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A community-dwelling sample of people with Parkinson's disease: characteristics of fallers and non-fallers

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Abstract

Background: people with Parkinson's disease often fall.
Objectives: to report the frequency of falls and characteristics of fallers and non-fallers in a community-based sample of people with Parkinson's disease.
Method: we administered a battery of standardized tests in the home and the laboratory.
Results: we recruited 63 people with Parkinson's disease through general practices. Forty (64%, 95% confidence interval 51–74%) had fallen in the previous 12 months. Many factors associated with falling in the general population were associated with Parkinson's disease fallers (e.g. use of multiple medication and greater physical disability). Fallers were more likely to be depressed and anxious than non-fallers. Condition-specific factors associated with falling included greater disease severity (although there were exceptions) and more marked response to levodopa treatment, including more dyskinesia and on–off phenomena. Fallers took more steps to complete a test of mobility. They also had a shorter functional reach and greater postural sway whilst completing a dual task than non-fallers.
Conclusion: this community-based study confirms the high risk of falling in Parkinson's disease. Our results suggest that disease-specific factors contribute to the increased risk and that there is scope for specific therapeutic interventions.

Keywords: *community, balance, falls, Parkinson's disease*

Introduction

Falling is an important problem in older people [1–4], and a number of risk factors have been identified [5–9]. Parkinson's disease causes postural instability but there is a lack of community-derived data on the incidence and prevalence of falling. Most Parkinson's disease studies have used selected samples such as outpatients from specialist clinics [10, 11] or known fallers and non-fallers [12]. Charlett *et al.* [10] found that 13 (54%) of 25 consecutive outpatients with newly diagnosed untreated idiopathic Parkinson's disease had fallen since diagnosis. In a specialist Parkinson's disease clinic, Koller *et al.* [13] reported a falling rate of about one-third, but supplied few details. A retrospective study by Johnell *et al.* [14] in a community-based sample found that, 10 years after the diagnosis of Parkinson's disease, 27% had new hip fractures. The increased risk of fractures was thought to be due more to types of falls than to osteoporosis. However, bone mass density around the hip has been found to be lower in people with Parkinson's disease than in controls [15].

Although there has been some work on mechanisms of falling in older people [6–9], there have been few studies on Parkinson's disease. Impairment of postural reflexes [16] reduces the limits of stability and is associated with difficulty in executing and timing responses to external challenges and unexpected perturbations [12]. Further research is required on the role of sway, truncal rigidity, reductions in stride length and heel strike, gait freezing, tremor and dyskinesia.

We present the largest community-based investigation to date of the prevalence of falling and of features associated with falling in Parkinson's disease. We address three questions: what is the frequency of falling among

people with Parkinson's disease?, which general characteristics are associated with having fallen?; and what specific impairments are associated with falling in Parkinson's disease?

Methods

Following ethical committee approval and written consent, we recruited the study sample through general practitioners, interviewed them at home and subsequently assessed them in a movement laboratory. Eligible subjects had a diagnosis of Parkinson's disease recorded in the general practitioner notes and could walk independently. Exclusion criteria were other neurological or vestibular conditions and gross cognitive impairment. Fallers were identified at interview. For statistical comparisons of continuous and categorical data from fallers and non-fallers we used χ^2 or Fisher's exact test and Mann–Whitney U tests.

Assessments

We interviewed participants while they were taking their usual medications, and hence at their usual levels of mobility. We recorded information about regular medications, response to levodopa, including dyskinesia and on–off phenomena, visual and hearing impairment, and autonomic symptoms. We asked participants about the frequency and circumstances of falls and of near-misses in the previous 12 months. We defined a fall as an event which results in a person coming to rest unintentionally on the ground or other level, not as the result of a major intrinsic event or overwhelming hazard [17]. We defined a near-miss as an occasion on which an individual felt that they were going to fall but did not actually fall [18]. To ensure that all possible falls were reported, questions about falling were raised more than once during the interview and participants were encouraged to have another person present to add detail or to confirm accounts.

We used the following measures: Hoehn and Yahr rating scale [19] and the Unified Parkinson's Disease Rating Scale (UPDRS) [20] for motor impairment; the 13-item gross motor function section of the Rivermead Motor Assessment [21] for motor ability; the Self Assessment Disability Scale [22] for measurement of perceived effort required for tasks such as turning in bed and writing; and the Middlesex Elderly Assessment of Mental State [23] and the Leeds scale [24] to assess cognitive function and mood respectively.

Subjects attended the movement laboratory within 3 weeks of being interviewed, and were studied midway between drug doses. We assessed mobility with the 'get up and go' test [25] which entails standing up from a chair, walking 3 m, turning around, walking back to the chair and sitting down, with ratings of number of steps, time taken, reduction of arm swing and heel strike and use of walking aids. We measured dynamic balance control using functional reach [26]—a reach as far forward as possible from a standing position without falling or taking a step. We measured postural sway with the Balance Performance Monitor (BPM–SMS Technologies) [27]. We asked subjects to stand on the foot plates in a standardized, predetermined position. Sway was the mean variability of proportional weight distribution, detected through sensors, in three 30-s tests. The sway test was performed both during quiet standing and whilst completing a distracting task, which required participants to make a simple colour judgement on a series of playing cards.

Results

We approached 39 local general practices; 62 general practitioners in 20 practices (estimated population 150 000) agreed to participate. Of the 119 people with Parkinson's disease whom we contacted, 71 (61%) consented to participate. Eight were excluded for the following reasons: awaiting surgery (one), moved to residential home (three), recent stroke (one) and history of vestibular problems (three). There remained 63 participants, 33 (52%) of whom were men, mean age 71 years (range 46–87).

Diagnostic features

All participants had a disorder compatible with Parkinson's disease, without features suggesting an alternative diagnosis. Diagnosis had been confirmed by a neurologist in 51 (81%). Table 1 shows the frequency

Table 1. Clinical features of 63 study participants

	No. of cardinal signs[a]			
Status at examination	0	1	2+	Total
Patient reported definite functional response to levodopa only	0	0	10	10
History of asymmetrical onset of symptoms	1	1	12	14
Both of the above	0	6	30	36
Neither of the above	0	0	3	3
Total	1	7	55	63

[a]Bradykinesia, tremor, rigidity.

of diagnostically-relevant clinical features found at the time of examination (midway between drug doses), tabulated against two criteria which support the diagnosis of Parkinson's disease: patient-reported functional responsiveness to levodopa, and asymmetry of features at the time of presentation. The diagnosis in four participants was questionable. One subject had no signs when tested, but when revisited demonstrated mild rigidity and a severe asymmetrical resting tremor. Three other subjects presented at least two cardinal signs but had neither an asymmetrical onset nor response to levodopa.

Falls and near-misses

Forty subjects (64%, 95% confidence interval 51–74%) reported having fallen in the previous 12 months, 29 (73%) more than once; 24 (60%) had also experienced near-falls. Among 23 non-fallers 14 (61%) had experienced near-falls. Further details are shown in Table 2.

Table 2. Fallers and non-fallers

	Fallers	Non-fallers
No. of subjects	40	23
Mean age, years (SD)	70.7 (8.7)	71.6 (7.4)
% men	50%	57%
Median no. of falls reported in 12 months	3	–
No. reporting >1 fall	29 (73%)	–
No. reporting near-misses (%)	24 (60%)	14 (61%)

Characteristics of fallers

Fallers had greater disease severity than non-fallers, with worse scores on the Rivermead Motor Assessment and Self Assessment Disability Scale and significantly higher Hoehn and Yahr grades and UPDRS scores (Table 3 and Figure 1; exceptions are discussed below). Neither of the subjects with Hoehn and Yahr grade I had fallen, all seven grade II fallers had only fallen once, whilst all 10 subjects with grade IV had fallen repeatedly, confirming the association between disease severity and falling.

More fallers than non-fallers reported dyskinesia (35% *versus* 13%), on–off phenomena (40% *versus* 9%) and a noticeable improvement in function after taking

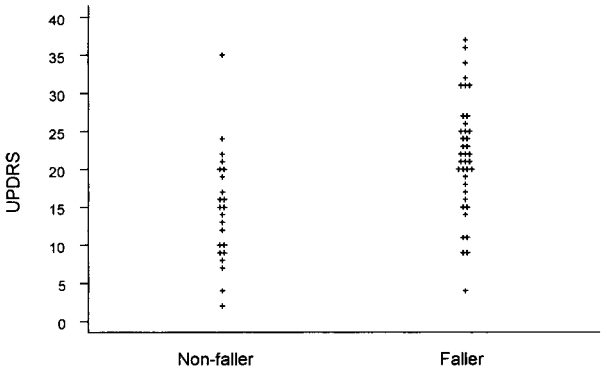

Figure 1. Distribution of scores on the unified Parkinson's diseases Rating Scale (UPDRS) of fallers and non-fallers.

Table 3. Summary of data collected at interview of fallers and non-fallers with Parkinson's disease

		Group		
Variable	Value	Non-fallers ($n=23$)	Fallers ($n=40$)	P value
Severity of disease: Hoehn and Yahr score[a]	I	2 (9%)	0	0.001[e]
	II	12 (52%)	7 (18%)	
	III	9 (39%)	23 (58%)	
	IV	0	10 (25%)	
Unified Parkinson's Disease Rating Scale[b,c]	Median	15	22	$P<0.0005$[f]
	Min–max	2–35	4–37 ($n=39$)	
Polypharmacy/use of drugs	Median	2	3	
	Min–max	0–7	0–7	
	Use >3 drugs	6 (26%)	19 (48%)	0.094[e]
Mobility: Rivermead Motor Assessment[d]	Median	12	10	0.010[f]
	Min–max	6–13	1–13	
Function: Self Assessment Disability Scale[c]	Median	38	56	0.002[f]
	Min–max	27–82	29–111	
Mood: Leeds scale[c]				
Anxiety	Median	6	9.5	0.008[f]
	Min–max	4–21	4–19 ($n=38$)	
Depression	Median	4	6.5	0.010[f]
	Min–max	0–11	2–14 ($n=38$)	

[a]I, unilateral signs no functional difficulty; II, bilateral, no balance difficulties; III, impaired righting reflexes, mild to moderate disability; IV, severe disability, independent walking; [b]Categories include speech, tremor, bradykinesia, rigidity, movement and posture; [c]High score = poor; [d]High score = good; [e]χ^2; [f]Mann–Whitney U test.

Table 4. Summary of mobility and balance data collected in the gait laboratory

Variable		Value	Group: Non-fallers ($n = 19$)	Group: Fallers ($n = 29$)	P value
Mobility: 'get up and go'	Time (s)	Median	14	16	0.216[c]
		Min–max	10–37	10–37	
	No. of steps	Median	18	22	0.020[c]
		Min–max	14–35	15–48	
	No. (and %) with decrease in				
	Arm swing	–	12 (75)	25 (86)	0.061[d]
	Heel strike	–	6 (32)	14 (48)	0.251[e]
Balance	Functional reach (cm)[a]	Median	22.7	16.8[f]	0.006[c]
		Min–max	6.3–28.7	8.8–27.0[f]	
	Postural sway[b]				
	Quiet standing	Median	2.7	3.8	0.073[c]
		Min–max	1.0–10.8	0.9–34.1	
	Quiet standing + other task	Median	2.5	5.9	0.017[c]
		Min–max	0.9–15.6	1.1–29.4	

[a]High score = good; [b]High score = poor; [c]Mann–Whitney U test; [d]Fisher's exact test; [e]χ^2; [f]$n = 26$.

levodopa (46% *versus* 24%). Similar proportions of fallers and non-fallers reported autonomic symptoms such as dizziness on standing, palpitations and bladder or bowel dysfunction (48% *versus* 53%). Two factors associated with falling in the general population were more frequent in Parkinson's disease fallers: polypharmacy (with 48% of fallers and 26% of non-fallers taking more than three types of medication) and impaired mood (with higher Leeds scale scores in fallers; Table 3).

Movement laboratory assessments

We tested 29 of the fallers and 19 of the non-fallers. Reasons for non-attendance included the difficulty of travelling (although three of 10 people with Hoehn and Yahr grade IV severity attended) and concern that symptoms might be exacerbated. Results are shown in Table 4. There was no significant difference between the proportions of fallers and non-fallers with reduced arm swing or decreased heel strike. However, fallers showed a significant reduction in mean functional reach (16.8 cm compared with 22.7 cm in non-fallers). They also swayed significantly more than non-fallers with the distracting task, although not in quiet standing. Fallers took no longer than non-fallers to complete the 'get up and go' test but took more steps. Postural hypotension, defined as a drop in systolic pressure of at least 30 mmHg on standing, was found in two fallers and in one non-faller.

Figure 1 shows that four non-fallers had high UPDRS scores (> 20). Three of these had Hoehn and Yahr grade III parkinsonism with severe bradykinesia, tremor and instability and worse scores than the average non-faller in most mobility and balance measures. They were highly anxious, and had high self-assessment scores, indicating their low perception of independence. These three participants had all had near-misses, and two had fallen before the previous 12 months; a fourth non-faller with a high UPDRS score had a severe tremor and a greater sway in quiet standing than the average non-faller, but a relatively better self-assessment score.

Five fallers had low UPDRS scores (< 12). They had Hoehn and Yahr scale grades of II and had each reported only one fall in the previous 12 months. None worried about falling. They differed from the average faller in that they rated themselves less disabled, and scored better on mobility tests. They had normal heel strike when walking, but had reduced arm swing.

Data from the sample were re-analysed excluding the three subjects for whom the diagnosis remained questionable. The overall results did not alter: all differences between fallers and non-fallers remained significant or non-significant.

Discussion

To date, ours is the largest community-based study of fallers among people with a diagnosis of Parkinson's disease. Our ascertainment and assessment methods ensured that the sample was representative of Parkinson's disease as it is encountered in the community. Re-analysis of results, excluding clinically atypical participants, made no difference to the conclusions. Considering the demands of the study, the consent rate was high.

Randomized controlled trials have demonstrated the benefits of multifactorial interventions in reducing falling, including muscle strengthening and balance training [28–31]. Parkinson's disease is associated with a high risk of falling and those with this diagnosis should be a priority for such interventions [32]. In our sample, derived from a defined community, the proportion reporting near-falls was three times that reported among older

people in general [33]. Nearly two-thirds had fallen in 12 months (twice the proportion predicted in the general population of similar age [1]) and nearly half fell repeatedly. Koller *et al.* [13] and Charlett *et al.* [10] reported lower rates of falling among their hospital-based series (38% and 54%, respectively), perhaps because severely disabled patients are under-represented in hospital studies. Our higher falling rate is more representative of community conditions. However, it may still be an under-estimate, as severely disabled people may have been reluctant to participate in research.

Many characteristics of Parkinson's disease fallers correspond to those of elderly fallers in general [34]: for example, the use of multiple medications. The fallers in our study were more physically disabled than the non-fallers. Disease severity was associated with falling and falling repeatedly, which is consistent with the findings of Koller *et al.* [13]. Unlike Charlett *et al.* [10], we found our fallers were more depressed than the non-fallers. The sample was not large enough to test the extent to which variables had independent effects on falling: depression and disease severity could be inter-related, for example. More fallers than non-fallers reported functional improvement following levodopa, dyskinesia and on–off phenomena, suggesting that erratic drug responses might precipitate falls.

The observed relationship between disease severity and falling suggests the existence of specific impairments predisposing to falling. This was confirmed by our laboratory findings. We found mobility and balance control were more impaired among fallers than non-fallers, in accordance with other researchers [34, 35]. Slow movement is a hallmark of parkinsonism, but our fallers and non-fallers completed the 'get up and go test' at similar speeds. Fallers, however, showed increased frequency of stepping [36, 37]. Short stepping might be an attempt to keep the centre of mass close to the centre of stability, as suggested by Horak *et al.* [36]. Like Grill [38], we found that fallers demonstrated shorter functional reach than non-fallers, indicating a smaller area of stability.

Dietz *et al.* [39] proposed that reduced sway in Parkinson's disease might be related to musculo-skeletal stiffness. We did not find that fallers swayed more than non-fallers during quiet standing. Fallers did, however, sway much more when challenged with dual tasks. This suggests an attentional mechanism: either increased cognitive demand for balance or reduction in attentional resources. Some elderly people experience difficulty in walking and talking simultaneously [40], suggesting that attentional mechanisms are implicated; impaired dual-task performance is associated with parkinsonism [41].

Our findings suggest a pattern of impairments, including reduced limits of stability (step length and reach) and increased sensitivity to distraction. The data provide a basis for developing new indicators of falling risk (such as tests of divided attention) and for developing new therapeutic strategies (for example, increasing the base of support and/or focusing attention).

Conclusion

The risk of falling is greatly increased in Parkinson's disease. Characteristics of fallers among elderly people in general are more prevalent among Parkinson's disease fallers than non-fallers. There is a strong association between falling and disease severity—although there are individual exceptions. Falling is associated with a specific pattern of impairments, including reduced limits of stability, the use of small frequent steps when walking and difficulty with dynamic balance when distracted. These factors should be used to develop a framework for therapeutic management.

Key points

- Two-thirds of people with Parkinson's disease in a community sample fell frequently.
- Fallers with Parkinson's disease in the community had several specific characteristics in addition to those found among the general elderly population.
- Fallers were more likely than non-fallers to experience a marked response to levodopa treatment, dyskinesia and on–off fluctuations.
- Fallers were distinguishable by their use of small frequent steps whilst walking, reduced functional reach and increased sway during a distracting task.
- There was a strong association between falling and disease severity, although there were exceptions.
- Non-fallers with high United Parkinson's Disease Rating Scale (UPDRS) scores were distinguishable by their anxiety and caution about falling; fallers with low UPDRS scores had experienced single falls.

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