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Research Article

# Prediction of Fall among Patients with Parkinson's Disease: A Cross-Sectional Study, India

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## Abstract

**Background:** The cross-sectional study aimed to identify the risk factors that lead to fall among patients with Parkinson's disease, assess the stage of severity; its contribution to fall, and also predict fall among the patients.

**Methods:** 94 patients diagnosed with Parkinson's disease were included using non-probability convenience sampling. A semi-structured questionnaire was employed to understand the demographic data, risk factors, disease severity, balance, and level of functioning using the Hoehn and Yahr scale, Berg Balance scale and Activities-Specific Balance Confidence scale respectively. Regression analysis was performed to identify the risk factors that lead to fall. A logistic regression analysis was performed to predict fall and Multivariate Analysis of Variance was employed to understand the difference in scores concerning the different stages of severity.

**Results:** The regression model showed that the Activities-Specific Balance Confidence score and severity of disease are the strongest contributing risk factors of fall among the participants ($p < 0.001$). Using Multivariate Analysis of Variance we conclude that there is a significant difference in the average mean Activities-Specific Balance Confidence score from 52.45 to 28.57 when patient proceeds to stage 3 (mild to moderate bilateral disease) from stage 2.5 (mild bilateral disease with recovery on pull test) according to the Hoehn and Yahr staging. Activities- Specific Balance Confidence score which in turn implies the level of functioning was found to be the variable used for prediction of fall.

**Conclusion:** An effective awareness regarding the stage transition where there is a high risk of fall needs to be understood. The Activities-Specific Balance Confidence score helps us predict the risk of fall among patients.

**Keywords:** Parkinson's disease (India); Fall Prediction; ABC Scale; Berg Balance Score; Hoehn and Yahr Scale; MANOVA; Disease Severity; Regression

## Abbreviations

MANOVA: Multivariate Analysis of Variance; ABC Score: Activities-Specific Balance Confidence Score; BBS: Berg Balance Scale; PD: Parkinson's Disease; SPSS: Statistical Package for the Social Sciences

## Introduction

Parkinson's disease [PD] is a neurodegenerative disorder that affects a large number of people all around the globe. It was first described as "Shaking Palsy" by James Parkinson in the year 1817 [1]. Parkinson's disease is characterized by tremor, rigidity [stiffness of limbs and trunk], bradykinesia [slowness of movement], gait disturbance, and postural instability [impaired balance and coordination] [2]. An estimated 10 million people in the world (0.3% of the world population) and 1% above 60 years of age have been affected by Parkinson's disease. In a study conducted in Bangalore district in South Karnataka, India in 2004, the prevalence was 33 per 100,000. [3] In the year 2006, a survey from Kolkata revealed the prevalence

of the disease to be 14.1 per 100,000 and among the Parsi community in Mumbai, a higher prevalence of 17.6% was observed [3]. The Parsi community in Mumbai has the world's highest incidences of Parkinson's disease and affects 328/100,000 people, despite living in a country with the lowest incidence of 70/100,000 [4].

People with Parkinson's disease are at a higher risk of fall compared to healthy individuals of the same age as well as patients suffering from other neurological conditions, ranking second after stroke [5]. As per research studies, it has been found that 38-87% of Parkinson's disease patients have experienced fall [6]. The European Consensus definition of fall is "an event in which the respondent comes to rest on the ground, floor or lower level" [7]. As per Kellogg International Work Group on the Prevention of falls by the Elderly, fall consists of three components; a person coming to rest inadvertently on the ground floor or lower level and that is not the result of a major intrinsic event or overwhelming external force [7]. Near falls were described as "A fall initiated but arrested by support from a wall, railing, another person, etc." [8]. Fall is one of the most debilitating problems for people suffering from Parkinson's disease. Evidence suggests patients with Parkinson's disease are twice as likely to fall compared to people with other neurological conditions [9]. The repercussions of fall are notable and result in fractures, disabilities, reduced activity levels, loss of independence, decreased quality of life, social isolation, depression, and functional impairment [9]. Fall-related injuries have a tremendous impact on both the physical and mental well-being of the patient [10].

As per a systematic review of Parkinson's disease in India by the Department of Neurology, NIMHANS Bangalore, there were only 92 original research articles and the contribution towards Parkinson's patients in association with fall prediction from an Indian community is nowhere found in the literature. All the major findings from the Western literature cannot be extrapolated to a heterogeneous Indian population due to the variation of the genetic, environmental, ethnic, and cultural factors within the communities [3].

The consequences of fall are numerous which affect the faller, their family as well as the community as a whole. The complications following fall are noteworthy and result in higher hospitalization rates, fractures, disabilities, reduced activity levels, loss of independence, decreased quality of life, social isolation, depression, and functional impairment. The economic burden of fall among patients with Parkinson's disease is very high and is estimated that the direct medical cost of fallers is double compared to the non-fallers [6]. Prevention strategies for falls at the population level have yet to be appropriately studied. Therefore, it is important to identify the risk factors contributing to fall to maximize the effectiveness of any proposed intervention. Only a limited number of studies have been done globally regarding fall among patients with Parkinson's disease. In many of the developed countries, there is a tremendous improvement in the quality of life among people suffering from Parkinson's disease. The incorporation of exercise and development of new movement strategies coupled with optimal medical management can prevent fall among Parkinson's disease patients [11].

## Materials and Methods

The main objective of this cross-sectional analytic study was to identify the risk factors that lead to fall among the patients suffering from Parkinson's disease, to assess the stage of severity among Parkinson's patients and its contribution to fall. The study also aimed at predicting fall among the patients suffering from this neurodegenerative disorder.

94 patients diagnosed with Parkinson's disease who were medically stable, and were able to follow the instructions without any difficulty were included in the study. Patients diagnosed with Parkinson's disease who were unable to understand the instructions, patients suffering from significant visual impairment, and bilateral hip replacement surgery were not included in the cross-sectional study. Among the 94 patients 74 patients were from Ernakulam district, Kerala (India), and the remaining 20 patients from Bangalore district, Karnataka (India).

A non-probabilistic convenience sampling technique was used since the prevalence of the disease was very low globally as well as nationally [12]. The sample size required for the research study was calculated using the formula $Z^2pq/d^2$ where "z" value differs for each confidence interval, "p" is the prevalence, and "q" is calculated using 1-p and "d" represent the margin of error. Here the sample size calculated was 94 taking z value as 1.96 (95% CI), prevalence to be 38%, and margin of error to be 10.

A semi-structured questionnaire was used to understand the demographic data, risk factors, disease staging, balance level, and level of functioning. Modified Hoehn and Yahr scale, a widely used clinical rating scale was used to assess the severity of the disease.

The scale defined the broad categories of motor function among Parkinson's patients [13].

Balance assessment was done using a five-point scale ranging from 0 - 4 called the Berg Balance Scale. The Berg Balance Scale (BBS) is an assessment tool used to measure the balance among people with impairment in balance function by assessing the performance of the functional tasks. The scale consisted of 14 tasks concerning the common movements of daily living such as transfers, turns, and balance. It is scored from 0 to 56 points. The scores were categorized as 0 - 20 for high fall risk, 21 - 40 for medium fall risk, and 41 - 56 for low fall risk [14,15].

Fear of fall among the Parkinson's patients was evaluated using an eleven point self- administered Activities-Specific Balance Confidence (ABC) scale which also measures the level of physical functioning. The rating consists of whole numbers (0 - 100) for each item. Totaling the ratings and dividing by 16 gave the ABC score. A score of less than 50% categorized them as low level of functioning, 50 - 80% as a moderate level of functioning, and greater than 80% to be a high level of functioning [14,16]. Considering the psychometric properties both the diagnostic tools reported good to excellent test-retest reliability and moderate to good sensitivity and specificity [14].

### Statistical analysis

Descriptive statistics were performed to understand the demographic and clinical characteristics of the respondents. The structure of risk factors associated with the balance distortion was determined using factor analysis and these factors were further subjected to regression analysis to understand the primary determining factor that contributed the most. To further predict the fall among patients with Parkinson's disease a binary logistic regression was performed. A Multivariate Analysis of Variance (MANOVA) was employed to understand the difference in scores with the different stages of severity. Statistical analysis was performed using the IBM SPSS software version 20.

## Results

Demographic and clinical data included information on age, gender, educational status, and family history, history of falls, therapy undertaken, and medication. Table 1 represents the demographic and background information for a total sample of 94 patients (n = 94).

| Sl. No | Variables | Characteristics | Percentage |
|---|---|---|---|
| 1. | Gender | Male | 80.9% |
| | | Female | 19.1% |
| 2. | Age | 36-50 years | 5.3% |
| | | 51-65 years | 42.60% |
| | | 66-80 years | 42.60% |
| | | Above 80 years | 9.60% |
| 3. | Educational status | Literate | 96.80% |
| | | Illiterate | 3.20% |
| 4. | Family History | Present | 14.9% |
| | | Absent | 85.1% |
| 5. | History of fall | Present | 56.4% |
| | | Absent | 43.6% |
| 6. | Drugs | Yes | 88.3% |
| | | No | 11.7% |
| 7. | Therapy | Yes | 51.10% |
| | | No | 48.9% |

**Table 1:** Background characteristics of the respondents.

Among the 94 patients included in the study, 80.9% were men and 83% of the cohort was in the age group 51-80 years. 96.8% were literate, 88.3% of the patients were under the medication and 51.10% attended various therapies. 14.9% of the respondents had a family history of Parkinson's disease and 56.4% of them had a history of fall. The severity of the disease was assessed using the staging and the percentage of the patients categorized on the Hoehn and Yahr staging has been depicted in table 2.

| Staging | Description | Percentage |
|---|---|---|
| 1.0 | Unilateral movement only | 30.9% |
| 1.5 | Unilateral and axial involvement | 12.8% |
| 2.0 | Bilateral involvement without impairment of balance. | 13.8% |
| 2.5 | Mild bilateral disease with recovery on the pull test | 10.6% |
| 3.0 | Mild to moderate bilateral disease; some postural instability; physically independent | 16% |
| 4.0 | Severe disability; still able to walk or stand unassisted | 9.6% |
| 5.0 | Wheelchair-bound or bedridden unless aided. | 6.4% |

**Table 2:** Modified Hoehn and Yahr Staging.

Berg Balance Scale was employed to categorize the cohort based on the balance level and it was found that 14.9% fall under the high-risk category, 36.2% in the medium fall risk category, and 48.9% under the low-risk category. ABC scores that measured the confidence level further classified the cohort based on the level of functioning. 47.7% were grouped under the low level of functioning, 26.6% under the moderate level of functioning, and 25.5% were classified into high level of functioning.

Factor analysis resulted in the extraction of 3 components out of the six variables which were subjected to principal component analysis. Factor 1 included ABC score and Hoehn Yahr staging, factor 2 included drugs and therapy, and factor 3 included disease comorbidity and family history. Factor 1 was named "determinant measures" because ABC score gives the level of functioning and confidence among the patients and the Hoehn and Yahr scale determines the severity of the disease. These variables are negatively correlated with each other which implies that with the increase in severity of the disease there is a decrease in the ABC score. So the variables were considered determinant measures for the fall risk. Subsequently, factor 2 was named "management" since it comprised of drugs and therapy. Management implies drugs and therapy as elements used for the overall management of the disease. These variables were also negatively correlated since people were attending different therapies for betterment but were also found to be under overmedication leading to a decrease in the balance score. The third factor was named "attribute" indicating that family history and other co-morbidities have an effect on the risk of fall among the patients. Table 3 represents the factor analysis for the variables considered as risk factors for the impairment of balance.

| Variables | Factor Name | Correlation |
|---|---|---|
| ABC score and Hoehn and Yahr staging | Determinant measure | Negatively correlated |
| Drugs and therapy | Management | Negatively correlated |
| Co-morbidity and family history | Attribute | Positively correlated |

**Table 3:** Factor analysis for the variables considered as risk factors for balance impairment.

Regression analysis was performed based on the factors extracted and to find out how these contribute to the score variations in balance. The dependent variable used in this was the Berg Balance score which gave the balance level and further categorization to the risk of fall among the patients. The Independent variables considered in the regression analysis included the three factors namely determinant measures, management, and attribute. Based on the three factors a regression analysis was performed resulting in "determinant measure" contributing the most with a significance level of less than 0.001. The R square value was found to be 72.1%. Table 4 depicts the regression coefficients and their significance level.

| Model | Standardized coefficients | P value | R square |
|---|---|---|---|
| Constant | 37.915 | <0.001 | |
| Factor 1: Determinant measure | -0.849 | <0.001 | 72.1% |
| Factor 2: Management | -0.017 | 0.766 | |
| Factor 3: Attribute | 0.019 | 0.730 | |

**Table 4:** Regression model: Risk factors.

The regression equation is represented as:

**Berg Balance score = 37.9159(β) - 0.840 (determinant measure).**

The equation implies that for every one unit change in the determinant measure there is a 0.84 times decrease in the berg balance score. With the increase in the severity of the disease and a decrease in the level of functioning there is an adverse effect on the balance of the patients with Parkinson's disease.

To predict fall among the patients suffering from the neurodegenerative disease a binary logistic regression analysis was performed with the independent variables taken into consideration namely Hoehn and Yahr staging, Berg Balance score, family history, drugs, therapy, and the ABC score. The results showed that only the ABC score contributed to the prediction of fall among patients and the mean value differed among the fallers and non-fallers. The mean ABC score among the fallers was 39.63 and among the non-fallers were found to be 62.15. Figure 1 shows the mean difference

**Figure 1:** Stem and leaf plot showing the difference in mean ABC scores among fallers and non-fallers.

in the ABC scores among the fallers (yes) and non-fallers (no) using the stem and leaf plots.

To further understand the contribution of ABC score towards fall prediction and also to see the difference in the mean ABC score, MANOVA was employed to understand the difference in scores concerning the different stages of severity measured using the Hoehn and Yahr staging. Here the dependent variable was the berg balance score and the ABC score and the independent variable taken for analysis were the Hoehn and Yahr staging. Results depicted that there is a significant difference in the average mean ABC score from 52.45 to 28.57 when the patient proceeds to stage 3(mild to moderate bilateral disease) from stage 2.5 (mild bilateral disease with recovery on pull test) according to Hoehn and Yahr staging. Berg balance scores also differed as patients proceeded from stage 1 to stage 5. Table 5 represents the MANOVA results for the ABC score concerning the staging of the disease.

| ABC Score | Stage 1 | Stage 1.5 | Stage 2 | Stage 2.5 | Stage 3 | Stage 4 | Stage 5 |
|---|---|---|---|---|---|---|---|
| Stage 1 | - | Not significant | Not significant | Not significant | <0.001 | <0.001 | <0.001 |
| Stage 1.5 | Not significant | - | Not significant | Not significant | <0.001 | <0.001 | <0.001 |
| Stage 2 | Not significant | Not significant | - | Not significant | <0.001 | <0.001 | <0.001 |
| Stage 2.5 | Not significant | Not significant | Not significant | - | <0.001 | <0.001 | <0.001 |
| Stage 3 | <0.001 | <0.001 | <0.001 | <0.001 | - | Not significant | Not significant |
| Stage 4 | <0.001 | <0.001 | <0.001 | <0.001 | Not significant | - | Not significant |
| Stage 5 | <0.001 | <0.001 | <0.001 | <0.001 | Not significant | Not significant | - |

**Table 5:** MANOVA table for the ABC score to the Hoehn and Yahr staging.

From the multivariate analysis, we find that the rate of decrease in ABC scores from stage 2.5 to stage 3 was found to 23.88. The change in ABC scores and the Berg balance score concerning the staging of the disease is represented in table 6 along with the respective rate of decrease.

| Staging | Mean berg balance Score | Rate of decrease | Mean ABC score | Rate of decrease |
|---|---|---|---|---|
| Stage 1 | 50.83 | | 74.04% | |
| Stage 1.5 | 45.83 | 5 | 59.12% | 14.92 |
| Stage 2 | 42.77 | 3.06 | 54.38% | 4.74 |
| Stage 2.5 | 36.90 | 5.87 | 52.45% | 1.93 |
| Stage 3 | 31.40 | 5.5 | 28.57% | 23.88 |
| Stage 4 | 14.11 | 17.29 | 9.20% | 19.37 |
| Stage 5 | 2.83 | 11.28 | 3.22% | 5.98 |

**Table 6:** The mean berg balance score and ABC score decrease rate to the severity of the disease assessed using the Hoehn and Yahr scale.

## Discussion

This cross-sectional study identified the major risk factors and severity staging transitions that lead to fall among patients with Parkinson's disease. The main strength of the study was the ability to assess disease-specific and balance-related measures in the same population and thereby predict fall risk. Though the factor analysis extracted three components out of the six variables namely drugs, therapy, ABC score, Hoehn and Yahr staging, co-morbidity and family history, the major risk factors associated with the variation in the balance score was found to be the Hoehn and Yahr staging and the level of functioning assessed through the ABC scale. The two significant variables were named determinant measures because they were considered significant in determining the balance impairment of the patients suffering from Parkinson's disease. A study conducted by Hyo Keun Lee., *et al.* also reported an underlying relationship between static and dynamic balance control and self-perceived balance among individuals with different severities of Parkinson's disease [17].

Researchers have found that people with an affected first degree relative such as a parent or sibling have a four to nine percent higher chance of developing PD as compared to the general population and we find that 14.9% of the respondents had a family history of this neurodegenerative disorder [18]. Familial aggregation

studies of PD have also estimated the overall relative risk for PD in affected first-degree relatives to be 2.9 [19].

To further predict the risk of fall among the patients the logistic regression results showed that the mean ABC score among the fallers was 39.63 and among the non-fallers was found to be 62.15. The ABC score gives the confidence level in whole numbers and also indirectly measures the level of functioning among the cohort. Evidence also shows that the mean ABC scores were relatively lower among fallers [20]. Using MANOVA we further understood the mean difference in the ABC score among the patients as they proceed to the higher staging of severity. The mean ABC score from 52.45 to 28.57 when patient proceeds to stage 3(mild to moderate bilateral disease) from stage 2.5 (mild bilateral disease with recovery on pull test) according to Hoehn and Yahr staging was the major finding as per study and the rate of decrease was also found to be the highest with a value of 23.88.

Additionally, to understand the variation in fall risk assessed using the Berg Balance Scale and the ABC scale for the confidence assessment; also measuring the level of functioning, we see that with the decrease in the level of functioning there is a decrease in the balance score. Figure 2 below depicts the percentage of the patients who fall under different levels of functioning concerning the risk of fall assessed using the ABC Score and the Berg Balance score. We can see from the graph that 14.89% of the patients are at a high risk of fall as they fall under the low- level functioning category measured using the ABC scale and 23.4% were under low risk as they had a high level of functioning. Research studies have reported a lower self-perceived balance confidence level (ABC score) to be associated with higher fall risk [20].

Few methodological limitations need to be acknowledged. Though the sample size was calculated using the formula, a non-convenience sampling methodology was employed due to the low disease prevalence globally and nationally. Future studies could include larger sample size for further generalizability. Also information on retrospective falls may not be accurate due to recall bias among the patients. In our study we have also not studied the impact of ON and OFF variations based on medication intake on the balance level. Forthcoming research studies need to address these limitations.

**Figure 2:** A graph depicting the percentage of the patients who fall under different levels of functioning to the risk of fall assessed using the ABC Score and the Berg Balance score.

## Conclusion

This descriptive-analytic study aims to provide benchmark data findings for monitoring the effect of fall prevention programs. The main strength of the study was to assess disease-specific and balance-related measures in the same population and thereby predict fall risk. This can be useful for tailoring fall prevention programs and also helps the patient suffering from Parkinson's disease manage and prevent fall. Improving gait through different therapies can be very helpful in preventing falls and also reduce the risk of other post-fall fatalities. The major finding regarding the rate of

decrease in the ABC score from stage 2.5 to stage 3 helps in understanding the transition stage which needs more attention and care to prevent fall. These findings also highlight the importance of assessing subjective self-perceived balance confidence level, the severity of disease staging as well as assessing balance in estimating fall risk. Emphasis on balance recovery, disease severity identification, and improving awareness on recurrent falls can be very useful in developing effective interventions to reduce and manage falls. These findings could also be helpful for researchers and clinicians to understand and interpret the PD patients' balance assessment, self-perceived confidence level, and severity staging to enhance early identification and prevention of patients at risk.

## Ethics Committee Approval

The study was approved by the Ethics Committee, SRM Institute of Science and Technology, Chennai (India). All the subjects included in the research study had given informed consent in writing before participation. This paper is published with the permission of the Ethics Committee, SRM Institute of Science and Technology as well as the participants involved in the study.

## Availability of Data and Materials

The datasets generated and analyzed during the research study are not publicly available since the dataset includes personal details of the subjects but are available from the author on reasonable request.

## Competing Interests

The authors declare that they have no competing interests.

## Funding

There was no funding provided for the design of study collection, analysis, interpretation, and manuscript writing.

## Author's Contributions

AA has access to all the data acquired in the study. AA was employed in study concept formation and data collection. AA and MB were involved in the design, analysis, and interpretation of the data. AA and GV were involved in the questionnaire preparation and revision. AA validated the dataset. AA and MB have worked together in the final interpretation of the dataset. AA was involved in writing the full manuscript and was critically revised by MB and GV. All the authors have seen and approved the final version of the manuscript.

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