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Fear of Falling and Postural Control in Parkinson's Disease

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Abstract: This study investigated the relationship between fear of falling (FOF) and qualitative and quantitative postural control in Parkinson's disease (PD). Fifty-eight nondemented PD patients were studied along with age-matched healthy controls. The degree of FOF was estimated using the Activities-specific Balance Confidence scale. Qualitative postural control was evaluated using a component of the Unified Parkinson Disease Rating Scale. Postural control was quantified, using centre of pressure measures obtained from a force plate, for eight standing balance tests of different challenges. The results showed that FOF was more evident for PD patients when compared with healthy individuals of similar age. Furthermore, FOF was significantly associated with a qualitative estimate of postural control in PD; individuals with PD who had a greater degree of posture impairment reported greater FOF. The results also showed that an estimate of FOF may help to explain quantitative postural instability in PD. FOF, when coupled with a qualitative estimate of postural control, was able to explain a greater amount of variation in quantitative balance performance for five of the eight balance tests. When considered independently, the qualitative measure of postural control, in general, could not well predict quantitative balance performance. The greater degree of FOF and its possible association with altered postural control suggests that FOF should be considered as an important, independent risk factor in the assessment and treatment of postural instability in patients with PD. © 2003 Movement Disorder Society

Key words: fear of falling; balance confidence; disease severity; Parkinson's disease; postural control

Fear of falling (FOF) is prevalent in the elderly,[1–7] and this fear may be even more common in a population known to have balance problems, such as individuals diagnosed with Parkinson's disease (PD). However, the degree of FOF in PD is unknown, and its impact on the control of posture in this population has not yet been investigated.

Postural instability is well known to occur in PD; alterations in postural control strategies have been documented during standing tasks,[8–11] when responding to an unexpected destabilizing perturbation,[9,12–15] or when performing voluntary movements.[16,17] These changes in postural control may increase risk of falling,[18] and evidence suggests that falls are highly prevalent for patients with PD.[19–23] The literature, therefore, suggests that accurate assessment of postural instability and prevention of falls are significant issues for this population.

Alterations in postural control strategies observed in PD are presumed to result from an underlying physiological cause associated with the disease process; however, FOF may also significantly contribute to these changes. There is mounting evidence to suggest that psychological factors have observable effects on balance performance. For example, elderly individuals who reported FOF demonstrated larger amplitude of postural sway when blindfolded and poorer scores when timed on a one-leg stance test compared to those who did not report FOF.[24,25] Alternatively, patients with phobic postural vertigo adopted a tighter control of posture characterized by smaller amplitude and higher frequency postural sway compared to normals.[26] A relationship between anxiety and postural control has been identified in an animal model with anxious strains of mice demonstrating poorer balance compared to nonanxious strains of mice.[27] Furthermore, in healthy young adults, FOF induced by providing a significant threat to posture, has been shown to influence postural control when stand-

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ing[28–30] and when responding to an unexpected push applied to the upper back.[31] The results from each of these studies demonstrate the possible confounding effects of psychological factors, such as FOF, on the control of posture.

The existence of postural instability in PD provides a significant reason to investigate the relationship between FOF and postural control in this population.[32] Alterations in postural control strategies in PD remain difficult for the clinician to estimate subjectively. Most often, balance performance is assessed by observing standing upright posture, the ability to rise up from a chair, and the response to a push or pull at chest level (retropulsion test); each of these tests is examined as part of the Unified Parkinson Disease Rating Scale (UPDRS). It should be noted that these qualitative tests may not accurately estimate balance performance; for example, the retropulsion test, due to the variability in which it is performed, is not highly related to postural instability for individuals with PD.[33] As FOF may confound both qualitative and quantitative postural control measures, the ability to identify psychological influences on postural instability is critical for accurate balance assessment.

This study investigates the degree of FOF in PD and examines the relationship between FOF and qualitative and quantitative postural control in PD. First, the extent of FOF in PD patients compared to healthy individuals of similar age is identified. The Activities-specific Balance Confidence (ABC) scale is used to provide an estimate of FOF.[34,35] FOF is hypothesized to be reported more often in PD patients due to altered control of posture and increased incidence of falls observed in this population. Second, the relationship between FOF and qualitative and quantitative postural control in PD is explored. In addition to FOF estimates, we selected a component of the UPDRS scale to qualitatively evaluate postural instability. We selected components of the UPDRS, while being aware of its limitations, as this measurement tool is widely used clinically to estimate postural instability in PD. FOF and qualitative estimates of postural control are then used in an attempt to explain variation in quantitative postural control for eight standing tests of different challenges. We hypothesized that an estimate of FOF coupled with a subjective evaluation of postural control may contribute additional information to explain the variation in quantitative postural control for the standing tests.

PATIENTS AND METHODS

Study Population

Fifty-eight patients diagnosed with idiopathic PD (39 men, 19 women; mean ± 1 SD: age, 66.2 ± 9.3 years; disease duration since diagnosis, 6.5 ± 4.9 years) and 30 age-matched healthy controls (14 men, 16 women; age, 66.7 ± 8.1 years) volunteered for this study. Patients with dyskinesia, dementia (Mini-Mental State Examination status score less than 27 of 30), significant musculoskeletal problems, or other neurological disorders were excluded from the study. All participants were living in the community and were ambulatory. Each participant, informed of the experimental procedures, provided written consent before the testing session. The University of Waterloo and University of Western Ontario Office of Research Ethics approved all experimental procedures.

All 58 PD patients and 30 age-matched, healthy controls completed the ABC scale. Twenty-one of the 58 PD patients (16 men; age, 67.1 ± 8.8 years; disease duration since diagnosis, 6.6 ± 4.4 years) were assessed on the motor component of the UPDRS and completed a series of eight standing balance tests. The UPDRS assessment and balance testing were initiated approximately 1 hour after patients had taken their antiparkinson medication, with the patients in the *on* state. All testing was completed on the same day in the afternoon period at the Movement Disorders Clinic London Health Sciences Centre.

ABC Scale

The ABC scale was used to provide an estimate of FOF[34,35] and requires participants to rate the degree of confidence they have for completing 16 activities of daily living (ADLs) without falling. The scale, expanded from the Falls Efficacy Scale (FES) developed by Tinetti and colleagues[36] to include ADLs of different difficulty levels, ranges from 0% (no confidence) to 100% (complete confidence). The ABC scale was designed specifically to detect loss of balance confidence in individuals of different functional levels, especially those individuals who may be more active. The scale includes both walking and reaching-oriented activities that challenge postural control and activities that are performed both indoors and outdoors (refer to the legend to Fig. 1 for a list of all 16 items of the ABC scale). Both the FES and ABC scales are based on Bandura's theory of self-efficacy.[37,38] In this study, low balance confidence reflected FOF. PD patients were instructed to complete the questionnaire considering that they were performing the activity when on their antiparkinson medication, essentially in their perceived optimal state. Mean ABC score across all 16 items was used to estimate the degree or level of FOF.

UPDRS Posture and Gait Component

A posture and gait subscore from the UPDRS motor score was used to qualitatively estimate postural insta-

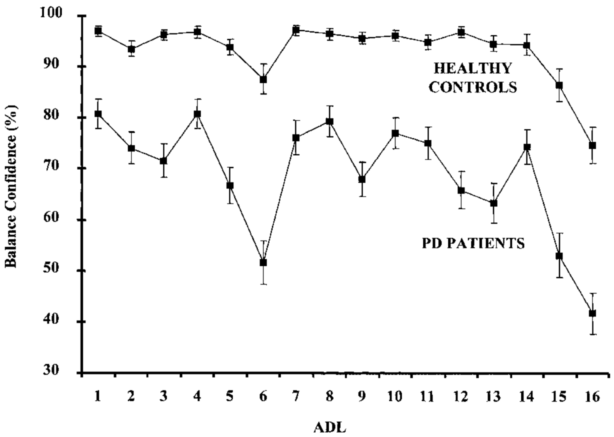

FIG. 1. Reported balance confidence for each of the 16 activities of daily living (ADLs) composing the Activities-specific Balance Confidence (ABC) scale for Parkinson's disease (PD) patients and healthy controls. The ADLs included walking around the house (1), walking up and down stairs (2), bending to pick up a slipper (3), reaching at eye level (4), reaching on tiptoes (5), reaching while standing on a chair (6), sweeping the floor (7), walking outside to a parked car (8), getting in and out of a car (9), walking across a parking lot (10), walking up and down a ramp (11), walking in a crowd (12), walking and being bumped (13), using an escalator holding a railing (14), using an escalator and not holding a railing (15), and walking on an icy sidewalk (16).

bility and gait impairment associated with the disease process. The posture and gait subscore included four items (scale number in parentheses): rising from a chair (27), standing posture (28), gait (29), and postural stability/retropulsion test (30). Scoring of each item ranged from 0 (normal) to 4 (severely affected) and was completed by the same trained evaluator. The score for each of the four items was summed and for the statistical analysis expressed as a percentage; a score of 100% would reflect the most severe stages of the disease process.

Standing Balance Tests

Patients performed a series of eight balance tests: normal stance with eyes open (EO), eyes closed (EC), or eyes open with the threat of a push or pull at shoulder level (THREAT); feet-together stance with EO, EC, or THREAT; normal stance on foam support with eyes open (FOAM); and one-legged stance with eyes open (1LEG). Each balance test was selected in an attempt to provide a different challenge or threat to posture through the manipulation of visual and proprioceptive information, changes in stance width or base of support or the introduction of an external threat to postural stability. Balance tests were presented in the same order for each patient: normal stance EO, EC; feet-together stance EO, EC; normal stance THREAT, feet-together stance THREAT, normal stance FOAM, one-legged stance EO. This presentation order prevented a more challenging stance task from influencing the performance on a less challenging stance task.[28]

Patients stood on a force plate for each balance test. The duration of each standing trial was 60 seconds except for the 1LEG standing task, which was performed for a maximum duration of 20 seconds. Patients were instructed to stand quietly on the force plate with their arms at their sides. For the normal stance condition, participants were asked to stand in a comfortable position on the force plate with no restrictions placed on their stance width, except for the force plate width (0.47 m). The feet-together stance condition required patients to stand on the force plate with the first metatarsals and heels touching, restricting the width of their base of support. The toes were placed at the anterior edge of the force plate for both the normal and feet-together stance conditions. Once established, foot position was traced to maintain the same stance position for each normal or feet-together stance trial. The average difference in stance width between normal and feet-together stance was 0.13 m. For all EO tests, patients were instructed to fixate on a target located 2 m in front of them at eye level. For all EC tests, patients began by fixating on the target and then were asked to close their eyes. For the FOAM test, a dense foam cushion, with the same dimensions as the force plate, was placed on the force plate to reduce the accuracy of proprioceptive information received from the lower limbs. For the THREAT condition, patients were instructed that at some point during the standing trial they might be pulled or pushed off balance at the shoulder level; the push or pull was carried out at a random interval after the completion of the 60-second trial. For the 1LEG stance test, patients were instructed to stand on their preferred limb but were asked not to rest the elevated limb against the stance limb during the balance test. At the completion of each trial, participants were seated and provided a 5-minute rest period.

Postural Control Measures.

Ground reaction force and moment of force signals were collected from the force plate with a frequency of 20 Hz. Centre of pressure (COP) was calculated for each 60-second record. COP can provide insight into how the central nervous system (CNS) is controlling the movement of the centre of mass (COM) as the COP tracks and controls the movements of the COM within the base of support when quietly standing.[39] In this study, sway area of the COP was used to describe the area of the COP stabilogram. This measure was calculated for each stance test, except the 1LEG stance test, by estimating the area enclosed by the COP per unit of time.[40] For the 1LEG stance test, stance duration instead of sway area of the COP was used to evaluate balance performance. The average duration of two attempts was used. Increased sway area of the COP and decreased 1LEG stance duration was thought to reflect increased postural instability.

Psychophysical Measures.

Before each balance test, patients rated their confidence in their ability to maintain balance and avoid a fall during the balance test. After each balance test, patients were asked to rate how fearful and also how stable they had felt standing during the test. The FOF rating included a series of questions addressing whether patients felt anxious, nervous, tense, or fearful of falling during the balance test. Postural stability ratings were obtained using the example of Schieppati and colleagues.[41] After completing the entire series of tests, balance test difficulty ratings were obtained as patients were asked to rate how difficult they perceived each task to be. All rating scales ranged from 0% (low levels of confidence, fear, stability, difficulty) to 100% (high levels of confidence, fear, stability, difficulty).

Statistical Analysis

The Kruskal-Wallis test was performed to compare group differences between PD patients and healthy controls for mean ABC scale score. Furthermore, each of the 16 items composing the ABC scale was examined separately using the same statistical test. Correlations were obtained between mean ABC scale score and UPDRS posture and gait score and mean ABC scale score and balance test-specific measures of confidence, fear, stability, and difficulty. Regression analyses were used to examine the contribution of the UPDRS posture and gait score and the mean ABC scale score to explaining the variation in balance performance, as estimated by sway area, for each balance test. In these analyses, disease severity was controlled for by forcing the UPDRS posture and gait score into the regression model first. The ABC scale score was then entered to determine its contribution to explaining the variation in sway area. Of note, the ABC scale score is an interval measure, whereas the UPDRS score is an ordinal measure.

RESULTS

Fear of Falling

There was a significant difference between PD patients and healthy controls for mean ABC scale score ($P < 0.01$). PD patients reported lower confidence in their ability to maintain balance and avoid a fall during ADLs (mean ± 1 SE = 68.7 ± 2.9%) compared to

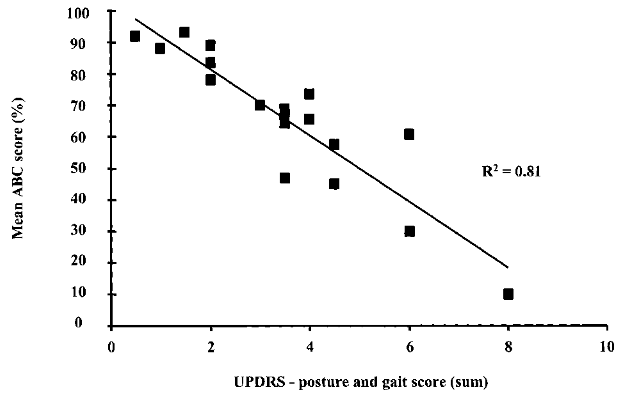

FIG. 2. Relationship between Unified Parkinson's Disease Rating Scale (UPDRS) posture and gait score and mean ABC scale score.

healthy controls (mean ± 1 SE = 93.2 ± 1.3%). Mean confidence scores for each item of the 16-item ABC scale are presented in Figure 1. This figure provides an indication of the specific types of ADLs that resulted in reports of lower confidence for the PD patients. All 16 items were significantly different between PD patients and healthy controls ($P < 0.01$). Several items, including reaching when standing on tiptoes (66.7%), reaching when standing on a chair (51.5%), getting in and out of a car (67.9%), walking in a crowd (65.8%), walking and being bumped (63.3%), using an escalator without holding a railing (53.0%), and walking on an icy sidewalk (41.7%) revealed dramatic decreases in confidence for PD patients compared to healthy controls. Three of these tasks also produced reports of lower confidence in healthy controls: reaching while standing on a chair (87.6%), using an escalator while not holding the railing (86.4%) and walking on an icy sidewalk (74.6%). However, the level of confidence reported for these specific tasks did not significantly drop below the level of confidence reported by PD patients for any of the 16 questionnaire items.

Fear of Falling and Qualitative Postural Control Relationship

There was a significant relationship observed between mean ABC scale score and UPDRS posture and gait score ($R^2 = 0.81$; $P < 0.01$). PD patients with a greater degree of balance and gait impairment reported less confidence in their ability to avoid falling during ADLs (Fig. 2).

Qualitative and Quantitative Postural Control Relationship

There was a significant relationship between UPDRS posture and gait score and sway area of COP on select

TABLE 1. *Variation in quantitative balance performance*

Balance test	Model 1 (R^2)	Model 2 (R^2) ABC added
Normal, EO	0.09	0.33[a]
Normal, EC	0.05	0.56[b]
Normal, THREAT	0.03	0.05
Normal, FOAM	0.28[3]	0.35[a]
Feet together, EO	0.24[1]	0.59[b]
Feet together, EC	0.28[1]	0.53[c]
Feet together, THREAT	0.06	0.41[c]
1LEG	0.50[2]	0.52[b]

Variation in balance performance (sway area for all normal and feet-together stance tests and stance duration for 1LEG stance test) explained by UPDRS posture and gait score alone (Model 1) and UPDRS posture and gait score and mean ABC score (Model 2).

[a]$P < 0.10$; [b]$P < 0.01$; [c]$P < 0.05$.

ABC, Activities-specific Balance Confidence (scale); UPDRS, Unified Parkinson's Disease Rating Scale; EO, eyes open; EC, eyes closed; THREAT, eyes open with the threat of a push or a pull at shoulder level; FOAM, on foam support with eyes open; 1LEG, one-legged stance with eyes open.

balance tests (Table 1; refer to Model 1). The UPDRS posture and gait score explained a portion of the variation in sway area of the COP for the normal stance with FOAM test ($R^2 = 0.28$), feet-together stance with EO test ($R^2 = 0.24$), and feet-together stance with EC tests ($R^2 = 0.28$). However, the relationship between UPDRS posture and gait score and sway area of the COP was marginally significant for each of these three balance tests ($P < 0.06$). For each of these tests, as UPDRS posture and gait score increased (patients were more severely affected), sway area of the COP increased. Variation in sway area of the COP was not well explained by UPDRS posture and gait score for the normal stance with EO, EC, or THREAT tests or the feet-together stance with THREAT test.

For the 1LEG stance test, stance duration instead of sway area of the COP was used to estimate balance performance. The UPDRS posture and gait score explained a significant amount of variation in stance duration for the 1LEG stance test ($R^2 = 0.50$; $P < 0.01$). As UPDRS posture and gait score increased (patients were more severely affected), stance duration decreased (1LEG stance was not maintained as long).

Fear of Falling, Qualitative and Quantitative Postural Control Relationship

When added to the regression model, the ABC scale score contributed information toward explaining the variation in sway area of the COP for five of the eight balance tests (Table 1; refer to Model 2). For example, when considered together, mean ABC scale score and UPDRS posture and gait scores explained significant variation in sway area of the COP for the normal stance with EO test ($R^2 = 0.33$; $P < 0.07$), normal stance with EC test ($R^2 = 0.56$; $P < 0.01$), feet-together stance with EO test ($R^2 = 0.59$; $P < 0.01$), feet-together stance with EC test ($R^2 = 0.53$; $P < 0.05$), and feet-together stance with THREAT test ($R^2 = 0.41$; $P < 0.05$). For each of these tests, as UPDRS posture and gait score increased (patients were more severely affected), ABC scale score decreased (patients reported less balance confidence), and sway area of the COP increased. The ABC scale score did not contribute additional information toward explaining the variation in sway area of the COP for the normal stance with THREAT or FOAM tests. Although related to stance duration for the 1LEG stance test ($R^2 = 0.49$; $P < 0.01$), the ABC scale score did not contribute additional information with the UPDRS posture and gait score toward explaining the variation in stance duration for this test ($R^2 = 0.52$; $P < 0.01$). Thus, as UPDRS posture and gait score increased (patients were more severely affected) and mean ABC scale score decreased (patients reported less balance confidence), stance duration decreased (1LEG stance was not maintained as long).

Balance Test-Specific Psychophysical Scores

There was a significant relationship between mean ABC scale score and the balance test-specific psychophysical scores (range, $R^2 = 0.18–0.34$; $P < 0.01$). Patients, who reported lower confidence on the ABC scale, also reported lower confidence, higher fear, felt less stable, and perceived the balance tests as more difficult than patients who reported higher confidence on the ABC scale. Different levels of confidence, fear, stability, and difficulty were reported across the eight balance tests. When vision was removed, the base of support reduced, or proprioceptive information disrupted, patients reported lower confidence, more fear, felt less stable, and perceived these specific balance tests as more difficult.

DISCUSSION

Our findings indicate that FOF is an important issue in PD, a population known to have postural disability. Our results showed that FOF was more evident for PD patients when compared to healthy individuals of similar age. For example, PD patients reported less confidence in their ability to perform ADLs without falling. Understanding FOF in PD is important, as negative consequences of restricted activity and reduced quality of life have been shown to be related to FOF in older adults.[42–44]

We also observed that individuals with PD, who displayed a greater degree of posture or gait impairment as estimated using selected components of the UPDRS, reported lower confidence in their balance abilities. Similarly, previous research has shown that FOF is more prevalent and associated with physical impairment in individuals with rheumatoid arthritis,[45] individuals who have undergone hip replacement surgery,[46,47] or individuals who have suffered a stroke.[48] The causal nature of the relationship between FOF and postural instability remains unclear; our data were not able to distinguish whether FOF results from postural instability related to the disease process or whether FOF exaggerates postural instability related to the disease process.

Our results also showed that an estimate of FOF might help to explain quantitative postural instability in PD. Increased sway area of the COP was considered to reflect postural instability. FOF, when coupled with a qualitative evaluation of posture and gait impairment, explained more variation in quantitative balance performance on select standing tests. When considered independently, the qualitative measure of posture and gait impairment, in general, could not well predict quantitative balance performance. Previous research has shown that these components of the UPDRS, especially the retropulsion test, do not provide accurate estimates of postural instability in PD.[33] One explanation for this finding is that the components of the UPDRS may simply examine different aspects of postural control than those that we chose to measure or that the scale may be inadequate in accurately estimating postural instability due to the subjective nature of the evaluation. In contrast, the components of the ABC scale may provide a more varied estimate of posture and gait control required for performance of ADLs and, thus, provides a better overall estimate of quantitative postural control. Our balance tasks were relatively easy, and FOF may better predict postural instability when performance is evaluated on more challenging balance tasks. It is important to note that our goal was not to confirm the accuracy or reliability of the UPDRS assessment; we chose to use the scale as it is widely used to estimate motor disability in PD. Instead, our question was to determine whether information concerning FOF could help to improve the ability of the clinician to predict quantitative postural instability in PD.

An issue that must be addressed is whether FOF increases the risk for falls in PD. FOF may act to promote greater caution in PD patients providing a successful compensatory strategy to avoid potential falls in challenging situations. However, in these challenging situations, a great amount of FOF may exaggerate alterations in postural control increasing the potential for falling, beyond the compensatory motor abilities of the patient. Thus, significant FOF may present serious consequences for this population. Further research is required to determine the nature of the relationship between FOF, postural instability, and falls in PD.

Morris[51] has outlined a comprehensive physical therapy model for PD patients. We recommend that FOF should be considered in the assessment and treatment of postural instability in PD. If possible, restoring patient confidence in their ability to perform ADLs could be essential to avoid the negative consequences of activity restriction and reduced quality of life.[42–44,49,50] Addressing FOF and its consequences using specific interventions in fearful elderly has been the subject of recent work.[52] Baumann[53] and King and Tinetti[54] have also suggested that efforts should be directed toward increasing balance confidence in individuals with FOF. Thus, counseling PD patients on their FOF may prove beneficial; however, future research must determine whether reducing FOF will benefit individuals with PD and most importantly not place these individuals at greater risk for falls.

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