Impaired directional perception of whole body perturbations in people with Parkinson's disease may contribute to balance impairment

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Introduction

- Parkinson's Disease (PD) is recognized as a motor disorder, with postural instability as a primary cardinal sign and falls due to loss of balance.
- Falls in PD has been strongly associated with the loss of control of center of mass [1].
- Automatic postural control is impaired in older adults and individuals with balance impairments leading to heavy reliance on attentional mechanism [2].
- Conscious and attentional perception of sensory information may be important to compensate for the deficit in automatic postural control [2,3].
- Sensory deficits in PD have been investigated in isolated limbs [5,6], and across different tasks and measures [7,8,9], but it is unknown whether the perception of whole body motion during standing balance is degraded during standing balance or associated with balance impairment as seen in PD.

Our hypotheses are:

1. Directional acuity to whole body perturbations during standing is worse in people with PD compared to healthy young adults (HYA).
2. Impaired directional acuity is associated with worse balance ability.

Methods

Data sources

1. **HYA data.** Previously-collected [10].
2. **PD subjects.**
- Recruited from a one-year longitudinal observational study of fall risk (J.L. McKay, PI).
- Interviewed for health history, previous falls, and assessed with a behavioral and cognitive outcome measure including MDS-UPDRS III (scored from video by a neurologist).
- 12-hour off medication state.
- Inclusion criteria: age ≥ 40, diagnosis of idiopathic PD with demonstrated response to levodopa, perception of vibration and light touch on feet.
- Exclusion criteria: significant musculoskeletal impairment as determined by the investigators.

PD & HYA Participants

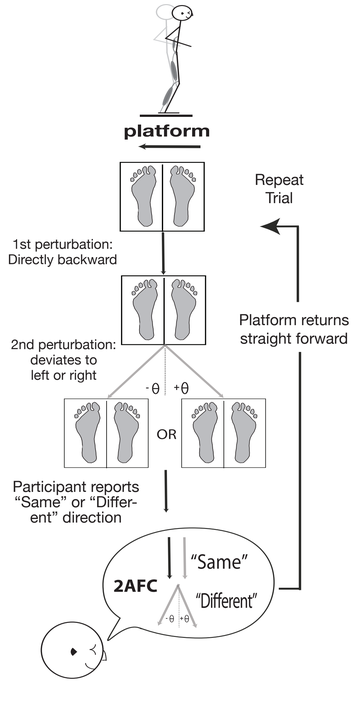
Table 1. Demographic and clinical features of study participants with PD.

Characteristic	PD Patients	Healthy Young Adults
N	15	11
Age, y	64.5±6.8	21.9±3.3
Sex		
Female	5 (33)	6(56)
Male	10 (67)	5(44)
MoCA, /30	27.4 ± 2.0	
Education, y	16.4 ± 1.7	
Disease duration, y	7.8 ± 6.0	
MDS UPDRS-I, /52	11.8 ± 5.5	
MDS UPDRS-II, /52	13.9 ± 6.2[a]	
MDS UPDRS-III, /132	27.7 ± 11.5	
MDS UPDRS-IV, / 24	4.9 ± 2.8[a]	
FOG-Q, /24	5.0 ± 4.0	
LEDD, mg	854 ± 515	
Mini-BESTest, /28	22.0±3.5	
Falls, 6 months		
0	6 (40)	
1	4 (27)	
3+	5 (33)	
Freezing of Gait		
Freezer	6(40)	
Nonfreezer	9 (60)	

Abbreviations: PD, Parkinson's disease; MoCA, Montreal Cognitive Assessment; UPDRS-III, Unified Parkinson's Disease Rating Scale, Part III: Motor Exam; FOG-Q, Freezing of Gait Questionnaire. [a]N=14.

Whole body directional acuity was measured standing during support surface translation [10]

Schematic of experimental protocol
Subject preparation:
A. Blindfold
B. Headphones playing white noise
C. Standardized stance width



Parameter estimation by sequential testing (PEST)
- 2-down-1-up adaptive algorithm uses subject's previous responses in determining the next stimulus.
- Targets a 75% correct response threshold
- Determines the directional threshold of each side as the step size falls to 0.5° .

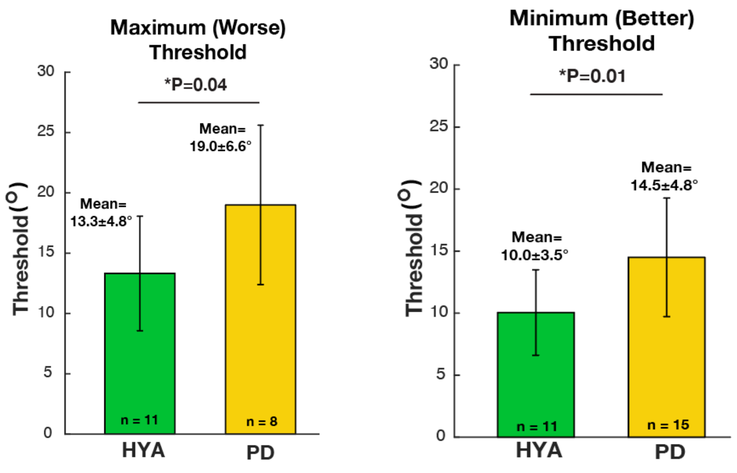
Dependent Variables:
- Left and right thresholds

Data Analysis:
- If the subject converged on both the left and rigth sides, the left and right thresholds were reclassified as maximum and minimum thresholds for each subject.
- If the subject only converged in one side, the threshold was classified as the minimum threshold.

Statistical Analyses:
Stastical analyses performed in SAS at p<0.05.
1. Differences between maximum and minimum directional thresholds within each group was analyzed using paired t-test.
2. Differences between PD and HYA thresholds were analyzed using Student t-test
3. Correlations of thresholds to MiniBESTest and MDS-UPDRS III were investigated using linear regression.

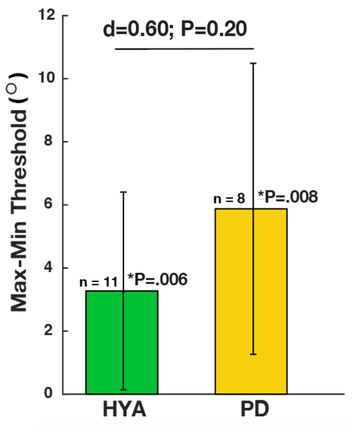
Results

1. Directional perception was poorer among PD patients than in healthy young adults



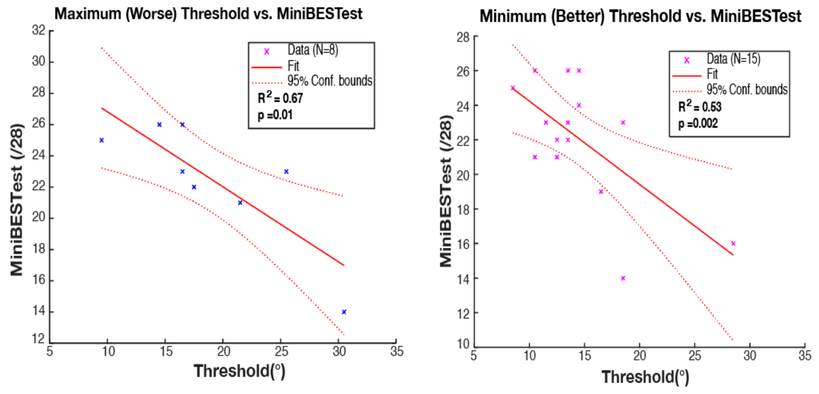
- Both the maximum and minimum thresholds in PD group were siginificantly different the maximum and minimum thresholds in HYA responsively.

2. Directional perception was asymmetric in both PD and HYA and marginally more so in PD

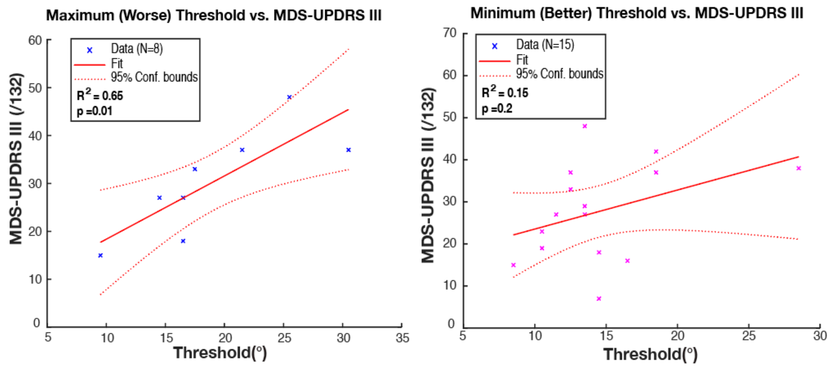


- In each group, the maximum thresholds were significantly different from the minimum thresholds, which indicated asymmetry in directional acuity between the left and right sides.
- However, there was not a significant difference in the directional acuity asymmetry between HYA and PD.
- 7 out of 15 PD subjects were only able to converge to one side threshold while all healthy young subjects were able to reach both sides thresholds.

3. Directional perception impairment in PD was correlated with worse balance and PD severity



- Among people with PD, the directional acuity threshold on the more and less sensitive sides was significantly correlated with balance score as evaluated by MiniBESTest.



- Among people with PD, the correlation between disease severity, as evaluted by MDS-UPDRS III, and directional acuity was only observed at the less sensitive side (worse performing side).
- The directional acuity on the more sensitive side (minimum thresholds) was not associated with PD severity.

Discussion

- **This is the first study demonstrating that perception of whole body center of mass motion direction is impaired in people with PD in a functional context.**
- **The correlation between poor whole-body movement perception and poor balance ability suggests that perceptual impairments could contribute to balance impairments that cause falls in people with PD.**
- **Postural perception can be asymmetric in both healthy and PD individuals, and in PD only the worse directional acuity thresholds were corrected to PD severity.**
- **Taken together, our results suggest that reduced whole-body directional perception could impair the efficacy of compensatory balance strategies that rely on attentional mechanisms, which may be necessary to compensate for poor automatic postural responses in people with PD.**

Limitations & Future Directions

- Comparison between PD and HYA cannot distinguish the effect of age. We are currently assessing a sample of neurotypical individuals age and sex matched to the PD group.
- This study used univariate linear regression to assess directional acuity threshold and miniBESTest score. Subsequent analysis will use a multivariate regression approach to control for potential clinical and demographic factors.

References: [1] Horak, Age and Ageing. 2006; [2] Woollacott et al., Gait Posture. 2002; [3] Allcock et al., Parkinsonism and Related Disorders. 2009; [4] Potter et al., J Physiotherapy. 2015; [5] Maschke et al., Brain. 2003; [6] Zia et al., Clinica Anatomy. 2002; [7] Tagliabue et al., Neuroscience. 2009; [8] Jacobs et al., Neuroscience. 2006; [9] Rickards et al., Brain. 1997; [10] Punkatalee et al., Gait Posture. 2016; [11] Bloem et al., J Neurol. 2001

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