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Influence of fear of falling on gait and balance in Parkinson's disease

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Abstract

Purpose—To study the relationship of fear of falling (FoF) with gait characteristics and balance in individuals with Parkinson's disease (PD).

Method—Seventy-nine non-demented individuals (62 males) with PD were studied. Their mean age was 69.22 ± 8.93 years. The average time since diagnosis was 8.27 ± 5.31 years. FoF was assessed by the Activities-specific Balance Confidence (ABC) Scale in which high scores indicate less FoF. Gait was measured using a computerized walkway. Balance was measured by timed tests including the 5-step test, 360 degree turn, timed sideways walk, and timed up and go test. Participants were divided into two groups based on their ABC score (high FoF, ABC score <69 ; low FoF, ABC score ≥ 69). Gait characteristics and balance measures of the two groups were compared.

Results—Gait speed and stride length for forward walking ($p < 0.0005$ for both) and backward walking ($p = 0.001$ and 0.002 , respectively) were lower for those with a high level of FoF compared to those with a low level of FoF. The time to take five steps ($p = 0.025$), time to turn ($p < 0.0005$), time to walk sideways ($p = 0.001$), and time to complete the up and go test ($p = 0.003$) were longer in those with a high level of FoF than in those with a low level of FoF. Number of steps to complete the turn ($p = 0.001$) and steps to walk sideways ($p = 0.002$) were greater in those with a high level of FoF than in those with a low level of FoF.

Conclusions—Gait and balance of individuals with PD with a high level of FoF were poorer than those with a low level of FoF, regardless of previous fall history.

Keywords

Activities-specific balance confidence scale; balance; fear of falling; gait; Parkinson's disease

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Introduction

Falling is one of the most serious and disabling features in Parkinson's disease (PD). The progression of the disease is eventually associated with a fear of falling (FoF) [1]. FoF is a lack of self-confidence that usual activities can be performed without falling. FoF is common in persons with PD due to balance impairment and postural instability, and it is potentially a serious problem over and above falling itself [2]. FoF may lead to restriction of mobility, decreased functional ability, loss of functional independence, as well as social isolation [3].

Individuals with PD were found to have more FoF than age-matched healthy persons [1]. FoF was reported to be associated with impaired postural control [1], and with some other clinical assessments including one-leg stance time, timed-up-and-go, Berg balance scale, 6-minute walk, and the motor score of the Unified Parkinson's Disease Rating Scale (UPDRS) [4]. A higher level of FoF was also associated with greater knee muscle weakness and increased gait instability and postural difficulty, indicated by a composite score of four items of the UPDRS (rising from a chair, posture, gait and postural stability) [5].

To date, the study of the association of gait characteristics with FoF has not included walking both forward and backward as well as balance measures in persons with PD. The purpose of the current study was to investigate gait parameters and balance measures in relation to the level of FoF in persons with PD. We hypothesized that persons with higher FoF would demonstrate poorer gait and balance performance than those with lower FoF. It may be important for clinicians to be cognizant of the role FoF plays when devising a treatment plan.

Materials and methods

Subjects

Seventy-nine non-demented individuals with PD were recruited from movement disorder outpatient clinics at the Michael E. DeBakey Veterans Affairs Medical Center and Baylor College of Medicine. The study was approved by the Institutional Review Board for Human Subject Research for Baylor College of Medicine and Affiliated Hospitals. All participants had experienced gait and balance problems from PD, however, they were able to stand and walk independently.

Equipment and measures

The UPDRS [6] and the Hoehn and Yahr (HY) [7] scale were used. A postural instability and gait disorder (PIGD) score was calculated by adding five items (falling, freezing, walking, gait and postural stability) of the UPDRS to represent clinical mobility and stability [8,9]. For fall history, subjects were asked whether they had fallen at least once in the 6 months prior to participation in the study and grouped into fallers (yes) and non-fallers (no).

Measure of FoF—Activities-specific Balance Confidence (ABC) Scale was used to estimate FoF. The ABC scale was developed to assess subjective balance confidence, a

construct similar to FoF [4,10]. Participants were asked to rate their self-perceived balance confidence level from 0 (no confidence) to 100 (complete confidence) in performing 16 activities of daily living. The mean score across all 16 activities was calculated and used to estimate the level of FoF [11]. A lower mean ABC score indicates a higher level of FoF. An ABC score of <69% has been found to be highly sensitive (93%) in identifying fallers [11]. This cut-off score was used in the current study to classify participants into high and low levels of FoF.

Measures of gait—The GAITRite system (GAITRite, CIR Systems Inc., Havertown, PA), is a 5-m, computerized instrumented walkway. While the subject walks, the system continuously scans the sensors to detect pressures, and transfers the information to the computer for calculating and storing gait characteristics. Two trials of walking were performed and the average of the two trials for each gait parameter was used in data analysis.

Performance-based quantitative balance tests—Timed tests to measure balance included the timed 5-step test, timed sideways walking, time to turn, and timed up and go test. For the timed 5-step test, the participants were timed while stepping up and back down an 8.8 cm step for five consecutive steps [12]. For time to walk sideways, participants were asked to walk sideways for 5 meters in each direction. For the time to turn test, the participants were asked to turn. Number of steps to complete the turn was also recorded [13]. For the timed up and go test, participants were asked to get up from a chair, walk forward for 5 meters, turn around and walk back to sit on the same chair [14,15].

Testing protocol

All participants read and signed an approved consent form prior to participation. They were assessed for disease severity using the HY and the UPDRS Motor section III prior to completing the ABC scale and performing the walking and balance tests. All clinical assessments and testings were performed when the participants were in the “on” medication state, approximately one hour after taking their medication. Participants walked on the computerized mat at their self-selected, usual speed in both forward and backward directions and performed timed balance tests as described above. One tester timed the walk with a stop watch and counted the number of steps to complete the 5-meter walking course for the timed sideways walk test, and to complete a 360 degree turn. Tests were performed involving turning clockwise and counterclockwise and walking sideways both left and right. The average of the two directions for each measure was used in data analysis. All walking and balance tests were performed twice and their averages were used in data analysis.

Statistical analysis

All analyses were performed using SPSS version 20.0 (IBM, Armonk, NY). The study used an observational, cross-sectional design to study gait characteristics and balance performance. Paired Student's *t*-tests and chi-squared tests were used to determine if significant differences existed between the two groups of participants with high and low levels of FoF on age, PD severity, gender, years with PD, fall history, gait parameters and timed balance tests. Multiple regression analysis was used to describe the association

between FoF (independent variable) and the gait and balance variables except cadence (dependent variables), after controlling for fall history. The significance level was set at $p < 0.05$.

Results

Subject characteristics

Seventy-nine individuals with PD participated in the study (78.5% men). All of them were community-dwelling individuals with PD. Their mean age was 69.22 (8.93) years. The time since diagnosis was 8.27 (5.31) years. The average HY stage was 2.44 (0.46). All participants were receiving dopaminergic treatment (carbidopa/levodopa or carbidopa/levodopa/entacapone) and had not had any brain surgery therapy for PD. Forty-six (58.2%) participants usually walked without any assistive device. Twenty (25.3%) walked with a cane, and thirteen (16.5%) walked with a rollator walker. All participants were able to perform all tests without any assistive device. All participants wore a gait belt and were guarded by a research assistant to prevent falls. Sixty-seven (67.08%) of the participants were fallers. The majority of participants with high FoF were fallers (Table 1). They all were able to perform gait and balance measures without assistance. Compared to participants with a low level of FoF, the ones with a high level of FoF had more years since diagnosis of PD ($p = 0.012$) and had more severe PD as indicated by the HY and UPDRS III scores ($p < 0.0005$, $p < 0.0005$, respectively). The PIGD scores were higher in participants with a high level of FoF ($p < 0.0005$) and more of them had fallen in the past 6 months ($p = 0.029$). The two groups were not different in mean age or gender distribution (Table 1).

Comparison of gait measures in individuals who had high and low levels of FoF

Gait performance of both forward and backward walking for participants who had a high level of FoF was poorer than for those with a low level of FoF. Specifically, gait speeds during forward and backward walking were slower in those with a high level of FoF compared to those with a low level of FoF ($p < 0.0005$ and $p = 0.001$, respectively). Stride lengths for both walking directions for the participants with a high level of FoF were shorter than for those with a low level of FoF ($p < 0.0005$ and $p = 0.002$, respectively). Cadence was not different between the two groups when walking in either direction (Table 2).

Comparison of balance in individuals who had high and low levels of FoF

Compared to those with a low level of FoF, participants with a high level of FoF took a longer time to perform all balance tests including the 5-step test, turning 360 degrees, walking sideways, and the timed up and go test ($p = 0.025$, $p < 0.0005$, $p = 0.001$, $p = 0.003$, respectively). Participants with a high level of FoF also took more steps to complete the 360-degree turn and the sideways walk than those with a low level of FoF ($p = 0.001$, $p = 0.002$, respectively; Table 3).

Multiple regression analyses demonstrated that after controlling for fall history, FoF remained significantly associated with all the included gait and balance variables (Table 4). FoF explained 13% to 34% of the variance in these measures after controlling for fall history

as indicated in the R^2 column. Fall history did not explain a significant portion of the variance (<1% to 4%) in any of these gait and balance measures ($p = 0.081$ to 0.927).

Discussion

The aim of the study was to study gait characteristics and balance performance in individuals with PD who reported FoF. Several investigators have previously reported that PD fallers were more impaired and had poorer measures of mobility and balance than non-fallers [16–18] but none had yet reported quantitative gait characteristics and balance performances in persons with PD who had different levels of FoF. FoF can develop from specific mobility disturbances associated with the progression of PD (e.g. festination, freezing) [19], medical and surgical treatments [20], perceived imbalance [21], previous falls [18], near fall experiences [22] or a psychological response from having PD [23].

Investigation of FoF in PD has been limited, despite the high risk of falls in persons with PD [2,24], especially in relation to gait characteristics and balance performance. FoF has been reported by other investigators to correlate with clinical ratings of balance and gait [1,25,26]. In this study, we initially examined quantitative gait characteristics and performance-based balance assessments in persons with PD who had different levels of FoF without discriminating between fallers and non-fallers. However, studies of differences in gait and balance performances in fallers and non-fallers with PD have been previously reported by several investigators [16,27–30]. In general, fallers performed less well than non-fallers. Therefore, because our sample consisted of both fallers and non-fallers, we examined the relationship of FoF with gait and balance after controlling for fall history.

FoF has been reported to be a significant predictor of future falls, after adjusting for prior falls and PD-specific impairments [11]. Therefore, understanding the influence of FoF in PD is important for clinicians, as FoF may independently exacerbate functional decline and reduce quality of life [1,2,31], or FoF could be protective against future falls by increasing caution during mobility.

This study demonstrated several new findings. First, our results demonstrated that gait speed and stride length during both forward and backward walks were poorer in participants with a high level of FoF, but cadence was similar in the two groups in both walking directions. Based on our literature search, this is the first study to report gait patterns in persons with PD relative to their level of FoF. When combined with a high level of FoF, slow gait speed, short stride length and balance deficits may predispose individuals with PD to falls. These characteristics were similar to those described earlier as a cautious gait in the elderly with gait disorders [23,32]. We also reported for the first time on backward walking gait characteristics in persons with PD who had FoF.

Second, our measures on turning performance supported the previous finding that difficulty in turning was associated with greater FoF [2,33]. Participants with higher FoF took a longer time and more steps to complete the 360-degree turn. Difficulty in turning is common and reported by more than 50% of persons with PD [34,35]. It is the major contributing factor to FoF [2,25]. A longer turning duration and an increased number of steps to turn might be a

response to perceived imbalance or a physical inability to turn more quickly with fewer steps.

Our finding on increased time to perform the up and go test was in agreement with a previous study, which found that excessive FoF was negatively correlated with the time to perform that test in persons with PD [26]. Rising from a chair, walking and turning are the main components of the timed up and go test. These three mobility tasks are known to be problematic for persons with PD [34] and have been reported to be associated with FoF [2,5,25].

We also used time to perform the 5-step test and timed sideways walking as part of our clinical balance assessment. Participants with high FoF took a longer time to perform these balance tasks. They also took more steps to complete the sideways walks. During the test, we asked participants to walk without deviating from an imaginary straight line, or to minimize drifting as well as possible. However, we did not measure the path deviation, which might be different in persons with different levels of FoF. Although sideways walking has been sparsely studied in the literature, walking in various directions including sideways is often used clinically for balance exercises [36].

The poorer gait and balance performance in persons with high levels of FoF, as demonstrated in our findings, may be due to actual physical deficits from the PD, or alternatively, the FoF could modify gait and balance. These two effects are not mutually exclusive, and may even occur in additive or potentiated fashion [37]. Individuals might compromise their gait and balance due to FoF, or the impaired gait and balance from PD itself may lead to FoF. It has been recommended that assessment of balance performance in persons with PD should include a measure of FoF [1,26]. For clinical applications, in addition to measuring functional ability, assessing individuals with PD on the FoF might be beneficial in planning an appropriate and effective intervention. However, future research should determine whether reducing FoF could improve gait and balance performances in individuals with PD, or whether improving performance reduces FoF.

After controlling for prior falls, the FoF continued to demonstrate a significant association with all gait and balance variables. The results allowed a clear conclusion with regard to our hypothesis that FoF has a negative relationship with gait and balance performance in persons with PD regardless of prior fall experience. The finding was in accordance with a previous study that found that poorer PD-specific activities were associated with greater FoF in persons with PD [2]. These specific mobility problems included difficulty in rising from a chair, difficulty in turning, start hesitation, festination, loss of balance and shuffling. Our results showed that prior falls did not significantly relate to gait and balance performance but FoF did.

Limitations

We acknowledge that our study has some limitations that need to be addressed. Given the cross-sectional nature of the study, inferences about a cause and effect relationship between gait and balance and FoF cannot be drawn. We were unable to ascertain whether FoF

modified gait and balance, or impaired gait and balance lead to FoF. Longitudinal studies are needed to establish such a relationship.

Second, our sample consisted of individuals with diagnosed idiopathic PD with mild-to-moderate severity who reported either gait or balance impairment or falls as a result of PD. Their level of FoF, gait and balance performance might be different from individuals with PD who had not demonstrated gait and balance impairments. All participants were community-dwelling persons with PD, were in HY stage 2–3, and were able to walk and perform all tests independently, which might limit the generalizability of the results to patients with different degrees of disabilities and to those who live in institutions.

Third, FoF is associated with many other factors. We elected to study only gait and balance performance because they are the main targets in rehabilitation for persons with PD. Despite these limitations, we believe that our study was the first that provides quantitative evidence establishing gait and balance performance in individuals with PD relative to the level of FoF.

Conclusions

In summary, the gait and balance of individuals with PD with high levels of FoF were poorer than those with low levels of FoF, regardless of previous fall history. Our results might help guide future research in this aspect of falls and may help develop the design of interventions that are tailored to the needs of these patients. It will be useful for clinicians to be aware of the relationship between gait and balance performance and the level of FoF.

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Implications for Rehabilitation

- The results demonstrates that fear of falling (FoF) is related to gait and balance in individuals with PD.
- Clinicians should be aware that FoF has a negative impact on gait and balance in individuals with PD.

Table 1

Subject demographics within high and low fear of falling groups.

	High FoF (N = 35)	Low FoF (N = 44)		
	Mean (SD)	Mean (SD)	<i>t</i>	<i>p</i> Value
Age	69.69 (9.60)	68.84 (8.45)	0.42	0.68
HY	2.63 (0.33)	2.28 (0.50)	3.69	<0.0005
UPDRS III	21.77 (8.23)	14.98 (6.78)	4.02	<0.0005
Gender				
Male	26 (74.29%)	31 (70.45%)		
Female	9 (25.71%)	13 (29.55%)	0.14 ^a	0.706 ^b
Years of PD	9.94 (4.86)	6.94 (5.32)	2.59	0.012
Fall history				
Non-faller	7 (20.00%)	19 (43.18%)		
Faller	28 (80.00%)	25 (56.82%)	4.75 ^a	0.029 ^b
PIDG	6.83 (2.80)	4.21 (2.11)	4.75	<0.0005
ABC score	47.21 (15.59)	82.63 (8.67)	-12.04	<0.0005

^aChi-square statistic.^bChi-square test.

PIDG = Postural Instability and Gait Disorder score, a composite score of five items (falling, freezing, walking, gait and postural stability) of the UPDRS.

ABC = Activities-specific Balance Confidence Scale, an assessment of FoF.

Table 2

Comparison of gait measures between individuals with PD who had high and low levels of fear of falling.

	High FoF (N = 35)	Low FoF (N = 44)		
Gait measures	Mean (SD)	Mean (SD)	<i>t</i>	<i>p</i> Value
Forward walking				
Gait speed	90.86 (24.44)	108.97 (16.83)	−3.74	<0.0005
Cadence	111.77 (16.78)	109.92 (12.10)	0.57	0.571
Stride length	94.44 (26.20)	119.67 (17.33)	−4.91	<0.0005
Backward walking				
Gait speed	53.20 (22.78)	71.27 (25.17)	−3.31	0.001
Cadence	111.23 (24.55)	115.12 (26.75)	−0.67	0.508
Stride length	59.51 (22.67)	75.97 (22.77)	−3.20	0.002

Table 3

Comparison of balance measures between persons with PD who had high and low levels of FoF.

Balance measures	High FoF (N = 35)	Low FoF (N = 44)	t	p Value
	Mean (SD)	Mean (SD)		
Timed 5-step test (s)	12.45 (4.13)	10.64 (2.36)	2.31	0.025
Time to turn (s)	5.36 (2.55)	3.43 (1.20)	4.11	<0.0005
Number of steps to turn	12.07 (5.25)	8.51 (3.28)	3.50	0.001
Timed sideways walk (s)	12.35 (6.52)	8.09 (2.56)	3.65	0.001
Number of steps in sideways walk	13.14 (4.61)	10.22 (3.17)	3.19	0.002
Timed get up and go test (s)	17.17 (7.95)	12.51 (3.79)	3.20	0.003

The association between gait and balance variables and fear of falling controlling for fall history: results of multiple regression analysis.

Table 4

Dependent variables	Independent variables	R ²	β Coeff.	p Value for β Coeff.
Forward walk				
Gait speed	Fall history	0.011	-0.102	0.369
	Fall history; FoF	0.247	-0.01; 0.495	0.924; <0.0005
Stride length	Fall history	0.021	-0.145	0.202
	Fall history; FoF	0.364	-0.033; 0.596	0.722; <0.0005
Backward walk				
Gait speed	Fall history	0.00	0.01	0.927
	Fall history; FoF	0.22	0.100; 0.478	0.335; <0.0005
Stride length	Fall history	0.01	-0.102	0.369
	Fall history; FoF	0.189	-0.022; 0.43	0.837; <0.0005
Timed 5-step test	Fall history	0.009	0.092	0.418
	Fall history; FoF	0.151	0.02; -0.385	0.851; 0.001
Time to turn	Fall history	0.001	0.038	0.742
	Fall history; FoF	0.321	-0.07; -0.576	0.468; <0.0005
Number of steps to turn	Fall history	0.003	0.054	0.638
	Fall history; FoF	0.207	-0.033; -0.46	0.755; <0.0005
Timed sideways walk	Fall history	0.011	0.104	0.361
	Fall history; FoF	0.270	0.007; -0.518	0.945; <0.0005
Number of steps in sideways walk	Fall history	0.039	0.198	0.081
	Fall history; FoF	0.173	0.128; -0.373	0.233; 0.001
Timed up and go test	Fall history	0.014	0.117	0.305
	Fall history; FoF	0.177	0.04; -0.411	0.708; <0.0005