COMPARISON OF AN AUTOMATIC AND VOLUNTARY TASK IN EARLY PARKINSON'S DISEASE

[1]Molly McVey, [1,2]Antonis Stylianou, [3]Kelly Lyons, [3]Rajesh Pahwa, [1,2]Carl Luchies, and [4]Paul Cheney
[1]Mechanical Engineering, The University of Kansas, Lawrence, KS, USA luchies@ku.edu
[2]Landon Center on Aging, [3]Parkinson's Disease and Movement Disorder Center, [4]Molecular and Integrative Physiology; The University of Kansas Medical Center, Kansas City, KS, USA

INTRODUCTION

The motor deficits associated with Parkinson's disease (PD) are well known and include akinesia/bradykinesia, resting tremor, rigidity, and postural instability. Although all of these deficits presumably stem from circuit dysfunction in the basal ganglia due to a loss of dopamine neurons, the underlying neural mechanisms are not well understood. The basal ganglia are known to be involved in making the necessary postural adjustments to maintain balance during voluntary movement [1]. The basal ganglia may also play a role in the automatic step response to a balance disturbance (balance recovery) since impairments in this task have been demonstrated in individuals with PD [2].

Previous studies have identified impairments caused by PD in both voluntary tasks (e.g. gait initiation) and automatic tasks (e.g. balance recovery). However, the balance recovery studies have primarily focused on persons with PD who already exhibit clinical signs of postural instability. Recently, several differences in balance recovery have been identified in persons with early PD and no clinical signs of postural instability [3]. The focus of this study was to determine if the same effects of early PD are also observed in gait initiation. We hypothesized that we would see similar effects of PD in the two tasks (differences in weight shift time, ankle angle, and COP movement).

METHODS

Participants: 10 subjects with Parkinson's disease (PD) and 11 healthy controls (HC) (PD: age 63.2 ± 8.9 years, H&Y 2; HC: age 68.0 ± 9.6 years) completed the study. The analysis reported here is based on a subgroup of 10 PD and 10 HC in the balance recovery task and a subgroup of 7 PD and 11 HC in the gait initiation task.

Tasks: In both tasks, the participant began each trial by standing quietly with feet a shoulder width apart. In the Gait Initiation (GI) task, the participant stood with arms relaxed at the sides and was instructed to initiate forward walking in response to a visual cue. The participant was allowed to self-select the foot used for the first step and the walking speed. Three trials were conducted. In the Balance Recovery (BR) task, the participant stood with arms crossed at the chest wearing a rigid waist harness attached via a cable to a weight-drop mechanism (dropped weight = 20% BW, pull distance = 8.7% waist height), which delivered a posterior waist pull. The participant was asked to respond naturally to the balance disturbance. A safety harness was used to ensure participant safety.

Data Collection: Force plate data were collected using three AMTI (Advanced Medical Technology Inc.; Watertown, MA) six-component force plates and EMG data were collected using bipolar surface electrodes (Noraxon; Scottsdale, AZ) from the tibialis anterior (TA) with a sampling frequency of 1080 Hz. Kinematic data were collected at 120 Hz using reflective markers and a six camera Vicon 512 (Vicon Peak; Lake Forest, CA) motion analysis system. Markers were placed bilaterally on the 2nd toe, ankle, heel, calf, and knee. All responses were video taped.

Data Analysis: Stimulus onset was defined as the onset of the light in the GI task and onset of the waist pull force in the BR task. Liftoff and landing were defined by the movement of the heel marker in the GI task and by force plate unloading/loading in the BR task. Temporal parameters included reaction time (stimulus onset to first TA onset), weight shift time (reaction time to liftoff), and step duration (time between liftoff and landing). Kinematic parameters included step length (distance traveled by the heel marker between liftoff and landing), step height (maximum vertical displacement of the heel marker between liftoff and landing), and ankle plantarflexion (PF)/dorsiflexion (DF) angle. Ankle angle was calculated at liftoff and landing. COP parameters included the anterior-posterior (AP) and medial-lateral (ML) displacement of the center of pressure (COP) at liftoff and landing of the first step. All data were processed with MATLAB (Mathworks, Natick, MA, USA). T-tests ($p<0.05$) were used to assess group differences using SPSS (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

In the BR task, significant differences were found between groups in weight shift time, ankle angle at liftoff, and COP displacement at landing. No significant differences were found in any of the other parameters. In the GI task, no significant differences were found between groups in any of the parameters (Table 1). In BR, the PD group had a longer weight shift time than HC, were in DF at liftoff while the HC were in PF, and the COP was further forward than HC at landing. In GI, both groups had similar weight shift times, were in DF at liftoff, and the COP displacement at landing was similar.

Study limitations include the differences across the two tasks in movement direction (anterior in GI, posterior in BR) and stimulus type (visual in GT and somatosensory in BR).

CONCLUSIONS

The results of this study suggest that in early PD, the first step in the voluntary gait initiation task is not impaired as is the first step of the automatic balance recovery task. This suggests that in the early stages of the progression of Parkinson's disease, the underlying neural mechanisms of the basal ganglia may affect voluntary tasks differently than automatic tasks.

REFERENCES

1. Kandel ER, et al. *Principles of Neural Science,* McGraw-Hill, New York, NY.
2. Jacobs JV, et al. *Neuroscience* **141**, 999-1009, 2006.
4. McVey MA, et al. *Proceedings of the Summer Bioengineering Conference,* Marco Island, United States, Abstract 192822, 2008.

.

ACKNOWLEDGEMENTS

Assistance from Michael Haines and Laura Zahner and support from the Self Graduate Fellowship and the Landon Center on Aging are acknowledged.

Table 1: Results in Balance Recovery (Automatic Response) and Gait Initiation (Voluntary Response)
*Indicates a p-value < 0.05. ML = medial-lateral, AP = anterior-posterior; a + angle indicates PF, - DF

	Balance Recovery		Gait Initiation	
	HC	**PD**	**HC**	**PD**
Temporal Parameters (ms)				
Reaction Time	124 (19)	123 (17)	161 (65)	173 (47)
Weight Shift Time	222 (54)*	500 (304)*	922 (135)	914 (121)
Step Duration	113 (51)	153 (33)	464 (24)	462 (62)
Kinematic Parameters				
Step Length (mm)	8.2 (3.7)	10.2 (4.6)	24.4 (3.6)	25.0 (6.2)
Step Height mm)	1.4 (2.0)	1.8 (2.5)	3.3 (1.2)	3.7 (1.8)
Liftoff Angle (°)	1.5 (3.8)*	-4.1 (3.6)*	-6.6 (2.4)	-7.3 (3.6)
Landing Angle (°)	-1.3 (4.0)	-5.1 (5.2)	-17.2 (16.8)	-26.0 (13.6)
COP Displacement (mm)				
ML at Liftoff	128 (19)	125 (34)	41 (27)	25 (20)
AP at Liftoff	29 (25)	64 (49)	-34 (26)	-26 (18)
ML at Landing	129 (22)	127 (33)	105 (27)	96 (27)
AP at Landing	42 (17)*	71 (37)*	16.8 (33)	30 (38)