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Balance Differences in People with Parkinson Disease with and without Freezing of Gait

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Abstract

Background—Freezing of gait (FOG) is a relatively common and remarkably disabling impairment associated with Parkinson disease (PD). Laboratory-based measures indicate that individuals with FOG (PD+FOG) have greater balance deficits than those without FOG (PD-FOG). Whether such differences also can be detected using clinical balance tests has not been investigated. We sought to determine if balance and specific aspects of balance, measured using Balance Evaluation Systems Test (BESTest), differs between PD+FOG and PD-FOG. Furthermore, we aimed to determine if time-efficient clinical balance measures (i.e. Mini-BESTest, Berg Balance Scale (BBS)) could detect balance differences between PD+FOG and PD-FOG.

Methods—Balance of 78 individuals with PD, grouped as either PD+FOG (n = 32) or PD-FOG (n =46), was measured using the BESTest, Mini-BESTest, and BBS. Between-groups comparisons

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Conflict of Interest

All authors of this manuscript have no conflicts of interest to declare.

were conducted for these measures and for the six sections of the BESTest using analysis of covariance. A PD composite score was used as a covariate.

Results—Controlling for motor sign severity, PD duration, and age, PD+FOG had worse balance than PD-FOG when measured using the BESTest (p=0.008, F=7.35) and Mini-BESTest (p=0.002, F=10.37), but not the BBS (p=0.27, F=1.26). BESTest section differences were noted between PD+FOG and PD-FOG for reactive postural responses (p<0.001, F=14.42) and stability in gait (p=0.003, F=9.18).

Conclusions—The BESTest and Mini-BESTest, which specifically assessed reactive postural responses and stability in gait, were more likely than the BBS to detect differences in balance between PD+FOG and PD-FOG. Because it is more time efficient to administer, the Mini-BESTest may be the preferred tool for assessing balance deficits associated with FOG.

Keywords

Parkinson disease; freezing of gait; balance; BESTest; Mini-BESTest

1. Introduction

Approximately 44–53% of all people with Parkinson disease (PD) experience freezing of gait (FOG)[1, 2]. Present in up to 80% of people with more advanced PD [3, 4], FOG may also be identified early in the course of the disease course [1]. Freezing of gait is defined as an “episodic inability to produce effective stepping”[p.S424], and typically occurs when individuals with PD initiate gait, turn during walking, or navigate through narrow spaces [5]. People with FOG commonly demonstrate significant gait variability during straight line walking, along with reduced step length and often leg trembling during FOG episodes [6]. A frequently disabling complication of PD, FOG is associated with recurrent falls [7–9], thus placing the individual at significant risk for experiencing devastating sequelae such as fractures and immobility [10]. While it is understood that cessation of gait during FOG may lead to falls, it is currently unclear if individuals with FOG (PD+FOG) have worse balance in general compared to those without FOG (PD-FOG) at times other than during FOG episodes.

Different facets of balance (i.e. center of mass control, postural sway, sensory orientation, and anticipatory and reactive postural responses) have been compared in PD+FOG and PD-FOG. Specifically, Vervoort and colleagues utilized static and dynamic posturography [11], laboratory-based measures of balance, and noted that PD+FOG had similar sensory orientation and strategies in response to external perturbations (i.e. reactive postural responses) compared to PD-FOG; however, PD+FOG had worse stability during a voluntary weight shifting task (i.e. anticipatory postural adjustment). Investigators have also compared differences in forward reactive stepping in those with FOG using platform translations, and reported that the majority of trials ended in a fall or inability to step [12]. Given these findings, it appears that there may be specific aspects of balance that are worse in PD+FOGs compared to PD-FOGs. However, to our knowledge, these differences between PD+FOGs and PD-FOGs have only been characterized in the laboratory. As such, it is not yet known if clinical tests of balance are sensitive enough to detect differences between PD+FOG and

PD-FOG. Second, it is unknown if deficits in different components of balance (i.e. reactive postural responses, anticipatory postural adjustments, sensory orientation), previously studied using laboratory-based measures, can be identified using clinical balance tests in PD +FOG.

The purpose of this study was two-fold. First, we aimed to determine if balance and specific aspects of balance differ between PD+FOG and PD-FOG. To achieve this aim, we used the Balance Evaluation Systems Test (BESTest) [13], a clinical balance test which utilizes a comprehensive and systematic approach to the assessment of balance. However, given that the BESTest can take greater than 30 minutes to administer, it is less feasible for clinical environments in which time is constrained. As such, the secondary aim of this study was to determine if more time-efficient balance assessments could distinguish between PD+FOG and PD-FOG. The Mini-BESTest[14] and Berg Balance Scale (BBS) [15] were used to achieve this aim. Both tests take approximately 15 minutes to administer and are reliable in predicting falls in people with PD [16]. We hypothesized that PD+FOG would demonstrate more impaired anticipatory and reactive postural responses and decreased stability in gait, as measured in the BESTest, compared to PD-FOGs. Furthermore, because the BESTest and Mini-BESTest include assessment of anticipatory and reactive postural responses and stability in gait, we hypothesized that the BESTest and Mini-BESTest would distinguish PD +FOGs from PD-FOGs while the BBS would not.

2. Methods

2.1 Participants

This cross-sectional study was a sub-project conducted as part of a large, multi-center longitudinal study [17]. As such, sample size calculations were not conducted as part of this specific study. Rather, participants were recruited to satisfy the requirements of sample size calculations for the multi-center study [17]. Participants were included if they were over the age of 40, diagnosed “definite” idiopathic PD [18–20], and with or without FOG. Participants with a history or presence of a neurological disorder other than PD, musculoskeletal injury limiting their ability to walk, or any serious medical condition were excluded. Clinical balance tests were conducted with the participants in the ON phase of their medication cycle, approximately 1 to 2 hours after medication intake. Balance examinations were conducted by a physical therapist and took place in the Locomotor Control Laboratory at Washington University School of Medicine. Because balance tests were completed prior to the administration of the Freezing of Gait Questionnaire (FOGQ), the physical therapist was considered blinded to the presence or absence of FOG. All participants provided written informed consent in accordance with the policies and procedures of the Human Research Protection Office at Washington University.

2.2 Outcome Measures

Assessment of balance was completed using three standardized tests: 1) BESTest, 2) Mini-BESTest, and 3) BBS. The BESTest is comprised of 36 items grouped into six sections: I) biomechanical constraints, II) stability limits/verticality, III) anticipatory postural adjustments, IV) reactive postural responses, V) sensory orientation, and VI) stability in

gait. The total BESTest score is a percentage derived from dividing the actual score by the total possible score of 108 and multiplying by 100. Section scores are also reported as percentages, derived by dividing the actual section score by the total possible section score and multiplying by 100. Higher scores indicate better balance.

The 14-item Mini-BESTest is a shortened version of the BESTest that was designed to be more feasible for clinical use. The maximum possible score is 28 with higher scores indicating better balance. The BESTest and Mini-BESTest are highly reliable when used in people with PD [21]. These measures were chosen for this study because they are accurate in predicting falls [16, 22] and because they include assessments of anticipatory and reactive postural responses and stability in gait not covered by the BBS. Furthermore, we were interested in the Mini-BESTest because it is more time efficient than the BESTest and is therefore more feasible for use in clinical practice.

The 14-item BBS primarily tests anticipatory and ongoing postural responses, but does not include assessment of reactive postural responses or stability in gait. The maximum possible score is 56 with higher scores indicating better balance. The BBS is highly reliable when used in PD [23]; however, it has also been shown to have a ceiling effect [24]. We chose to include the BBS because it is a time-efficient measure commonly used in clinical practice, is accurate in predicting falls [16], and has recently been recommended as a tool to be used in the examination of postural instability in those with PD at risk for falls [25]. The BBS was tested first, followed by the BESTest/Mini-BESTest. Due to overlap between items of each balance test, a custom scoring form was developed so that overlapping items were scored only once.

Freezing of gait was assessed using the Freezing of Gait Questionnaire (FOGQ) [26]. Participants reporting a score of greater than 1 on item 3 were classified as PD+FOG. This response indicates that the participant has experienced a freezing episode at least once in the past month. Total scores on the FOGQ range from 0 to 24, with higher scores indicated greater FOG severity. The Movement Disorder Society-Unified Parkinson Disease Rating Scale subsection III (MDS-UPDRS III) was administered by a trained examiner to measure the severity of motor signs. Total scores on the MDS-UPDRS III range from 0 to 132 with higher scores indicating greater motor sign severity.

2.3 Data Analysis

Demographic characteristics of PD+FOG and PD-FOG were compared using independent t-tests or the non-parametric equivalent as appropriate. Separate analyses of covariance were used to identify differences between PD+FOG and PD-FOG in BESTest total score, each BESTest section score, Mini-BESTest total score, and BBS total score ($\alpha = 0.05$). For the covariate, we used principal component analysis to calculate a PD composite score based on motor symptom severity (i.e., MDS-UPDRS III score), years since diagnosis, and age. Greater motor symptom severity and longer duration of PD have been reported previously as more common among PD+FOG [27]. Age was included in the covariate to account for the possibility that the PD+FOG and PD-FOG groups would differ in this regard. SPSS version 21.0 was used to conduct all analyses.

3. Results

The sample included 78 individuals with idiopathic PD, 32 of whom were categorized as PD +FOG (Table 1). On average, PD+FOG had worse motor severity, longer PD duration, and a higher FOGQ score.

After accounting for motor severity, years since PD diagnosis, and age, PD+FOG had lower BESTest total scores compared to PD-FOG. Analyses of the BESTest section scores show that PD+FOG performed worse in reactive postural responses and stability in gait compared to PD-FOG (Table 2). Regarding more time-efficient, clinical measures of balance, Mini-BESTest scores were lower for PD+FOG compared to PD-FOG after accounting for motor severity, years since PD diagnosis, and age. There was no between-group difference in BBS score (Table 2).

4. Discussion

The key result of this study was that balance differences between PD+FOG and PD-FOG, which previously had been identified using laboratory-based measures of postural control (9–10), also could be revealed using a comprehensive assessment of balance (i.e. BESTest). Importantly, the difference in balance was detected only using the BESTest or Mini-BESTest and could not be accounted for by differences in disease severity, age, and disease duration. Section-specific analyses of the BESTest demonstrate that performance related to reactive postural responses and stability in gait may be driving the observed balance differences between PD+FOG and PD-FOG.

With respect to reactive postural responses, there is lack of consensus among previous studies aimed at determining whether or not these differ between PD+FOG and PD-FOG. Jacobs and colleagues studied forward reactive postural responses in those with FOG and reported 69% of trials ended in a fall or inability to step [12]. Vervoort and colleagues reported PD+FOG had worse weight-shifting ability than PD-FOG, but the groups did not differ in their response to forward and backward platform translations [11]. Smulders and colleagues studied forward reactive postural responses and noted PD+FOG had smaller reactionary steps than PD-FOG, but the groups did not differ in number of steps needed to regain balance [28]. One possible reason for the difference between our findings and those of Smulders et al. is that the BESTest and Mini-BESTest assess reactive postural responses in backward and lateral directions in addition to forward. To support the notion that multi-directional assessment of reactive postural responses is clinically important, King and colleagues reported people with PD, without regard for FOG, had worse lateral stepping responses compared to healthy controls [29].

With respect to the difference in stability in gait between PD+FOG and PD-FOG, it is well-documented that PD+FOG have more asymmetric and less coordinated gait than PD-FOG [30]. Individuals with FOG also have difficulty with turning [31], initiation of gait [6], and obstacle avoidance [32], all of which factor into items assessed within the BESTest. Walking with a dual task, which is also assessed in the BESTest, is also known to be difficult for PD+FOG compared to PD-FOG [33].

Clinically, while balance is thoroughly examined using the BESTest, it is inefficient given the time it takes to administer (i.e. 45–60 minutes) in someone with mild to moderate PD. In examining less time intensive measures, we noted balance differences between PD+FOG and PD-FOG using the Mini-BESTest, but not the BBS. Our findings underscore the importance of testing reactive postural responses and stability in gait, both of which are included in the Mini-BESTest but not the BBS, in the overall assessment of balance in PD. Because it is reliable [21, 34], able to detect balance differences between PD+FOG and PD-FOG, accurate in predicting falls [16], and clinically time-efficient, we recommend its use as a clinical balance test in those with PD. However, users should be cognizant of the measurement error associated with the tool and be properly trained in its administration and scoring [34].

4.1 Study Limitations

Results from this study should be interpreted in the context of several limitations. First, there were a different number of participants in the PD+FOG and PD-FOG groups; however, all statistical tests showed homogeneity of variance between groups for all measures. Second, we recognize that we used an older version of the FOGQ while there is a new version that includes a video to assist participants in identifying whether or not they have FOG. This should not have affected our results as Nieuwboer and colleagues reported that the addition of the video did not add to the sensitivity and specificity of FOG detection [35]. Finally, participants were tested in the on phase of their medication cycle, which may not reflect their true disease state but does reflect their typical state during daily life. In the future, investigators should test for balance differences among PD+FOG and PD-FOG off anti-PD medication and seek to determine whether or not scores on clinical and laboratory measures are related in those with and without FOG [36].

5. Conclusion

When measured using the BESTest to assess balance, PD+FOG demonstrated greater balance impairment compared to PD-FOG after controlling for motor symptom severity, age, and years since PD diagnosis. Analyses of specific components of the BESTest show that PD+FOG have worse reactive postural responses and stability in gait than PD-FOG. In examining time-efficient clinical assessments of balance, PD+FOG differed from PD-FOG in Mini-BESTest scores, but not BBS scores. Because it requires less time to administer, use of the Mini-BESTest may be preferred over the BESTest in clinical practice when assessing balance in those with PD with and without FOG.

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Highlights

- Individuals with freezing of gait (FOG) have worse balance than those without FOG.
- Those with FOG have worse reactive postural responses and stability in gait.
- The Mini-BESTest, a time-efficient assessment of balance, is recommended in PD.

Table 1

Demographic characteristics for PD+FOG and PD-FOG.

	PD+FOG (n=32)	PD-FOG (n=46)	*p*
Gender (% Female) §	41	43	0.87
Age*	69.94 ± 7.03	66.90 ± 10.55	0.17
MDS-UPDRS III Total*	50.25 ± 12.96	35.30 ± 12.76	< 0.001
Years Since Diagnosis*	10.63 ± 5.03	7.07 ± 4.14	0.001
FOGQ Total*	12.88 ± 3.86	2.96 ± 2.49	< 0.001

*Independent t-test used for group comparison.

§Nonparametric equivalent to Independent t-test used for group comparison.

Values are mean ± standard deviation.

Table 2

Comparisons of BESTest and Mini-BESTest total and section scores and BBS scores between PD+FOG and PD-FOG.

	PD+FOG		PD-FOG		Between Group Effects	
	Mean ± SD	**95% CI**	**Mean ± SD**	**95% CI**	***p***	**F**
BESTest Total	59.66 ± 15.45	54.61, 64.72	77.31 ± 13.53	73.10, 81.53	0.008	7.35
I. Biomechanical Constraints	48.75 ± 20.49	41.49, 56.01	65.80 ± 20.69	59.75, 71.84	0.34	0.91
II. Limits of Stability / Verticality	75.45 ± 12.98	71.21, 79.68	82.61 ± 11.32	79.08, 86.14	0.80	0.06
III. Anticipatory Postural Adjustments	58.68 ± 17.62	52.15, 65.21	76.21 ± 19.16	70.76, 81.65	0.16	2.04
IV. Reactive Postural Responses	52.95 ± 23.14	46.11, 59.80	78.74 ± 16.41	73.04, 84.45	< 0.001	14.42
V. Sensory Orientation	65.83 ± 22.58	58.29, 73.37	81.16 ± 20.57	74.87, 87.45	0.41	0.69
VI. Stability in Gait	53.87 ± 20.58	47.39, 60.35	77.23 ± 16.74	71.82, 82.63	0.003	9.18
Mini-BESTest	13.75 ± 5.25	11.96, 15.54	20.46 ± 4.98	18.96, 21.95	0.002	10.37
BBS	43.97 ± 9.31	41.29, 46.65	50.39 ± 6.16	48.16, 52.62	0.27	1.26

*Means are unadjusted. Between group effects are adjusted based on analyses using the PD composite score as a covariate.