Thursday, May 20th			
Start Time (UTC)	**Finish Time (UTC)**	**Event**	**Presenter**
4:30pm	**5:15pm**	**Poster session #1**	
	Murray	IMPLEMENTATION OF AN ANKLE FOOT ORTHOSIS TO IMPROVE MOBILITY IN PERIPHERAL ARTERY DISEASE	Ayisha Z. Bashir
	Murray	ACL RECONSTRUCTION RESTORES KNEE FLEXION ANGLE VARIABILITY BUT NOT SHEAR FORCE CONTROL VARIABILITY: A PRELIMINARY STUDY	Lindsey Remski
	Glassow	ACCURACY OF AN EXPERIMENTAL ACCELEROMETER FOR ASSESSING VERTICAL JUMP HEIGHT	Dimitrije Cabarkapa
	Lee	THE EFFECT OF A TRAINING INTERVENTION ON CORTICAL ACTIVATION DURING GROSS MANUAL DEXTERITY TASKS WITH AN UPPER LIMB PROSTHESIS	Kaitlin Fraser
	Glassow	POSTURAL REGULATION STRATEGIES IN EHLERS-DANLOS SYNDROME HYPERMOBILITY TYPE	Emma Dupuy
	Walker	LEVODOPA-INDUCED DYSKINESIA ALTERS SWAY RATIOS IN PEOPLE WITH PARKINSON’S DISEASE	Jenny Maun
	Murray	INVESTIGATING GAZE PATTERNS DURING TREADMILL WALKING ON AN OSCILLATING SUPPORT SURFACE WITH MATCHED OR CONFLICTED VISUAL FEEDBACK	Stephanie Mace
	Walker	EFFECTS OF THREE DIFFERENT VISUAL BIOFEEDBACK STRATEGIES ON REDUCING JOINT LOADING ASYMMETRIES DURING BILATERAL SQUATS IN INDIVIDUALS AFTER ACL RECONSTRUCTION	Namwoong Kim
	Walker	TIMEKEEPER: DEVELOPMENT OF A WEB-APP TO IMPROVE MOTOR TIMING AND RHYTHM IN PEOPLE WITH PARKINSON’S DISEASE	Meghan Prusia
	Lee	EFFECTS OF TASK PRIORITIZATION DURING DUAL-TASK WALKING ON GAIT VARIABILITY IN PEOPLE WITH PARKINSON’S DISEASE	Johanna Bustamante-Salgado
	Glassow	VALIDATION OF VIRTUAL REALITY PRISM ADAPTATION FOR UNILATERAL SPATIAL NEGLECT INTERVENTION	Sydney Andreasen
	Gilbreth	THE DECAY AND CONSOLIDATION OF EFFECTOR-INDEPENDENT MOTOR MEMORIES	Shancheng Bao
	Lee	HETEROGENEITY IN MOTOR VARIABILITY IN PATIENTS WITH CHRONIC LOW BACK PAIN: A SYSTEMATIC SCOPING REVIEW	Lars Dijk

Poster rooms shown in the right column above next to the poster title.

IMPLEMENTATION OF AN ANKLE FOOT ORTHOSIS TO IMPROVE MOBILITY IN PERIPHERAL ARTERY DISEASE

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Presentation Preference: **Poster**

INTRODUCTION

An ankle- foot orthosis (AFO) can contribute to push-off during walking by storing energy from heel strike in the rigid strut and subsequently returning force during push-off. Through the substitution paradigm, the AFO decreases muscle and blood flow demand by substituting for the ankle plantar flexor torque and power[1,2]. Peripheral artery disease (PAD), a manifestation of systemic atherosclerosis, blocks the arteries supplying blood to the legs and causes muscle pain and weakness, which leads to difficulty in walking. Wearing an AFO immediately increases the distance patients with PAD can walk. However, subjects almost immediately decide whether to adopt or not adopt the AFO. Our goal is to assess factors contributing to early AFO intervention withdrawal (wAFO) and AFO intervention completion (cAFO).

METHODS

Participants (n=21) were recruited and consented to wear an AFO for 3 months. The subjects were assessed for early AFO intervention withdrawal (n=6) and completion (n=15). Fifteen subjects completed the study. Semi-structured interviews were conducted (Table 1), and data were analyzed using a summative content analysis approach. The interview guide was developed following the standards of Bowen and colleagues for feasibility studies[3]. Results were compared between those who did and did not complete the intervention.

Area of focus	**Example: AFO interview questions**
Minimal use	How much time did you wear the AFO?
Perceptions	Tell me about your experience using AFO? How often do you wear the AFO? What stops you from wearing it? What would encourage you to wear it more?
Barriers	What factors impact your use of the AFO? How does the AFO fit within your current lifestyle?

Table 1: Examples of AFO interview guide questions

RESULTS AND DISCUSSION

Several key differences in responses were found. Only six of fourteen of cAFO subjects described their initial reactions to the AFO as negative versus three of six wAFO subjects. The wAFO group reported higher levels of physical discomfort with the use of the AFO (4/6 vs 7/15) and pre-existing health issues as a barrier to the use of the AFO (3/6 vs 5/15). Patients withdrawing prior to completion of the AFO intervention tended to have increased negative perceptions, comorbidities, and physical discomfort. Both groups reported positive aspects of the AFO such as ease in standing and walking, walking straighter and longer with less pain.

CONCLUSIONS

The subset of preliminary data from the AFO intervention will be beneficial towards assessing the implementation success and improvement in quality of life in patients who wore the AFO for three months. In those subjects who did not complete three months of AFO use, their responses help determine the barriers and reason for a lack of adoption.

FUTURE DIRECTIONS

We expect that an AFO intervention will be feasible to implement and improve quality of life for three months for some patients with PAD. However, the results of this study indicate certain patients have barriers to wearing the AFO or other reasons for a lack of adoption. Follow-up studies will contact those patients who successfully finished the AFO intervention to determine whether the patients maintained AFO use. Implementation will be assessed using a mixed methods approach guided by i-PARIHS framework [4]. Future studies related to investigating the role of telehealth and supervised exercise therapy in managing these patients can also be explored [5,6].

REFERENCES

1. Koutakis P, et al. *Journal of vascular surgery*.1;51(1):80-8,2010
2. McGrath D, et al. *Clinical Biomechanics*. 27(10):1058-63,2012
3. Bowen et al.*American journal of preventive medicine*. 2009 May 1;36(5):452-7.
4. Harvey G, et al. *Implementation science*.11(1):33, 2015
5. Haveman ME, et al. *Expert review of medical devices*.2;16(9):777-86. 2019.
6. Ata R, et al. *NPJ digital medicine*.1(1):1-8, 2018

ACKNOWLEDGEMENTS

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ACL RECONSTRUCTION RESTORES KNEE FLEXION ANGLE VARIABILITY BUT NOT SHEAR FORCE CONTROL VARIABILITY: A PRELIMINARY STUDY

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Presentation Preference: **Poster**

INTRODUCTION

Despite being cleared for full activity, individuals with anterior cruciate ligament deficiency (ACLD) and reconstruction (ACLR) are at increased risk for subsequent injury [1]. Nonlinear dynamics, specifically the Lyapunov exponent (LyE), has revealed altered neuromuscular control in individuals with ACLD and ACLR [2,3]. Knee flexion angle variability has been shown to be lower in ACLD participants compared to uninjured controls while it is higher in ACLR participants [2]. Additionally, shear force control variability has been shown to be higher in both ACLD and ACLR participants compared to uninjured controls [3]. However, presence of altered knee flexion angle variability and shear force control variability in these individuals have not yet been evaluated together.

The purpose of this preliminary study was to assess changes in knee flexion angle variability and shear force control variability in individuals with ACLD and ACLR. In accordance with results of previous studies, we first hypothesized that ACLD participants would have lower knee flexion angle variability compared to uninjured participants and that ACLR participants would have higher knee flexion angle variability compared to uninjured participants. Our second hypothesis was that both ACLD and ACLR participants would have higher shear force control variability compared to uninjured participants

METHODS

Four ACLD, four ACLR, four collegiate soccer players, and four healthy participants completed this study. A walking task was completed to measure knee flexion angle variability and a force control task was completed to measure shear force control variability. The walking task consisted of two-minutes of walking on a treadmill while 3D knee kinematics were recorded using motion capture at 60 Hz. The force control task consisted of two-minutes of continuous force generation in the anterior-posterior (AP) or medial-lateral (ML) directions at a cadence of 60 bpm while force plates recorded shear ground reaction forces. The largest LyE was calculated for knee flexion angles from the walking task and force profiles from the force control task using Wolf et al's algorithm [4]. One-way ANOVAs with Tukey HSD post-hoc were performed to determine differences between participant groups in knee flexion angle variability of the involved/non-dominant limb and in AP shear force control variability of the uninvolved/dominant limb. Normality assumptions for determining differences in knee flexion angle variability of the uninvolved/dominant limb, AP shear force control variability of the involved/non-dominant limb, and ML shear force control variability in both limbs between groups were not met. Therefore, Kruskal-Wallis tests with Dunn's post-hoc were performed for these comparisons. Significance was determined using an alpha of 0.05.

RESULTS AND DISCUSSION

Our first hypothesis that ACLD participants would have lower knee flexion angle variability and ACLR participants would have higher knee flexion angle variability compared to uninjured participants was partially supported. Knee flexion angle variability of ACLD participants was significantly greater than ACLR and uninjured participants. This indicates that knee flexion angle variability following ACL injury may be restored through surgery. Our second hypothesis that ACLD and ACLR participants would have higher shear force control variability compared to uninjured participants was supported. This indicates that force control variability is altered in individuals with ACLD and ACLR and implies that force control is not restored with reconstructive surgery. It is then possible that force control is a more robust biomechanical parameter to evaluate ACL reconstruction.

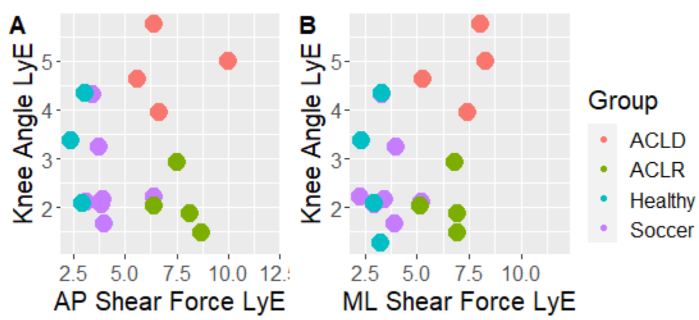

Figure 1: Scatter plots of knee flexion angle variability vs. shear force control variability in both AP and ML directions for the involved/non-dominant limb.

CONCLUSIONS

This preliminary study shows that while ACLR restores knee flexion angle variability, shear force control variability remains impaired. Future work should include larger samples to unequivocally determine whether these impairments may be related to increased risk for re-injury.

REFERENCES

1. Wiggins AJ, et al. *Am J Sports Med* **44**, 1861-1876, 2006.
2. Decker LM, et al. *Knee Surg Sport Traumatol Arthrosc* **19**, 1620-1633, 2011.
3. Lanier AS, et al. *J Orthop Res* **38**, 1746-1752, 2020.
4. Wolf A et al. *Physica D: Nonlinear Phenomena* **16**, 285-317, 1985.

ACCURACY OF AN EXPERIMENTAL ACCELEROMETER FOR ASSESSING VERTICAL JUMP HEIGHT

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Presentation Preference: [**Poster**]

INTRODUCTION

Vertical jump performance can be assessed in a variety of ways. A laboratory force plate has been considered the gold standard for vertical jump performance assessment, as it allows for precise measurement of ground reaction forces and flight times [1]. However, this may be impractical in many settings as this method requires access to expensive testing equipment. To provide an alternative to a force plate that is not solely restricted to laboratory usage and can assess force-time characteristics, accelerometry has been used in a variety of cases. Previous research has found that a triaxial accelerometer consistently overestimated peak force, rate of force development, peak power, flight time, and vertical displacement when compared to a force plate and linear position transducer [2]. Thus, the purpose of this study was to examine the accuracy of an experimental accelerometer for testing vertical jump heights derived from flight times when compared to a laboratory-based force plate system as a criterion measure.

METHODS

Fifteen healthy recreationally active subjects, ten female (age= 22.2±2.9 years, body mass= 69.9±7.7 kg, height= 168.1±7.6 cm) and five male (age= 22.2±3.3 years, body mass= 84.8±19.5 kg, height= 179.8±5.2 cm), performed three sets of three non-sequential maximal countermovement vertical jumps with 1-2-minute rest between each set. The accelerometer (Strive, Beta Version 1.0, Bothell, WA, USA) sampling at 100 Hz was placed 3 cm inferior to the umbilicus and secured with an elastic band. A uni-axial force plate (Rice Lake Weighing Systems, Rice Lake, WI, USA) and data acquisition system (BioPac MP 150, Goleta, CA, USA) sampling at 1000 Hz was used to measure flight times from ground reaction forces. Both devices collected the data simultaneously. The force plate data was converted to 100 Hz to match the sampling rate of the accelerometer.

RESULTS AND DISCUSSION

When compared to the force plate as the criterion measurement, the accelerometer overestimated vertical jump heights by an average of 3.1 cm. However, the standard error of estimate magnitude was only 2.6 cm, indicating a small prediction error. Pearson correlation coefficient (r=0.927) and explained variance (r^2=0.859) magnitudes indicated strong association and substantial goodness-of-fit of the linear regression model. Additionally, the intra class correlation coefficient (ICC=0.913) indicated strong agreement between the measurements and Cronbach's alpha value (α=0.962) denoted excellent internal consistency. The scatter plot of the linear regression and Bland-Altman plot showing the agreement between the devices are presented in Figures 1 and 2, respectively.

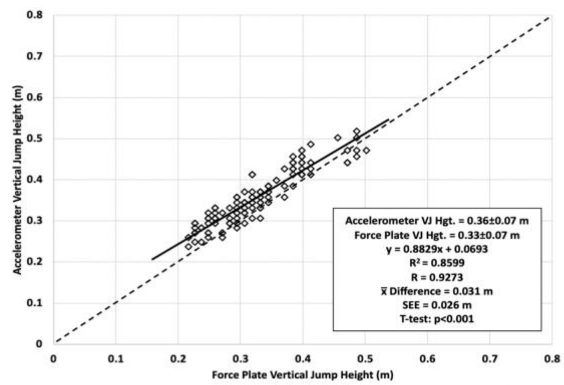

Figure 1: Comparison of vertical jump heights determined from the force plate and the experimental accelerometer. Dashed line=line of agreement. Solid bold line=regression line.

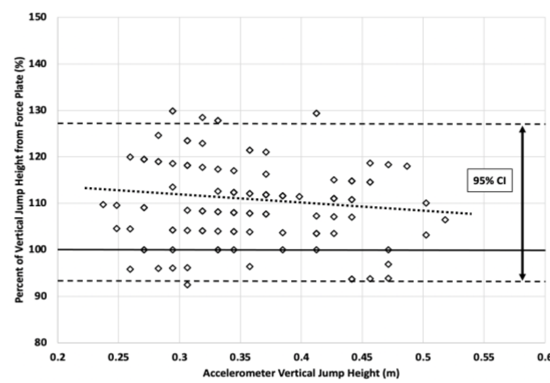

Figure 2: Bland-Altman plot demonstrating agreement in vertical jump heights measurements between the force plate and the experimental accelerometer. Dashed lines=95% CI. Dotted line=regression line. Solid bold line=line of agreement.

CONCLUSIONS

Based on our findings we conclude that the experimental accelerometer examined in this study demonstrated as an acceptable tool for assessment of vertical jump height. However, due to the tendency to overestimate vertical jump heights on average by 3.1 cm, the validity of the device was slightly impaired. While this discrepancy in measurement may be easily fixed by a simple algorithm correction, it may not be an issue in a practical setting where user-friendliness and the ability to provide instantaneous feedback regarding an athlete's performance is of critical importance.

REFERENCES

1. Menzel HJ, et al. *Perceptual and Motor Skills* 110, 150-8, 1994.
2. Ruben RM, et al. *Journal of Strength and Conditioning Research,* 25, S37.

THE EFFECT OF A TRAINING INTERVENTION ON CORTICAL ACTIVATION DURING GROSS MANUAL DEXTERITY TASKS WITH AN UPPER LIMB PROSTHESIS

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Presentation Preference: Poster

INTRODUCTION

An estimated 35-58% of children with upper limb reductions (ULR) reject their prosthesis due to various factors including weight, discomfort, and lack of functionality [1-2]. Previous studies have observed that training can improve prosthetic function in individuals with ULR [3]. However, no studies to date have documented the effects of training on coordination, neuromuscular adaptions, and cortical changes. Therefore, this experiment was designed to assess the impact of training sessions on cortical, neuromuscular, and coordination adaptions in an individual with ULR using a partial hand prosthetic.

METHODS

A 19-year-old female with a congenital ULR on her left hand was recruited for this case study. She was fitted with a body powered prosthetic which flexes the fingers into a pinch grip [4]. During two visits to the lab, the participant completed a Box and Blocks (BB) test of gross manual dexterity while cortical hemodynamic activity was recorded using functional near-infrared spectroscopy (fNIRS). Between data collections, the participant completed an 8-week at-home training program.

During the BB test, the participant was instructed to individually move as many blocks as possible from one side of a divided box to the other. The number of blocks moved in the first 30 seconds for each trial were averaged and recorded for each hand during each visit.

The fNIRS probes were set up over the primary motor, premotor, and somatosensory cortices (Figure 1). The fNIRS results data from 5-30 seconds of the task were analyzed in Homer3 [5] using a general linear model [6]. This time period was selected to coincide with expected peak hemodynamic activity. The beta values representing the shape of the hemodynamic response of oxy-hemoglobin (HbO) were then mapped onto a representation of the cortical regions of interest using AtlasViewer [7].

The training program consisted of a twice-weekly supervised home intervention over 8-weeks. The tasks during training included cutting a piece of putty with a knife and fork, throwing a ball, drawing on paper, cutting paper, and placing pieces of tape on paper. Additionally, the participant was asked to complete turning tasks such as carrying a tray in a figure eight and turning on a bicycle. During the first and last week of the training, she also completed block stacking activities. Through all activities, the participant was encouraged to use the prosthetic as much as possible.

RESULTS AND DISCUSSION

During the Baseline visit, the participant moved (M ± SD) 6 ± 1.73 blocks with her affected hand and 27.67 ± 3.21 blocks with her unaffected hand during the BB. During the Follow-Up, she moved 10.3 ± 3.21 blocks with her affected hand and 35 ± 2.00 blocks with her unaffected hand. The increased values of BB results suggest an increase in gross manual dexterity with the prosthesis. The increase in gross dexterity may have resulted in increased activation of the cortical representation of the affected hand in the contralateral hemisphere.

The mapped HbO responses during the Box and Blocks test are displayed in Figure 1, which might demonstrate a decrease in ipsilateral dominance after training. The decreased degree of changes in HbO after training may additionally indicate higher levels of automaticity in the control of the prosthetic. Further testing with more participants should be conducted to examine whether similar changes in hemodynamic activity occur with training programs.

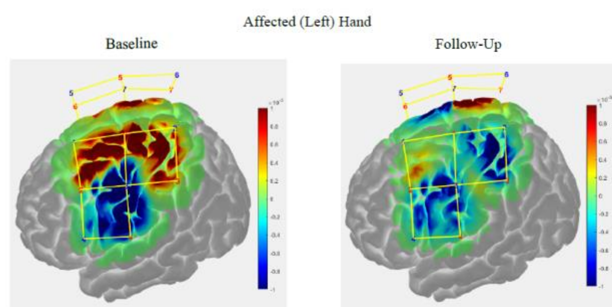

Figure 1: Representation of the oxy-hemoglobin activity in the left hemisphere during unimanual movements with the affected limb from Baseline (A) and Follow-Up (B). The range of calculated HbO changes spans from $1x10^{-3}$ (red) to $-1x10^{-3}$ (blue) µM. Yellow lines indicate imaging channels between sources (red dots) and detectors (blue dots).

REFERENCES

1. L. Resnik et al., *Arch. Phys. Med. Rehabil.*, **93**, 710–717, 2012.
2. E. A. Biddiss and T. T. Chau, *Prosthet. Orthot. Int*., **31**, 236–257, 2007.
3. A. W. Dromerick et al., *Arch. Phys. Med. Rehabil*., **89**, 1199–1204, 2008.
4. Zuniga et al., *BMC Research Notes*, **8**, 1-8, 2015.
5. T. J. Huppert et al., *Appl. Opt*., **48**, D280–D298, 2009.
6. Barker et al., *Biomed. Opt. Express*, **4**, 1366-1379, 2013.
7. C. Aasted et al., *Neurophotonics*, **2**, 1-16, 2015.

Postural regulation strategies in Ehlers-Danlos Syndrome hypermobility type

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Presentation Preference: **Podium**

INTRODUCTION

Ehlers-Danlos syndrome (EDS) is the clinical manifestation of connective tissue disorders, comprising several clinical forms. The EDS hypermobility type (EDSh) is characterized by generalized joint hypermobility, tissue fragility, variable skin hyperextensibility, and predominantly impact proprioception. The impaired proprioceptive system is likely a major contributor to the postural instability observed in EDSh patients and to their functional disabilities encountered in daily life [1]. This study addresses how the EDSh affects automatic and cognitive (higher order) processes involved in postural control during upright stance under the presence and absence of environmental constraints.

METHODS

Postural control of 19 EDSh patients (28 ± 11.68 years old) and 19 age-matched controls (25.6 ± 5.4 years old) was assessed with eyes open under single- (EO-ST) and dual-task (EO-DT) conditions, and with eyes closed (EC-ST), from the two force platforms integrated underneath the M-Gait treadmill's belts (Motekforce Link). COP time series were analyzed in both anteroposterior (AP) and mediolateral (ML) directions. Short-range and long-range correlations in COP velocity time series (α_{ST} and α_{LT} scaling exponents of detrended fluctuation analysis – DFA) were calculated [2]. α_{ST} is considered to reflect lower-level automatic processes, and α_{LT}, the cognitive involvement in postural control [3]. Variability and regularity of postural sway were assessed through the root mean square (RMS) and the sample entropy (SampEn) of COP position time series, respectively.

RESULTS AND DISCUSSION

Regardless of the environmental constraints, automatic postural control processes of EDSh patients tended to be less efficient in AP direction compared to controls (increased α_{ST}). Moreover, they were more variable (increased RMS) and their postural sway was more regular (decreased SampEn), in AP and ML directions. In both groups, the EO-DT condition increased regularity in postural sway in ML direction compared to the EO-ST condition. Yet, in EDSh patients, under both EO-DT and EC-ST, cognitive control of postural sway in AP direction was tighter (decreased α_{LT}) compared to the EO-ST condition.

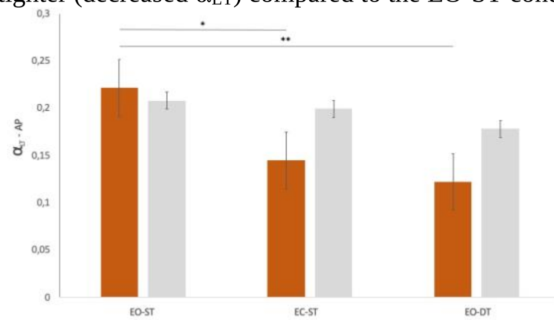

Figure 1. Means and standard deviations of the α_{LT} relative to postural sway in AP direction, in both EDSh patients (red) and controls (grey), according to the experimental condition. ***: p < 0.01; *: p < 0.05.*

CONCLUSIONS

The results showed that automatic processes for regulating postural sway in AP direction tend to be deteriorated in EDSh patients, likely due to internal noise within the proprioceptive system. Therefore, EDSh patients present with greater postural instability/variability (increased RMS) and rigidity/stiffness (increased regularity) than controls. The increased regularity in EDSh patients is suggested to reflect a greater cognitive involvement in their postural control [4]. In order to secure their balance in challenging situations (restriction of either sensory or cognitive resources) and compensate for proprioceptive loss, EDSh patients strongly regulate postural sway in AP direction as they reach stability boundaries. Collectively, these findings demonstrate that loss of complexity in postural control system expresses through impaired automatic adjustments and rigid compensatory active control strategies in EDSh patients.

REFERENCES

1. Rombaut L, et al. *Arthritis Care & Research* **63**, 1432-1439, 2011.
2. Delignières D, et al. *PLoS Computational Biology* **7**, e1001089, 2011.
3. Peterka RJ. *Biological Cybernetics* **82**, 335-343, 2000.
4. St-Amant G. *Human Movement Science* **70**, 102587, 2020.

Table 1. Between-group and between-condition differences in CoP parameters.

Experimental condition	**EO-ST**		**EC-ST**		**EO-DT**		**ANOVA main effects**	
	EDSh	***Controls***	***EDSh***	***Controls***	***EDSh***	***Controls***	***Group***	***Condition***
α_{ST} AP $_{mean \pm SD}$	1.05 ± 0.13	0.95 ± 0.15	1.00 ± 0.11	0.99 ± 0.15	1.01 ± 0.14	0.96 ± 0.17	0.089	-
SampEn AP $_{mean \pm SD}$	0.75 ± 0.17	0.95 ± 0.17	0.70 ± 0.23	0.84 ± 0.19	0.71 ± 0.23	0.96 ± 0.17	**0.005**	-
SampEn ML $_{mean \pm SD}$	0.75 ± 0.17	0.88 ± 0.11	0.74 ± 0.24	0.80 ± 0.14	0.68 ± 0.25	0.82 ± 0.15	**0.025**	-
RMS AP $_{mean \pm SD}$	9.41 ± 4.71	5.31 ± 1.87	10.55 ± 8.43	6.54 ± 1.98	8.19 ± 4.81	5.19 ± 1.18	**0.011**	**0.014**
RMS ML $_{mean \pm SD}$	3.62 ± 2.57	2.37 ± 1.91	5.03 ± 6.15	2.07 ± 1.26	4.75 ± 4.46	1.85 ± 0.73	**0.024**	-

LEVODOPA-INDUCED DYSKINESIA ALTERS SWAY RATIOS IN PEOPLE WITH PARKINSON'S DISEASE

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Presentation Preference: [**Poster**]

INTRODUCTION

Levodopa as the main medical treatment for Parkinson's disease (PD) is a double-edged sword, as the long-term use can induce dyskinesia – abnormal, involuntary movement – indicating a lack of inhibitory control [1]. Our prior research showed PD with levodopa-induced dyskinesia were less stable while standing (i.e., increased postural sway) and had a higher incidence of falls [1]. While postural sway increased, the relative contribution of each segment to this overall increase of sway is unclear. The aim of this study was to characterize the relative contribution of these abnormal, involuntary movements to the overall postural sway in individuals with PD using accelerometry.

METHODS

Individuals with idiopathic PD (n = 26; 14 showed clinical signs of dyskinesia) performed two types of conditions for 30 seconds each: (1) single task: standing quietly with arms along their sides and (2) dual task: standing while performing a serial subtraction cognitive task. Individuals were tested in their OFF state (i.e., after withholding their anti-parkinsonian medication for at least 12 hours) and ON state (i.e., at least 1 hour after medication intake of a levodopa challenge dose, approximately 1.25x their regular dosage). Postural sway was collected using tri-axial accelerometers attached to anthropometric landmarks (Figure 1). The root-mean-square (RMS) accelerations were calculated from the head and lumbar sensors. Sway ratios were determined as the superior segment's sway relative to the inferior segment's sway [2]. The head-to-lumbar sway ratio was calculated as:

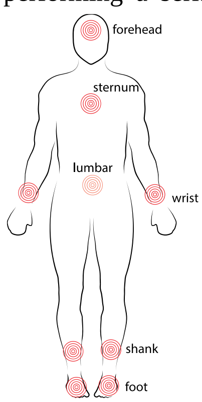

Figure 1: Placement of inertial sensors

$$SwayRatio_{Head2Lumbar} = \frac{RMS_{Head}}{RMS_{Lumbar}} \times \frac{h_{Lumbar}}{h_{Head}}$$

where h is the measured height of each sensor relative to the ground. A ratio of 1 indicates equal relative amount of sway between the head and lumbar. A ratio greater than 1 indicates the head sways more than the lumbar, while a ratio lesser than 1 indicates the lumbar sways more than the head.

RESULTS AND DISCUSSION

In the single task, head-to-lumbar sway ratios were similar between groups and medication state (Figure 2). Only two PD with dyskinesia increased their sway ratio with medication, indicating greater amount of sway at the head than lumbar.

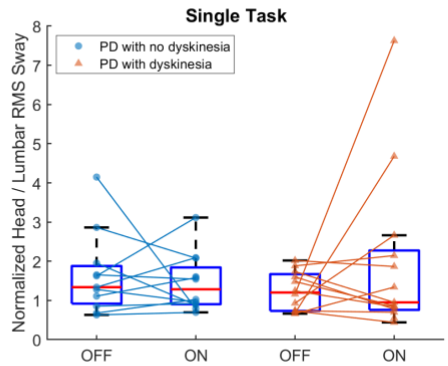

Figure 2: Effect of medication on sway ratio head-to-lumbar during single task in PD with and without dyskinesia

In the dual task, head-to-lumbar sway ratios were similar between PD with and without dyskinesia in the OFF state (Figure 3). However, PD with dyskinesia produced ~3x greater sway ratio compared to PD without dyskinesia, in the ON state, indicating that the head of individuals with dyskinesia swayed 3x more than those without dyskinesia.

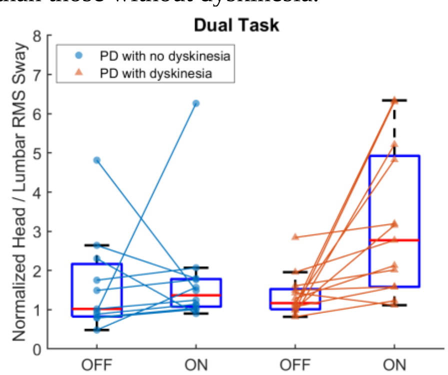

Figure 3: Effect of medication on sway ratio head-to-lumbar during dual task in PD with and without dyskinesia

CONCLUSIONS

Our results showed that head-to-lumbar sway ratios increased in PD individuals with dyskinesia during the dual task. This greater sway suggests reduced inhibitory control. Further analysis includes characterizing whether the body segments were swaying in/out of phase (i.e., the temporal coupling).

REFERENCES

1. Curtze C, et al. *Movement Disorders* **30,** 1361-1370, 2015.
2. Fino P, et al. *J Biomech* **112**, 110045, 2020.

ACKNOWLEDGEMENTS

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INVESTIGATING GAZE PATTERNS DURING TREADMILL WALKING ON AN OSCILLATING SUPPORT SURFACE WITH MATCHED OR CONFLICTED VISUAL FEEDBACK

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Presentation Preference: [**Poster**]

INTRODUCTION

The inability to maintain balance control during gait can be caused by a wide range of conditions such as Parkinson's disease, stroke, and multiple sclerosis (A.Mirelman, et al. 2011; A. Peruzzi, et al. 2013). This disruption of balance control can stem from one or more of the sensorimotor feedback systems including vision, proprioception, and the vestibular system. In static and dynamic movements, the ability to maintain balance and stability is a foundational component that is pertinent in allowing individuals to carry out their activities of daily living safely. Disruption of such foundation can lead to falls and injuries that can impair an individual for weeks, months, and even years depending on the severity of the fall. Vision is one of the key senses needed to assist individuals to determine their position and movement through space and maintaining balance. Vision is also the primary source of information from childhood onward, and a disturbance of this sense can cause other stability-related sensory systems to lead to dysfunction. Gaze is a primary component of the visual system that allows for the individual to observe their environment to gain information. This gaze can be towards a consistent point in front of the individual in a stable environment or it can be highly varied if the environment is unstable (J. Matthis, et al. 2018).

The main research aim of this study was to determine how gaze varies while walking with matched and conflicting sensory feedback sources in comparison to a controlled baseline. Sensory conflicts were created using oscillating visual and oscillating support surface manipulations during walking that were either matched (oscillating in congruence) or anti-phase (incongruent oscillations). It was hypothesized that participants would have the most difficulty in completing the incongruent condition as the platform and the optic flow are moving in opposite directions and create the most unstable environment.

METHODS

Seventeen healthy young participants performed three conditions while on a Computer Assisted Rehabilitation Environment (CAREN) System (Motek, Amsterdam, Netherlands) and wearing the Tobii Eye Tracker 2 Glasses. After a 5-minute familiarization trial, trials for seven conditions were completed. The three conditions of interest for this study were completed at their preferred walking speed and consisted of: (1) Baseline – normal AP optic flow (OF) and normal AP treadmill movement, (2) Congruent – oscillating OF with matched oscillating platform, (3) Incongruent – oscillating OF with antiphase platform rotation. Each condition was 4-minutes long in length. The Tobii Eye Tracker 2 was utilized to track the participants gaze throughout the entirety of the three conditions. Data is currently being processed with a custom MATLAB (Mathworks R2020b) code that trims the beginning and end of each of the 4-minute trials. This truncating of the data allows for isolation of the gaze while the participant is fully immersed in the optic flow and platform perturbations. The data was then resampled to take the data from every 10ms. Next, the code utilized a function to create hexscatter plots (Figure 1) which distributes the data points into areas of interest. Then finally the code was used to determine the 5% - 95% interval of each condition, and then the difference between the 5% (lower bound) value and 95% (upper bound) value was calculated to determine the spread of data points. Once data processing is completed, we will conduct a one-way ANOVA to observe any differences between the three conditions. If any significances are observed, we will conduct post-hoc testing to see where the significances are located.

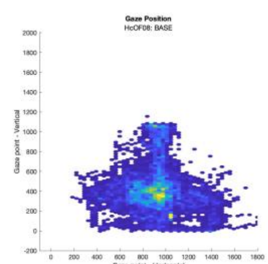

Figure 1 displays the gaze point throughout the entire baseline trial for one participant. The darker color (blue and purple) indicates where the gaze was located the least. The lighter color (yellow and orange) indicates where the gaze was located the most during the trial.

REFERENCES

1. A. Mirelman, et al. Gerontol. A. Biol. Sci. Med. Sci., 66(2), 234–40, 2011.
2. J. Matthis, et al. *Curr Biol.*, 28(8), 1224-12333, 2018.
3. A. Peruzzi, et al. Eur. Int. J. Sci. Technol., 2(6), 171–181, 2013.

ACKNOWLEDGEMENTS

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EFFECTS OF THREE DIFFERENT VISUAL BIOFEEDBACK STRATEGIES ON REDUCING JOINT LOADING ASYMMETRIES DURING BILATERAL SQUATS IN INDIVIDUALS AFTER ACL RECONSTRUCTION

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INTRODUCTION

Joint loading asymmetry that off-loads the surgical limb is still present 2 years after ACL reconstruction (ACLR) [1]. This abnormal joint loading asymmetry has been associated with an increased risk for secondary ACL injury and early onset of knee osteoarthritis. Compensation strategies that either overload the nonsurgical limb or place excess loads on the hip or ankle of the surgical limb are persistent during bilateral squats after ACLR. Therefore, a targeted rehabilitation strategy to reduce loading asymmetry during bilateral squats is needed.

The purpose of this study was to identify the effect of three different visual biofeedback strategies (vGRF, COP, and vGRF + COP) on reducing joint loading asymmetry during bilateral squats in individuals with ACLR.

METHODS

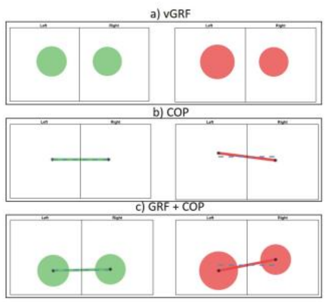

Figure 1. Illustrations of three different visual biofeedback strategies. Figures on the right column represent visual biofeedback when subjects do not meet our symmetry target.

One male recreational soccer player (age 20 yrs; mass 86.5 kg) and one female high school soccer player post ACLR (age 16 yrs; mass 64.8 kg; 8-month post ACLR) were analyzed for this study. Three-dimensional marker position and GRF data were collected at 200 Hz and 2000 Hz respectively. Participants were asked to perform 3 sets of 5 consecutive squats with each foot on a separate force plate for each condition: 1. Natural, 2. vGRF, 3. COP, 4. vGRF+COP. For vGRF condition, two circles displayed on a monitor were used to represent vGRF for each limb. Participants were asked to keep the two circles an equal size. For the COP condition, a straight line and dashed line (reference line) were displayed on a monitor. The participants were asked to keep the line horizontal. The color of the circle and bar were changed from green to red when the vGRF and COP difference between each limb exceeded a certain threshold (≥10% of greater vGRF and/or COP difference: 5% of subject's shoe size). For the GRF + COP condition, both two circles and a straight line were used with the same instructions and threshold. Variables were averaged across 3 repetitions (middle 3 out of 5) from 3 trials for each subject. The surgical limb to nonsurgical limb ratio (nondominant to dominant limb for recreational athlete) was used to characterize limb loading symmetry (LLS) and peak knee extensor moment (reported as internal moment).

Table 1. Peak knee extensor moment between limb ratio.

	Natural	vGRF	COP	vGRF+COP
ACLR	0.78 ± 0.04	0.89 ± 0.07	0.79 ± 0.02	0.87 ± 0.04
Healthy	1.00 ± 0.05	1.01 ± 0.04	1.13 ± 0.03	1.12 ± 0.08

RESULTS AND DISCUSSION

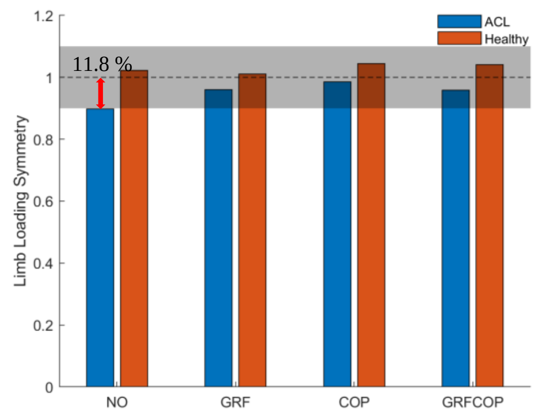

Figure 1: Limb loading symmetry during bilateral squats across conditions (natural, vGRF, COP, and GRF+COP). Shaded area represents a symmetry target (±10 % difference).

For the natural condition, limb loading symmetry was lower in the individual with ACLR during bilateral squats compared to visual biofeedback conditions. When receiving visual biofeedback, LLS was increased to above 95% for all conditions in individuals with ACLR (Figure 1). For the natural condition, individuals with ACLR showed greater asymmetry in peak knee extensor moment between limb ratio compared to the healthy control (Table 1). When receiving visual biofeedback, asymmetries in peak knee extensor moment between limb ratio decreased in individuals with ACLR (Table 1).

CONCLUSIONS

Three different visual biofeedback strategies improved limb loading symmetry and knee extensor moment symmetry in 1 participant after ACLR. Peak knee extensor moment between limb ratio improved the most when receiving vGRF feedback. While LLS improved the most when receiving COP feedback. Additional data analysis is required to determine the effect of three different visual biofeedback strategies on reducing joint loading asymmetry in individuals with ACLR during bilateral squats.

REFERENCES

[1] C. Baumgart et al., Knee Surg Sports Traumatol Arthrosc., 2017.
[2] M. Chan et al., Med Sci Sports Exerc., 2019.

TIMEKEEPER: DEVELOPMENT OF A WEB-APP TO IMPROVE MOTOR TIMING AND RHYTHM IN PEOPLE WITH PARKINSON'S DISEASE

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INTRODUCTION

Parkinson's Disease (PD) leads to motor timing and rhythm deficits. This may be caused by malfunction of neural circuitry that processes rhythm and is responsible for finger tapping and gait impairments[1]. The use of rhythmic auditory stimulation (RAS) can improve the gait of people with PD[2]. Studies have shown a tight connection between basic motor timing and the success of RAS interventions. The general dysrhythmia hypothesis suggests that training basic motor timing may lead to improvements in other rhythmic activities such as gait. Currently there is no protocol to selectively train rhythmic skills in PD patients.

Our goal is to develop innovative, accessible patient-centered interventions to improve motor functions in people with Parkinson's Disease. Our Timekeeper Web-app is based on the hypothesis that the accuracy and variability in timing will increase and decrease, respectively, with practice.

METHODS

The web-application is currently available at https://ractrainer.firebaseapp.com/. We use a typical synchronization-continuation paradigm, where users listen and tap in time with a metronome, and try to 'keep the rhythm' when the metronome stops. A training regimen using this task could improve the motor timing of PD participants, because it could train them to internally generate rhythm. Based on their performance during the continuation phase, users are provided a score as a percentage, where 100% means that they perfectly reproduced the rhythm.

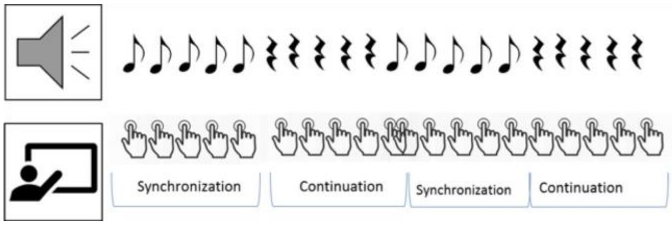

Figure 1: Representation of the synchronization-continuation paradigm. Illustrated here are two cycles of 5 taps "on" (with metronome) and 5 taps "off" (without metronome).

So far, we have only tested the web-app with healthy adults and a single person with PD. We will recruit a few more volunteers to have them involved and provide their feedback about usability.

The web-app allows us to create individual accounts for users that will track their progress. The main screen lists the available "assignments", which vary in difficulty based on the tempo, the time with metronome "on" or "off", the presence of a visual feedback, and the number of repetitions. Users also have access to a "Custom Session" that allows them to change all of the parameters listed above.

The game instructs participants to tap the space bar to the beat and continue to do so until the end. When they start, they will tap with a metronome, but after a certain amount of time the metronome will fade, and they will have to continue to tap at the same frequency.

Once they have completed the game a screen appears telling them their score along with a graph. They have the option to look at their inter-tap interval graph or their asynchrony graph. Information about the graphs is also included on their screen.

RESULTS AND DISCUSSION

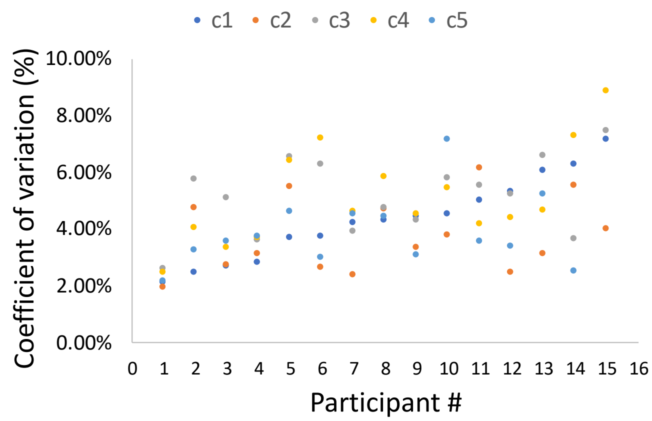

Figure 2. Coefficient of variation (%) in 5 different conditions (c1-c5) for 15 healthy adults. Notice how the first participant (on the left) present a consistent low CV across all conditions: this participant was the only musician in the group.

Further work is needed to validate our web-app against gold-standard equipment, before testing it as a training intervention for people with PD. Our long-term goal is to create a patient-centered intervention to improve motor and potentially cognitive functions in people with Parkinson's Disease. We are working on improving this app further to create a mobile version for the phone, and to transform the "assignments" into a game.

REFERENCES

1. Cock et al. *npj Parkinson's Disease* **4**, 2018.
2. Benoit et al. *Frontiers in Human Neuroscience* **8,** 2014

Effects of task prioritization during dual-task walking on gait variability in people with Parkinson's disease

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INTRODUCTION

Parkinson's Disease (PD) is the second most common neurodegenerative disease, generally for those over the age of 50 years[1]. Walking with PD requires considerable amounts of attention[2], dividing their attention to secondary tasks (dual tasking) may place people with PD at an increased risk of falling as they run out of resources to produce normal walking[3]. Gait dynamics can be measured with the coefficient of variation (CV), that quantifies the 'amount' of variability, and by the detrended fluctuation analysis (DFA), which quantifies the randomness of stride-to-stride intervals. People with PD typically walk with greater CV and DFA values close to 0.5, indicative of unstable and random gait patterns[4].

Attentional control of gait can change α-DFA, suggesting that each stride is a correction from the last to meet environmental demands. The task prioritized (locomotor vs. cognitive) may also have a specific effect on gait variability, but there is a gap of knowledge regarding the effect of task-prioritization during dual-task walking on gait variability in people with PD.

In this study, the effects of dual task walking will be measured in people with PD and aged matched controls. Our hypotheses are that 1) during single and dual-task walking, there will be more random stride-to-stride variation in PD participants compared to the control group; and 2) instructing people with PD to focus on the locomotor task will increase stride-to-stride randomness.

METHODS

Five people with PD and seven older adults (OA) completed this study. Data collection is currently in progress. Participants completed clinical task before being fit with pressure sensitive insoles and given headphones and an iPod. They completed five conditions (random order): single cognitive task (not reported here), single walking task, dual-task walking without prioritization, dual-task walking with locomotor priority, and dual-task walking with cognition priority. The cognitive task consisted in listening to an audiobook while counting two predefined words, and answering questions about the story at the end of the trial. Each trial lasted 10 min, with at least 5 min rest between trials. Stride-to-stride intervals were extracted from the insoles, and CV and DFA applied to these time series.

RESULTS AND DISCUSSION

Contrary to our hypothesis, our preliminary results show that stride-to-stride variations in PD are lower than OA only during single-task walking (Figure 1). Compared to the 'no-prior' condition, focusing on either gait or cognition seems to increase DFA, which is surprising, and may be due to our small sample size. In contrast, CV increased in DT conditions only for PD – and was maximal for DT with priority on cognition, which may suggest that this variable will be better to discriminate between groups or conditions. Analysis are in progress to compare these behavioral data to cortical data collected in this study.

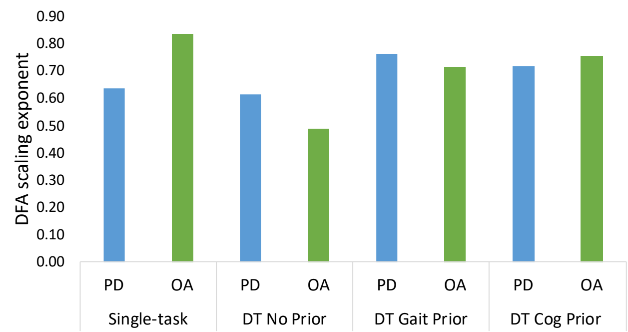

Figure 1. Mean DFA values of stride time intervals as a function of experimental conditions for PD and OA groups. Notice how DFA is lower at baseline for PD compared to OA, but increases when gait is prioritized. In contrast, DFA is greatly reduced in OA during DT no-prioritization.

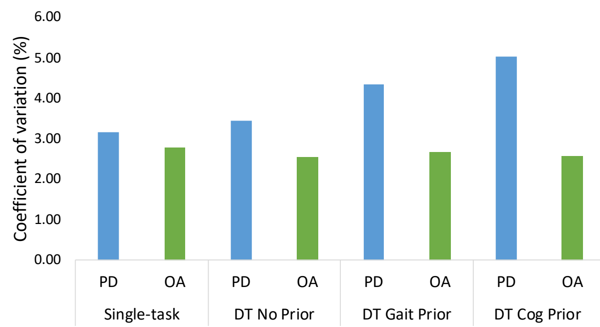

Figure 2. Mean coefficients of variation (%) of stride time intervals as a function of experimental conditions for PD and OA groups. Notice how PD always present greater CV and increases in both DT-prior conditions for PD only.

REFERENCES

1. De Lau, L, et al, *The Lancet Neurology*, **5**(6), 525-535, 2006
2. Chen TY, et al. *J Gerontology Series* **67**(6), 720-728, 2012.
3. Kelly V, et al. *Parkinson's Disease, 1-14, 2012*.
4. Marmelat V, et al. *Gait & posture* **70**, *229-234*, 2019.

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VALIDATION OF VIRTUAL REALITY PRISM ADAPTATION FOR UNILATERAL SPATIAL NEGLECT INTERVENTION

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INTRODUCTION

Unilateral spatial neglect (USN) is a common impairment following stroke. USN is an attentional deficit that significantly reduces quality of life. Symptoms include the inability to respond to stimuli on the side opposite of the stroke [1]. One successful form of USN treatment is called prism adaptation (PA), in which individual interacts with their surroundings while wearing prism goggles that shift their visual environment to the ipsilesional side. Over time, PA intervention can contribute to decreased USN symptoms [1]. Virtual reality may be a novel and effective way to implement a visually complex and quantitative version of this intervention [2]. Before testing a simulation on a patient population, we aim to determine if our PA VR software results in expected errors during reaching with a healthy population. During baseline, we hypothesize that individuals will have negligible error, followed by rightward error during a rightward prism shift and a leftward after-effect error.

METHODS

Nine neurologically intact adults (5M, aged 27.11 ± 7.22 years) volunteered to participate in this study. Each individual performed reaching tasks in VR during baseline (no visual shift), prism (a 10˚ rightward shift), and after-effect (no visual shift) trials. Participants reached for targets that were arranged at ±20˚ ±15˚, and ±10˚ bilaterally and vertically from an anthropomorphic average sternal notch, each attempted 4 times in randomized order for a total of 48 reaches. Hand occlusion was simulated by neglecting to render the virtual hand until the individual was within the last 25% of the anterior distance to the target. Each target was spherical with a radius of 1.25 cm. A furnished room appeared in the background for aiding in depth perception and providing a life-like scenario.

Fingertip positions were continuously recorded from a reset position at the chest to the point of collision for each target. To determine the error in each reach, we calculated the maximum mediolateral deviation (mMLD), by determining the largest mediolateral distance between the actual finger position and an ideal path drawn from start to the center of each target [3]. Negative mMLD represented leftward errors, while positive values represented rightward errors in reaching.

Due to the fact that the participants were neurologically healthy and could therefore quickly adjust to visual perturbations, only the first ten mMLD values were considered in analysis. This was for the purpose of testing the validity of the simulation and the reaching errors it would cause, as opposed to testing the ability of the participants to learn and adjust throughout each trial. Repeated measures one-way ANOVAs were performed to determine the difference in mean errors between baseline, prism, and after-effect trials. When an overall difference was present, follow-up pairwise comparisons were performed with a Bonferroni correction.

RESULTS AND DISCUSSION

Repeated measures one-way ANOVA showed significant differences (Figure 1) between baseline and prism errors ($p = 0.001$), as well as between prism and after-effect errors ($p < 0.001$). The visual perturbations of the simulated PA showed expected reaching errors. The baseline trial resulted in negligible error, rightward mMLD values in the prism trial, and leftward mMLD values during the after-effect trial.

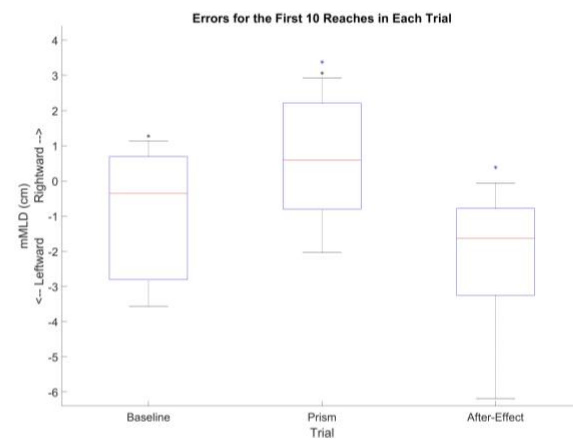

Figure 1: Reach error comparisons across trials. The mMLD for the first ten reaches for each trial was averaged for each subject and is shown on a standard boxplot. Significant pairwise comparisons are shown with color-corresponding asterisks.

These results validate our simulated PA software and indicates that it could also produce reaching errors in a population which could benefit long-term from repeated used of the simulated intervention. Future work will investigate the feasibility of implementing this system into a clinical setting and its efficacy with the USN population to produce intervention results equal to or possibly better than a standard PA intervention.

REFERENCES

1. Parton A, et al. *JNNP* **75**, 13-21, 2004.
2. Rizza A, Kim GJ. *Presence of Teleoperators Virtual Environ.* **14**, 119-146, 2005.
3. Ogourtsova T, et al. *Neurorehabil Neural Repair* **32**, 46-61, 201

The Decay and Consolidation of Effector-Independent Motor Memories

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INTRODUCTION

Learning a motor adaptation task produces intrinsically unstable or transient motor memories. We exploit inter-effector transfer to determine how the memory traces decay in different contexts (Kitago et al. 2013) and whether an offline consolidation protects memories against decay (Krakauer et al. 2005).

METHODS

<u>Subjects</u>. Ninety-eight young and healthy right-handers participated in the study.

<u>Experiment 1.</u> The experiment consists of three phases: learning, decaying, and testing. During the learning, the subjects adapted to a 30° visuomotor perturbation in a target-oriented reaching task with the non-dominant arms. Then the movement was restored to the normal state in the decaying phase. Finally, the subjects performed the same tasks with the dominant arms in the testing phase. The subjects are divided into two groups during the decaying phase: (1) removing the perturbation from the motor task (Group 1.1), and (2) sitting idle for about 15 minutes (Group 1.2).

<u>Experiment 2.</u> The experimental paradigm was similar to *Experiment 1*, while the subjects were divided into three groups during the decaying phase: (1) removing the visual-feedback error during the reaching (Group 2.1), (2) applying a force-channel that restricts the movement along the optimal direction (Group 2.2), and (3) removing the visual-feedback throughout the decaying (Group 2.3).

<u>Experiment 3.</u> Three groups of subjects did similar tasks as Group 1.1, 1.2, and 2.3. To consolidate the memories before decaying, a six-hour break was inserted between the learning and decaying phases.

RESULTS AND DISCUSSION

<u>Experiment 1.</u> Faster learning or decreased initial error of the dominant arm indicated retrieval of memories across arms.

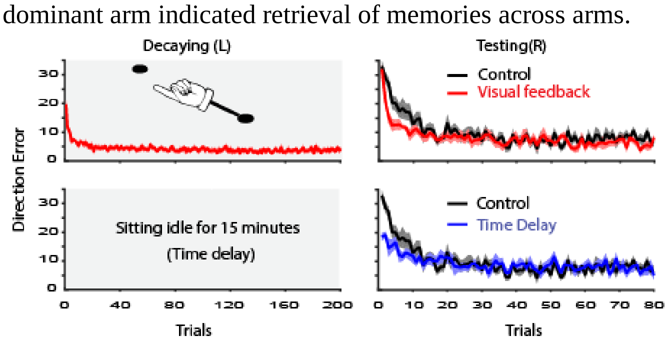

Figure 1: After the decaying phase, Group 1.1 exhibited faster learning in the testing phase, and the initial error of Group 1.2 decreased substantially.

<u>Experiment 2.</u> The effector-independent memories were erased during the decaying phase.

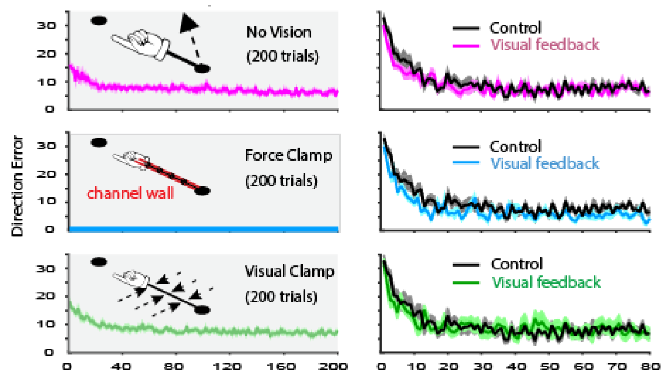

Figure 2: The Performance in the testing was no different from naïve control subjects after no visual feedback, force clamp, or visual clamp trials during the decaying phase.

<u>Experiment 3.</u> The memories were protected against decaying by the six-hour offline consolidation.

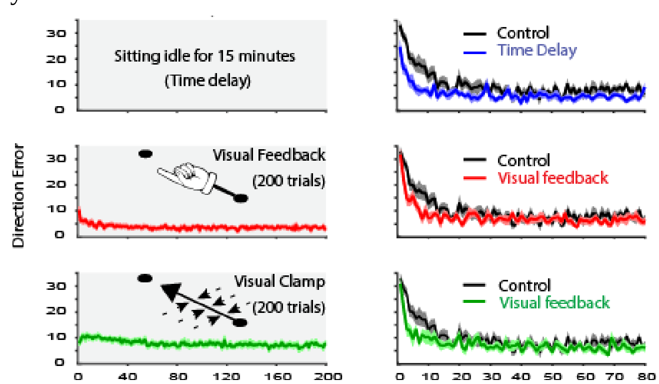

Figure 3: By adding a six-hour break before the decaying, all three groups exhibited faster learning during the testing phase, indicating offline consolidation and generalization of the motor memories during the resting period.

CONCLUSIONS

Newly-acquired memories formed with one effect could be partially retrieved by the untrained effector to enhance its performance when the decay occurred with the passage of time or washout trials on which error feedback was provided. But the retrieval was abolished with the absence of performance error or sensory feedback unless consolidated offline in a resting period after the learning.

REFERENCE

Kitago et al. *Front Hum Neurosci* **7**, 307, 2013.

Krakauer et al. *J Neurosci* **25**, 473-478, 2005.

HETEROGENEITY IN MOTOR VARIABILITY IN PATIENTS WITH CHRONIC LOW BACK PAIN: A SYSTEMATIC SCOPING REVIEW

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INTRODUCTION

Chronic low back pain (CLBP) is a widely prevalent condition [1]. Literature suggests that the heterogeneity in motor control in the CLBP population is hampering the effectiveness of rehabilitation therapies [2]. Motor variability parameters have received considerable attention in recent years and have been proposed in frameworks for stratification of CLBP patients potentially tailoring therapy to patients' specific needs [3]. Yet, it is not known if CLBP patients can be classified in more homogeneous subgroups based on distinct patterns of motor variability. The aim of this scoping review was (1) to investigate differences in patterns of motor variability between CLBP patients and pain-free controls during functional tasks, and (2) to evaluate motor variability of functional tasks and CLBP across time by including longitudinal studies, to better understand the relationship between pain and motor variability across time, and to gain a good insight into the between and within group heterogeneity in terms of motor variability.

METHODS

The primary search was conducted in Pubmed, EMBASE and Web of Science up to April 2020. The following articles were included for selection criteria: (1) cross-sectional or longitudinal study design; (2) adult (>18 years) population with chronic (>3 months) non-specific low back pain (without identification of underlying mechanisms); (3) assess functional tasks and (4) include measures of motor variability, operationalized as muscle recruitment patterns and/or kinematic movement patterns.

RESULTS AND DISCUSSION

In total 22 cross-sectional studies met the inclusion criteria comprising the following functional tasks: bending (n=3), gait (n=10), lifting (n=3), standing (n=3) and sit-to-stand (n=3). Longitudinal studies examining the effect of an intervention on motor variability over time were scarce (n=3).

Dissimilar neuromuscular control between CLBP patients and controls during functional tasks was observed. A tendency towards more rigid, in-phase trunk movements (particularly in the transverse plane) and irregular coordination of lumbar erector spinae muscle activity was reported in CLBP, albeit with conflicting results between studies. No distinct patterns of differences between both groups in movement variability associated with specific functional tasks were identified. (Figure 1).

Studies showed a variety in methodologies and metrics to assess motor variability. The results could not be pooled.

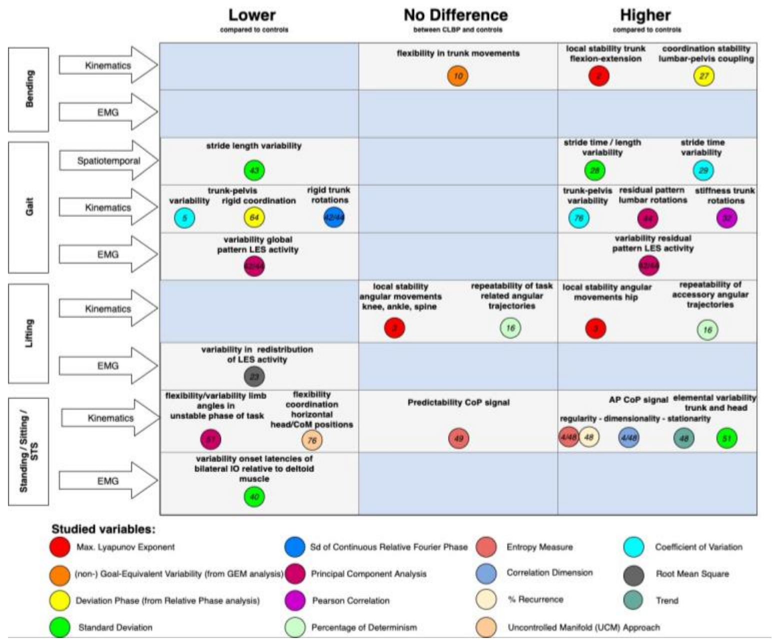

Figure 1: Findings and Literature Gap Map.

All three longitudinal studies, reported motor control changes following various interventions, suggesting that motor variability can be manipulated in CLBP. None of the studies revealed a clear relationship between motor variability and pain intensity, and/or other patient characteristics.

CONCLUSIONS

No stratification of homogeneous subgroups was found. This might be due to several factors; 1) small sample sizes of all studies; 2) substantial differences in methodologies and metrics to assess motor variability; 3) differences in how tasks were assessed; 4) most study designs are cross-sectional. To gain better insight in patterns of motor variability in CLBP future research should focus on longitudinal designs with standardized sets of motor variability metrics and functional tasks. Clinical assessments should be reported more comprehensively to take into account the multidimensional clinical presentation of CLBP.

REFERENCES

1. Meucci RD, et al. *Revista de saude publica* **49**, 49-73, 2015.
2. Van Dieën JH, et al. *J Orthop Sports Phys Ther* **49(6)**, 370-379, 2019.
3. Van Dieën JH, et al. *J Orthop Sports Phys Ther* **49(6)**, 380-388, 2019.