nuclei. Exertional test findings support an association between blast exposure and exercise induced symptomology. VFT and ENG confirm the aVOR gain findings of vestibular and oculomotor dysfunction in the symptomatic relative to the asymptomatic group.

Clinical Relevance: These data provide important new evidence linking post-blast dizziness with vestibular pathology in patients with TBI and suggest that existing principals of vestibular physical therapy would be appropriate in this challenging patient population.
Purpose/Hypothesis: Non-invasive brain stimulation is emerging as a promising tool for enhancing task-oriented therapy of the upper limb in stroke patients. However, for the lower limb little is known regarding the efficacy of adjuvant stimulation to enhance paretic leg motor practice. The extension of conclusions from studies of upper limb recovery to the lower limb is limited by fundamental differences in the neural control of hand and leg. Hence the purpose of this study was to examine the effect of non-invasive brain stimulation as an adjuvant to paretic leg motor practice in stroke patients. We recently found that the non-lesioned hemisphere is maladaptive to lower limb motor control in some stroke patients, especially in patients with strong ipsilateral conductivity to the paretic ankle compared with those with weak or no ipsilateral conductivity. Hence, we hypothesized that increasing cortical excitability of the lesioned motor cortex (M1) will augment the effect of practice, but not when cortical excitability of the non-lesioned M1 is increased.

Number of Subjects: Ten moderately impaired individuals with chronic sub-cortical stroke.

Materials/Methods: Subjects practiced a visuomotor tracking task with their paretic ankle for 15 minutes while receiving facilitatory anodal transcranial direct current stimulation (tDCS) to the lesioned M1, non-lesioned M1 or sham stimulation over three different sessions. Pre and post cortical excitability measures were obtained to verify that tDCS achieved an up-regulation of the stimulated hemisphere. Pre and post tracking accuracy was calculated as the main outcome variable. Diffusion tensor imaging was used to estimate the integrity of the descending corticospinal tracts.

Results: Preliminary results from the seven patients revealed a significant main effect of stimulation (p < 0.001) on tracking accuracy. Tracking accuracy was significantly higher during stimulation of the lesioned M1 (14.8 % improvement) compared to sham (5.9 % improvement) or non-lesioned M1 (–4.3 % degradation).

Conclusions: This is the first study to report a change in motor control of the paretic lower limb following adjuvant enhanced motor practice.

Clinical Relevance: The study makes a significant contribution towards developing non-invasive brain stimulation as an adjuvant to enhance paretic lower limb control, laying the foundation for the development of new stimulation-enhanced gait training protocols for individuals with stroke.
**TITLE:** Bilateral Transcranial Direct Current Stimulation (tDCS) Improves Bilateral Hand Function in Non-Disabled Individuals

**AUTHORS/INSTITUTIONS:** E. Ahn, D. Beer, N. Kaminsky, S. Lew, Physical Therapy, University of Miami Miller School of Medicine, Coral Gables, FL; J. Rios-Gomes, E.C. Field-Fote, The Miami Project to Cure Paralysis, Miami, FL; 

**ABSTRACT BODY:**

**Purpose/Hypothesis:** Transcranial direct current stimulation (tDCS) is a non-invasive form of brain stimulation that modulates neural excitability. In individuals post stroke, unilateral application of anodal tDCS over the lesioned cortex improves hemiplegic hand function. Similar to individuals with stroke, individuals with cervical spinal cord injury (SCI) have maladaptive cortical reorganization, which adds to the impairment of bilateral hand function resulting from the SCI. In preparation for tDCS studies involving individuals with tetraplegia, we assessed the effects and safety of bilateral tDCS on bilateral hand function and short-term memory (STM) in non-disabled individuals. We hypothesized that bilateral tDCS would be associated with greater improvement on a bimanual keystroke task compared to sham-tDCS.

**Number of Subjects:** Eighteen non-disabled individuals (9 females, aged 19-48 years) participated.

**Materials/Methods:** Participants were randomized to either a low intensity tDCS (1mA; Phoresor II) or a sham-tDCS group. TDC was applied bilaterally to the cortical area identified (via transcranial magnetic stimulation) as the "hot spot" for activation of the thenar flexor muscles. Participants received tDCS or sham for 5 consecutive days. Each daily session consisted of pre-testing, 20 minutes of tDCS or sham intervention, and post-testing. A follow-up test was performed one week after the last intervention. Pre-, post-, and follow-up testing consisted of a bimanual typing task and a STM task. A two-way, repeated measures ANOVA was used to assess the effect of tDCS, and post-hoc t-tests were used to assess change in the tDCS group and sham group.

**Results:** There was an overall effect of time (p=0.01), and a time*group interaction (p=0.04). There was a significant difference in pre-test versus post-test scores for the bimanual typing task in the tDCS group (p=0.004) but not in the sham group (p=0.35). The tDCS group did not retain the improved motor performance, as follow-up scores were not significantly different from the pre-test scores. There was no significant effect of either tDCS or sham (p > 0.05 for both groups) on the STM task. No adverse effects of bilateral tDCS were encountered.

**Conclusions:** These data suggest bilateral tDCS is associated with significant improvements in bimanual motor task performance in non-disabled individuals. Short-term memory does not appear to be influenced by bilateral tDCS. While improvements were not retained at follow-up, it is possible that combining tDCS with training that involves bimanual practice will result in improved retention.

**Clinical Relevance:** Bilateral tDCS may have clinically useful applications in improving motor function in individuals with neural disorders that result in bilateral impairment of hand function. We hypothesize that these effects are due to increased cortical excitability that results in greater voluntary drive. The tDCS device has advantages of being portable and non-invasive, and could be applied concurrently with motor training.
Objective measures of community mobility in persons with SCI: Preliminary results from the MAPS Project

Purpose/Hypothesis: Spinal cord injury (SCI) is a debilitating disease which profoundly affects functional mobility, often limiting an individual’s participation with society. A primary goal of physical therapy following SCI is to promote increased participation in the home and community. While measures of ICF defined participation are multidimensional, measures of physical aspects of participation typically rely on questionnaires and structured interviews. However, these tools are subjective and limited by self/proxy report – many physical measures of participation are amenable to objective measures. For example, the use of wearable accelerometers can detect stepping activity in the disabled population. Unfortunately, such measures do not indicate where this stepping activity takes place. The Mobility And Participation following Spinal cord injury (MAPS) Project will combine wearable accelerometry with Global Positioning Satellite (GPS) technology to gain accurate measures of real-world physical activity and community mobility (CM) in the SCI population. The current hypothesis is that objective measures and clinical tests, spanning the ICF framework of disability, will correlate with measures of CM in individuals with chronic SCI.

Number of Subjects: Preliminary data in four subjects with chronic SCI (178±88 months) have been collected (3 community ambulators and 1 community wheelchair user).

Materials/Methods: Real-time GPS and step activity was collected for 10 consecutive days using 2 separate passive data logging devices. The primary measure of CM is the magnitude of time outside of home/day. Additional secondary measures include variability of mobility, assessed using coefficient of variation (CoV) and approximate entropy (ApEn). More traditional objective and subjective measures of impairments, activity limitations and participation were obtained for each subject.

Results: Individuals with SCI spend 330 ± 19 minutes outside of their home per day. The CoV of CM ranged from 0.42 to 0.66 and the ApEn ranged from 0.17 to 0.27. In ambulatory subjects, clinical based measures of locomotor ability do not appear to correlate with CM measures; for instance, an ambulatory individual who is a self-described community wheelchair user spends on average 1 hour/day more in the community with a more variable pattern of movement than an ambulating cohort. Subjective measures, such as SF36 and depression scores, account for this discrepancy.

Conclusions: Objective measures of physical activity and CM can be obtained in individuals with SCI. Both magnitude and variability of these measures may provide an objective method to quantify participation. Self-perceived vs objective measures of mobility may correlate with CM in individuals with SCI. Limitations include seasonal variation in activity/mobility and demand characteristics of the instrumentation; parallel aims of the MAPS Project are planned to address each of these limitations.

Clinical Relevance: The development of objective measures of participation may provide an effective means to optimize physical therapy interventions.
Purpose/Hypothesis: Hypokinetic movement is a cardinal sign of Parkinson's Disease (PD) and results from reduced dopaminergic stimulation of motor systems of the central nervous system. Hypokinetic movements in PD are produced by muscle contractions that are less forceful than contractions during full range movements. It is unknown if the less forceful muscle contractions of hypokinesia are associated with a general deficit in central activation of motor units. Our purpose was to assess the ability of people with PD to generate voluntary maximal motor unit recruitment of the quadriceps and to distinguish PD-related central activation changes from the effects of aging.

Number of Subjects: 9

Materials/Methods: Subjects for this pilot project included 3 young adult controls (YAC; 3M; 23.3+/-.1.5 yrs(m+/-sd)), 3 older adult controls (OAC; 2M, 1F; 51.7+/-.5 yrs), and 3 adults with idiopathic PD that reported leg fatigue after walking (PDF; 2M, 1F; 63.0+/-.3.6 yrs). PD subjects were community ambulators (H&Y 2.5 to 3; UPDRS Motor 16.3+/-.1.5) tested ON anti-PD medication. A separate training session familiarized subjects with the torque collection and e-stim. Testing consisted of maximal voluntary isometric contractions of the quadriceps (Biodex System 3; knee flexed to 60 degrees) without (MVIC) and with (MVIC+S) transcutaneous femoral nerve stimulation (twitch interpolation using the Digitimer DS7A). Data extraction included MVIC, MVIC+S, MVIC normalized to body weight (NMVIC), MVIC+S normalized to body weight (NMVIC+S) and the Central Activation Ratio (CAR). CAR is the ratio of MVIC torque to MVIC+S torque. CAR less than 1 indicates e-stim increased torque implying that central activation did not recruit all available motor units. Data were compared using ANOVA with p<0.05.

Results: TORQUE in Nm (mean, sd) = YAC: MVIC(186.3, 63.7); MVIC+S(189.1, 57.5). OAC: MVIC(121.3, 29.8); MVIC+S(128.1, 39.7). PDF: MVIC(118.4, 44.7); MVIC+S(124.3, 55.9). No significant torque differences due to e-stim or between groups. NORMALIZED TORQUE in Nm/Kg (mean, sd) = YAC: NMVIC(2.6, 0.4); NMVIC+S(2.6, 0.4). OAC: NMVIC(1.4, 0.4); N-MVIC+S(1.3, 0.3). PDF: NMVIC(1.4, 0.7); NMVIC+S(1.5, 0.9). No significant normalized torque differences due to e-stim. The YAC group was stronger than OAC and PDF (MVIC: YAC vs OAC, p=0.041; YAC vs PDF p=0.042). CAR (mean, sd) YAC(0.98, 0.04); OAC(0.96, 0.07); PDF(0.97, 0.08). No significant CAR differences between groups.

Conclusions: Although younger subjects could produce more torque per unit of body weight, our pilot data show no differences in MVIC activation of the quadriceps between young, aged or PD subjects. Small torque increases produced by electrical stimulation were not significant. Mean CAR by group showed 96% to 98% voluntary activation which is consistent with the literature. The data are drawn from a small number of individuals and show high variability. A larger sample is needed to confirm these pilot data.

Clinical Relevance: Central drive for isolated muscle contraction is unaffected at H&Y stage 2.5 to 3. Strength and endurance training can recruit the majority of motor units.
TITLE: Robotic Exoskeletons: A View into the Future of Rehabilitation

AUTHORS/INSTITUTIONS: A. Jayaraman, C. Kinnaird, S. Madhavan, M. Rafferty, K. Nance, Sensory and Motor Performance Program, Rehabilitation Institute of Chicago, Chicago, IL; K. Oikawa, E. Yousuke, Fundamental Technology Research Center, Honda R&D Co., Ltd., Tokyo, JAPAN; Z.W. Rymer, Physical Medicine and Rehabilitation, Northwestern University, Chicago, IL; T. Hornby, Physical Therapy, University of Illinois at Chicago, Chicago, IL;

ABSTRACT BODY:

Purpose/Hypothesis: Recovery of independent over-ground ambulation is a major goal of rehabilitation for individuals with neurological impairments, as occurs in people following stroke and incomplete spinal cord injury (SCI). Traditional rehabilitation robots are typically limited to providing stepping practice on a treadmill or constrained environment, and do not provide the challenge and specificity of walking practice over-ground. However, the use of unconstrained robotic exoskeletons may allow gait rehabilitation to be integrated with activities of daily living. The objective of this proposed study is to examine the effects of a prototype walk assistive device designed by Honda R&D® on biomechanical and physiological aspects of walking performance in individuals with neurological injury. The specific aims are: 1) to investigate changes in clinical walking performance, walking energetics and gait kinematics during a single session with and without the device and 2) to investigate changes in corticospinal excitability during walking with and without the device.

Number of Subjects: Preliminary data has been collected in six individuals (three with chronic incomplete spinal cord injury [SCI] and three with chronic unilateral stroke).

Materials/Methods: The battery-operated exoskeleton fits around the pelvis and thighs, with motors aligned at each hip. During operation, the user’s walking pace is monitored through hip angle sensors, and provides correctly timed swing- and stance-phase assistance through the thighs frames; such assistance is thought to facilitate gait by lengthening the user’s stride and increasing gait efficiency. Outcome measures include clinical measures of functional ambulation, oxygen consumption, EMG, gait kinematics and corticospinal motor evoked potential area (MEP area) using transcranial magnetic stimulation (TMS).

Results: Preliminary data indicate improvements in the 6-minute walk (33-115 ft increase in subjects with stroke, 24-77 feet in SCI) group over a single session. Average metabolic costs were lower during overground and treadmill walking people post-stroke, with no major improvements in the SCI group. Improvements towards normal patterns were observed for hip-knee coordination, stepping consistency, hip flexion angles, and EMG activation patterns in the stroke group. Large increases in corticospinal excitability in the paretic side of the stroke group and more affected side of the SCI group was also observed during walking with the device on.

Conclusions: Preliminary data shows promise of the device to facilitate over-ground walking performance in subjects post-stroke. Further research is needed to see if Honda® assistive device will aid clinical training, act as an assistive device, or both. Further testing is on-going with plans for a future clinical trial.

Clinical Relevance: The Honda® assistive device has shown promise in improving walking in the neurological population in addition to being light weighted (6-lbs) and easily adjustable per individual requirements.
PURPOSE/HYPOTHESIS: A primary aim of physical therapy intervention in people with Parkinson’s disease (PD) is to improve quality of life. Physical therapists typically conduct a variety of common physical mobility tests during the examination process. The relationship between performance on tests of physical mobility and health related quality of life in patients with PD is not well understood. Our purpose was to determine which tests of physical mobility, commonly implemented by physical therapists, best predict health related quality of life in people with PD.

NUMBER OF SUBJECTS: Two-hundred and twenty individuals with PD participated in a cross-sectional study (mean age = 67.7 +/- 8.9, H&Y = 2.37 +/- .65, disease duration 6.4 +/- 4.9, 57% male).

MATERIALS/METHODS: The Parkinson’s Disease Quality of Life Questionnaire (PDQ-39) and the Freezing of Gait Questionnaire (FOG-Q) were self-administered by all patients. An examination of physical mobility (balance, walking, hand function) was conducted with patients on medication using the Functional Gait Assessment (FGA), the Berg Balance Test (BBT), the Functional Reach Test (FR), the Timed Up & Go (TUG), the 10 meter walk test (10MWT), the 6-minute walk test (6MWT), and the 9 Hole Peg Test (9-Peg). Pearson correlation coefficients were conducted to examine the strength of association between the PDQ-39 mobility subscore and all tests of physical mobility. Those mobility tests found to correlate significantly (p<.001) with a magnitude of r > 0.4 with the PDQ-39 mobility subscore were entered into a stepwise regression model with the PDQ-39 mobility subscore and the PDQ-39 total score as dependent variables.

RESULTS: The mean PDQ mobility subscore was 24.0 +/- 22.8 and the mean PDQ-39 total index score was 21.2 +/- 13.2. A poorer performance on the FOG, BBS, FR, FGA, 10MWT and 6MWT was significantly correlated to poorer PDQ-39 total scores with magnitudes ranging from .42 to .72. The FOG-Q (R2 =.500) and the FGA (R2 change = .132) predicted 63.2% of the total variance in the PDQ-39 mobility subscore and 44.9% of the variance in the PDQ-39 total score.

CONCLUSIONS: Performance on the FOG-Q and the FGA appear to be important predictors of health related quality of life in people with PD. These results suggest that balance and gait related limitations and particularly the presence of freezing episodes are important to address.

CLINICAL RELEVANCE: Given the many tools available to physical therapists to measure gait and balance, this study suggests that the FOG-Q and the FGA may be better indicators of poorer quality of life than the BBS, FR, TUG and timed walking tests. However, the relationship between changes on the FOG-Q and the FGA and improvements in quality of life is unknown and needs further investigation.
**ABSTRACT BODY:**

**Purpose/Hypothesis:** People with Parkinson disease (PD) experience functional difficulties (e.g., with gait, balance, transfers, and ADLs) even in early stages of the disease. Typically the effects of PD and response to interventions are quantified using the Unified Parkinson’s Disease Rating Scale (UPDRS). This scale does not adequately describe the patient’s difficulties with physical function and disability and may be less responsive to rehabilitation interventions than other more specific measures of function. Our purpose was to describe a profile of functional limitation across stages of disease severity using a variety of standard measures of functional ability in individuals in the early and mid-stages of Parkinson Disease (PD) and to provide normative data for these common measures.

**Number of Subjects:** 339 subjects with a diagnosis of idiopathic PD, Hoehn & Yahr stages 1-3.

**Materials/Methods:** Baseline data were combined from 5 randomized controlled exercise trials and cross-sectional studies. Mean disease duration was 6.0 (5.1) years and mean age was 66.1 (9.3). Means, medians, standard deviations, and ranges of physical function were calculated for measures of overall functional capacity (Continuous Scale Physical Functional Performance Test – (CS-PFP)), balance (Functional Reach (FR), Timed Up & Go (TUG), 360 turn test), gait (6 minute walk test (6MWT) and 2 minute walk test (2MWT)) and basic functional mobility (supine to stand and functional axial rotation (FAR)). A functional profile using these measures was described in relation to disease severity using the modified Hoehn & Yahr (H&Y) categorized into stages 1.5, 2, 2.5 and 3 and using the UPDRS motor scores categorized as follows: 1-15, 16-30, 31-45, and 46-60.

**Results:** Forty four percent of the sample was in Stage 1, 1.5 or 2 (early stages) while 56% of the sample was in Stages 2.5 or 3 (mid-stages). The UPDRS motor subscores ranged from 2-59.5 with a mean (SD) score of 25.2 (9.56). At each stage of PD (from least to most involved) the scores on all functional measures indicated a significant and progressively reduced functional status. The CS-PFP, 6MWT and the FAR identified limitations throughout the disease process whereas the FR, TUG, 360 turn test, 2MWT and supine to stand were more useful identifying limitations in the mid-stages of PD.

**Conclusions:** The results of this study provide a greater appreciation of the functional limitations associated with different stages of Parkinson Disease and can guide timely initiation of rehabilitation interventions.

**Clinical Relevance:** The results can also be used to guide the choice of functional outcome measures at different stages of disease severity. In addition, these data provide normative values across multiple functional measures allowing clinicians and researchers to compare their data to points of reference facilitating more meaningful interpretation.
TITLE: PROFILE PD: Profile Of Function and Impairment Level Experience with PD. Clinimetric Properties of a Rating Scale for Physical Therapist Practice

AUTHORS/INSTITUTIONS: M. Schenkman, Physical Therapy Program; Dept of Physical Medicine and Rehabilitation, University of Colorado, Aurora, CO; A.E. Baron, K. McFann, Biostatistics and Informatics, School of Public H, University of Colorado, Aurora, CO;

ABSTRACT BODY:

Purpose/Hypothesis: The Unified Parkinson's Disease Rating Scale (UPDRS) is the gold standard for examination of people who have Parkinson disease (PD). This scale has several problems that limit its applicability for physical therapist practice. A clinical test is needed that is reliable, valid, applicable to physical therapist practice, and appropriate for use in early and mid-stages of the disease. PROFILE PD is one such scale, consisting of 24 items that would typically be assessed during the physical therapist’s examination and evaluation of patients with PD. The purpose of this paper is to report on clinimetric properties of the PROFILE PD and to make the test available for use.

Number of Subjects: 86 individuals in early and mid-stages of PD

Materials/Methods: Inter-rater reliability was determined using the intra-class correlation coefficient (ICC) and consisted of a comparison of data obtained by the two physical therapists who administered that test at two separate times within a single test session. Internal consistency was established using Cronbach’s alpha. Individual item contributions were examined by using the alpha if item deleted option. Construct validity was established by correlating the UPDRS (the current gold standard), the Continuous Scale Physical Functional Performance test (CS-PFP), and the Schwab & England Activities of Daily Living Scale (S&E) to the PROFILE PD total score. To establish discriminant validity, the correlation was estimated between the PROFILE PD and a common measure of depression (CES-D). Construct validity and structure of the PROFILE PD were further examined using exploratory factor analysis (EFA) using Principal Component Analysis (PCA) with Promax rotation which allows a correlated factor structure.

Results: The ICC was estimated as 0.97. Construct validity was demonstrated with the UPDRS (r = 0.86, p < 0.0001), S&E (r = -0.83, p < 0.0001), and CS-PFP (r = -0.62, p < 0.0001). PCA demonstrated a single scale.

Conclusions: The PROFILE PD is a reliable and valid scale that can be used to quantify alterations in body systems and activity of individuals in early and mid-stages of PD. Future investigations will determine whether PROFILE PD is more responsive to change than the UPDRS in participants with PD undergoing a physical intervention.

Clinical Relevance: Profile PD can be used by physical therapists to structure the examination of individuals in early and mid-stages of PD. This information, obtained during the initial examination, can provide the physical therapist with a quantitative documentation of the patient’s status in almost all areas that are assessed globally. These data are not intended to substitute for the quantitative performance data (e.g., measures of balance and gait) or for the UPDRS score. However, they can complement such data and provide an overall summary of the patient’s difficulty with body systems and activities associated with PD.
TITLE: Physical activity characteristics of fallers and non-fallers with Parkinson disease

AUTHORS/INSTITUTIONS: K.B. Foreman, L.E. Dibble, Physical Therapy, University of Utah, Salt Lake City, UT; J. Cavanaugh, Physical Therapy, University of New England, Portland, ME; T. Ellis, Physical Therapy, Boston University, Boston, MA; G.M. Earhart, Physical Therapy, Washington University, St Louis, MO; M. Ford, Physical Therapy, University of Alabama at Birmingham, Birmingham, AL;

ABSTRACT BODY:

Purpose/Hypothesis: To examine differences in physical activity among individuals with Parkinson disease (PD) based on fall history.

Number of Subjects: Eighty-one community-dwelling individuals with PD participated (mean age = 68.6 +/- 8.2 years, disease duration 4.9 +/- 4.1 years, median H&Y 2 +/- 0.6, 63% male); all were enrolled in a longitudinal study of quality of life and mobility decline.

Materials/Methods: Only baseline data were included for analysis. Motor status was quantified using the motor subscore of the Unified Parkinson’s Disease Rating Scale (MDS-UPDRS). Postural stability was quantified using the Berg Balance Test (BBT). Self-reported physical activity over 7 days was quantified using the Physical Activity Scale for the Elderly (PASE); actual physical activity was recorded over multiple days using a step activity monitor (SAM; Orthocare Innovations, Inc., Mountlake Terrace, WA). Variables extracted from SAM data included overall activity (STEPS) and two indices of activity intensity (MINUTES of moderate intensity activity (i.e., > 100 steps/minute) and MAX output (steps/minute during most active 30 consecutive minutes)). Fallers were classified as participants who had fallen at least once in the previous 6 months. Between-group differences and relationships among variables were examined using parametric and non-parametric tests (α = 0.05).

Results: There were 44 fallers and 37 non-fallers. Groups were similar [p>0.05] in age (69.9 +/- 8.1 vs. 66.9 +/- 8.1 years), days of SAM recording (6.8 +/- 1.4 vs. 6.8 +/- 1.4), MDS-UPDRS (29.5 +/- 13.0 vs. 26.0 +/- 10.5), and STEPS (8,017 +/- 3,416 vs. 9,822 +/- 4527). Groups were different in BBT score (49.25 +/- 8.9 vs. 53.4 +/- 4.3, p < 0.01), PASE score (126.5 +/- 64.4 vs. 164.3 +/- 78.6, p = 0.04), MINUTES (8.3 +/- 11.7 vs. 19.0 +/- 22.8, p = 0.01), and MAX (22.3 +/- 10.4 vs. 30.7 +/- 13.4, p < 0.01). SAM variables were strongly related to one another (rho > 0.70). MDS-UPDRS motor score was only modestly related to PASE score (rho = - 0.35), STEPS (rho = - 0.33), MINUTES (rho = - 0.14), and MAX (rho = - 0.27).

Conclusions: In this sample of individuals with PD, fallers were less physically active than non-fallers. Even most non-fallers, however, did not meet Center for Disease Control recommended levels of physical activity. The MDS-UPDRS was a relatively poor delineator of fall status and appeared to provide substantially different information than activity measures.

Clinical Relevance: The study provides preliminary information to begin the development of specific physical activity targets that may alter the rate of PD-related mobility decline. In particular, targets that reflect activity intensity show promise for determining fall risk in PD. Whether those who routinely engage in at least moderate intensity physical activity are less likely to sustain a future fall has yet to be determined.

Acknowledgements: Funding for this project was provided by the Davis Phinney Foundation, the Parkinson Disease Foundation and NIH K12 Building Interdisciplinary Research in Women’s Health
TITLE: Determining an optimal duration of locomotor training to maximize functional improvements post stroke
AUTHORS/INSTITUTIONS: K.A. Danks, D. Reisman, S. Binder-Macleod, Physical Therapy, University of Delaware, Newark, DE; M. Roos, Biomechanics and Movement Science, University of Delaware, Newark, DE;

ABSTRACT BODY:

Purpose/Hypothesis: Locomotor intervention studies in persons with chronic stroke have varied between 4 weeks and 6 months. The ideal length of treatment is currently unknown and may vary based on the intervention itself and on the level of impairment of participants. The purpose of this study was to determine the optimal duration needed to maximize functional improvements with a new treadmill training intervention. We hypothesized that a minimum of 12 weeks of fast treadmill training with functional electrical stimulation (FES) to the dorsiflexors (DF) and plantarflexors (PF) in those with chronic stroke would be needed to show a clinical change that would be maintained at follow-up.

Number of Subjects: Twelve subjects with chronic (>6 months) post-stroke hemiparesis were included in this study.

Materials/Methods: During training, subjects walked on a treadmill and over ground. In each training session, subjects walked a total of 30 minutes with FES to the DF and PF of the impaired lower extremity with on/off cycles of FES of one minute. Subjects walked in short bouts on the treadmill, the session concluded with over ground walking practice. Clinical testing was conducted pre-training (PT), at 4 weeks (TE1), 8 weeks (TE2), 12 weeks (TE3), and at 3 months post training (3mo). Clinical testing included the 6 Minute Walk Test (6MWT), Self Selected Gait Speed (SS), Functional Gait Assessment (FGA), Stroke Impact Scale-Participation (SIS-P), and the Timed Up and Go (TUG).

Results: Repeated Measures ANOVA revealed a significant difference (p <0.050) between all time points during training for all measures, except between TE1 and TE2 for the 6 MWT and the FGA. From TE3 to 3mo, there was a significant decline in the 6 MWT (p=0.030), while TUG (p=0.523), FGA (p=0.202) and SS (p=0.068) had no significant change in scores over the 3 month time period, though all values declined. There were 2 subjects with high levels of functional impairment prior to starting the intervention whose improvements in function plateaued between 4 and 8 weeks of training.

Conclusions: Results of this study demonstrate that functional changes can be expected with a minimum of 12 weeks of fast treadmill walking with FES. Less than 12 weeks of training will result in improvements in only some functional measures. Since there was no plateau in function between 8 and 12 weeks of training, it is possible that additional significant gains would be observed if training continued beyond 12 weeks. This is reinforced by the fact that gains in function were not maintained for all measures at the 3 month follow-up, suggesting that further training may be needed. Another possibility is that a walking program following the intervention may be necessary for the maintenance of functional gains.

Clinical Relevance: Fast treadmill walking programs for subjects post stroke should include a minimum of 12 weeks of training. However, results from 2 subjects suggest that the influence of dosage on functional improvement may be individually mediated by the level of impairment.
TITLE: Gait Training Trends in Spinal Cord Injury Rehabilitation

AUTHORS/INSTITUTIONS: L. LaBarbera, Carolinas Rehabilitation, Charlotte, NC; S. McDowell, Shepherd Center, Atlanta, GA;

ABSTRACT BODY:

Purpose/Hypothesis: Describe details of gait training during physical therapy (PT) sessions and variation in time spent for patients with traumatic spinal cord injury (SCI). Investigate the timing of gait training onset post SCI.

Number of Subjects: 600 patients with traumatic SCI

Materials/Methods: Physical Therapists providing regular care to patients with SCI documented the content of each PT session using a portable electronic devices featuring customized software. Session type (group vs. individual), session activities, and time spent on each activity were documented. Patient and injury characteristics were obtained via chart review. Level and completeness of SCI were determined using the International Standards of Neurological Classification of SCI. Total minutes of treatment per week were calculated. Inter-group comparisons of patient characteristics and treatment time were made using Chi-square tests and ANOVA.

Results: PTs provided gait training to 36% of patients in the SCIRehab study during 2,773 PT sessions; 96% of patients with AIS D level of injury received gait training. Much variability in time spent was seen between and within injury groups. The interquartile range for patients with AIS D was 35-115 minutes per week (median 78, mean 70). The mean onset of gait training for all AIS categories was 41 days (SD 33) post injury (range 4-248 days). Significant variation was seen by injury level; patients with AIS D began work on gait significantly sooner than patients with other AIS classifications. (25 versus 53 mean days).

74% of gait training occurred during individual PT sessions and 26% occurred in groups. Most gait training occurred on level terrain using a walker for assist and 26% of patients were able to ambulate between 101 and 200 feet during at least one PT session. External joint stabilization was used with 40% of patients. Body weight support (BWS) was used in 15% of gait training sessions and for those patients trained with BWS, 56% were assisted manually and 39% received robotic assist. Minimal assistance with ambulation was needed by 49% of patients.

Conclusions: Much variability was seen in the dosage of gait training regardless of level and completeness of injury. When gait training is included in a patient’s treatment regimen, it comprises a significant portion of inpatient PT time. Timing for initiation of gait training post injury was highly variable.

Clinical Relevance: A significant amount of research is examining gait training after SCI. This study begins to look at what is actually occurring in SCI rehabilitation on a daily basis. Careful analysis of dosage and timing of gait training will assist in efficient treatment planning and may help to guide future research.

Support: NIDRR grant #H133A060103
Purpose/Hypothesis: Superior canal dehiscence syndrome (SCD) is a condition in which there is a fistula, or opening, of the bony covering over the superior semicircular canal. Patients with SCD often present with hyperacusis of bone conducted sounds (i.e. patients can hear physiologic sounds such as their eyes moving, heartbeat, etc.), autophony, and conductive hearing loss among other symptoms. SCD is typically diagnosed by high resolution CT in combination with audiometric and Vestibular Evoked Myogenic Potential (VEMP) testing and is treated with surgical intervention; canal plugging and resurfacing. Deficits in angular vestibulo-ocular reflex (aVOR) function have been documented in the plane of the superior canal both prior to and following surgical repair, however little is known about the functional impairment and extent of recovery following surgical repair. The purpose of the study is to characterize the degree of functional aVOR impairment and recovery post SCD repair.

Number of Subjects: Normal controls (n=22), and patients with documented SCD (n=19)

Materials/Methods: All subjects completed dynamic visual acuity (DVA) testing, which measured visual acuity during two conditions: active horizontal head rotation and passive head rotations in the plane of each semicircular canal (right and left anterior, posterior and horizontal). Patients with SCD completed testing: 1.) prior to surgical repair; 2.) post surgical repair <1 week and; 3.) post surgical repair > 3 months. Responses were compared to those of normal controls and between the 3 trials to determine the extent of functional aVOR impairment in each canal and extent/pattern of recovery in 3 months following surgery.

Results: Prior to surgical repair, no significant difference in active or passive dynamic visual acuity between patients with SCD and normal subjects was demonstrated. One week post surgical repair (mean: 5.2 days), we observed abnormal active horizontal DVA in patients with SCD on the affected side (n=5). Greater than 3 months post surgical repair (mean: 3.8 months), we observed abnormal passive DVA in the superior canal only (n=14).

Conclusions: In patients with SCD, preliminary data suggest that active horizontal DVA is reduced directly following surgical repair of SCD and improves to within the normal range by 3 months, while passive DVA remains abnormal in the affected, superior semicircular canal.

Clinical Relevance: Vestibular rehabilitation incorporating gaze stability exercises is warranted for individuals recovering from SCD repair.
TITLE: Ipsilateral muscle activity in the upper limb revealed by motor cortical stimulation

AUTHORS/INSTITUTIONS: L.R. Montgomery, Neuroscience Graduate Studies Program, The Ohio State University, Columbus, OH; S.L. Moran, W.J. Herbert, Division of Physical Therapy, The Ohio State University, Columbus, OH; J.A. Buford, Center for Brain and Spinal Cord Repair, The Ohio State University, Columbus, OH;

ABSTRACT BODY:

Purpose/Hypothesis: The primary motor cortex (M1), supplementary motor area (SMA), and dorsal premotor cortex (PMd) constitute the cortical motor areas that are the primary source of the corticospinal tract. A majority of corticospinal fibers (~80-90%) decussate and travel as the lateral corticospinal tract influencing motor output in the contralateral limb. The remaining 10-20% of corticospinal fibers however do not cross and instead influence the motor output in the ipsilateral limb (left motor areas influence left limb movement). These ipsilateral fibers are a potential source of motor recovery following a cortical injury and yet few studies have used neurophysiological techniques such as EMG to look at this system in primates. We used stimulus trains to investigate the role of the ipsilateral corticospinal system in the control of reaching in non human primates.

Number of Subjects: Three M. fascicularis monkeys

Materials/Methods: A craniotomy was made over the left motor cortex and a recording chamber was placed over the craniotomy. For several months two to four microelectrodes per day were placed in different sites in the cortical motor areas and a train of 36 pulses at 333Hz was applied 10-12 times to each electrode. Muscle activity from EMG electrodes in 24 muscles in the trunk and upper limbs was recorded during the stimulus, and this activity was then analyzed using a computer software package. Statistical analysis was carried out using SPSS and Microsoft Excel software.

Results: Axial and shoulder muscles had the highest number of ipsilateral responses compared to more distal muscles around the elbow and wrist. When comparing each of the cortical motor areas we found that a larger percentage of ipsilateral responses occurred following stimulation of SMA than any of the other cortical motor areas. Combining data from all motor areas we found that about 30% of muscle responses were in the ipsilateral upper limb. This number appears higher than numbers from anatomical studies, however this difference may be accounted for by the fact that our EMG comes mainly from proximal muscles (which are often the target of projections from the ventral corticospinal tract where most of the ipsilateral fibers are located). Thus our sampling of muscles may lead us to sample more of the ipsilateral output than we otherwise would if the focus had been on hand and finger musculature.

Conclusions: The ipsilateral corticospinal system has a significant influence over proximal muscles involved in reaching, with SMA providing the largest number of projections in this ipsilateral system compared with the other cortical motor areas.

Clinical Relevance: It has been suggested that the ipsilateral corticospinal system may have a strong role in motor recovery following stroke. As we have shown, ipsilateral cortical motor outputs do play a role in the control of reaching. Our findings provide evidence that the ipsilateral corticospinal system has the capacity to influence upper limb motor recovery following injury to the contralateral corticospinal system that occurs following stroke.
TITLE: Shoulder Kinematics during Glenohumeral Elevation in Individuals with Paraplegia and Impingement and an Able-bodied Cohort

AUTHORS/INSTITUTIONS: D.A. Nawoczenski, Physical Therapy, Ithaca College, Rochester, NY; L.M. Riek, School of Nursing, University of Rochester, Rochester, NY; P. Ludewig, Department of Physical Medicine and Rehabilitation, University of Minnesota, Minneapolis, MN;

ABSTRACT BODY:

Purpose/Hypothesis: Following spinal cord injury (SCI), shoulder demands are radically altered as usage and weight-bearing increase. Consequently, shoulder pain is common in persons with paraplegia (40-67%) and nearly 70% are diagnosed with shoulder impingement syndrome (SIS). Altered kinematics have been linked to impingement in the able-bodied population (decreased scapular posterior tilt (PT), increased internal rotation (IR), and decreased upward rotation (UR), and increased glenohumeral (GH) IR) however, there are limited data investigating shoulder kinematics in people with SCI. The purposes of this study were to 1) assess scapular and GH kinematics during humeral elevation in persons with SCI with and without SIS; and 2) compare these kinematics to an able-bodied cohort without SIS. When compared to the SCI group without pain, we hypothesized that the SCI impingement group would demonstrate decreased scapular PT, increased IR, and decreased UR, as well as increased GH IR.

Number of Subjects: 41 individuals with paraplegia divided into two groups: no pain (n=20, mean age 37.6 ± 7.9 years) and pain consistent with SIS (n=21, mean age 46.9 ± 12.1 years).

Materials/Methods: The Flock of BirdsTM magnetic tracking device was used to acquire three dimensional motion of the trunk, scapula, and humerus during GH elevation in the scapular plane. Scapula and GH kinematic data were analyzed at specific angles of humerothoracic elevation (30, 60, 90, and 120 degrees). A two-way repeated measures ANOVA with factors of group (no pain and pain) and elevation angle was used to test the hypothesis. Means and standard error values generated from current literature in an able bodied cohort without pain were used to compare SCI and able-bodied groups.

Results: When comparing SCI groups, the pain group showed increased scapular PT, decreased IR, increased UR, and decreased GH IR. However, these differences were not significant (p>.05). When comparing SCI and able-bodied groups, the SCI group exceeded two standard errors for GH IR (increased), scapular PT (decreased) and IR (increased) at higher levels of elevation. These motions are in directions that have been linked to increased risk for SIS in able-bodied individuals.

Conclusions: Surprisingly, there were no significant kinematic differences between the SCI pain and no pain groups. In fact, the SCI pain group displayed kinematic patterns that were closer to the able-bodied cohort without pain. Perhaps more concerning is that both SCI groups, as compared to the able-bodied cohort, showed kinematic patterns that are considered detrimental to shoulder health.

Clinical Relevance: The detrimental kinematic patterns that occur during scapular plane elevation may help to explain the high incidence of shoulder pain in the SCI population. Prevention and/or interventions that are directed to improving shoulder kinematics such as selective shoulder stretching and strengthening, combined with modified wheelchair postures may help reduce SIS in this high risk group.
TITLE: Reliability of spatiotemporal asymmetry during overground walking for individuals following chronic stroke

AUTHORS/INSTITUTIONS: E. Randall, M.D. Lewek, Division of Physical Therapy, University of North Carolina at Chapel Hill, Chapel Hill, NC;

ABSTRACT BODY:

Purpose/Hypothesis: After stroke, walking often becomes slow and asymmetric. Rehabilitation to correct asymmetries are important because asymmetric gait is energy inefficient, and presents a challenge to balance control, which in turn increases the risk of falls and secondary injuries. Understanding the test-retest reliability of spatiotemporal asymmetry (STA) from session to session is essential for determining if changes made in response to treatment exceed normal day-to-day variation. Currently, there are no measures of clinically meaningful changes in STA for individuals with chronic stroke.

Number of Subjects: We recruited 23 individuals (14M/9F) with chronic (>6 months) hemiparesis resulting from a unilateral, non-cerebellar stroke. Participants were permitted to use AFOs or assistive devices, but had to be able to walk 10m without assistance.

Materials/Methods: All subjects participated in two visits, at least one week apart, to record STA. At each visit, participants walked overground, across a 14-foot GAITRite mat (CIR Systems, Havertown, PA) for 3 trials at self-selected speed (SSV) and 3 trials at the fastest possible walking speed. STA ratios (paretic/non-paretic) were calculated for step length, stance time, and swing time. Excessive asymmetry was defined as < 0.9 or > 1.1 (Patterson, 2008). Intraclass correlation coefficients (ICC 2,1) were calculated to determine reliability between sessions. Minimal detectable changes (MDC90) were calculated to determine whether a change in an STA variable was clinically significant and exceeds day-to-day variations.

Results: Subjects self-selected gait speed was 0.78±0.30m/s (range: 0.21 – 1.27m/s) for visit one and 0.70±0.25m/s (range 0.31 – 1.15m/s) for visit two. STA variables were highly consistent from session to session with ICCs ranging from 0.962 to 0.991. Stance time asymmetry exhibited the lowest ICC’s (SSV: 0.964; Fast: 0.962). MDC90 values were calculated for step length (SSV: 0.12; Fast: 0.16), swing time (SSV: 0.22; Fast: 0.17), and stance time asymmetry ratios (SSV: 0.06; Fast: 0.06). Gait speed MDC90 values were 0.17m/s for SSV and 0.19m/s for fast walking.

Conclusions: Despite the ability to walk at a range of gait speeds, if consistent instructions are given, individuals with chronic stroke produced a remarkably consistent STA and gait speed. The consistency of STA persisted even when subjects were challenged with a fast walking speed. This may suggest that even though therapeutic interventions may be successful at improving gait speed, the presence of spatiotemporal asymmetries may be harder to eliminate.

Clinical Relevance: These data provide clinically meaningful changes in STA, which are appropriate for setting clinical goals for patients with chronic stroke, in response to treatment. As further treatments are developed to minimize asymmetries, these data will allow us to determine if between-session changes in asymmetry should be considered important.
TITLE: Uncovering PT Rehabilitation Practice Patterns Following Traumatic Spinal Cord Injury: Findings from the SCIRehab Project

AUTHORS/INSTITUTIONS: S. McDowell, D. Backus, , Shepherd Center, Atlanta, GA; S.M. Taylor, , Rehabilitation Institute of Chicago, Chicago, IL; J. LaBarbera, , Carolinas Rehabilitation, Charlotte, NC; A. Natale, , Craig Hospital , Englewood, CO; J. Gassaway, , Institute for Clinical Outcomes Research, Salt Lake City, UT; J.M. Zanca, , Mount Sinai Medical Center, New York , NY;

ABSTRACT BODY:

Purpose/Hypothesis: Describe variability in the type and time spent on interventions patients receive during individual or group physical therapy (PT) sessions for initial rehabilitation following a traumatic spinal cord injury (SCI).

Number of Subjects: 600 patients with traumatic SCI

Materials/Methods: Physical Therapists providing regular care to patients with SCI documented the content of 37,306 PT sessions in the SCIRehab project using a portable electronic device featuring customized software. Session type (group vs. individual), session activities, and time spent on each activity were documented. Patient and injury characteristics were obtained via chart review. Level and completeness of SCI were determined using the International Standards of Neurological Classification of SCI. Total minutes of treatment per week was calculated and compared among groups using Chi-square tests and ANOVA.

Results: The mean amount of time spent in PT was 7.3 hours per week (range 2-17, SD 2, median 7). Significant differences were seen in the amount of time spent on PT activities among the 4 injury groups. PT services were delivered most commonly in individual sessions (77%) vs. group sessions (33%). During individual sessions, 35% of PT time was spent performing mobility training activities (e.g. transfers, gait, wheelchair mobility (w/c) and bed mobility) while 44% of the time focused on preparatory therapeutic activities directed toward strength training, range of motion (ROM)/stretching, balance, gaining upright tolerance, etc. Nearly all patients (98%) spent time during individual sessions working on transfers and strengthening; 95% received ROM/stretching; 86% performed bed mobility skills, 84% worked on manual w/c skills and 35% worked on gait. Patients with C1-4, AIS A, B or C spent the most amount of individual session time performing ROM/Stretching and/or strength training (34%), transfers (11%) and power w/c mobility (7%). Patients with C5-8, AIS A, B or C worked most commonly on transfers (17%), ROM/Stretching (16%), strength training (12%) and bed mobility (7%). For patients with paraplegia, 22% of the time was spent performing transfers while 33% was spent in a combination of ROM/stretching and strengthening and 10% on manual w/c skills. SCI patients presenting with an AIS D classification, regardless of level of injury, spent the highest amount of time working on gait (15%), followed by strengthening (11%), and transfers (7%). For group sessions, most time was spent performing strength training (43%) followed by manual w/c mobility skills (17%).

Conclusions: Time spent on PT activities and the variability of these activities relates to the motor level and impairment (AIS) of injury.

Clinical Relevance: Data related to time spent and the specific interventions performed during PT sessions begin to describe current PT practice for SCI rehabilitation. Future investigation of this data and associated patient outcomes may give insight into optimal practice patterns. Support: NIDRR grant #H133A060103
Purpose/Hypothesis: There is evidence that post-stroke sensory dysfunction slows motor recovery, and while up to 89% of stroke survivors have sensory dysfunction, sensory retraining is uncommon in the clinic. In this small clinical trial, functional and structural MRI measures were used to quantify cortex changes after an intensive two week sensory discrimination training program. Neural substrates supporting the observed behavioral changes are proposed.

Number of Subjects: Six chronic stroke subjects participated in pre and post-testing and the 2 week training paradigm.

Materials/Methods: Behavioral outcome measures included the Hand Active Sensation Test, the Hand Object Recognition Task, the Wrist position sense test, the Weinstein Enhanced Sensory Test and the Motor Activity Log (MAL). Structural and functional MRI scans were obtained using a Phillips 3 Tesla scanner. The fMRI protocol included both a brush perception and a brush discrimination task, applied manually at 1 Hz to the index finger, for a 21 second epoch in a box car design. Raw data were analyzed using Oxford Centre for Functional MRI of the Brain Software Library (FSL); fMRI analysis used FSL’s FMRI Expert analysis Tool v. 5.4 with Z>2.3 and p>0.05. Group statistic images were threshold using clusters determined by Z>2.3 and a corrected cluster significance threshold of p=0.05. One-sample paired T-Test fixed effects analysis was used to identify brain areas activated in the post-test that were not activated in the pre-test. Cortical volume and thickness were estimated from magnetization prepared rapid gradient echo (MPRAGE) structural images analyzed using Freesurfer v.4.5.0.

Results: Following training, five out of six subjects had improved sensory function on at least one measure, pre-post MAL scores were significantly different (MAL-A p=.001, MAL-H p=.026). Paired T-Test (post-test minus pre-test) of fMRI during perception yielded activation in the right parietal cortex, while discrimination activation was increased in the left superior temporal pole following training. Cortical volume increases, though not statistically significant, were noted in the right parietal cortex, the same region in which functional activation was greater following training.

Conclusions: Two weeks of intensive sensory discrimination training resulted in improved motor function in all participants and improved sensory function in 5 of 6 participants although not on the same measure. Following training functional brain activation increased in the parietal cortex during a perception task. Parietal cortex changes may support sensory and motor functional improvement in sensory impaired stroke survivors.

Clinical Relevance: Sensory discrimination training may be a valuable addition to stroke rehabilitation protocols.
TITLE: Contributions of the corticospinal and reticulospinal systems in recovery of reaching following cortical ischemic brain injury in the non-human primate

AUTHORS/INSTITUTIONS: W.J. Herbert, J.A. Buford, Physical Therapy, Ohio State University, Columbus, OH; L.R. Montgomery, Neuroscience Graduate Studies Program, Ohio State University, Columbus, OH;

ABSTRACT BODY:

Purpose/Hypothesis: The loss of upper extremity motor function after stroke is one of the most devastating consequences. The prognosis for recovery of arm function remains poor. We do not fully understand the basis for these chronic upper limb impairments following stroke or how people recover. In order to develop more effective therapeutic interventions, we require a better understanding of the neural substrates that underlie normal upper limb motor function and recovery following stroke. The purpose of this study was to explore contributions of both the corticospinal and reticulospinal systems in recovery of reaching following cortical ischemic brain injury in the non-human primate.

Number of Subjects: Two female adult macaque monkeys (M fascicularis)

Materials/Methods: A vasoconstrictive peptide, Endothelin-1 (ET-1), was used to create a focal ischemic injury in the shoulder/elbow representation of left primary motor cortex (M1). Repetitive microstimulation was used to physiologically map motor outputs from right and left cortical motor areas, and upper limb motor outputs from the pontomedullary reticular formation (PMRF). EMG responses were recorded from shoulder girdle, limb extensor and limb flexor muscles of both upper limbs; 16 muscles were implanted. Functional deficits were assessed using a behavioral reaching task conducted at set time points before and after the ET-1 induced lesion. MRI scans were used for confirmation of lesion location and quantification of lesion volume.

Results: In one subject with a mild lesion, reaching was mildly impaired after 2 weeks of spontaneous recovery. Changes were evident in the shoulder/elbow representations of both the affected and contralesional M1. No substantial changes were noted in the pattern of PMRF output. In a subject with a severe lesion, reaching was severely impaired immediately after the lesion. With intensive rehabilitation, gross reaching recovered in a few weeks, and reach times were slow but comparable to pre-injury levels after 16 weeks. Surprisingly, however, the shoulder/elbow representation in the affected M1 remained completely absent after recovery, and there was very little change evident in the contralesional M1. The novel result was that there was greater right arm (impaired) representation from left PMRF sites in this subject.

Conclusions: This suggests that there may be increased reliance on PMRF motor outputs associated with upper limb recovery after a severe cortical injury.

Clinical Relevance: This opens a new line of investigation to compliment cortical plasticity research to understand reticulospinal contributions to functional recovery of reaching after stroke.
TITLE: Reticulospinal control of reaching in the non-human primate: a critical system for normal control and recovery from cortical injury

AUTHORS/INSTITUTIONS: W.J. Herbert, S.L. Moran, Allied Medicine - Physical Therapy, The Ohio State University, Columbus, OH; J.A. Buford, Center for Brain and Spinal Cord Repair, The Ohio State University, Columbus, OH; L.R. Montgomery, Neuroscience Graduate Studies Program, The Ohio State University, Columbus, OH;

ABSTRACT BODY:

Purpose/Hypothesis: The reticulospinal system has long been considered an important alternative system for voluntary control of movement, but most evidence for this function has been inferential. We have developed a non-human primate model for the study of neural control of reaching using normal subjects and subjects recovering from cortical ischemic injury. This model affords the combined study of corticospinal and reticulospinal contributions to the control of movement. Findings from a series of recent studies in this model are described here.

Number of Subjects: Five adult macaque monkeys (M fascicularis), 2 female and 3 male

Materials/Methods: The model allowed repeated access with microelectrodes to record and/or stimulate in the cortical motor areas (M1, SMA, PMd) as well as the pontomedullary reticular formation (PMRF), the source of the reticulospinal tracts. In two female subjects, a stroke model was created by injecting a potent vasoconstrictor (endothelin-1) into the cortical tissue. Movement times, reaction times, and other behavioral measures were monitored during performance of reaching tasks. Electromyographic analysis with fine wire EMGs provided data from shoulder, elbow, and wrist muscles bilaterally.

Results: Recording studies of the neural activity in the PMRF revealed that these cells were modulated in preparation for reaching and during reaching, with neural activity related to the patterns of muscle recruitment used for reaching. Electrical stimulation studies in the PMRF revealed that upper limb muscles were recruited bilaterally by the reticulospinal system. The most frequent responses were found in a pattern mimicking the limb movements for the asymmetric tonic neck reflex, though there was some deviation from this most common pattern. When cortical and PMRF sites were stimulated simultaneously, the corticospinal and reticulospinal outputs combined to contribute to the recruitment of limb muscles bilaterally – ipsilateral cortical effects were common. There were also cases where the corticospinal system gated out the ability of the reticulospinal system to recruit muscles, and vice versa. Finally, after severe cortical ischemic injury, we have observed changes in the outputs from the reticulospinal system that could contribute to the functional recovery of reaching after a long period (16 weeks) of intensive upper limb rehabilitation training.

Conclusions: The reticulospinal system plays a central role in the recruitment of upper limb muscles for skilled reaching in the non-human primate, and neural plasticity within this system may be a key factor in functional recovery after stroke.

Clinical Relevance: Improved understanding of reticulospinal control of reaching in the normal and pathological situations may lead to better understanding of mechanisms of recovery from stroke.
TITLE: Three weeks of supervised 3-D robotic training of a paretic arm results in improvement in motor tests and untrained tasks after chronic stroke.

AUTHORS/INSTITUTIONS: S.N. Maxfield Panker, Interdisciplinary Program in Neuroscience, Georgetown University, Washington, DC; H. Schambra, L.G. Cohen, Human Cortical Physiology Section, NINDS, National Institutes of Health, Bethesda, MD;

ABSTRACT BODY:

Purpose/Hypothesis: Reaching in 3-dimensional(3D) space is crucial for completing activities of daily living(ADL) and is deficient after stroke. Robotic training has been used to deliver consistent, repetitive planar(2D) movements with reported improvements in motor tests(Volpe et al) and movement quality(Dipietra et al). Less is known about the effects of 3D robotic training, more important to reaching in daily life. This presentation was part of a larger study to evaluate the effects of non-invasive brain stimulation on 3D robotic training; the purpose is to demonstrate the improvement in motor and untrained tasks after supervised 3D robotic training (SRT).

Number of Subjects: Fourteen patients with chronic stroke (ave 60 months) participated. Of these, 4 were excluded due to discomfort or excessive spasticity, resulting in an inability to perform or train 3D tasks.

Materials/Methods: Subjects underwent 3 weeks (22 sessions) of SRT for 1 hour BID. During training, the paretic arm was supported in a forearm splint and attached to a mast that allowed 3D movements. The specific exercises and the number of repetitions practiced was determined by the physical therapist based upon the subject's ability and functional level. Subjects reached to 2D and 3D targets presented on a screen by manipulating the mast and lifting their limb. The primary endpoint was the time to complete an untrained 3D exercise using the robotic device. Secondary endpoints included the Fugl Meyer Assessment(FMA), used to evaluate arm movements(max score=42), and the Wolf Motor Function Test(WMFT), a timed test(max=120s) of 15 activities that mimic ADLs. Measures were taken at baseline (1B), post-training (2P), and at 3 month follow-up(3F).

Results: Seven of the 10 subjects completed the untrained 3D robotic task faster at 2P; 3 of these subjects were not able to complete the task at 1B. Follow-up revealed maintenance or improvement in all 7 subjects. There was a significant main effect(ANOVA p=0.026) for time, with significant differences between 1B and 3F(p< 0.016, Bonferroni corr). The FMA improved for 9 subjects, with a significant main effect(ANOVA p= 0.039) and a significant pairwise comparison between 1B and 2P(p<0.016, Bonferroni corr). For the WMFT, 9 subjects improved on the reach and retrieve task, with an average of 2.75s, 1.31s, and 1.67s over time. Some subjects were unable to complete every task in 120s at 1B. After training, 4 subjects were newly able to fold a towel, and 3 were able to turn a key in a lock.

Conclusions: These data indicate that 3 weeks of SRT improves movement tests for most subjects and results in better performance time when completing untrained 3D and functional tasks for some. Subject recruitment and data analysis are ongoing.

Clinical Relevance: Robotic training that is supervised by a physical therapist results in improvements in clinical measures and untrained tasks. Further study is required to determine which patients may be most appropriate for SRT intervention after chronic stroke.
ABSTRACT BODY:

Purpose/Hypothesis: The purpose of this study was to examine the effects of medication on the attentional demands of precision (Pre) and power (Pow) grips in individuals with PD. We hypothesized that the attentional demands of the grip tasks would be greater during the ‘off medication’ state (OFFMeds) compared to the ‘on medication’ state (ONMeds).

Number of Subjects: 9 participants with PD (Hoehn-Yahr stage 1-2) with a mean age of age of 68.2(±13.5) yrs were tested both ONMeds and OFFMeds.

Materials/Methods: We used six axial force sensors mounted on a circular platform that rotated in both directions. Forces were recorded as participants rotated the device in either direction, under both single and dual task conditions (Pre using a 2.5 cm and Pow using a 6 cm cap). Performance on the motor task was quantified using peak force levels (PF) and the time to reach peak force (TTP). To assess attentional demands of the motor task, participants performed an auditory analogue of the Stroop test while performing the motor task. In the dual task conditions, participants were instructed to focus on the motor task. Response latency (RL) and accuracy for the auditory task were recorded during single and dual task conditions. Dual task cost (DTC) for all outcome variables was calculated as the percent difference between the RL for the dual and single task conditions, normalized to the RL for the single task condition. Data were analyzed using repeated measures ANOVA.

Results: There were no significant differences in the force variables between single and dual task conditions for either grip task (both p>0.32). There was a significant effect of medication on PF (both p<0.005), but not on TTP (both p>0.13). Changes in the performance of the auditory task were primarily reflected in the greater RL during the dual task condition compared to the single task condition (p=0.01). RL was reduced with medication for the single task condition only (RLsingle p<0.01), RLdual (p>0.42). RL DTC for both grips were greater (p<0.005) when participants were ‘ONMeds’ (Mean[95%CI]: Pre=25.7[14.7-36.7], Pow=37.08[26.5-47.7]) compared to ‘OFFMeds’ (Pre=12.6[1.5-23.6], Pow=10.98[0.4-21.6]).

Conclusions: Participants with PD were able to keep performance on the motor task constant under single and dual task conditions, suggesting appropriate prioritization when instructed. Medications affected single task RL favorably but not the dual task RL. Contrary to our initial hypothesis, a greater RL DTC was seen during the ‘ONMeds’ state compared to the ‘OFFMeds’ state.

Clinical Relevance: These data suggest that force control during both grip tasks remains attentionally demanding even on medications. Since a large proportion of people with PD first notice symptoms in their hand, we are examining fine motor control in greater detail to identify a task that would help unmask subtle deficits and monitor them as a possible marker of disease progression. As a first step, these data will help us understand the effects of medication on the attentional demands of precision and power grips.
TITLE: Integrated versus Isolated Arm and Hand Training Using Adaptive Robotics and Virtual Reality Simulations

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ABSTRACT BODY:

Purpose/Hypothesis: Robotic-assisted arm training devices integrated with strategically placed virtual targets or virtual reality gaming simulations are increasingly being used for rehabilitation of upper extremity (UE) deficits post-stroke. Most of these robotic therapies focus on training proximal effectors or distal effectors in isolation. Neural control mechanisms indicate that arm transport and hand-object interaction are interdependent, suggesting that training on tasks requiring coordinated effort of both upper arm and hand may be more effective for optimizing recovery of real world hand function. This study presents preliminary data from an ongoing experiment comparing integrated hand and arm training versus isolated hand and arm training on motor function in persons with hemiparesis.

Number of Subjects: Eleven subjects (7 male, 4 female) mean (SD) age of 58 (14) years, and mean (SD) time post stroke 6 (5) years, performed hand and arm together (HAT) training. Eight subjects (6 male, 2 female) mean (SD) age 50 (10) years, and mean (SD) time post stroke 5 (4) years, performed hand and arm separate (HAS) training.

Materials/Methods: Both groups trained eight days, 2-3 hours/day. Training was performed in three dimensional, haptically rendered, virtual environments with as needed robotic facilitation and adaptive task parameter scaling. HAT training was divided equally between four simulations that trained the shoulder, elbows and fingers simultaneously. HAS subjects followed an identical schedule dividing time between three hand and three arm training simulations. Reaching and hand kinematics were automatically collected during training. Twenty-four hour UE activity was measured using tri-axial accelerometers in a subset of subjects. Wolf Motor Function Test (WMFT), and Jebsen Test of Hand Function (JTHF) were performed pre and post training.

Results: Both groups made statistically significant improvements in WMFT and JTHF. Changes in WMFT for both groups exceed published minimum detectable change and minimum clinically important difference for this test. HAT training changes were larger than HAS training improvements for all three tests but these comparisons have not reached statistical significance. Both groups made statistically significant improvements in reaching trajectory smoothness, path length, proximal stabilization and finger individuation.

Conclusions: An intense program of robotically facilitated repetitive task practice in virtual environments had a positive impact on UE function in persons with stroke. Larger sample sizes may be needed to determine if there is a meaningful difference between HAS and HAT training paradigms.

Clinical Relevance: This study adds to evidence supporting effectiveness of the use of robotic-assisted devices to enable longer training sessions. As a group subjects demonstrated robust changes in the kinematics of both arm and hand movements. These positive changes were reflected in the clinical outcome measures.