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ORIGINAL ARTICLE

# Psychometric properties of the Berg balance scale in idiopathic Parkinson' disease in the drug off-phase

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## Abstract

**Background** Having an appropriate tool for assessment of the balance status during the drug off-phase in idiopathic Parkinson's disease (PD) is relevant for clinical and research settings. Our objective was to assess the clinimetric properties of the Berg balance scale (BBS) during drug off-phase in PD.

**Method** Balance of 98 PD patients (mean age ± SD, 59.19 ± 10.88 years) was evaluated with the BBS. Other assessments in the study included the Fall Efficacy Scale-International (FES-I), Functional Reach Test (FRT), Section II of the Unified Parkinson's Disease Rating Scale-3.0, Parkinson's Disease Questionnaire-39 (PDQ-39), and Schwab and England Activities of Daily Living Scale. All evaluations took place during the drug off-phase. Internal consistency and inter- and intra-rater reliability were evaluated by Cronbach's alpha coefficient and intraclass correlation coefficient, respectively. Dimensionality was explored by factor analysis. Discriminative validity was tested by comparing BBS score between PD patients with and without a history of falling.

**Results** Internal consistency was high ($\alpha = 0.98$), as were intra- and inter-rater reliability (ICC = 0.98 and 0.95, respectively). Factor analysis identified only one dimension for the BBS, whose convergent validity with FES-I, FRT, and domain mobility of the PDQ-39 were moderate or high ($r_S = |0.60–0.74|$). Correlation of BBS with functional scales and PDQ-39 Summary Index was moderate ($r_S = |0.45–0.62|$). Finally, the BBS showed a moderate strength to discriminate between PD patients with and without a history of falling.

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**Conclusion** Our study suggests that BBS has satisfactory internal consistency, reliability, and construct validity for measuring functional balance in people with PD during the drug off-phase.

**Keywords** Psychometric properties · Berg balance scale · Parkinson' disease · Drug off-phase

## Introduction

Disturbance in balance, which increases the risk of falls and injuries resulting in decline in mobility and quality of life, is one of the main problems of Parkinson's disease (PD) [1, 2]. Assessment of balance over time, using valid clinical tools, would allow to monitor the state of this function and to demonstrate changes induced by treatment (pharmaceutical and non-pharmaceutical).

On the other hand, disease progression and continuous use of levodopa promote the appearance of motor fluctuations, a complication characterized by the alternation between phases in which the beneficial effect of the medication is evident (on) and others in which this benefit disappears (off) [3].

Impairment in balance, regardless of drug status, can be identified by clinical and laboratory instruments [4]. Most studies assessing balance have been carried out in the drug on-phase. Since people with PD may have more problems during a period when the effect of the dopaminergic treatment is suboptimal (drug off-phase), the risk of falling increases at that time [5]. For assessing the effect of drugs, rehabilitation, or progression of the disease, the evaluations should be carried out in both drug phases [6]. Morris, in 2001, noted that "when performing neurological assessments for patients with PD, we believe it is important for the physical therapist to sample performance in both the "off" and "on" phases, so that the full spectrum of mobility disorders can be documented. Rehabilitation interventions may be more effective if they are tailored to changing mobility status" [7, 8].

Various tools are available for measuring functional balance [9]. One of the most commonly used tools is the Berg balance scale (BBS). This functional scale does not require training and special tools (except for a ruler, pencil, stool, and chronometer) for use in a clinical setting. The BBS score has a satisfactory ability to predict the influence of the balance status on the performance of daily living activities (ADL) [10].

Several studies have examined the psychometric properties of this scale specifically in the Parkinson's population. Studies by Nova and Landers showed that the BBS had the ability to separate functional balance in people with PD between the drug on- and off-phases, as well as between people with and without a history of falling [11, 12]. In the studies by Scalzo and Babaei, two factors have been reported for this scale, static and dynamic [13, 14].

The aim of our study was to assess the psychometric properties of the Berg balance scale during drug off-phase.

## Methods

Ninety-eight subjects with Parkinson's disease (73 males and 25 females; mean age (± SD), 59.91 (± 10.88) years) participated in this study.

Inclusion criteria for the present study were (1) diagnosis of idiopathic Parkinson's disease by a neurologist based on the UK brain bank criteria [15]; (2) ability to understand the test instructions in Persian language; (3) absence of evident cognitive problems (Mini-Mental State Examination > 21) [16]; (4) stability of the drug therapy program (levodopa and its antagonists) for a time interval of 7–10 days, for re-test; (5) absence of other diseases that affect balance (neurologic, orthopedic, inner ear, etc.) according to the patient's or physician's report; and (6) not taking medications that can affect balance (e.g., sleep medication) according to the physician's report.

The Fall Efficacy Scale-International (FES-I), Functional Reach Test (FRT), Unified Parkinson's Disease Rating Scale-part II (UPDRS-II), Parkinson's Disease Questionnaire-39 (PDQ-39), and Schwab and England Scale for Activity of Daily Living (SE-ADL) were applied in a random order, initially in the off-phase (12 h after the last dose of levodopa [8]) and later during the drug on-phase (1 hour after a dose of levodopa) by two experienced occupational therapists. The main therapist (M. M) applied these tests, and the same procedure was followed for the retest. The average time for evaluations was 30–50 min (depending on the duration of drug on- and off-phases) in a room with constant conditions.

This study was approved by the ethics committee of the Student Research Center at Iran University of Medical Sciences (number, IR.IUMS.REC.1394.94-01-19.25617). All patients signed an informed consent for participation to the study.

### Assessments

Berg balance scale (BBS) is a scale that evaluates various dimensions of balance needed for the activities of daily living. The instruments used for this scale were chronometer, ruler, and a stool that was 18 cm high. The BBS contains 14 items, each of which being scaled from 0 to 4. A full score is 56, which indicates a good balance, and a score of zero indicates a severe impairment of balance. The average time required to complete the tests of this scale depends on the ability of

subjects and could vary between 10 and 20 min. The Persian version of the BBS has a very high reliability in people with Parkinson's disease [14].

Functional Reach Test (FRT) is a test that was first developed as a rapid screening tool for assessing problems of balance and the risk of falling in the elderly. The FRT procedure is as follows: standing with feet shoulder-width apart, fingers are fist up to 90° of flexion, without lifting the legs, the examinee has to step as far as he/she can and extend his/her hand forward. The difference between the start and end position at the midpoint of the metacarpophalangeal joint of the middle finger is measured by a therapist with a ruler. An average of the thrice-repeated test is calculated as the FRT score. There have been several studies on the psychometric properties of this test showing acceptable reliability and validity of the scale [17].

Fall Efficacy Scale-International (FES-I) is a frequently used scale to measure the fear of fall and self-efficacy. This questionnaire has 16 items that assess the fear of falling during 10 activities of daily living (including cleaning house, wearing clothes, preparing snacks, and bathing) and 6 social activities (including walking on sliding surfaces, visiting friends and acquaintances, going to college, going out somewhere, walking on a non-level place, climbing and falling down, and going out to attend ceremony). A higher score means more fear of falling is more than falling. The reliability of this scale has been demonstrated in people with Parkinson's disease [18, 19].

Parkinson's Disease Questionnaire-39 (PDQ-39) is a specific questionnaire for measuring the quality of life in patients with Parkinson's disease. This questionnaire has 39 items in eight separate dimensions, which include (1) mobility; (2) activities of daily living; (3) emotional well-being; (4) stigma; (5) social support; (6) cognitions; (7) communication; and (8) bodily discomfort. Each item in this questionnaire has five options of response. A lower score indicates a higher level of quality of life. The Persian-translated version of this questionnaire has been shown to be valid and reliable [20].

Unified Parkinson's Disease Rating Scale-Version 3.0 Part II (UPDRS-II) is a commonly used scale specific for Parkinson's disease. This scale has appropriate validity and reliability and consists of four domains (behavior and mood; activities of daily living; motor examination; and complications of therapy). The second part of this scale examines activities of daily living with 13 items, each with a score of 0–4. A higher score on this scale reflects a lower functional ability [21].

Schwab and England Scale for Activities of Daily Living (SE-ADL) is a measure specifically used to evaluate the daily performance in people with Parkinson's disease. This scale is scored as 0–100%, and lower scores represent a greater dependence for activities of daily living [22].

## Data analysis

Distribution of the data was tested with the Shapiro-Francia test, and total score of BBS was not normally distributed. Descriptive statistics (percentage, mean, and standard deviation) were applied to demographic and historical data as well as to BBS scores.

Ceiling and floor effects were determined, considering acceptable a level ≤ 15% [23]. The acceptable skewness range is from − 1 to + 1 [24].

The internal consistency of the BBS was analyzed calculating Cronbach's alpha coefficient, with values > 0.70 considered adequate [25]. The inter-item correlation was used to determine the relationship between each item with the other items, where a correlation coefficient ≥ 0.2 was considered acceptable [26]. Item homogeneity coefficient ≥ 0.15 was deemed acceptable [27]. Corrected item-total correlation was also calculated, with values ≥ 0.20 as standard threshold [28].

The inter-rater and test-retest reliability of the BBS total score was calculated by the intraclass correlation (ICC) coefficient, two-way and one-way (respectively) random effect, single measure, with a confidence interval of 95%. An ICC above 0.70 indicates adequate reliability [26, 29]. For each item of the BBS, these attributes were analyzed using weighted kappa with quadratic weights. Kappa coefficient results are interpreted as follows: 0.81–0.99 almost perfect agreement, 0.61–0.8 substantial agreement, 0.41–0.6 moderate agreement, 0.21–0.4 fair agreement, and ≤ 0.20 poor agreement [30].

For exploring the precision of the scale, the standard error of measurement (SEM) was calculated. The SEM represents variation of the score with repetition of the measurement, calculated by the formula $SEM = SD\sqrt{(1-r_{xx})}$, where SD is from the first assessment total score, and $r_{xx}$ is the ICC from the test-retest. In this study, SEM < 1.2 SD was considered acceptable [31].

In order to investigate the BBS dimensionality, an exploratory factor analysis (principal component analysis) with varimax rotation was used (eigenvalues ≥ 1) [32].

To assess the BBS convergent validity, we applied Spearman rank correlation test to examine the correlation between the total BBS score and other scales: FES-I, FRT, UPDRS-II, PDQ-39, and SE-ADL. Coefficient values < 0.30 were consider weak; 0.30–0.70, moderate; and > 0.70, strong correlation [33].

Discriminative validity using Mann-Whitney test and Cohen's *d* effect size (mean difference divided by standard deviation pooled (faller and non-faller)) to determine between different groups (people with PD with and without a history of fall in the last 6 months). A Cohen's *d* effect size of 0.2, 0.5, and 0.8 reflects small, medium, and high magnitude of difference between groups, respectively [34]. A Wilcoxon test was

also used to compare the drug on- and off-phase with a significant level of $p < 0.05$ [35].

## Results

The study population ($n = 98$) consisted of 48 patients (49%) in stage 1; 37 (38%) in stage 2; 11 (11%) in stage 3; and 2 patients (2%) in stage 4 of the Hoehn and Yahr scale (in drug on-phase), with (mean ± SD) 6.6 ± 6.51 years since diagnosis of PD. The average of total score of the Berg balance scale was 48.4 ± 12.12, ranging between 7 and 56, in the drug off-phase. Forty-six (46.93%) patients had on-off fluctuations.

**Acceptability** For the total BBS score, ceiling and floor effects were 35.35% and 0%, respectively, and the skewness was − 2.

**Reliability** Cronbach's α coefficient of the BBS was 0.98. If any single item was deleted, Cronbach's α coefficient value for all the items on this scale was still greater than 0.96, indicating the same importance of all items. The inter-item correlation of the BBS ranged from 0.57 to 0.89 (Table 1). The item homogeneity coefficient value was 0.77, and the corrected item-total correlation ranged from 0.75 for item 14 (standing on one leg) to 0.91 for item 2 (standing unsupported).

The ICCs for the total BBS score for inter-rater reliability and test-retest were 0.98 (95% CI = 0.98–0.99) and 0.95 (95% CI = 0.95–0.97), respectively, and the range of kappa agreement for each item was 0.61–0.92 and 0.82–0.96, respectively (Table 2). The SEM of the BBS was 2.71 (1/2 SD value = 6.6).

**Table 2** Weighted kappa values for Berg balance scale (BBS) in "off" state ($N = 98$)

| Item | Test-retest Kappa | Inter-rater Kappa |
|---|---|---|
| 1. Sitting to standing | 0.63 | 0.91 |
| 2. Standing unsupported | 0.91 | 0.87 |
| 3. Sitting unsupported | 0.66 | 0.86 |
| 4. Standing to sitting | 0.70 | 0.88 |
| 5. Transfers | 0.80 | 0.83 |
| 6. Standing with eyes closed | 0.66 | 0.96 |
| 7. Standing with feet together | 0.71 | 0.82 |
| 8. Reaching forward with outstretched arm | 0.89 | 0.95 |
| 9. Retrieving objects from floor | 0.88 | 0.95 |
| 10. Turning to look behind | 0.61 | 0.82 |
| 11. Turning 360 | 0.88 | 0.88 |
| 12. Placing alternate foot on stool | 0.78 | 0.88 |
| 13. Tandem standing | 0.68 | 0.85 |
| 14. Standing on 1 leg | 0.69 | 0.87 |

**Dimensionality** Factor analysis for the BBS with varimax rotation showed only one component (eigenvalue = 10.44; total variance = 74.44; Kaiser-Meyer-Olkin = 0.92; Bartlett's sphericity test, $p < 0.001$).

**Table 1** Inter-item correlation for Berg balance scale (BBS) in people with idiopathic Parkinson's disease ($N = 98$)

| Items of BBs | Inter-item correlation matrix | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1 | 1 | | | | | | | | | | | | | |
| 2 | 0.84 | 1 | | | | | | | | | | | | |
| 3 | 0.88 | 0.86 | 1 | | | | | | | | | | | |
| 4 | 0.89 | 0.87 | 0.80 | 1 | | | | | | | | | | |
| 5 | 0.87 | 0.72 | 0.70 | 0.84 | 1 | | | | | | | | | |
| 6 | 0.67 | 0.82 | 0.79 | 0.66 | 0.59 | 1 | | | | | | | | |
| 7 | 0.74 | 0.86 | 0.82 | 0.74 | 0.64 | 0.89 | 1 | | | | | | | |
| 8 | 0.80 | 0.88 | 0.85 | 0.81 | 0.67 | 0.82 | 0.86 | 1 | | | | | | |
| 9 | 0.83 | 0.89 | 0.82 | 0.85 | 0.73 | 0.81 | 0.87 | 0.84 | 1 | | | | | |
| 10 | 0.72 | 0.79 | 0.80 | 0.72 | 0.66 | 0.82 | 0.73 | 0.83 | 0.75 | 1 | | | | |
| 11 | 0.74 | 0.76 | 0.71 | 0.79 | 0.71 | 0.70 | 0.75 | 0.75 | 0.78 | 0.79 | 1 | | | |
| 12 | 0.81 | 0.79 | 0.73 | 0.77 | 0.72 | 0.72 | 0.75 | 0.81 | 0.81 | 0.74 | 0.78 | 1 | | |
| 13 | 0.75 | 0.71 | 0.68 | 0.73 | 0.71 | 0.69 | 0.75 | 0.72 | 0.75 | 0.71 | 0.80 | 0.79 | 1 | |
| 14 | 0.66 | 0.64 | 0.64 | 0.61 | 0.57 | 0.67 | 0.66 | 0.69 | 0.63 | 0.70 | 0.71 | 0.77 | 0.79 | 1 |

1. Sitting to standing, 2. Standing unsupported, 3. Sitting unsupported, 4. Standing to sitting, 5. Transfers, 6. Standing with eyes closed, 7. Standing with feet together, 8. Reaching forward with outstretched arm, 9. Retrieving objects from floor, 10. Turning to look behind, 11. Turning 36012. Placing alternate foot on stool, 13. Tandem standing, 14. Standing on 1 leg

**Convergent validity** The correlation of the total BBS score with FES-I and FRT scores was 0.74 and − 0.70, respectively, indicating strong convergent construct validity. The correlations between the total BBS score and the PDQ-39 (mobility), UPDRS-II, and SE-ADL were − 0.66, − 0.62, and − 0.61, respectively, which indicates moderate-high association (Table 3).

**Discriminative validity** The difference in BBS scores for faller vs. non-faller (mean ± SD, 45.42 ± 11.88 vs. 49.86 ± 12.05) was significant (Mann-Whitney test, $p < 0.003$). BBS had a moderate effect size (ES = 0.37) in the separation of the Parkinson's disease patients with and without fall history. Wilcoxon test showed a statistically significant difference between BBS score in "on" and "off" states (mean ± SD, 50.42 ± 9.92 vs. 48.12 ± 12.12; $p < 0.001$).

## Discussion

The aim of this study was to evaluate the psychometric properties of the Berg balance scale in the drug off-phase in patients with idiopathic Parkinson's disease. The results showed that the scale has satisfactory reliability and validity during the drug off-phase. Furthermore, BBS has the ability to differentiate between people with Parkinson's disease with or without a history of falling, although a moderate ceiling effect (highest scores, indicative of good balance) was observed for this scale in our study. This finding could be attributed to the composition of the sample, because patients were mainly in 1 to 3 stage of the Hoehn and Yahr classification, with no or mild balance impairment. This moderate ceiling effect of the BBS in the drug off-phase could challenge the interpretation of results, for example, in intervention studies using this scale. Such a high ceiling effect has been previously shown by other studies during the drug on-phase, too [36].

Looking at the distribution of scores (Table 3), items 11 (360° turning), 12 (alternating feet on a stool), 13 (stand of tandem), and 14 (standing on one leg) had the lowest frequency of the highest score (4 points). In line with our results, the same items (except 12, alternating feet on a stool) were also reported to be more impaired in the Franchignoni's study during the drug on-phase [37].

**Table 3** Correlation between total score of Berg balance scale (BBS) and other measures ($N = 98$)

| Scales | FRT | SE | FES-I | PDQ-39 | | UPDRS-II |
|---|---|---|---|---|---|---|
| | | | | Mobility | Total | |
| BBS | 0.74 | 0.61 | − 0.71 | − 0.60 | − 0.45 | − 0.62 |

All coefficients, $p < 0.001$.

*BBS*, Berg balance scale; *PDQ-39*, Parkinson Disease Questionnair-3; *FRT*, Functional Reach Test; *FES-I*, Fall Efficacy Scale-International; *SE*, Schwab and England-Activities of Daily Living Scale; *UPDRS-ADL*, Unified Parkinson's Disease Rating Scale-Activities of Daily Living

The present study suggests a high reliability for the total BBS score in the drug off-phase in patients with idiopathic Parkinson's disease, which is in line with previous studies in the drug on-phase in these patients [13, 14, 37–39].

The strength of the agreement for the inter-rater reliability of each item of the BBS in the drug off-phase was similar to the results of the study done by Babaei et al. [14], the test-retest reliability during the drug off-phase was found between substantial to perfect.

The SEM value obtained in the drug off-phase in the present study (2.71) was not far from the standard error of measurement for the BBS in the drug on-phase (SEM = 1.71). This finding suggests that the scale has an adequate precision (low measurement error) both in drug on- and drug off-phases [38].

The unidimensionality of the BBS shows that, in our patients, all items group together around a general concept of functional balance during the drug off-phase, a circumstance different from the studies conducted by Scalzo and Babaei in the drug on-phase in PD population in which two factors were found [13, 14].

On the other hand, the results of the present study showed a moderate correlation of the total BBS score in off-phase with independence in activities of daily living and quality of life, a finding consistent with the results of previous studies in the drug on-phase [13, 36, 40, 41]. The results of our study showed that the BBS has ability to predict the fear of falling in people with Parkinson's disease during the drug off-phase. People who had further concerns of falling during the drug off-phase had a lower BBS total score.

Similar to the results of Landers et al. in the drug on-phase, we also showed that the BBS has the ability to separate PD patients with a history of fall from those without a history of falling [12]. BBS was capable of detecting change in the balance status of people with Parkinson's disease between different drug phases, which is aligned with the results of Nova et al. who found, as in our study, a statistically significant difference ($p < 0.001$) between "on" and "off" state [11]. This finding could be helpful for interpretation of outcomes in clinical trials examining the response of drugs in PD population. However, the magnitude of the difference we found (2 points on a scale with theoretical maximum score of 56) makes doubtful the pragmatic value of such difference in real life.

Main limitations of our study are related to the sample relatively low size and mild-to-moderate severity of PD (stage 1–3 of the Hoehn and Yahr scale). These limitations should be considered for generalizability of our findings and addressed in future studies.

## Conclusion

Therapeutic strategies in the drug on- and off-phase can be different from each other (in terms of type and severity). Therefore, obtaining accurate information from the balance status of people with PD, especially in the drug off-phase, can be helpful in designing a more efficient plan for treatment. The results of our study suggest that the BBS has acceptable reliability and validity to evaluate the functional balance during the drug off-phase in idiopathic PD. We suggest, however, that the use of this scale for clinical decision-making requires further studies in future.

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### Compliance with ethical standards

This study was approved by the ethics committee of the Student Research Center at Iran University of Medical Sciences (number, IR.IUMS.REC.1394.94-01-19-25617). All patients signed an informed consent for participation to the study.

**Conflict of interest** The authors declare that there is no conflict of interest.

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