Parkinsonian single fallers versus recurrent fallers: different fall characteristics and clinical features

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Running title: Fall and clinical characteristics in Parkinson's disease

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Abstract

Objectives: The study aimed to compare the fall characteristics between Parkinsonian single (P-SF) and recurrent fallers (P-RF), and the clinical features among Parkinsonian non-fallers (P-NF), P-SF, P-RF and age-matched healthy controls. *Methods:* Seventy-two patients with PD and 74 healthy subjects completed the study. Each subject was evaluated for gait speed, timed-up-and-go test, one-leg-stance test, 6-minute walk test, 5-time-sit-to-stand test, and activities-specific balance confidence (ABC) scale at baseline. Subjects were then followed up for 12 months by telephone interview to record the fall incidence and fall characteristics. *Results:* Among the PD patients, 12 fell once (P-SF) and 13 fell 2-29 times (P-RF), accounting for a total of 133 falls in the 12-month follow-up period. The most common fall-related activity for both P-SF and P-RF was walking. P-SF fell mostly outdoors because of "tripping", while P-RF mostly fell at home due to "muscle giving way". Clinical measures indicated that P-SF did not differ from P-NF. However, P-RF had significantly longer 5-time-sit-to-stand time, shorter 6-minute walk distance, and lower ABC score than P-SF. *Conclusions:* P-RF could be distinguished from P-SF by fall characteristics (i.e. location and perceived causes of falls), and by clinical measures including leg muscle weakness, reduced exercise endurance and increased level of fear of falling. Findings from the present study suggest that P-NF/P-SF and P-RF may require different intervention strategies to prevent future falls.

Keywords: Accidental falls, Parkinson's disease, gait disorders, muscle weakness, postural balance

Introduction

Falls are common in people with Parkinson's disease (PD). Between 39% to 68% of people with PD experienced at least a fall in 3- to 12-month follow-up (Ashburn et al. 2001, Bloem et al. 2001, Wood et al. 2002, Pickering et al. 2007). The high fall rate in PD patients was also observed in a prospective study with a 20-year follow-up period [12]. It was reported that falling occurred in 87% of patients, with 35% of them sustaining a fracture. Fall-induced physical injuries together with fear of falling [24] could lead to immobility, increased risk of nursing home admission and higher mortality rate [18]. In view of the potentially devastating outcomes of falls, early interventions to prevent falls are essential. Identification of fall characteristics is the first crucial step in developing effective treatment plan to reduce fall incidence in PD patients.

Previous studies have reported that the most common fall-related activity in PD patients was walking (45%), followed by standing (32%), and transfer activities such as sit-to-stand (15-21%) [1, 3]. The occurrence of falls during these activities could be attributed to tripping, freezing, postural instability, misjudgment and distraction [1]. In these studies, fall characteristics were examined without discrimination between single and recurrent fallers. Recurrent fallers, however, were found to experience significantly greater functional decline than single-fallers in 12-month follow-up [6]. Repeated fallers may also be exposed to a higher risk of injury than single fallers. It is thus clinically important to explore the fall characteristics in PD single and recurrent fallers separately. A thorough understanding of the fall characteristics and the associated clinical features in PD single and recurrent fallers may allow the design of fall prevention programs that are more tailored to the needs of these two groups of patients. The objectives of the present study were to compare (1) the fall characteristics between PD single and

recurrent fallers (i.e. fall-related activities, circumstances surrounding the fall, perceived causes of falling), and (2) the clinical characteristics of PD non-fallers, single fallers and recurrent fallers (i.e. motor impairment, balance, mobility, fear of falling).

Methods

Subjects

Seventy-four healthy subjects and 72 patients with PD completed the study (Figure 1). Healthy subjects were recruited from local community health centres whereas PD patients were recruited from the Hong Kong Parkinson's Disease Association, a self-help patient group. For inclusion, PD subjects had to be diagnosed by neurologists to have idiopathic PD according to the United Kingdom PD Society Brain Bank Criteria [17], aged 40 years or above, medically stable, and able to walk independently with and without assistive device. Subjects were excluded if they had neurological conditions other than PD, communication deficits, cognitive impairment (Mini Mental State Examination score<24) [10], visual disturbance or vestibular dysfunction, significant cardiovascular or musculoskeletal disorders limiting locomotion or balance. Healthy subjects followed the same inclusion and exclusion criteria except that they did not have PD. Informed consent was obtained from each subject in accordance with the Declaration of Helsinski, and all experimental work was carried out with the approval of the University ethics committee.

Procedure

All assessments were carried out at the University gait and motion research laboratory. PD patients were tested within 2 hours after taking their anti-Parkinsonian medications (i.e.

during "on" phase of the medication cycle). Each subject underwent evaluation of the following outcomes at baseline.

Baseline measurement of demographic and clinical characteristics

In addition to the basic demographics, physical activity level was measured by the modified version of the Minnesota Leisure-Time Physical Activity (MNLTPA) questionnaire (Tsang and Hui-Chan). Subjects were classified into 3 separate categories according to the types of habitual physical activities that they most frequently participated in during the past year [Level I: light intensity (<4 METs), Level II: moderate intensity (4-5.5 METS), Level III: heavy intensity (>5.5METs)]. Disease severity and PD-specific motor impairments were determined respectively by Hoehn and Yahr staging scale (HY) [14] and Unified PD rating scale motor III (UPDRS) [9]. Information on the number of fall events over previous 12 months was obtained by patient interview. Subjects were classified as having a positive fall history if they had 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." [36]

Gait speed (m/s) was measured by instructing subjects to walk at their natural speed on a 4-metre Gaitrite walkway (SMS Technologies Ltd, Harlow Essex UK) [2]. The Timed-up-and-go (TUG) test was used to measure a subject's ability to perform a sequential functional movement [27]. Subjects were instructed to stand up from an armchair, walk forward at their self-paced velocity for 3 meters, they then turned, walked back to the chair and sat down. The whole procedure was timed and the result was recorded (in seconds). One-leg-stance (OLS) test was conducted to assess standing balance [19]. Subjects were instructed to stand on their non-dominant leg with eyes open, and hands placed on the hips. OLS time (in seconds) was

commenced when the dominant foot left the ground and stopped if the same foot touched the ground, or when the hands swung away from their hips, or when a 30-second OLS duration was reached. Five-time sit-to-stand (5xSTS) test is a composite measure of functional muscle strength of the lower extremities [8, 22]. Subjects crossed their arms over the chest and sat on a chair with their back against the chair. On the command "begin", they had to stand up fully and then sat down, and with their buttocks touching the chair on the fifth repetition as quickly as possible. The time taken to complete 5xSTS was measured in seconds. The six-minute walk (6MW) test was used to determine exercise endurance [35]. In a 15-metre unobstructed corridor, subjects were instructed to cover as much distance as possible in six minutes. The total distance walked was measured in metres. The above-mentioned measurement tools have been found to have excellent test-retest reliability when used in PD patients (intraclass correlation coefficient (ICC=0.89-0.97)) [22, 27, 30, 35].

The validated Chinese version of Activities-specific Balance Confidence (ABC) scale was used to provide an estimate of fear of falling [23, 32]. 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 of the 16 activities was calculated, ranging from 0 to 100, with a low ABC score reflecting more fear of falling. Depression was measured by the Chinese version of the short form of Geriatric Depression Scale (GDS) [20, 21]. The questionnaire contained 15 questions, and each subject was instructed to respond to each question by a "YES" or "NO" answer. The score ranges from 0 to 15, with a score > 6 indicating depression.

Prospective assessment of falls and their characteristics

After the baseline assessment, patients were contacted by phone on a monthly basis to record any fall incidence, for a 12-month period [36]. Persons were classified as single or recurrent fallers if they had one fall or more than one fall respectively within the follow-up period. If subjects sustained a fall, they were asked to describe details about the circumstances surrounding the fall with an open-ended questionnaire (setting, fall-related activity, self-perceived cause of falling) and the data were recorded.

Statistical analysis

Descriptive statistics (e.g. frequency count) and chi-square test were used to analyze the fall characteristics data and physical activity level. For the demographic and clinical variables, normality of data was first checked using the Shapiro Wilk statistic. One way analysis of variance (ANOVA; for continuous data), and chi-square test (for nominal variables) were used to compare the difference among control non-fallers, Parkinsonian non-fallers (P-NF), Parkinsonian single fallers (P-SF) and Parkinsonian recurrent fallers (P-RF) for demographic data and other variables of interest. Tukey's tests were used to analyse the data post-hoc as necessary. All statistical analyses were performed using SPSS 16.0 and a significance level of 0.05 (two-tailed) was set for all statistical tests.

Results

Comparison of demographic and disease characteristics

A total of 146 subjects (74 healthy controls, 72 PD patients) completed the study. During the 12-month follow-up period, PD patients reported 133 falls, whereas control subjects reported only 6 falls. Twelve and 13 PD subjects were classified as P-SF, and P-RF (2-29 falls), respectively. No recurrent falls were reported in the control group. The risk of sustaining at least

one fall was thus much higher in PD patients than control subjects (Relative risk=4.2). Table 1 shows that P-RF had significantly higher HY score (i.e. more advanced PD) and daily dosage of levodopa than P-NF (P<0.05). P-RF also had significantly higher UPDRS motor score and UPDRS (item 30 - pull test) score than both the P-NF and P-SF (P<0.05).

Comparison of fall characteristics between P-SF and P-RF

The most frequent activity leading to falls in both P-SF and P-RF was walking (60% and 67% respectively), followed by standing (17% and 28 % respectively, χ^2=0.776, P=0.676, Figure 2). In addition, both groups of fallers had similar physical activity level as measured by MET and they sustained similar degree of physical injuries after falls (Table 2). Regarding the location of falls, P-SF reported that the majority of falls occurred at outdoors (67%), whereas P-RF sustained more falls at home (78%) than outdoors (22%), (χ^2=14.30, P=0.001). The perceived causes of falling were also different between P-SF and P-RF (χ^2=14.65, P=0.012, Figure 3). Among P-SF, the most common perceived cause was tripping (36%), followed by slipping (18%), loss of balance (18%) and loss of concentration or misjudgment (18%). In contrast, the most common perceived cause of falls among P-RF was "muscle giving way" (46%), followed by dizziness due to position change (21%), and loss of balance (14%). Only P-RF, not P-SF, used walking aids but these patients fell while they were using their walking aids (Table 2).

Comparison of baseline clinical measures among P-NF, P-SF and P-RF

Table 2 shows the comparison of physical and psychological functioning among different groups. P-SF took a significantly longer time to complete TUG (by 35%), and achieved a significantly shorter OLS time (by 40%) than controls (P<0.05). Interestingly, no significant difference existed between P-NF and P-SF for any of the parameters. P-RF, on the other hand, had the poorest performance in all clinical measures. Specifically, P-RF had significantly

reduced gait speed (by 20%) and 6MW distance (by 24%) as well as longer TUG time (by 34%) and 5xSTS time (by 33%) when compared with P-NF ($P<0.05$). P-RF also had significantly shorter 6MW distance (by 30%) and longer 5xSTS time (by 38%) than P-SF ($P<0.05$). In terms of psychological measures, P-RF had significantly lower ABC score than P-SF ($P<0.05$), indicating that they had more fear of falling.

Discussion

This is the first study to show that P-RF have different fall characteristics and clinical features from P-SF. Moreover, the different self-perceived causes of falling in P-RF and P-SF are substantiated by their respective findings in objective measurements of physical and psychological functioning.

Comparison of fall and clinical characteristics between P-SF and P-RF

The finding that PD patients had a higher risk of falling than control subjects is consistent with that was reported previously [3, Wood et al. 2002, Pickering et al. 2007, Latt et al. 2009]. Our PD subjects had a fall rate of 35% in 12-month follow up, which was lower than 45-68% reported previously (Wood et al. 2002, Latt et al 2009). Previous studies recruited PD subjects from hospitals or outpatient clinics, and our patients were recruited from the community and they were members of a self-help patient group. These patients could be more active and less disabled, which may explain the lower fall rate. The control subjects in the present study had an annual fall rate of 8% which was markedly lower than 32% reported in a local study by Leung et al. (Leung et al. 2010). The subjects in their study were applying for placement in long-term care institutions and thus represented a sample of frail older adults living in the community (Leung et al. 2010). Our healthy subjects were recruited from community health centres, and were very

active in performing regular exercises and/or volunteer work. The difference in subject characteristics may account for the discrepancy in fall rate.

For fall characteristics, previous studies reported that over 80% of PD patients fell indoors [1, 3]. The most common causes of falls were tripping (28%) and distraction (12%) [1], and the most frequent fall-related activity was walking [3,11]. Falls resulted in physical injuries in 35-40% of patients (Bloem et al. 2001, Gray and Hildebrand 2000). In accordance with the previous findings, majority of falls occurred during walking and standing activities in both P-SF and P-RF, and about 35% of falls resulted in physical injuries in each group of patients. However, these two groups of PD patients showed a number of important differences in fall characteristics. Specifically, P-SF fell mostly outdoors and the most common perceived cause of falling was tripping, slipping, and loss of balance. This was in line with the objective findings of their poorer balance ability (shorter OLS time) than controls. Previous studies have demonstrated that PD patients have poor walking pattern, inflexible postural responses [15] and impaired visuo-spatial perception [16]. PD fallers had more increase postural sway in standing, poorer leaning stability and had a higher incidence of freezing of gait than PD non-fallers (Latt et al. 2009). These factors could create difficulty for P-SF to maintain their stability in more challenging outdoor environments such as curbs, uneven ground, or slippery surfaces. Previous studies have shown that when PD patients attended to a concurrent task during walking or standing, more gait disturbance and postural instability emerged [25, 37]. This may contribute to increased falls due to “misjudgment or distraction”.

P-RF have very different fall characteristics. Unlike P-SF, most falls in P-RF occurred in their own homes. The single major perceived cause of falling was “muscle giving way” which could be interpreted as decreased muscle strength. This was substantiated by our finding that

only P-RF, but not P-SF, had significantly lower leg muscle strength and exercise endurance, as indicated by a longer 5xSTS time and shorter 6MW distance than P-NF and controls. Lower extremity muscle weakness was reported in PD fallers [34], and was found to be one of the factors contributing to postural instability [28] and falls in PD patients (Latt et al. 2009). Therefore, lower limb weakness could have increased the risk of falling in our P-RF. An alternative explanation for the perceived "muscle giving way" might be associated with end of dose or "off" syndrome. We did not collect information about their medication status during the fall events, therefore further study is warranted to examine this possibility. It is important to note that significantly higher proportion of P-RF had a positive fall history. P-RF also had significantly more severe PD-specific motor impairment (higher UPDRS score), more balance impairment (higher UPDRS-30 score), and more fear of falling (lower ABC score) than P-SF. When taken together, the results suggest a possible scenario that although P-RF had similar physical activity level as P-SF, they chose to stay at home or were afraid to venture out due to more severe PD impairments and fear of falling, leading to further activity restriction and physical deconditioning, which manifests itself in the form of decreased leg muscle strength and exercise endurance. A vicious cycle of recurrent falls, increased fear of falling, and further activity restriction may continue. Further study is needed to prove this proposal. An interesting finding was that falls in P-RF occurred while they were using walking aids, suggesting that walking aids might not be useful to prevent falls (Morris 2006).

The second most common cause of falling among P-RF was dizziness due to position change (21%), which concurred with "lightheadedness" reported previously [11]. P-RF took a higher daily dosage of levodopa medication than P-NF (Table 1), a finding that agreed with Latt et al. (2009). One of the side effects of increased dosage of levodopa was othrostatic hypotension

[5] and increased postural sway in standing [26], hence these could increase the risk of falling in P-RF.

Clinical and research implications

The most important clinical implication of this study is that P-SF and P-RF may require different intervention strategies to prevent future falls. In addition, it was very interesting to note that although P-NF did not fall during 12-month follow-up, P-NF and P-SF were very similar in PD disease severity, PD-specific impairments, postural instability, and gait disturbance (Table 2). Interventions that aim to improve postural stability during ambulatory and standing activities could be useful to prevent new falls in P-NF and P-SF. Previous studies reported that gait re-education using treadmill [33], and combined strength and balance training [13] could enhance postural stability and walking in PD patients. According to a recent systematic review, there was moderate evidence that balance enhancement programs could improve postural stability and balance task performance in PD patients (Dibble et al. 2009). Home-based balance and ambulatory training was further found to have a trend towards lower fall rate at 6-month follow-up, although the reduction did not reach significance (Ashburn et al. 2007). Canning et al. (2009) designed a 6-month exercise intervention to examine its cost-effectiveness and fall reduction in PD fallers (Canning et al. 2009). More studies are required to determine optimal treatment interventions to prevent/reduce falls in P-NF or P-SF. Moreover, since P-SF fell mostly outdoors, treatment should incorporate activities that would improve their ability to negotiate outdoor environmental hazards.

On the other hand, intervention programs that aim to break the vicious cycle of fear of falling, secondary deconditioning, activity restriction, and repeated falls may be more appropriate for P-RF. Specifically, enhancement of lower extremity muscle strength, exercise

endurance and balance confidence may be key elements in fall prevention programs for P-RF. In older people, combined strength and endurance training was reported to reduce fall rate by 18% in 12-month follow-up [4]. Cognitive-behavioral education programs together with resistance exercise training was found to enhance balance confidence and reduce the fall risk of elder fallers by 31% at 14-month follow-up [7]. Further studies are needed to examine the effects of restoring balance confidence, enhancing muscle strength and exercise endurance in reducing future falls in P-RF. One of the important perceived causes of falls in P-RF is dizziness due to positional change, which might be associated with a higher dosage of levodopa that these patients received. While levodopa improves PD-related symptoms, its side effect of orthostatic hypotension and possible association with falls in P-RF should warrant attention. Review of drug dosage, advice to patients to avoid sudden rise into a standing position, or the use of low dose fludrocortisones may be helpful to relieve othrostatic hypotension in PD patients [29]. Additionally, proper description and use of walking aids might need to be reinforced in P-RF. Since the majority of falls occur at home, modification of the home environment may be an important strategy to reduce incidence of falls in P-RF.

The present study has some limitations. First, the sample was a group of ambulatory, community-dwelling individuals recruited from a self-help patient group at the beginning of the study. As the study progressed, we did not continue to recruit other potentially eligible patients in different community settings. Hence, this was not a consecutively recruited cohort. Findings of the present study could not be generalized to PD patients with different degree of disabilities and to those who live in long-term care institutions. Second, both P-SF and P-RF had a small sample size, which may partially explain some of the insignificant results (e.g. walking speed and TUG time). Third, we performed baseline assessment during “on” medication phase and

none of the patients exhibited freezing of gait. Assessment after withdrawal of levodopa and inclusion of data on gait freezing might give more information about their fall characteristics. Fourth, subjects were follow-up by telephone interview on a monthly basis instead of using fall diary [9] because most of the subjects did not have education beyond the elementary level and some were even illiterate. Therefore, we excluded those who had cognitive impairments (MMSE<24), in order to minimize recall bias.

To conclude, walking and standing were the most common fall-related activities for both P-SF and P-RF. However, P-SF fell mostly outdoors, whereas P-RF fell mostly at home. The most common perceived cause of falling among P-SF was “tripping”, “slipping”, and “loss of balance”, which was consistent with the significantly poorer performance in balance tests than controls. “Muscle giving way” was identified by P-RF as the most common cause of falling, which was substantiated by the objective finding of significantly lower leg muscle strength and exercise endurance in this group than P-SF, P-NF and controls. The different fall characteristics and clinical features between P-NF/P-SF and P-RF may call for different treatment interventions to reduce falls but will need further study.

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Table 1 Subject characteristics

	C-NF (n=68)	P-NF (n=47)	P-SF (n=12)	P-RF (n=13)	*P* values		
					P-NF vs P-SF	P-NF vs P-RF	P-SF vs P-RF
Age (years)	64.0 ± 8.3	63.7 ± 8.4	60.6 ± 6.3	65.2 ± 8.4		0.340	
Weight (kg)	61.7 ± 10.2	59.2 ± 9.6	60.6 ± 10.4	56.0 ± 9.2		0.450	
Height (cm)	160.2 ± 8.9	160.4 ± 7.5	156.4 ± 7.5	159.3 ± 6.9		0.259	
Gender (F)	30	22	5	7		0.514	
Fall history (number)	4	13	4	11	0.976	< 0.001*	0.027*
Falls in 12-month follow-up (number)	0	0	12	121	-	-	< 0.001*
MMSE score (0-30)	28.5 ± 2.0	27.8 ± 1.9	27.9 ± 1.8	27.3 ± 1.9		0.116	
PD duration (year)	-	6.3 ± 3.7	9.3 ± 5.1	8.0 ± 3.5		0.051	
HY score (0-5)	-	2.6 ± 0.4	2.6 ± 0.7	2.9 ± 0.4	0.188	0.016*	0.523
UPDRS score (0-108)	-	21.3 ± 9.4	21.3 ± 8.0	30.2 ± 9.3	1.000	0.007*	0.046*
UPDRS-30 score (0-4)	-	0.57 ± 0.58	0.42 ± 0.51	1.08 ± 0.64	0.680	0.020*	0.016*
Levodopa daily dosage (mg)	-	379.9 ± 310.9	460.4 ± 474.5	710.6 ± 329.1	0.753	0.009*	0.175

* *P* <0.05
C-NF: Control non-fallers
P-NF: Parkinsonian non-fallers
P-SF: Parkinsonian single fallers
P-RF: Parkinsonian recurrent fallers
F: Female
HY: Hoehn and Yahr
UPDRS: Unified Parkinson's disease rating scale

Table 3 Comparison among control and PD subjects for balance and mobility performance characteristics

	C-NF (n=68)	P-NF (n=47)	P-SF (n=12)	P-RF (n=13)	*P* values					
					C-NF vs P-NF	C-NF vs P-SF	C-NF vs P-RF	P-NF vs P-SF	P-NF vs P-RF	P-SF vs P-RF
Gait speed (cm/s)	123.5 ± 23.4	110.3 ± 21.8	107.9 ± 16.5	88.8 ± 23.4	0.012*	0.121	<0.001*	0.988	0.013*	0.145
TUG time (s)	10.9 ± 2.6	13.9 ± 4.0	14.8 ± 3.0	18.6 ± 9.3	0.001*	0.016*	<0.001*	0.895	0.002*	0.105
OLS time (s)	23.8 ± 9.8	15.8 ± 11.7	14.0 ± 10.0	10.0 ± 8.5	<0.001*	0.016*	<0.001*	0.951	0.275	0.759
6 MWD (m)	431.6 ± 81.4	350.9 ± 73.2	379.9 ± 64.9	269.5 ± 84.3	<0.001*	0.150	<0.001*	0.658	0.006*	0.003*
5x STS time (s)	11.3 ± 3.7	13.4 ± 5.7	12.9 ± 3.3	17.8 ± 5.7	0.094	0.692	<0.001*	0.990	0.016*	0.048*
ABC score (0-100)	84.8 ± 14.2	70.4 ± 15.6	75.0 ± 17.1	58.9 ± 14.1	<0.001*	0.164	<0.001*	0.768	0.072	0.039*
GDS score (1-15)	3.2 ± 3.0	5.1 ± 4.0	5.7 ± 4.6	6.5 ± 4.2	0.028*	0.128	0.013*	0.963	0.586	0.931

* $P < 0.05$
C-NF: Control non-fallers
P-NF: Parkinsonian non-fallers
P-SF: Parkinsonian single fallers
P-RF: Parkinsonian recurrent fallers
5xSTS: Five-time sit-to-stand
6 MWD: 6-minute walk distance
ABC: Activities-specific balance confidence scale
GDS: Geriatric depression scale
OLS One-leg-stance
TUG: Timed-up-and-go

Table 2 Comparison between Parkinsonian single and recurrent fallers for fall characteristics

	P-SF (N^a=12)	P-RF (N^a=13)	χ^2	P value
Walking aids				
No	12	8	5.769	0.016*
Yes (cane/quadripod/walker)	0	5 (3/1/1)		
Physical activity level				
MET 1 (< 4)	8	10	1.518	0.468
MET 2 (4-5.5)	1	2		
MET 3 (> 5.5)	3	1		
	P-SF (N^b=12)	P-RF (N^b=121)		
Walking aids				
No	12	83	5.276	0.002*
Yes (cane/quadripod/walker)	0	38 (31/2/5)		
On/off symptoms				
On	12	113	2.335	0.127
Off	0	20		
Injury				
No	7	76	7.809	0.099
Cut	0	15		
Bruise	3	27		
Fracture	1	1		
Others	1	2		

* P <0.05
N^a Number of subject
N^b Number of fall incidence
MET Metabolic equivalent

Figure legends

Fig. 1 A flow chart indicating subject selection procedure

Fig. 2 Fall-related activities among control single fallers, Parkinsonian single fallers and recurrent fallers

Fig. 3 Perceived causes of falling among control single fallers, Parkinsonian single fallers and recurrent fallers

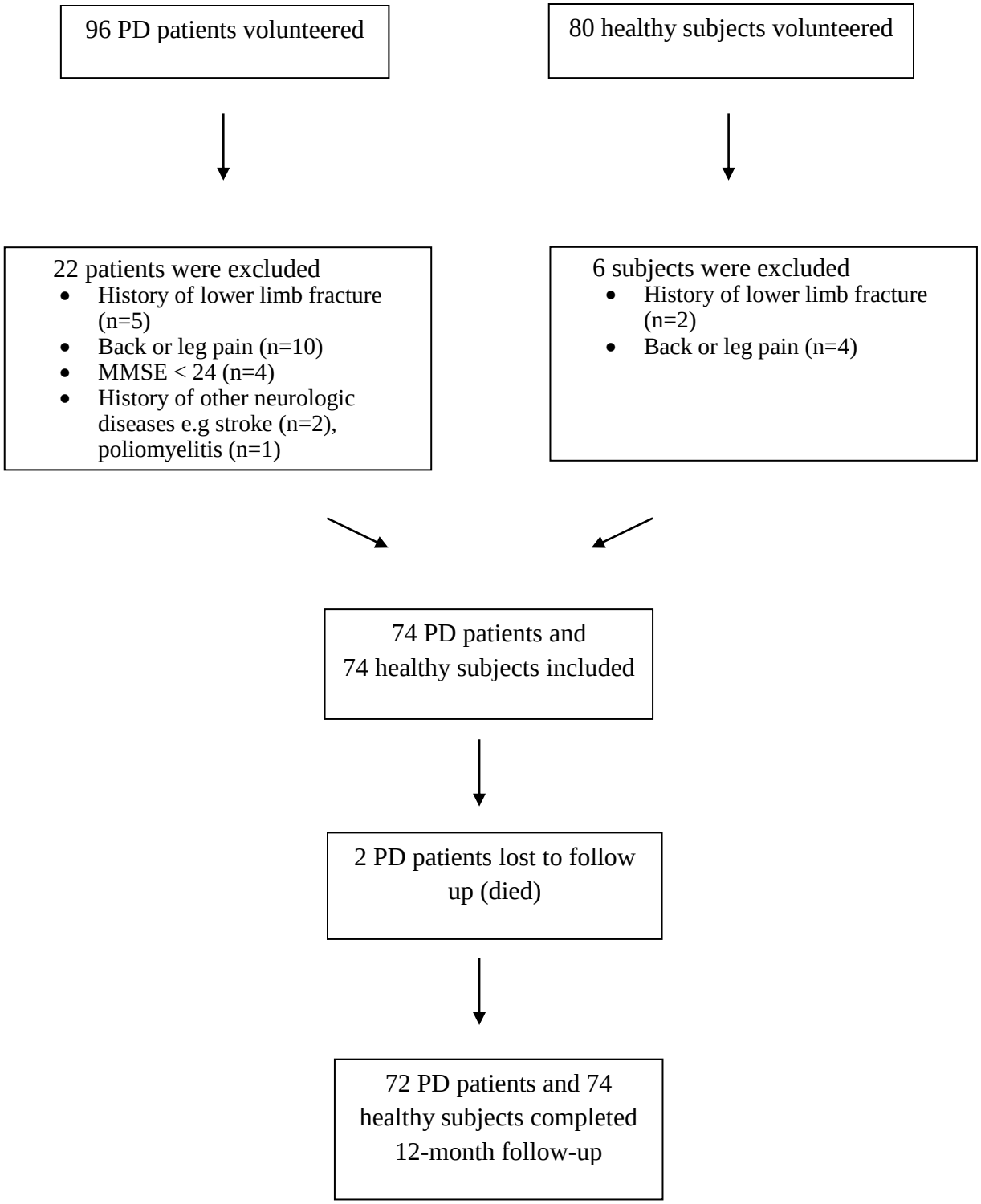
96 PD patients volunteered
80 healthy subjects volunteered
22 patients were excluded
History of lower limb fracture (n=5)
Back or leg pain (n=10)
MMSE < 24 (n=4)
History of other neurologic diseases e.g stroke (n=2), poliomyelitis (n=1)
6 subjects were excluded
History of lower limb fracture (n=2)
Back or leg pain (n=4)
74 PD patients and 74 healthy subjects included
2 PD patients lost to follow up (died)
72 PD patients and 74 healthy subjects completed 12-month follow-up

Fig. 1

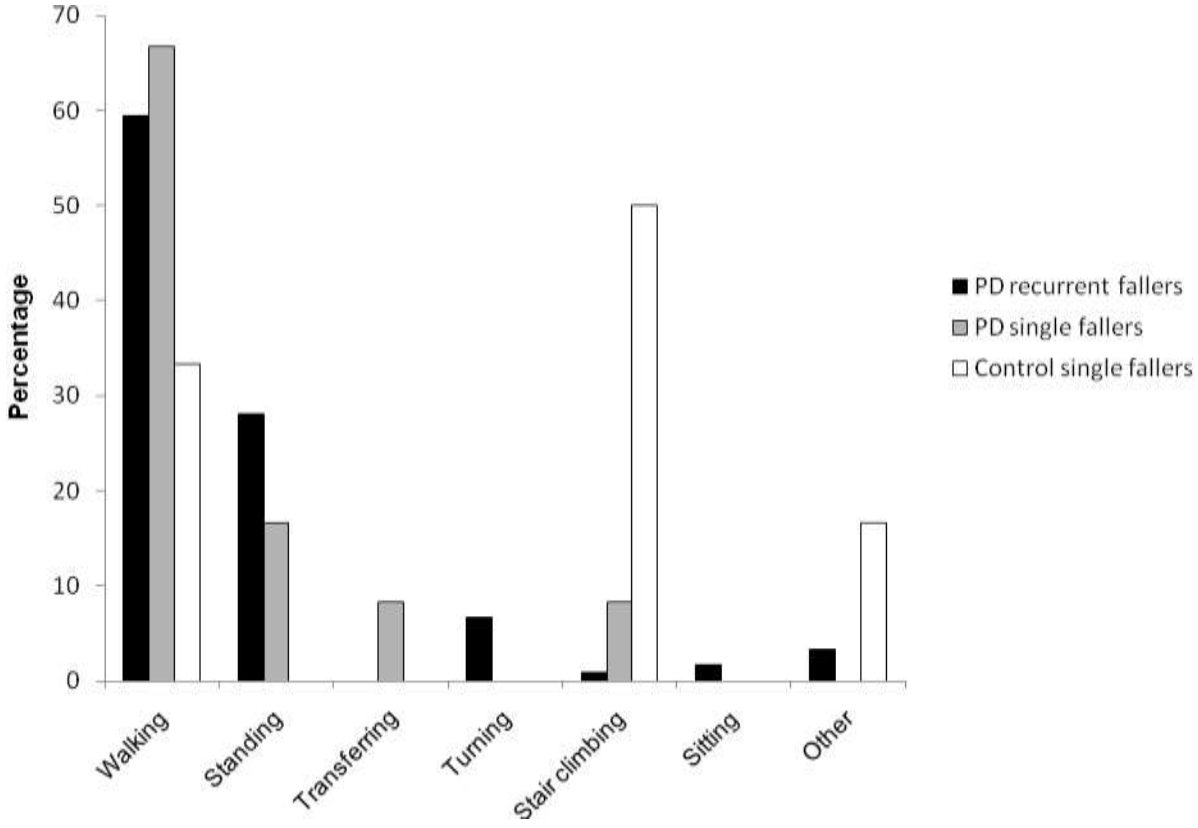
70
60
50
40
30
20
10
0
Percentage
Walking
Standing
Transferring
Turning
Stair climbing
Sitting
Other
PD recurrent fallers
PD single fallers
Control single fallers

Fig. 2

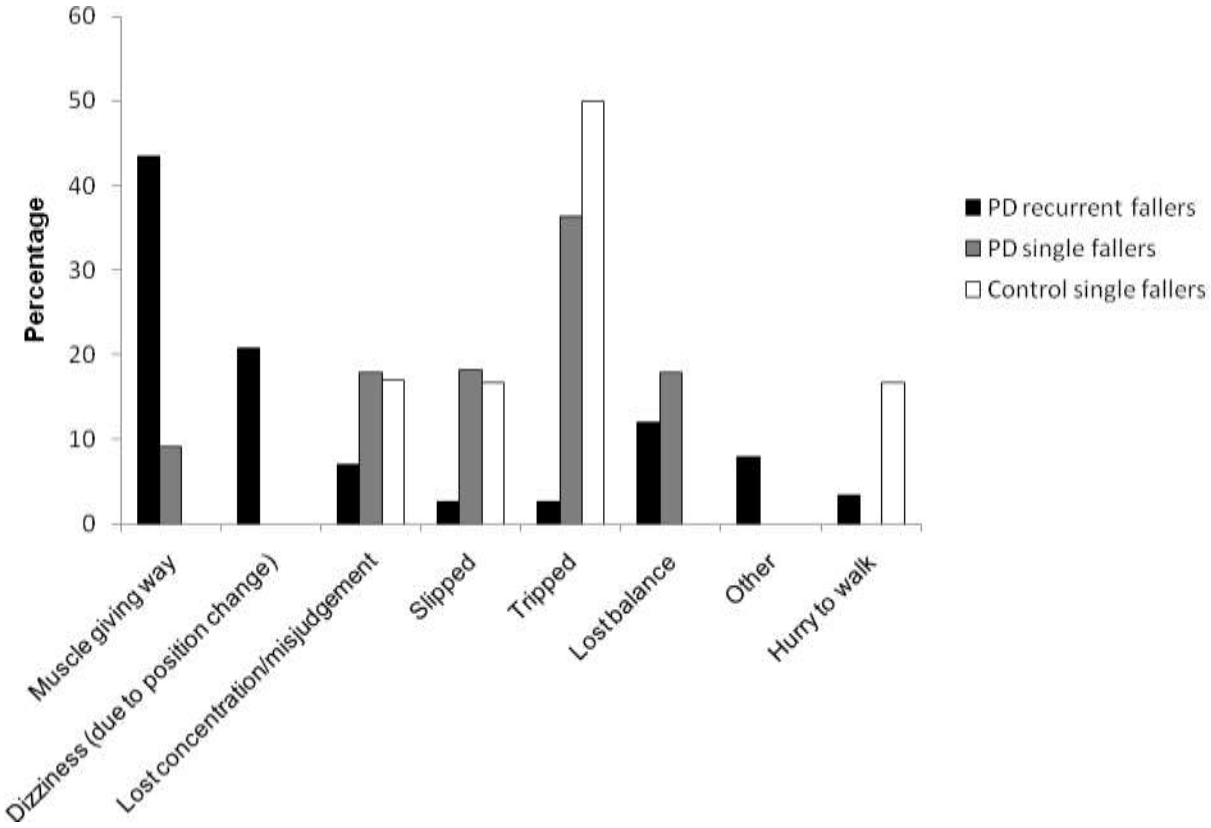
60
50
40
30
20
10
0
Percentage
PD recurrent fallers
PD single fallers
Control single fallers
Muscle giving way
Dizziness (due to position change)
Lost concentration/misjudgement
Slipped
Tripped
Lost balance
Other
Hurry to walk

Fig. 3