THE EFFECT OF MODERATE PARKINSON’S DISEASE ON THE PREPARATION FOR COMPENSATORY BACKWARD STEPPING

Molly A. McVey, Annaria Barnds, Kelly E. Lyons, Rajesh Pahwa, and Jonathan D. Mahnken, Carl W. Luchies

1University of Kansas, Lawrence, KS, USA
2University of Kansas Medical Center, Kansas City, KS, USA
email: luchies@ku.edu

INTRODUCTION

Postural instability leading to falls is one of the most disabling symptoms of Parkinson’s disease (PD) with 46% of those with PD falling in a given 3 month period [1]. PD impairs the step response needed to recover from a large balance disturbance and prevent a fall. Investigation of the control of the center of pressure (COP) during the step response has shown impairments in PD, such as the use of multiple anticipatory postural adjustments (APAs) leading to delayed liftoff times and the use of additional and shorter steps to regain balance [2].

Previous studies of postural instability have focused on patients who already exhibit balance deficits, however we have demonstrated impairments in balance recovery in mild PD with no clinical signs of postural instability (H&Y severity level 2) such as a longer weight shift time, altered ankle rotation prior to liftoff, and a more posterior displacement of the COP at landing of the first step in the response [3]. In addition, the COP patterns observed during the step initiation stage of the response were quite different between the two groups. Therefore, the goal of this study was to investigate the COP movement during the preparation stage of the step response in PD patients with moderate PD (clinically diagnosed postural instability- H&Y 3), compared to healthy controls.

METHODS

Ten participants with moderate PD (PD: Age 68 ± 4 years, H&Y 3) and 10 healthy controls (HC: Age 68 ± 5 years) completed the study. All participants gave written informed consent. Participants stood with arms crossed at the chest wearing a rigid waist harness attached via a cable to a weight-drop mechanism (dropped weight = 20% body weight, pull distance = 8.7% waist height), which delivered a posterior pull. The participant was asked to respond naturally. A harness was used for safety.

Data Collection: Motion data were sampled at 100 Hz using an Optotrak (Northern Digital, Inc., Waterloo, Canada) dual bar motion analysis system. Markers were placed bilaterally on the 2nd toe, ankle, heel, calf, and knee. EMG (Delsys, Boston, MA, USA) from the tibialis anterior (TA) and force plate data from three six-component force plates (AMTI, Watertown, MA, USA) were sampled at 1000 Hz. All responses were videotaped.

Data Analysis Data from all trials were processed using MATLAB (Mathworks, Natick, MA, USA). Trials were classified as single or multiple step trials. Only the first step in a multiple step response was compared. A step was defined if the foot lifted off the force plate and repositioned to change the base of support. The foot was required to translate 50 mm or more in order to be considered a step.

The whole body center of pressure (COP) was calculated between disturbance onset to liftoff of the first step, and divided into two stages. Stage 1 was defined as disturbance onset to weight shift onset. Stage 2 was defined as weight shift onset to step foot liftoff. Weight shift onset was defined as the last change in the location of the COP in the medial-lateral (ML) direction prior to liftoff. The anterior-posterior (AP) and ML displacement, path length, average velocity, and the duration of each stage were calculated. APAs were defined based on the movement of the lateral COP signal. The baseline signal was defined by the average of the signal for
500 ms prior to onset of the disturbance. If the COP traveled more than 1cm from the baseline an APA was noted to begin. Trials were classified as having 0, 1, or 2 or more APAs.

Statistical analysis was done with SPSS 20.0 (SPSS Inc., Chicago, IL). The Fisher’s Exact Test was used to evaluate group differences in the number of trials where multiple APAs were used and consistency of preparation strategy. Normally distributed COP parameters were analyzed with Student’s T-tests, those that were not were analyzed using the Mann-Whitney U Test. Follow up tests were done to compare stepping strategy (0 or 1 APAs compared to 2 or more APAs) to the COP parameters using linear mixed modeling.

RESULTS AND DISCUSSION

PD, compared to HC, utilized significantly more steps to recover from the balance disturbance (HC: 1.66 ± 0.63, PD: 2.43 ± 0.79, p = .035). PD used multiple APAs in 37% of all trials, compared to HC who never used multiple APAs (p=.0003). There were significant differences in several COP parameters, all in the first stage of the response (table 1). Follow up tests found significant differences in COP parameters based on number of APAs (figure 1). These results suggest that COP measures during the preparation phase of the response may be early indicators of postural instability. This is exciting because the preparation phase of the response cannot be visually observed, so the use of these measures may offer clinical insight that is not otherwise available.

Limitations of this study include the small sample size, the predictable nature of the disturbance, and that PD participants were tested only in the ON medication state. These choices were made to reflect the clinical pull test (UPDRS # 33).

CONCLUSIONS

The preparation phase of the response to an external perturbation is impaired in moderate PD. The use of multiple APAs results in delayed liftoff times and significantly different movement in the COP prior to liftoff. Furthermore, the differences in the response can be attributed to the stage of preparation prior to final weight shift. This portion of the response and these parameters should be further investigated for their value in a more sensitive measure of postural instability.

REFERENCES


ACKNOWLEDGEMENTS

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