PAPER

Incidence and prediction of falls in Parkinson's disease: a prospective multidisciplinary study

B H Wood, J A Bilclough, A Bowron, R W Walker

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authors' affiliations
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Correspondence to:
Dr R W Walker,
Department of Medicine,
North Tyneside General
Hospital, Rake Lane, North
Shields, Tyne and Wear
NE29 8NH, UK;
Richard.walker@
northumbria-healthcare.nhs.uk

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Objectives: To accurately establish the incidence of falls in Parkinson's disease (PD) and to investigate predictive risk factors for fallers from baseline data.

Methods: 109 subjects with idiopathic PD diagnosed according to the brain bank criteria underwent a multidisciplinary baseline assessment comprising demographic and historical data, disease specific rating scales, physiotherapy assessment, tests of visual, cardiovascular and autonomic function, and bone densitometry. Patients were then prospectively followed up for one year using weekly prepaid postcards along with telephone follow up.

Results: Falls occurred in 68.3% of the subjects. Previous falls, disease duration, dementia, and loss of arm swing were independent predictors of falling. There were also significant associations between disease severity, balance impairment, depression, and falling.

Conclusions: Falls are a common problem in PD and some of the major risk factors are potentially modifiable. There is a need for future studies to look at interventions to prevent falls in PD.

F alls are not a new problem in Parkinson's disease (PD). Indeed in his description of PD or "paralysis agitans",[1] James Parkinson made several references to falls. Despite this there are few publications on falls in PD.

In the general population risk factors for falls include muscle weakness,[2] visual impairment,[3] polypharmacy (the use of at least four medications),[4] neurocardiovascular instability,[5] and environmental factors.[6] Many falls have a multifactorial aetiology.[7] Falls, gait impairment, and postural instability can lead to an increased risk of mortality and morbidity in PD.[8 9] Fractures, particularly of the femoral neck, are among the most devastating complications of falling in parkinsonian patients.[10–14] Falls in PD can lead to increased dependency and risk of nursing home admission[15] along with a deleterious effect on quality of life.[16 17] Fear of future falling has also been described in PD.[16 18]

Before the commencement of this study there were no published prospective studies of falling in PD. The few retrospective studies have shown an increased risk of falling in PD.[18–21] The problem with looking retrospectively at falls is that elderly patients may forget they have fallen.[22–24]

In this study we therefore investigated the baseline characteristics of a cohort of community dwelling patients with PD and assessed the incidence of falls prospectively over a one year period.

METHODS

The diagnosis of PD was assessed by the United Kingdom Parkinson's Disease Society brain bank criteria[25] in patients from a district general hospital PD service register. Local ethical committee approval was obtained. The only exclusion criteria were a patient being totally bedfast and severe medical instability. All 141 eligible patients were invited to participate and 109 subjects agreed. Written informed consent was obtained.

Baseline assessment

The baseline assessments were performed over a period of six months and all took place at the same time of day (in the afternoon). The subjects had fasted overnight with no caffeine consumption on the day of assessment.

Routine demographic data were collected, including duration of disease, number of falls in the previous year, and current medication.

Subjects' level of disease activity, along with physical and mental functioning, were assessed using the following well validated rating scales: unified Parkinson's disease rating scale (UPDRS),[26] modified Hoehn and Yahr (MHY) scale,[27] Folstein's mini-mental state examination (MMSE),[28] geriatric depression scale–short form (GDS15),[29] and a quality of life scale (short form Parkinson's disease questionnaire, PDQ-8).[30]

Gait and balance functionality were assessed by a physiotherapist. Presence of bradykinesia (including initiation difficulty, festination, and loss of arm swing) or dyskinesia at assessment were noted. Times and ratings for changes in position from lying to sitting and from sitting to standing, and stair climbing were recorded, along with gait velocity and stride length over a 10 m walk. Gait and balance were assessed according to Tinetti's scales.[31]

The visual acuity of each eye was assessed using a Snellen chart. Visual impairment was defined as acuity worse than 6/9 in the best eye, using visual aids if the patient was wearing them at the time of assessment.

Autonomic function was assessed using standard bedside tests[32] (heart rate and blood pressure responses to standing, deep breathing, Valsalva manoeuvre, and cold pressor stimulus) and compared with age matched reference data.[33] Parasympathetic dysfunction was defined as abnormalities in at least two of three parasympathetic assessments; sympathetic dysfunction was defined as abnormalities in at least one of two sympathetic assessments.

The following cardiovascular investigations were performed after measurement of heart rate and supine blood pressure: an active stand using digital photoplethysmography to investigate orthostatic hypotension and, where indicated, carotid

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Abbreviations: GDS15, geriatric depression scale–short form; MHY, modified Hoehn and Yahr scale; MMSE, mini-mental state examination; PD, Parkinson's disease; PDQ-8, short form Parkinson's disease questionnaire; UPDRS, unified Parkinson's disease rating scale

Table 1 Historical data and falls among 101 patients with Parkinson's disease

Characteristic	Fallers (n=69)	Non-fallers (n=32)	Test	p Value
Age (years)	75 (54–92)	75 (60–92)	1	0.526
Male sex	37 (53.6%)	13 (40.6%)	2	0.224
Duration of symptoms (years)	6 (1–37)	4.5 (1–11)	3	0.006**
In long term care (years)	6 (8.7%)	1 (3.1%)	2	0.427
Number of falls in previous year	3 (0–500)	0 (0–5)	3	<0.001**
History of any fall	50 (72.5%)	12 (37.5%)	2	0.003**
History of recurrent falls	43 (62.3%)	5 (15.6%)	2	<0.001**
Levodopa dose (mg)	400 (0–1250)	375 (0–800)	1	0.102
Dopamine agonist use	10 (14.5%)	8 (25%)	2	0.199
Benzodiazepine use	6 (8.7%)	3 (9.4%)	2	0.911
Polypharmacy	7 (10.1%)	5 (15.6%)	2	0.428

Data are median with range or absolute number with percentages. **p<0.01. 1, independent samples t test; 2, χ^2 test; 3, Mann-Whitney U test.

sinus massage. Orthostatic hypotension was defined as at least a 20 mm Hg fall in systolic blood pressure, with or without symptoms. Carotid sinus massage was performed if there was a history of at least two unexplained falls or syncopal episodes, according to local guidelines. Cardioinhibitory carotid sinus hypersensitivity was diagnosed if there was an asystolic pause of at least 3 seconds following massage. Vasodepressor carotid sinus hypersensitivity was diagnosed if there was at least a 50 mm Hg systolic blood pressure drop following the procedure.

Bone density was measured by dual energy *x*-ray absorptiometry. Osteoporosis was defined as a T score of less than –2.5 in either the spine or hip.

Prospective assessment of falls

A fall was defined as an unexpected event where the person inadvertently came to rest on the ground or other lower level not due to a major intrinsic or extrinsic event.[34]

Following baseline screening, each subject was given a set of weekly prepaid postcards to return for one year. On each card subjects had to write a single number documenting the number of occasions that they had fallen in the previous week. Subjects were encouraged to include anything that might constitute a fall, including slips, trips, and stumbles. Assistance from carers in this respect was obtained where necessary.

A positive number recorded on a card was followed up by telephone to outline the exact circumstances of the fall event and to ensure that this event met the definition of the fall outlined above. If cards were not returned one week after expected, this would also prompt telephone contact to inquire about the number of falls in the week in question.

Statistical methods

Categorical variables were cross tabulated and statistically assessed for association using the χ^2 test or Fisher's exact test (where there were fewer than five in a cell) to compare fallers with non-fallers. Normally distributed continuous variables were assessed using an independent samples t test. The Mann-Whitney U test was used for variables that were not normally distributed. From these exploratory analyses a backwards stepwise logistic regression was performed to evaluate odds ratios for those factors independently associated with future falls. Factors with a positive association with a p < 0.1 were initially entered into the regression and the least associated variables were removed in turn.

RESULTS

The mean (SD) age of the 109 subjects in the study was 74.7 (7.9) and 52 (47.7%) were male. The median duration of disease was 3 years (1–31) and the median MHY rating was 2.0 (range 1.0–4.0). The 32 subjects who refused to participate were older (mean age 78.8 (6.8)), more of them were female (62.5%), and they had a disease of longer duration (median 3.5 years, range 1–19) and greater severity (median MHY rating 2.50, range 1.0–5.0). Over the course of the one year follow up period, five subjects died and three left the area and were lost to follow up. The following results are reported on the 101 subjects who completed the study.

Number of falls

Over the one year follow up period, 69 (68.3%) subjects reported a fall. Fifty one (50.5%) subjects reported at least two falls during the year and were described as recurrent fallers.

Table 2 Disease severity and rating scales

Rating scale	Fallers (n=69)	Non-fallers (n=32)	Test	p Value
MHY	2.0 (1.0–4.0)	1.5 (1.0–3.0)	2	0.055
MHY >2.5	21 (30.4%)	2 (6.3%)	2	0.009**
UPDRS 30 (shoulder pull) >1	34 (49.3%)	11 (34.4%)	2	0.161
UPDRS subtotal I	4 (0–10)	2.5 (0–7)	1	0.037*
UPDRS subtotal II	13 (1–30)	10 (3–18)	1	0.001**
UPDRS subtotal III	16 (6–28)	14 (5–21)	1	0.004**
UPDRS total	37 (8–64)	28 (9–44)	1	<0.001**
History of "off phenomena"	17 (24.6%)	1 (3.1%)	2	0.01*
Positive history of tremor	57 (82.6%)	31 (96.9%)	2	0.057
MMSE	27 (0–30)	29 (19–30)	3	0.002**
Dementia present (MMSE <24)	18 (26.1%)	2 (6.3%)	2	0.03*
GDS	6 (1–14)	4 (0–11)	1	0.01*
PDQ-8	17 (8–29)	12 (8–24)	3	0.001**

Data are median with range or absolute number with percentages. *0.01<p<0.05; **p<0.01. 1, independent samples t test; 2, χ^2 test; 3, Mann-Whitney U test; GDS, geriatric depression scale–short form; MHY, modified Hoehn and Yahr scale; MMSE, mini-mental state examination; PDQ-8, short form Parkinson's disease questionnaire; UPDRS, unified Parkinson's disease rating scale.

Table 3 Physiotherapy assessment and falls

Assessment	Fallers (n=69)	Non-fallers (n=32)	Test	p Value
Tinetti gait score	13 (9–18)	11.5 (9–17)	1	0.056
Tinetti balance score	25 (13–37)	20 (13–34)	1	0.006**
Total Tinetti score	36 (23–54)	32 (22–49)	1	0.004**
Walking velocity (m/s)	0.71 (0.1–1.43)	0.87 (0.34–1.43)	1	0.055
Stride length (m)	0.48 (0.12–0.77)	0.54 (0.27–0.77)	1	0.065
Lying to sitting time (s)	4 (1–23)	3.5 (2–26)	3	0.233
Sitting to standing time (s)	2 (1–16)	2 (1–6)	3	0.322
Climb down four stairs time (s)	6 (2–89)	5 (2–15)	3	0.086
Loss of arm swing	37/55 (67.3%)	10/30 (33.3%)	2	0.003**
Dyskinesia present	13 (18.8%)	1 (3.1%)	2	0.034*
Festination present	12 (17.4%)	1 (3.1%)	2	0.057

Data are median with range or absolute number with percentages. *0.01<p<0.05; **p<0.01. 1, independent samples t test; 2, χ^2 test; 3, Mann-Whitney U test.

The total number of falls experienced was 585 (median 3, range 1–60).

Comparison between fallers and non-fallers

Table 1 shows the differences in demographic and historical data between fallers and non-fallers. It should be noted that one subject reported 500 falls in the year before assessment; otherwise, the range would have been 0–100. Fallers had longer disease duration than non-fallers and were more likely to describe previous falls.

Table 2 shows the differences between fallers and non-fallers in disease severity and other rating scales. There is a strong association between disease severity and the risk of falling. This is particularly true with an MHY rating > 2.5 and with higher UPDRS subtotal II (activities of daily living), subtotal III (motor functioning), or total UPDRS score. Cognitive impairment was also associated with increased GDS or PDQ = 8 and a risk of falls. One subject had an MMSE of 0; otherwise, the range would have been 15–30.

Although there was no association between a worse shoulder pull and falling, there was an association between an increased number of falls and a positive shoulder pull, using the positive pull as the independent variable in a Mann-Whitney U test (p = 0.035).

Table 3 outlines physiotherapy assessment data. In cases where all subjects could not complete an assessment the figures are quoted as a fraction with a percentage in parentheses. There was a significant association between a decreased Tinetti's balance score and falling. Presence of dyskinesia at assessment and loss of arm swing were also significant.

Different sample sizes are quoted for the cardiovascular and autonomic assessments owing to different entry criteria and withdrawals. In these cases fractions and percentages are quoted (table 4). None of the cardiovascular or autonomic data were associated with falling.

Logistic regression model

Several variables were independent predictors of falling. These were falling in the previous year, loss of at least one arm

Table 5 Independent predictors of falling

Predictor	Odds ratio	95% Confidence interval
Previous falls	4.0	1.3 to 12.1
Loss of arm swing	4.3	1.3 to 13.7
Each year of disease	1.3	1.1 to 1.6
Dementia	6.7	1.1 to 42.5

swing, dementia, and longer disease duration. Table 5 shows the odds ratios with 95% confidence intervals.

DISCUSSION

Strengths of this study

Until recently there were no published prospective studies investigating falls in PD. Prospective studies give more accurate data for fall rates than other studies using retrospective data. Two recent studies have used prospective methods,[35][36] and this work has added to the knowledge of falling in PD, as well as approaching the problem from different angles. Unlike previous work, the follow up period of the present study was a year, which should more accurately measure the true incidence of falls.

The present study included subjects with cognitive impairment, a group that has been shown to be at greater risk of falling.[2] Compared with previous studies, the participants were relatively old (74.7 years) and are more representative of a typical sample of community dwelling persons with PD. The local PD team provides a service for PD patients that is not age related and all known patients were invited to participate. A recent unpublished study attempted to identify all known patients with PD in the catchment area of this team. We tried to use assessments that can be reproduced by professionals in most settings, which is relevant to the practising clinician.

The use of cardiovascular and autonomic assessment is also beneficial, as they have not been studied in relation to falls in

Table 4 Cardiovascular, autonomics, and miscellaneous assessments

Assessment	Fallers (n=69)	Non-fallers (n=32)	p Value
Orthostatic hypotension	31/64 (48.4%)	10/27 (37.0%)	0.318
Cardioinhibitory CSH	3/14 (21.4%)	2/7 (28.6%)	0.717
Vasodepressor CSH	3/14 (21.4%)	3/7 (42.9%)	0.354
Parasympathetic dysfunction	20/49 (40.8%)	10/25 (40.0%)	0.946
Sympathetic dysfunction	22/57 (38.6%)	10/24 (41.7%)	0.796
Visual impairment	56/68 (82.4%)	21/32 (65.6%)	0.064
Osteoporosis	27/68 (39.7%)	13/31 (41.9%)	0.834

Data are absolute numbers with percentages. χ^2 test (or Fisher's exact if fewer than five in a cell) was used. CSH, carotid sinus hypersensitivity.

PD, even though the findings of this study are negative for these domains.

Shortcomings of this study

The authors recognise that there are shortcomings of this study.

It may be argued that subjects should have been assessed a certain time after taking their antiparkinsonian medication. This could not happen, largely for logistical reasons such as patient transportation and the need for patients to be assessed by a variety of professionals.

No controls were used. This was because the study was designed to be descriptive and to compare the differences between fallers and non-fallers with PD, rather than the healthy elderly population.

Despite the methods used for prospective assessment, some falls are still likely to have been missed. The high incidence of falls quoted is likely to be an underestimate of the number of falls that occurred. Perhaps only highly sophisticated long term mechanical monitoring methods would be able to give the true incidence, but these would be impractical.

The confidence intervals in the logistic regression model are wide probably due to the small numbers of subjects. All patients who were available to the authors were recruited, however, so this was unavoidable. Multicentre studies or perhaps meta-analysis would perhaps fully address these issues.

It should also be noted that 32 potential subjects did not participate. These patients were older with more severe disease of longer duration. If they had been included, the incidence of falls may have been even higher.

Falls incidence

The incidence of falls in this study is 68%, and the majority of the fallers fell again in the year. This incidence is higher than that found in the prospective studies by Bloem et al (51%)[35] and Gray et al (58%)[36] and, not surprisingly, higher than in retrospective studies of falling in PD, where the incidence ranges from 37–64%.[18–21 37 38] This also means that certain people with PD are falling early in their disease, which is a factor not commonly recognised. One reason for this may be that the methods of this study are very thorough, creating a higher incidence than would become apparent in a clinical setting. The risk of falling in PD is approximately twice that of community dwelling older people. Many of these fallers are at risk of falling recurrently. This, in association with high rates of osteoporosis found in this and other studies,[39–42] may lead to increased fracture risk.

Factors associated with falling in PD

Unsurprisingly a history of prior falls was associated with a higher risk of future falls. These results are similar to those found by Bloem et al[35] and are mirrored in a study looking at falls in the general population.[43] Patients with PD who describe prior falls should be thought of as being at risk of future falls.

The association between duration and severity of disease and falling is also important. In this study the risk of falling increased with greater disease severity, but it is important to note that only one subject was in stage IV and none were in stage V. It has been postulated that at more advanced stages the risk of falling may decrease owing to limitations on mobility.[44] Dyskinesia, bradykinesia, and wearing off phenomena may be particularly important for falls risk.

Cognitive impairment was an independent predictor of falling. This is very important because dementia is a common problem in PD and has been minimally studied. Falls prevention in patients with dementia is difficult but recent work suggests that tailored interventions are of benefit in dementia sufferers[45] and this may be extrapolated to dementia in PD. Further studies should address this area.

The physiotherapy assessments found several noteworthy areas. A worse Tinetti's balance score was associated with an increased risk of falling, but the differences in scores are subtle and may not be clinically relevant. The simple observation that loss of arm swing (either unilateral or bilateral) was an independent predictor of falls risk may be of more benefit. This is presumably caused by impairment of balance mechanisms. Most patients, even when well treated, exhibit some loss of arm swing and further research is required to document this finding more accurately. The shoulder pull test of retropulsion is very widely used as a diagnostic and clinical assessment in PD. Bloem et al[44 46] have questioned the validity of this test. In their recent study of a relatively young PD population they did not find the test useful in predicting falls. In this study there was also no association between an abnormal pull test and a risk of future falls. However, if an abnormal pull test is used as the independent variable, there is a significant association with a higher number of future falls. Further work is required to quantify fully the benefit of this test.

The association between falls and depression and quality of life is an important finding but many potential confounding variables may affect the scales used. Common sense would dictate that falls are going to impinge upon both mood and quality of life.

Although a high prevalence of cardiovascular, autonomic, and visual abnormalities was found, none of these abnormalities was significantly associated with falling. One possible reason for the negative findings is that if an abnormality had been found (for example, cardioinhibitory carotid sinus hypersensitivity requiring pacing) the authors would have been ethically bound to intervene, thus removing the potential risk factor. A true observational study may have created different results.

Conclusions

Falls are a common problem in PD. Previous falls, disease duration, dementia, and loss of arm swing are independent predictors of the risk of falling in the following year. PD is often quoted as a reason for falling. We believe that patients with PD who fall should be thoroughly assessed to look at the reason for falling in that person and the potential risk factors present. Future studies should aim at looking specifically at interventions for these risk factors.

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Authors' affiliations

B H Wood, 25 Churchill Mews, St Peter's Marina, Newcastle upon Tyne NE6 1BH, UK
J A Bilclough, Jubilee Day Hospital, North Tyneside General Hospital, Rake Lane, North Shields, Tyne and Wear NE29 8NH, UK
A Bowron, R W Walker, North Tyneside General Hospital, Rake Lane, North Shields, Tyne and Wear, NE29 8NH, UK

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