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ORIGINAL COMMUNICATION

Balance confidence and functional mobility are independently associated with falls in people with Parkinson's disease

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Abstract The present study aimed to examine the association of falls with self-perceived balance confidence level, and balance and mobility performance in patients with Parkinson's disease (PD). Forty-nine healthy subjects and 71 subjects with PD completed the study. Among the PD patients, 33 (46%) were fallers and 38 were non-fallers. All subjects were tested with the activities-specific balance confidence scale (ABC), one-leg-stance test (OLS), and timed-up-and-go test (TUG). Results indicated that PD fallers had significantly lower ABC scores, shorter OLS times and longer times to complete TUG than PD non-fallers ($P < 0.05$). Having a high ABC score (>80) was significantly associated with a lower fall risk, after adjusting for age, gender, and duration of PD, and for depression [odds ratio (OR) = 0.06, $P = 0.020$]. For performance-based measures of balance and mobility, a longer TUG time (≥16 s) was independently associated with increased risk of falling after controlling for relevant factors (OR = 3.86, $P = 0.043$); OLS time, however, was not significantly associated with falls. A lower self-perceived balance confidence level and a prolonged time to complete TUG were associated with increased risk of falling in patients with PD. Interventions to improve these modifiable risk factors could be useful in reducing future falls in the PD population and will require further study.

Keywords Balance · Balance confidence · Falling · Parkinson's disease · Risk factors

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Introduction

Recurrent falls are common in people with Parkinson's disease (PD). The reported fall incidence in PD patients ranges from 33 to 68% [2, 9, 22, 41]. Fractures, particularly in the femoral neck, are among the most devastating complications of falling in patients with PD [16, 21]. The combination of fracture and PD can lead to increase in functional dependency, risk of nursing home admission and mortality rate [17]. Identification of fall risk factors is essential so that early intervention can be tailored to at-risk patients.

A few prospective studies, with follow-up period durations ranging from 3 to 12 months, have attempted to identify the fall risk factors in PD patients [2, 6, 15, 41]. History of fall, disease severity as indicated by Hoehn and Yahr staging [15, 18], disease duration, and dementia have been identified as fall predictors [2, 6, 15, 41]. A recent meta-analysis of these prospective studies found that the best predictor of falling was two or more falls in the previous year [30]. However, since fall history and other factors such as disease severity and disease duration cannot be altered, identification of modifiable factors would be more meaningful in fall risk assessment.

Previous studies identified balance deficits and gait impairment as potential fall risk factors for patients with PD [4, 6, 20]. However, commonly used clinical tests of balance were not sensitive to identifying fallers in the PD population. These included tandem stance time [6], functional reach test [4, 20], and the retropulsion test [6, 20]. Using multiple balance tests, Jacob et al. [20] found that a combination of one-leg-stance time and unified PD rating scale (UPDRS) gait score achieved high sensitivity and specificity in identifying PD fallers. These findings implied that the "multiple tasks" design could be more useful than

tests comprising a single postural component in fall prediction of PD patients. Bloem et al. [6] and Gray and Hildebrand [15] reported that PD patients fell most commonly during walking, turning, and rising from a chair. Perhaps clinical tests that included these fall-prone components could be useful in fall prediction.

Apart from physical factors, psychological factors such as self-perceived balance confidence cannot be overlooked. About 42% PD fallers were reported to have fear of future falls [6]. Lower balance confidence level in people with PD was related to poorer postural stability, as reflected by increased postural sway in the standing position [1], and decline in physical performance [13]. Self-perceived balance confidence level was found to be the best discriminator of stroke fallers from non-fallers [5]. A declined self-perceived balance confidence level was also the strongest risk factor for falls in individuals with stroke [23]. No study hitherto reported the risk of falling associated with balance confidence level in PD patients.

The objective of the present study was to examine whether the risk of falling was associated with self-perceived balance confidence, and balance and mobility performance in PD patients. A better understanding of the role of physical and psychological factors in fall prediction would enable more focused intervention toward balance enhancement and reducing falls in the PD population.

Methods

Subjects

One hundred and twenty subjects completed the study. Seventy-one subjects with idiopathic PD diagnosed by neurologists according to the United Kingdom PD Society Brain Bank Criteria [19] were recruited from the Hong Kong Parkinson's Disease Association, which is a patient self-help group with about 700 members with PD. These patients have different degrees of mobility level, from independent walkers to wheelchair users. In addition, 49 healthy subjects were recruited from the relatives of our PD subjects, as well as from a community elderly center. The elderly center has about 400 members, the majority of whom are able to walk independently. The purpose of the study was explained to potential participants through seminars and distribution of project brochures. All subjects were recruited on a volunteer basis. Informed consent was obtained from each subject in accordance with the 1964 Declaration of Helsinki, and all experimental work was carried out with the approval of the University ethics committee.

To be included in this study, both healthy and PD subjects were required to be between 40 and 85 years of age, medically stable, able to walk 6 m at least three times with and without assistive devices, and able to understand simple commands (Mini-mental state examination score $\geq$24 [12]). Subjects were excluded if they exhibited postural hypotension, visual disturbance or vestibular dysfunction affecting balance, or significant cardiovascular or musculoskeletal disorders limiting locomotion or balance. Furthermore, subjects with PD were excluded if they had neurological conditions other than idiopathic PD as determined by a neurologist, while control subjects were also excluded if they had any neurological conditions. All subjects with PD were tested within 2 h after medication, i.e., during the "on" phase of the medication cycle.

Procedure

All evaluations were carried out at the University gait and motion research laboratory. Demographic data including age, body mass, body height, and medications were recorded. We measured disease severity by the Hoehn and Yahr staging scale (HY) and the motor component of UPDRS, and we measured level of depression by the geriatric depression scale (GDS) [42]. All subjects were tested with the activities-specific balance confidence scale (ABC), one-leg-stance test (OLS), and timed-up-and-go test (TUG). Information on the number of fall events over the past 12 months was obtained by patient interview. Subjects were classified as fallers if they suffered at least one fall in the past 12 months. A fall is defined as "an event during which a subject comes to rest on the ground or at some lower level, not as the result of a major intrinsic event, e.g. syncope, stroke and seizure, or overwhelming hazard" [39]. There were only three (6%) fallers in the control group, when compared with 33 (46%) fallers in the PD group.

Self-perceived balance confidence level

Balance confidence level was measured by the ABC scale [32]; the validated ABC Chinese version was used in this study [24]. Subjects were asked to rate their self-perceived balance confidence level from 0 (no confidence at all) to 100 (full confidence) for completing 16 activities of daily living. The mean score was calculated for each subject, with a minimum score of 0 to a maximum of 100. ABC scores of $<$50, 50–80, $>$80 indicated low, moderate and high level of balance confidence, respectively, in older adults [27].

One-leg-stand test

The OLS was conducted to assess standing balance. The OLS time was found to be sensitive in predicting fallers

among patients with PD [20]. Subjects were instructed to stand on their non-dominant leg with eyes open, and hands placed on the hips. OLS time was recorded in second(s) with a stopwatch. Timing commenced when a subject's dominant foot left the ground and stopped when the subject's raised foot touched the ground, or when subject's hand swung away from the hips, or when the subject reached a 30-s duration. A cut-off of 10 s was used as it was found to have high level of sensitivity in discriminating PD fallers [20].

Timed-up-and-go test

Timed-up-and-go test was modified from a "get-up-and-go" test which was developed to assess balance in older people based on an ordinal scale of 1–5 [25]. Podsiadlo and Richardson [31] modified the original test by timing the test and proposed it to examine functional mobility in community-dwelling, frail older adults. The TUG test was found to have excellent test–retest and inter-rater reliability in PD patients [26]. In the present study, subjects were instructed to stand up from an armchair and walk forward at their normal speed for 3 m. They then turned, walked back to the chair and sat down. The whole procedure was timed in seconds and the result was recorded. Okumiya et al. [28] found that older adults who completed TUG with a duration $\geq$16 s were 2.6 times more likely to fall in a 5-year follow up. This test was chosen because it assessed multiple postural components (i.e. balance control, physical mobility, and gait performance), which might be more useful for fall prediction [6, 20].

Statistical analysis

All statistical analyses were performed using SPSS 14.0 and a significance level of 0.05 (two-tailed) was set for all statistical tests. The Shapiro Wilk statistic was used to check data normality. One-way analysis of variance (ANOVA; for continuous variables), and the chi-square test (for nominal variables) were used to compare the difference among controls, PD non-fallers and PD fallers for demographic data and other variables of interest. Tukey's tests were used to analyze the data post hoc as necessary. In addition, independent t tests were used to compare the years since diagnosis of PD and UPDRS score between PD fallers and non-fallers, whereas the Mann–Whitney U test was used to compare the H and Y stage (an ordinal variable) between these two groups.

Univariate logistic regression analyses were first used to examine the association of falls (0 = no fall, 1 = one or more falls) with ABC scores, OLS time, and TUG time, respectively, among PD subjects. In these analyses, the subjects were divided into different categories based on the cut-off scores for ABC (group 1: <50, group 2: 50–80, group 3: >80), OLS (group 1: <10 s, group 2: $\geq$10 s), and TUG (group 1: <16 s; group 2: $\geq$16 s). The variables that showed significant association with falls in the univariate analysis would then be entered into a single multivariate logistic regression analysis to identify the determinants of falls after accounting for age, gender, and duration of PD.

Results

Subject demographics

Table 1 shows the summary of the characteristics of the PD fallers, PD non-fallers and control subjects. Results of one-way ANOVA demonstrated no significant difference among the three groups for age, body mass, and height. No significant difference was found between PD fallers and non-fallers for H and Y stage or UPDRS scores. However, significant difference was shown among the subject groups for GDS scores ($P = 0.006$). Post hoc multiple comparisons showed that PD fallers had significantly higher GDS scores than control subjects ($P = 0.004$), but no difference existed between PD fallers and non-fallers ($P = 0.225$). Table 1 also summarizes the anti-Parkinsonian medications taken by PD patients. All patients responded well to the medications, without complications such as postural hypotension that affected their balance.

Self-perceived balance confidence level and balance/mobility performance

Significant differences were found for ABC score, OLS time, and TUG time among three groups of subjects (Fig. 1a–c). Post hoc tests revealed that PD non-fallers had significantly lower ABC scores ($P < 0.05$) and OLS durations than control subjects ($P < 0.05$). Significant differences were further found between PD fallers and non-fallers for ABC score ($P < 0.01$), OLS and TUG time ($P < 0.05$).

Univariate logistic regression analysis

In univariate logistic regression analysis, a high (>80) or moderate ABC score (50–80) was significantly associated with reduction of fall risk, with odds ratio (OR) of 0.05 (95% CI: 0.01, 0.52, $P = 0.013$), and 0.06 (95% CI: 0.01, 0.59, $P = 0.016$), respectively. On the other hand, a longer TUG time was significantly associated with increased fall risk (OR = 3.80, 95% CI: 1.15, 12.54, $P = 0.028$). OLS time, however, was not significantly associated with falls (OR = 0.38, 95% CI: 0.14, 1.04, $P = 0.059$).

Table 1 Demographic data of subjects

	Mean ± 1 SD			*P* value
	Control ($n = 49$)	PD non-fallers ($n = 38$)	PD fallers ($n = 33$)	
Age (years old)	65.6 ± 7.6	62.3 ± 7.1	64.2 ± 8.5	0.137
Female gender	21	16	17	0.675
Weight (kg)	61.5 ± 11.3	60.4 ± 9.9	56.8 ± 9.4	0.134
Height (cm)	160.3 ± 9.8	160.2 ± 7.1	158.2 ± 8.3	0.504
GDS score	3.7 ± 3.4	4.8 ± 3.8	6.4 ± 3.9	0.006**
Duration of PD (years)		7.4 ± 4.3	7.9 ± 4.8	0.688
HY score		2.7 ± 0.6	2.9 ± 0.3	0.095
UPDRS score		22.8 ± 9.1	23.7 ± 10.0	0.698
Anti-Parkinsonian medications		PD non-faller ($n = 38$)	PD faller ($n = 33$)	
Levodopa		11	13	
Levodopa + entacapone		3	1	
Levodopa + selegiline		7	4	
Levodopa + dopamine agonist		7	7	
Levodopa + dopamine agonist + amantadine		2	2	
Levodopa + dopamine agonist + entacapone		2	3	
Levodopa + dopamine agonist + selegiline		1	1	
Dopamine agonist		3	0	
Dopamine agonist + selegiline		2	2	

GDS geriatric depression scale, *HY* Hoehn and Yahr staging scale, *PD* Parkinson's disease, *UPDRS* unified Parkinson's disease rating scale, *SD* standard deviation

** $P < 0.01$

Multivariate logistic regression analysis

Activities-specific balance confidence scores and TUG time were then entered into a multivariate logistic regression model, after accounting for age, gender, disease duration, and depression (Table 2). The results showed that ABC score and TUG time remained independently associated with falls even after accounting for the relevant demographic factors. Specifically, reduced fall risk was associated with a high (>80) ABC score (OR = 0.06, CI = 0.01, 0.65, $P = 0.020$), but not with moderate ABC scores (50–80) (OR = 0.10, CI: 0.01, 1.29, $P = 0.078$). A longer TUG time (≥16 s) was significantly associated with increased risk of falling (OR = 3.86, CI: 1.05, 14.27, $P = 0.043$).

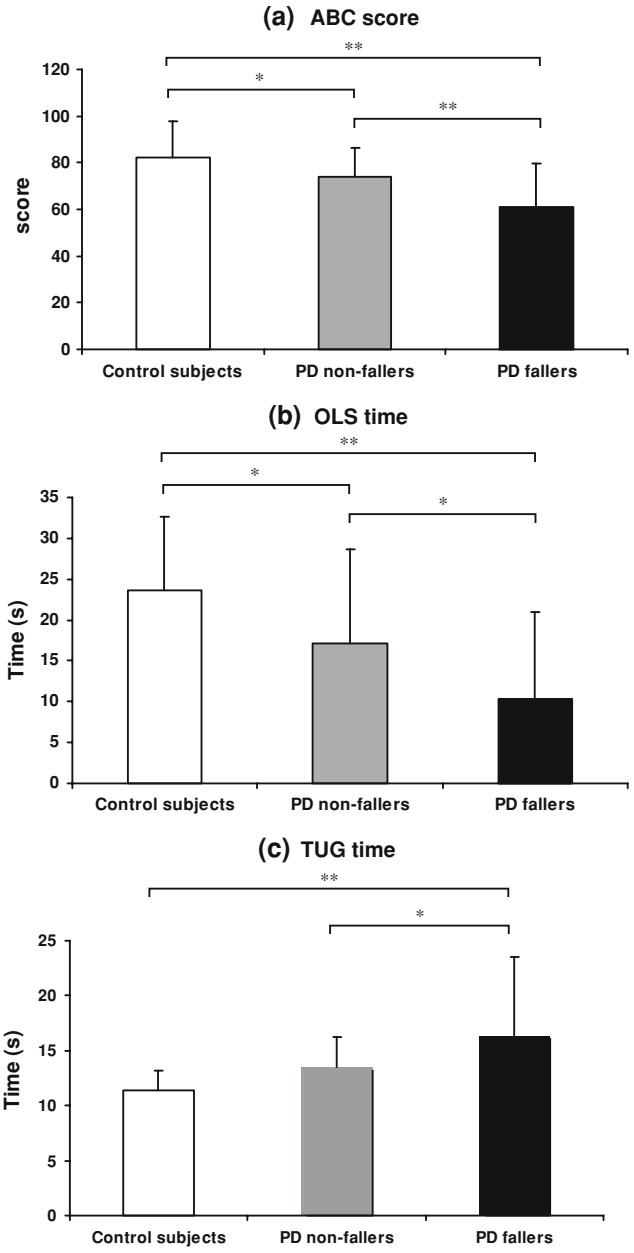
Discussion

The important finding of this study is that fear of falling as reflected by poor balance confidence, and a longer TUG time were major fall risk factors in PD patients. This finding highlights the importance of considering both psychological and physical measures in fall risk assessment.

Self-perceived balance confidence and falls

The mean ABC score in PD fallers was significantly lower than that in PD non-fallers, and was also substantially lower than that previously reported (mean ABC score = 68–72) in other PD populations [1, 20]. It is very interesting to note that the six ABC items that PD fallers had the lowest scores (reach in tip toes, stand on chair to reach, walk in crowded mall, walk in crowded mall/bumped, escalator not holding rail, walk on slippery sidewalk) coincided with those of the abbreviated ABC-6 scale adopted by Oude Nijhuis et al. [29]. It appears that these 6 ABC items were useful in assessing fear of falling in PD patients.

In the present study, a high balance confidence level (ABC score >80) was associated with reduction in fall risk. Previous studies reported that self-perceived balance confidence could best discriminate subjects with and without balance disorders [40], and stroke fallers from non-fallers [5]. Lamb et al. [23] further found that reduced balance confidence during dressing was the strongest risk factor for fall in stroke individuals (OR = 7.0). Our findings concur with previous studies and suggest that self-perceived balance confidence has a significant predictive value for evaluating fall risk in people with PD. Excess fear could



**p<0.01 (Post-hoc Tukey's test)
*p<0.05 (Post-hoc Tukey's test)

ABC Activities-specific balance confidence scale
OLS One-leg stance test
TUG Timed-up-and-go test

Fig. 1 Comparison among control and Parkinsonian subjects for **a** activities-specific balance confidence score, **b** one-leg-stance time and **c** timed-up-and-go time

increase risk of immobility, social isolation, depression [34], and reduced quality of life in PD patients [7]. Given the debilitating consequences of fear of falling, balance confidence is a construct that needs to be included in fall risk assessment of people with PD.

Our study shows a significant relationship between fear of falling and falls in PD patients. An important question would be: Does fear of falling cause falls, or does a previous fall cause fear of falling? On one hand, patients who had prior falls could have recognized the fall-inducing situations and the adverse outcomes of falls, leading to development of fear of falling. On the other hand, fear of falling often leads to self-induced restriction of activities and further physical de-conditioning [11, 14, 37]. The resulting deterioration in physical function may in turn increase the risk of falling [14]. Previous data has provided evidence on both scenarios in the elderly. In a large prospective cohort study, Friedman et al. [14] revealed that older people who had more fear of falling at baseline were more likely to fall at 20-month follow-up, and those who had a fall history were also more likely to develop fear of falling than non-fallers at follow-up (OR = 1.8 for both factors), indicating that individuals who had either a history of falls or fear of falling could have a higher risk of developing the other. The cross-sectional design of the present study does not allow us to establish causality. However, our results would provide a strong basis for a future prospective study to determine whether the phenomenon of "spiraling risk of fall, fear of fall and functional decline" observed in the elderly as suggested by Friedman et al. [14] also occurs in PD patients.

Balance/mobility performance and falls

Parkinson's disease fallers took significantly longer time to complete TUG than PD non-fallers, a finding that agreed with those reported in previous studies [2, 34]. The multivariate logistic regression model further found that a prolonged TUG time was associated with a higher risk of falling in PD subjects. TUG consists of a sequence of functional tasks such as walking, turning and rising from a chair, which were often reported in connection with falls [6, 15]. For example, 24–46% of PD subjects were reported to have fallen during walking and turning [6, 15], and 15% of patients fell during transferring from sitting to standing [6]. On one hand, hypokinesia and deficits in balance responses resulting from PD could prolong TUG time. On the other hand, patients who were not stable would slow down their movement to ensure safety during the test. Both factors could lead to prolonged TUG time, particularly in PD fallers. A test that comprises all fall-prone components such as TUG could thus considerably challenge the balance and mobility functions of PD patients and may be more useful in predicting their risk of falling.

Various TUG cut-off scores, ranging from 13.5 s [36], 16 s [28] to 20.1 s [10], have been used to identify fall risk in older people. The present study adopted 16 s as a TUG cut-off score since Okumiya et al. [28] demonstrated in a

Table 2 Risk factors for falling in people with PD: multivariate logistic regression analysis

Independent variables	Number (%) of subjects	*B*	SE	Odds ratio	95% Confidence interval	*P* value
Step 1						
Age		0.043	0.034	1.04	0.98, 1.11	0.202
Gender		0.695	0.525	2.00	0.72, 5.60	0.185
Duration of PD		0.027	0.057	1.02	0.64, 1.03	0.638
Depression		0.131	0.068	1.14	0.05, 1.14	0.054
Step 2						
Age		−0.025	0.042	0.97	0.90, 1.06	0.552
Gender		0.648	0.593	1.91	0.60, 6.12	0.275
Duration of PD		0.022	0.063	1.02	0.90, 1.16	0.727
Depression		0.129	0.081	1.14	0.97, 1.33	0.110
ABC score >80	18 (25)	−2.771	1.192	0.06	0.01, 0.65	0.020*
ABC score = 50–80	42 (59)	−2.324	1.317	0.10	0.01, 1.29	0.078
TUG time ≥16 s	20 (28)	1.351	0.667	3.86	1.05, 14.27	0.043*

PD Parkinson's disease, *ABC* activities-specific balance confidence scale, *TUG* timed-up-and-go test, *SE* standard error

* $P < 0.05$

large scale prospective study that a TUG duration >16 s was very significant in predicting fall risk in older people. When using TUG score to discriminate fallers from non-fallers, a cut-off score of 13.5 s achieved 87% of sensitivity and specificity [36], while that of 20.1 s obtained a low sensitivity of 59% [10]. However, Shumway-Cook et al. [36] excluded older subjects with neurological disorders, therefore the TUG cut-off score used (13.5 s) might not be appropriate for PD patients.

Parkinson's disease fallers maintained a significantly shorter OLS time than PD non-fallers. We established fall risk using an OLS cut-off score of 10 s, which had been shown to be sensitive in identifying PD fallers [20]. However, in the present study, the association between falls and OLS time failed to reach a significant level, although it was close ($P = 0.059$). We cannot rule out the possibility that a significant association could have been found if a larger sample size had been used. Another possibility is that the OLS test assesses subjects' ability to maintain their balance during a transition from a large to a small base of support in a static rather than a dynamic situation. This test might thus be less sensitive than TUG in predicting fall risk in PD patients.

The results of this study have several important clinical implications. First, clinicians could consider using TUG and ABC scores to identify high risk fallers among PD patients. Second, as both risk factors are potentially modifiable, interventions should be designed toward improving not only physical mobility but also balance confidence, which tends to be overlooked in current clinical practice. Published data on people with PD reported the effect of physical training such as balance and strengthening exercises in improving postural stability [3, 33]. In older adults, cognitive-behavioral education programs which included identification of fall risk factors, discussion of coping strategies to falling, as well as low-resistance exercise training have produced gains in balance confidence [8, 38] and perceived health status [8]. For stroke patients, physical training using task-oriented walking exercise has also been shown to enhance balance confidence [35]. However, no study has examined the effects of different therapeutic strategies on fostering balance confidence in a PD population and so will require further study.

Our study has several limitations. First, recall bias (under-reporting) may have produced inaccuracy in reporting fall history retrospectively over the 12-month period. Therefore, we included subjects who were cognitively intact (MMSE ≥24) to minimize this bias. Second, we examined ambulatory, community-dwelling people with PD, as their relatively higher mobility level would presumably expose them to more fall-inducing situations. Findings of the present study could apply to PD subjects who did not have any co-morbidity but could not be generalized to PD patients at all ambulatory stages or those who are living in institutions. Third, we did not identify those patients who had experience of freezing of gait and therefore could not establish the fall risk relating to PD freezers. Fourth, this is a cross-sectional study, hence a causal relationship between falls and balance confidence, balance and mobility score could not be established. Nevertheless, significant findings obtained in the present study are valuable in guiding the direction of future prospective studies in this area. Future studies should include a larger sample of patients at all disease stages, with different mobility and cognitive levels, with and without experience of freezing of gait.

Conclusions

This is the first study to show that lower balance confidence level and a longer duration to complete TUG were significant risk factors of falling in PD patients. These findings highlight the importance of assessing subjective self-perceived balance confidence level as well as assessing physical performance in estimating fall risk. As both ABC and TUG are reliable, valid, sensitive, and easy-to-administer, these clinical measures could be useful in screening PD patients with high risk of falling.

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