Research Report

Comparison of the Fullerton Advanced Balance Scale, Mini-BESTest, and Berg Balance Scale to Predict Falls in Parkinson Disease

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Background. The correct identification of patients with Parkinson disease (PD) at risk for falling is important to initiate appropriate treatment early.

Objective. This study compared the Fullerton Advanced Balance (FAB) scale with the Mini-Balance Evaluation Systems Test (Mini-BESTest) and Berg Balance Scale (BBS) to identify individuals with PD at risk for falls and to analyze which of the items of the scales best predict future falls.

Design. This was a prospective study to assess predictive criterion-related validity.

Setting. The study was conducted at a university hospital in an urban community.

Patients. Eighty-five patients with idiopathic PD (Hoehn and Yahr stages: 1–4) participated in the study.

Measurements. Measures were number of falls (assessed prospectively over 6 months), FAB scale, Mini-BESTest, BBS, and Unified Parkinson's Disease Rating Scale.

Results. The FAB scale, Mini-BESTest, and BBS showed similar accuracy to predict future falls, with values for area under the curve (AUC) of the receiver operating characteristic (ROC) curve of 0.68, 0.65, and 0.69, respectively. A model combining the items "tandem stance," "rise to toes," "one-leg stance," "compensatory stepping backward," "turning," and "placing alternate foot on stool" had an AUC of 0.84 of the ROC curve.

Limitations. There was a dropout rate of 19/85 participants.

Conclusions. The FAB scale, Mini-BESTest, and BBS provide moderate capacity to predict "fallers" (people with one or more falls) from "nonfallers." Only some items of the 3 scales contribute to the detection of future falls. Clinicians should particularly focus on the item "tandem stance" along with the items "one-leg stance," "rise to toes," "compensatory stepping backward," "turning 360°," and "placing foot on stool" when analyzing postural control deficits related to fall risk. Future research should analyze whether balance training including the aforementioned items is effective in reducing fall risk.

Approximately 60% of people with Parkinson disease (PD) fall at least once a year; 39% are considered recurrent "fallers" with more than one fall.[1] Risk of hip fracture due to falls is 2.8-fold higher in women with PD and 5.3-fold higher in men with PD in comparison with healthy older adults.[2] Previous falls, freezing of gait (FOG), postural instability, reduced leg strengths, and cognitive impairment are predictors of future falls.[3–6] Paul et al[6] showed that a simple 3-test tool including the assessment of previous falls during the past 12 months, the occurrence of FOG during the last months, and gait speed is an easy and quick way to predict future falls, with an accuracy of 0.80 for the area under the curve (AUC) of the receiver operating characteristic (ROC) curve. However, clinicians performing this test gain only limited information about patients' specific impairments and how to guide future treatment.

Clinical balance scales are useful tools to assess postural control, as they are able to reflect various dimensions of postural control (eg, static/dynamic postural control, sensory reception and integration, feedforward/feedback postural control). However, the prediction of future falls with clinical balance scales alone is limited, as postural instability represents only one part of the multivariate causes leading to falls. One advantage of multidimensional clinical balance scales is the potential capacity to describe one symptom in detail and provide further information about potential mechanisms for falls that could be used to guide treatment. Indeed, previous studies have shown that a significant reduction of falls due to interventions was accompanied with a significant improvement of postural control.[7,8] Additionally, a motor examination is more reliable than simple self-reports on fall history, as the latter can be influenced by neuropsychiatric manifestations such as cognitive impairment or dementia.[9]

When analyzing a test's capacity to predict future falls, falls should be ascertained prospectively rather than retrospectively. However, it has to be kept in mind that some studies focused on the prediction of faller status in recurrent fallers with more than one fall versus nonrecurrent fallers,[10–14] whereas other studies differentiated between fallers with one or more falls and "nonfallers."[6,15–18]

The Mini-Balance Evaluation Systems Test (Mini-BESTest) is a valid and reliable clinical balance scale to assess postural control in people with PD.[19,20] The test consists of 14 items, and each task is assessed with a 3-point ordinal scale.[21] Previous studies have shown that this test can predict faller status for a prospective assessment time of 6 months with an accuracy of 0.75[10] and 0.87[11] of the AUC of the ROC curve. Note that these studies did not focus on the differentiation between fallers and nonfallers but rather on the distinction between recurrent fallers and nonrecurrent fallers.

For a long time, the Berg Balance Scale (BBS) was considered the "gold standard" of clinical balance scales.[22] This scale is a valid and reliable means to assess postural control in people with PD.[19,23] However, the test has some limitations, such as the lack of assessing reactive postural control (eg, response to a perturbation),[22] low responsiveness,[19,24] and a ceiling effect.[19,20,25] Some studies analyzed the test's ability to predict recurrent fallers from nonrecurrent fallers,[12,14,26] and the test showed an accuracy of 0.79 of the AUC.[12] A single study focused on the prediction of fallers versus nonfallers but was limited by the low sample size included.[18] To our best knowledge, no study has been conducted to analyze the BBS with a prospective assessment of falls.

Recently, the Fullerton Advanced Balance (FAB) scale was validated and compared with the Mini-BESTest and BBS to assess postural control in people with PD.[25] This test consists of 10 items (each with a 5-point ordinal scale) that require static and dynamic postural control.[27] In contrast to the BBS, the FAB scale includes the assessment of dynamic postural control (eg, reactive postural control in response to a perturbation and gait performance). The FAB scale has excellent reliability, is quicker to perform than the Mini-BESTest and the BBS, and—in contrast to the BBS—is not limited by the occurrence of ceiling effects.[25] In healthy older adults, the FAB scale is able to predict recurrent fallers from nonrecurrent fallers with a sensitivity of 74.6% and a specificity of 52.6%.[13] It remains unclear, however, whether the FAB scale is an appropriate test to predict future falls in people with PD.

As previously discussed, postural instability is one risk factor for falls in PD. Postural control is a complex motor skill involving different sensorimotor processes (for a review, see Horak and colleagues[28,29]). Studies comparing postural control in nonfallers versus fallers have shown that patients with PD who fall have increased postural sway,[5,30] especially in an anterior-posterior direction, when standing with eyes open on a firm surface[31]; reduced reactive postural control[17,32,33]; and an impaired ability to perform tandem stance/walk.[34] In contrast, the ability to voluntarily lean forward does not differentiate between fallers and nonfallers.[31,35] The results of these studies indicate that some, but not all, aspects of postural control are associated with fall risk. Most of these previous studies focused on a few aspects of postural control and often assessed with instrument-based methods, making it difficult to judge which aspect of postural control is strongest related to falls. In this context, analyzing subitems of clinical balance scales would lead to a broad multidimensional description of postural control, with the advantage to compare and judge multivariate aspects of postural control associated with fall risk. To our knowledge, no study has analyzed which items of the FAB scale, Mini-BESTest, and BBS might contribute to the detection of fall risk. Yet, investigating subitems of these scales would help in interpreting test results and characterizing postural control deficits of patients at risk for falls in order to guide future treatment.

Consequently, the current study had 2 aims. The first aim was to compare the capacity of the FAB scale, the Mini-BESTest, and the BBS to identify fallers from nonfallers with PD in a prospective manner. As the detection of first falls is important to initiate early preventive treatment, we preferred to distinguish between nonfallers without any falls and fallers with one or more falls instead of recurrent versus nonrecurrent fallers. As the items of the FAB scale have a more differentiated scaling than the items of the Mini-BESTest, we hypothesized that the FAB scale would be able to describe postural control more precisely and, therefore, might better predict future falls than the Mini-BESTest. Due to the ceiling effect of the BBS and because the BBS does not assess reactive postural control, we expected that the FAB scale and the Mini-BESTest would predict faller status more accurately than the BBS.

Second, we wanted to specify which of the items of the 3 balance scales are the best predictors of future falls. We anticipated that only a few of the items of the scales are related to higher fall risk and that a model combining these items will result in better accuracy to differentiate fallers from nonfallers. Providing predictor variables would help clinicians to focus on special items of the balance scales when analyzing postural control deficits with respect to fall risk. Moreover, the indication of selected subitems as predictor variables would describe postural control deficits of patients being at risk for falls in more detail and would give indications for future treatment.

Method

Participants

Eighty-five individuals with idiopathic PD participated in this study. All participants met the following inclusion criteria: (1) diagnosed with idiopathic PD by a neurologist who specialized in movement disorders, (2) Hoehn and Yahr (H&Y) stage 1 through 4, and (3) greater than 40 years of age. Exclusion criteria were: (1) deep brain stimulation; (2) other diseases and conditions that could influence stance and gait performance (eg, peripheral neuropathy, orthopedic injuries), determined by clinical examination of a neurologist; (3) any change of medication during 4 weeks prior to participation; and (4) cognitive impairment assessed through clinical examination by a neurologist. In ambiguous cases, patients were excluded. People with cognitive impairments were excluded, as they might not be able to give reliable information about fall status. To cover a broad spectrum of disease stages and patients, the use of assistive devices was not defined as an exclusion criterion. All patients gave written informed consent prior to participating.

Testing Procedure

All participants were assessed in the "on" state of their medication. Each participant underwent the same order of testing for the following tests: FAB scale, Mini-BESTest, BBS, and Unified Parkinson's Disease Rating Scale (UPDRS). Any item that was duplicated among the different balance scales was performed only once and scored using criteria from each scale. To ensure that the participants perform each test under the same physical conditions, a seated rest was proposed by the assessor several times. The assessment was administered by 2 trained examiners who had experience completing these tests in patients with PD.

Fall history was assessed by asking the participants how often they had fallen during the previous 6 months. Participants with one or more falls were considered to have a positive fall history. Future falls were ascertained prospectively by monthly telephone interviews over a period of 6 months. Participants were asked the question: "How often have you fallen during the last 30 days?" A fall was defined as coming to rest on the ground or other lower surface not as the result of a major intrinsic event.[4,6] We inquired carefully about the frequency of falls, and participants were encouraged to have another person present to add detail or to confirm the accounts. Individuals reporting one or more falls during the prospective 6 months were considered fallers.

FAB scale. The FAB scale is a 10-item balance scale with a 5-point ordinal scale (0–4) for each item and a maximum score of 40 points (higher values indicate better performance).[27] It takes 10 to 12 minutes to perform the scale,[25,27] and the following equipment is required: a stopwatch to assess stance time under various conditions; a pencil and 30.5-cm (12-in) ruler to measure forward limits of stability; a bench (height=15.2 cm, [6 in], length=45.6 cm [18 in], width=35.6 cm [14 in]) for a step task to elevate dynamic postural control; masking tape to assess a forward jump; 2 balance pads (Airex AG, Sins, Switzerland) for stance on an unstable surface; and a yardstick and metronome to assess a secondary task while walking. The German version of the FAB scale was used in this protocol.[36] Patient instructions were given according to the standardized test protocol.

Mini-BESTest. The Mini-BESTest is a 14-item scale with a 3-point grading (0–2) for each item and a maximum score of 28 points (higher values indicate better performance).[21] It takes 10 to 15 minutes to perform the scale,[19] and the following equipment is required: a stopwatch to assess stance time under various conditions and to perform the Timed "Up & Go" Test (TUG) item; one balance pad for stance on an unstable surface; a 10-degree-incline ramp (at least 0.61 × 0.61 m [2 × 2 ft] to stand on) to measure stance performance on an inclined surface; a stair step (height=15.2 cm [6 in]); 2 stacked shoe boxes for gait assessment with obstacles; a chair without armrest for a sit-to-stand test; and masking tape for the TUG item. Patient instructions were given according to the standardized test protocol.

BBS. The BBS is a 14-item balance scale with a 5-point grading (0–4) for each item and a maximum score of 56 points (higher values indicate better performance).[37] It takes up to 20 minutes to perform the scale,[25] and the following equipment is required: a stopwatch to assess stance and sit performance under various conditions, a ruler to measure forward limits of stability, 2 chairs (one with and the other without an armrest) for a sit-to-stand transfer task, and a stepper. Patient instructions were given according to the standardized test protocol.

Data Analysis

For statistical analysis, IBM SPSS Statistics version 19.0 (IBM Corp, Armonk, New York) was used. Demographic and disease-related variables were summarized with descriptive statistics. Between-group comparisons of fallers versus nonfallers were performed with nonparametric tests for independent groups (Mann-Whitney U tests).

The participants' prospectively assessed faller status was used as the gold standard for diagnosis as a faller (one or more falls) or nonfaller. Receiver operating characteristic curves were conducted for each balance scale, and the AUC of the ROC curve was calculated. The AUC is the probability of correctly identifying a faller from a randomly selected pair of patients, one being a faller and one being a nonfaller.[38] The AUC ranges from 0.50 (no identification ability) to 1.00 (perfect identification ability). The sensitivity (ie, number of identified true fallers) and specificity (ie, number of correctly classified nonfallers)[39] values were calculated. Cutoff values were computed by maximizing sensitivity and specificity by choosing the minimal value of $(1 - sensitivity)^2 + (1 - specificity)^2$.[40]

Positive likelihood ratios were calculated as *sensitivity/(1 − specificity)*. A positive likelihood ratio indicates how much the likelihood of a person being a faller increases given a positive test result.[39] Negative likelihood ratios were computed as *(1 − sensitivity)/specificity*. A negative likelihood ratio indicates how much the likelihood of a person being a faller decreases given a negative test result.[39]

To specify which of the items of all 3 balance scales are the best predictors of faller status, an approach was used as described by other authors.[6] First, univariate logistic regression analysis was performed with each item as the independent variable and faller status as the dependent variable. Second, odds ratios were calculated for each item dichotomized by a median split. Candidate predictors were those with $P<.05$ in the univariate regression analysis and with odds ratios >2.0 or <0.5. Correlations between the candidate predictor variables were assessed by calculating Spearman rank correlation coefficients (Spearman rho). To avoid multicollinearity, a candidate predictor was excluded from the multivariate logistic regression if the predictor had a strong correlation (Spearman rho ≥.7) and a lower odds ratio than the other predictor. After choosing candidate predictor variables, a multivariate logistic regression was performed in 2 ways: (1) all prior chosen predictors were included (model 1), and (2) the prior chosen predictors were reduced by a stepwise forward logistic regression (model 2). Variance inflation factors were calculated for each predictor entered into the multivariate model to assess severity of multicollinearity. A variance inflation factor greater than 10 indicates high multicollinearity.[41] The predefined level of significance was set at $P<.05$.

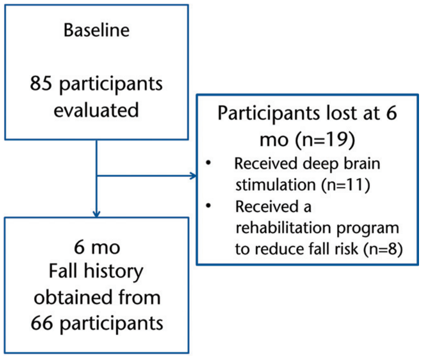

Figure 1.
Flow diagram showing number of participants evaluated and reasons for loss.

Role of the Funding Source

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Results

Evaluations were performed between April 2013 and February 2014. Eighty-five participants met the inclusion criteria and were tested at baseline. Falls were prospectively assessed during the 6-month follow-up period. Nineteen patients were excluded from further analysis because they received either deep brain stimulation or a rehabilitation program to improve postural control during the 6-month follow-up period (Fig. 1). The included patients and the dropouts did not differ in age, disease severity, number of prior falls, or any score of the 3 balance scales. Fifty percent of all participants fell at least once during the follow-up period. A comparison of nonfallers and fallers is shown in Table 1.

Table 2 shows the candidate predictors for the multivariate regression analysis. We excluded FAB scale item 5 and BBS item 14 from the analysis, as they correlated (Spearman rho >.70) with other items that had higher odds ratios. The following 6 items were included as independent variables in the multivariate model, with faller status as the dependent variable (model 1): Mini-BESTest: item 2 ("rise to toes"), item 3 ("standing on one leg"), and item 5 ("compensatory stepping backward"); BBS: item 11 ("360° turning"), item 12 ("placing alternate foot on stool"), and item 13 ("tandem stance"). Variance inflation factors were <3, indicating a low risk of multicollinearity. Model 1 was significant (P=.026, R^2=.47). When performing the stepwise forward multivariate logistic regression with the same prior chosen candidate predictors as independent variables, only BBS item 13 ("tandem stance") was included in the model (model 2). Model 2 was significant (P=.003, R^2=.25).

The FAB Scale, Mini-BESTest, and BBS showed similar accuracy to predict fallers with one or more falls from nonfallers, with AUCs of the ROC curve of 0.68, 0.65, and 0.69, respectively (Tab. 3). For the FAB scale, a cutoff score of 27 points maximized sensitivity (0.67) and specificity (0.58). We found cutoff scores of 19 for the Mini-BESTest (sensitivity=0.52, specificity=0.70) and 52 for the BBS (sensitivity=0.64, specificity=0.67). Model 1 had an accuracy of 0.84 (95% confidence interval [CI]=0.75, 0.94) of the AUC of the ROC curve. Model 2 showed an AUC of 0.71 (95% CI=0.59, 0.84) and a sensitivity of 0.82 and a specificity of 0.61 when choosing 3 points as a cutoff score for this item (Tab. 3). Figure 2 shows the ROC curves of the FAB scale, Mini-BESTest, BBS, model 1, and model 2.

Discussion

One important finding of our study was that the FAB scale, Mini-BESTest, and BBS showed similar accuracy in differentiating fallers with one or more falls from nonfallers in PD. Overall, all 3 balance

Table 1.
Participant Characteristics[a]

Characteristic	Nonfallers[b] (n=33)	Fallers[c] (n=33)	P
Age (y)	66.0 (11.6)	68.1 (7.5)	.63
Median (range)	67 (40–82)	69 (51–82)	N/A
Sex (female), n (%)	8 (24)	13 (39)	N/A
Fall history[d]	7 (21)	23 (70)	N/A
BMI (kg/m^2)	25.5 (3.8)	26.8 (5.0)	.48
Disease duration (y)	6.9 (5.2)	9.3 (6.5)	.15
Median (range)	5 (1–18)	7 (1–23)	N/A
H&Y stage			
1–4	2.5 (0.8)	2.8 (0.7)	.17
1	3	1	N/A
1.5	1	0	N/A
2	7	3	N/A
2.5	9	14	N/A
3	9	9	N/A
4	4	6	N/A
UPDRS			
Total score	40.2 (17.3)	44.0 (16.0)	.37
Part II	11.4 (6.1)	14.5 (7.6)	.03*
Part III	23.9 (12.0)	23.3 (9.7)	.89
PIGD score	3.8 (3.0)	4.4 (3.2)	.50
FAB scale	27.8 (8.8)	21.8 (9.7)	.01*
Mini-BESTest	21.2 (5.0)	17.1 (7.2)	.04*
BBS	52.0 (5.8)	47.6 (8.7)	.001*

[a] Values are mean (SD) or as otherwise indicated. BMI=body mass index, H&Y=Hoehn and Yahr, UPDRS=Unified Parkinson's Disease Rating Scale, PIGD=postural instability and gait disorder, FAB=Fullerton Advanced Balance, Mini-BESTest=Mini-Balance Evaluation Systems Test, BBS=Berg Balance Scale, N/A=not applicable. *$P<.05$.
[b] Patients without any fall during prospective 6-month follow-up assessment.
[c] Patients with one or more falls during prospective 6-month follow-up assessment.
[d] Number of patients (%) with one or more falls during the previous 6 months; *P* value of independent-samples Mann-Whitney *U* test.

scales had only moderate predictive capacity. In the present sample of patients with PD and with the cutoff scores chosen in this study, the FAB scale was able to correctly classify almost 7 out of 10 patients who will experience one or more falls during the next 6 months, whereas the BBS detected only a little more than 6 out of 10 true fallers, and the Mini-BESTest detected a little more than 5 out of 10 true fallers. The FAB scale identified almost 6 out of 10 true nonfallers, and the Mini-BESTest and BBS correctly identified 7 out of 10 patients not falling in the next 6 months. The likelihood ratios indicate that the individual likelihood for being a faller will increase by the factor 1.6, 1.7, and 1.9 given a positive test result on the FAB scale, Mini-BESTest, and BBS, respectively.

Although previous studies reported better accuracy for the Mini-BESTest, with AUCs of 0.75[10] and even 0.87,[11] these studies analyzed the prediction of recurrent versus nonrecurrent fallers. In contrast, we distinguished between fallers with one or more falls versus nonfallers, as the detection of first falls is important to initiate preventive treatment as early as possible. Notably, accuracy increased when we analyzed recurrent fallers (with ≥2 falls) versus nonrecurrent fallers, with AUCs of 0.72, 0.70, and 0.74 for the FAB scale, Mini-BESTest, and BBS, respectively.

In our sample, a cutoff score of 27 points maximized sensitivity and specificity for the FAB scale. Hernandez and Rose[13] proposed a cutoff score of 25 points for healthy elderly individuals, but they only considered every 5 points of the FAB scale as possible cutoff scores. We found a cutoff score of 19 for the Mini-BESTest, which is in good agreement with other authors who found the same cutoff score when analyzing the prediction of recurrent versus nonrecurrent fallers.[10] Duncan et al[11] proposed a cutoff score of 20 for the Mini-BESTest, but this result has to be interpreted with caution, as they used a different scoring (with a maximal total score of 32 points) that diverged from the scoring proposed in the original version of the Mini-BESTest.[42] For the BBS, cutoff scores of 45[14] and 47[12] were proposed in previous studies that assessed number of falls retrospectively. We assessed fall rates prospectively, which might explain why we found a different cutoff score for the BBS.

The moderate predictive capacity of all 3 balance scales emphasizes that postural instability is only one cause of falls, besides other contributors such as FOG, cognitive impairments, or reduced muscle strength.[4,5]

With respect to our second study aim, we found that only a few of the items of the 3 balance scales were useful to predict future falls. To our knowledge, this is the first study analyzing the predictive capacity of the separate items of 3 commonly used balance scales. Our results showed that performing worse on the items "tandem stance/walk," "one-leg stance," "rise to toes," "compensatory stepping backward," "turning 360°," and "placing foot on stool" was strongly associated with higher fall risk. A model combining these items showed better accuracy than each of the 3 balance scales, indicating that some of the items of the balance scales do not contribute to the prediction of future falls. Our study, therefore, extends the findings made by other authors describing postural control deficits of patients at risk for

Table 2.
Candidate Predictor Variables[a]

Test	P	OR
FAB scale		
Item 1 (standing with feet together, EC)	.03[b]	1.63
Item 2 (functional reach)	.30	2.13
Item 3 (360° turning)	.10	1.83
Item 4 (stepping over a bench)	.20	2.30
Item 5 (tandem walk)[c]	.003[b]	6.92
Item 6 (standing on one leg)	.09	3.07
Item 7 (standing on foam, EC)	.09	2.08
Item 8 (jump)	.28	1.64
Item 9 (walk with head turns)	.28	4.41
Item 10 (reactive postural control)	.18	2.41
Mini-BESTest		
Item 1 (sit to stand)	.76	1.61
Item 2 (rise to toes)[c]	.04[b]	3.62
Item 3 (standing on one leg)[c]	.004[b]	10.20
Item 4 (compensatory stepping–forward)	.13	3.75
Item 5 (compensatory stepping–backward)[c]	.04[b]	4.12
Item 6 (compensatory stepping–lateral)	.26	2.03
Item 7 (standing on firm surface, feet together)	.24	3.20
Item 8 (standing on foam surface, feet together, EC)	.05	3.62
Item 9 (incline, EC)	.11	2.10
Item 10 (change in gait speed)	.12	3.75
Item 11 (walk with head turns)	.08	2.12
Item 12 (walk with pivot turns)	.046[b]	1.83
Item 13 (step over obstacles)	.73	1.17
Item 14 (TUG)	.27	2.22
BBS		
Item 1 (sit to stand)	.54	1.29
Item 2 (standing unsupported)	.22	3.20
Item 3 (sitting unsupported)	.24	0.00
Item 4 (stand to sit)	.00	1.00
Item 5 (transfers)	.06	4.17
Item 6 (standing, EC)	.24	3.20
Item 7 (standing with feet together)	.23	2.13
Item 8 (functional reach)	.20	1.00
Item 9 (retrieving object from floor)	.10	3.20
Item 10 (turning to look behind)	.44	1.27
Item 11 (360° turning)[c]	.02[b]	4.45
Item 12 (placing alternate foot on stool)[c]	.03[b]	4.17
Item 13 (tandem stance)[c]	.003[b]	2.32
Item 14 (standing on one leg)[c]	.03[b]	4.80

[a] OR=odds ratio, FAB=Fullerton Advanced Balance, Mini-BESTest=Mini-Balance Evaluation Systems Test, BBS=Berg Balance Scale, TUG=Timed "Up & Go" Test, EC=eyes closed.
[b] P value of the univariate logistic regression $<.05$.
[c] Candidate predictor variable with $P<.05$ in the univariate logistic regression and an OR >2 or <0.5.

falls.[5,17,30–33,43] Interestingly, the simple use of item 13 ("tandem stance") of the BBS had better predictive accuracy than the complete execution of each of the balance scales. It should be noted that the item "tandem stance" is scaled less differentially than the other variables. This difference in scaling might have contributed to a reduced AUC for model 2. Consequently, it would be interesting to include continuous data for tandem stance in future studies.

The inability to perform tandem stance of patients at risk for falls is in agreement with the results of other authors.[43] During tandem stance, lateral postural control mechanisms are primarily involved to gain balance due to the narrow base of support. Lateral postural instability, which is known to be increased in people with PD in comparison with healthy elderly people,[44,45] appears to be an important indicator for future falls. On the other hand, items that require retaining balance under conditions with reduced visual information, on unstable surfaces, and items of dynamic postural control, such as walking, jumping, or transfers, were not associated with faller status. Clinicians who analyze postural control deficits to identify patients being at risk for falls should particularly focus on the items "tandem stance/walk," "one-leg stance," "rise to toes," "compensatory stepping backward," "turning 360°," and "placing foot on stool." Moreover, the detection of these predictor variables could be useful to guide future treatment. An improvement in the aforementioned items might result in a reduction of falls. Future studies should analyze whether balance training including exercises with a narrow base of support, such as tandem stance/walk, one-leg stance on a stable surface, 360-degree turning with only few steps, compensatory stepping backward, and rise to toes, is effective in reducing fall risk.

Study Limitations

The following limitations of the study have to be announced. First, fall rates were assessed by monthly telephone calls. Although we inquired carefully about the frequency of falls and encouraged the participants to have another person present to confirm the accounts,

Table 3.
Predictive Values for the FAB Scale, Mini-BESTest, BBS, Model 1, and Model 2[a]

Test	AUC (95% CI)	Cutoff Score	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR− (95% CI)
FAB scale	0.68 (0.55, 0.81)	≤27/40	0.67 (0.50, 0.80)	0.58 (0.41, 0.73)	1.57 (0.99, 2.50)	0.58 (0.33, 1.02)
Mini-BESTest	0.65 (0.52, 0.78)	≤19/28	0.52 (0.35, 0.68)	0.70 (0.53, 0.83)	1.70 (0.92, 3.14)	0.70 (0.46, 1.06)
BBS	0.69 (0.56, 0.82)	≤52/56	0.64 (0.47, 0.78)	0.67 (0.50, 0.80)	1.91 (1.11, 3.30)	0.55 (0.33, 0.91)
Model 1	0.84 (0.75, 0.94)	N/A	0.79 (0.62, 0.90)	0.82 (0.65, 0.92)	4.33 (2.06, 9.13)	0.26 (0.13, 0.51)
Model 2	0.71 (0.59, 0.84)	≤3/4	0.82 (0.65, 0.92)	0.61 (0.44, 0.75)	2.08 (1.32, 3.27)	0.30 (0.14, 0.65)

[a] FAB=Fullerton Advanced Balance, Mini-BESTest=Mini-Balance Evaluation Systems Test, BBS=Berg Balance Scale, AUC=area under the curve, CI=confidence interval, LR+=positive likelihood ratio, LR−=negative likelihood ratio, N/A=not applicable. Model 1 consists of 6 items: Mini-BESTest items 2, 3, and 5 and BBS items 11–13. Model 2 consists of BBS item 13 ("tandem stance").

shorter inter-call intervals might increase the reliability of the reports. We additionally gave fall diaries to the participants. As some of the participants lost their diaries and others forgot to fill in their falls even when reminding them with each telephone call, we consider the data collected by telephone interview more reliable than the fall rates collected with fall diaries. Second, assessments were performed only in the medication "on" state. It remains unclear whether the accuracy of fall prediction would change if assessing the patients in the "off" state of medication. Third, our sample size was reduced, as 19 patients could not be included in the analysis because they received a treatment that might have influenced fall incidence during the prospective assessment time. However, note that dropouts and patients who were included did not statistically differ in the participant characteristics. Furthermore, although a seated rest was given during the assessments, all participants underwent the same order of testing, and results could have been influenced by fatigue. Finally, we did not document any changes in medication during the 6-month fall assessment that could affect the number of falls.

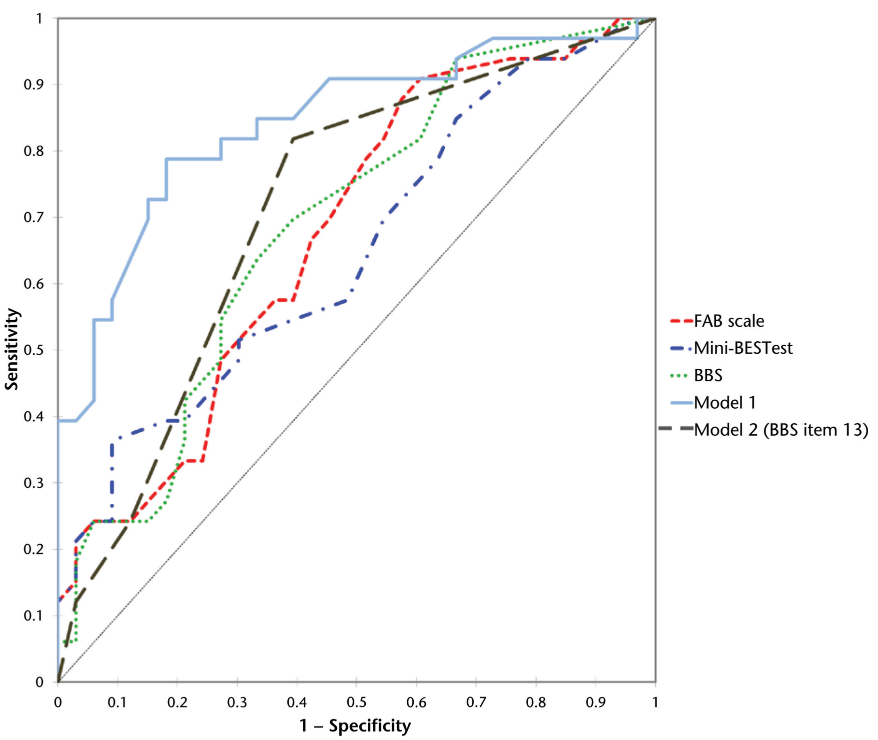

Figure 2.
Receiver operating characteristic curves for the Fullerton Advanced Balance (FAB) scale, Mini-Balance Evaluation Systems Test (Mini-BESTest), Berg Balance Scale (BBS), model 1, and model 2.

In community-dwelling individuals with PD, the FAB scale, Mini-BESTest, and BBS showed only moderate predictive capacity to differentiate fallers with one or more falls from nonfallers for a prospective period of 6 months. Analyzing the items of the scales separately revealed that especially the item "tandem stance," in addition to the items "one-leg stance," "rise to toes," "compensatory stepping backward," "turning 360°," and "placing foot on stool," were associated with fall risk. A model combining these items resulted in better accuracy to predict future falls than each of the balance scales alone. Clinicians who analyze postural control deficits aimed at detecting patients being at risk for falls should particularly focus on these items. Future research should analyze whether balance training including exercises with narrow base of support, such as tandem stance/walk, one-leg stance on a stable surface, 360-degree turning with only few steps, compensatory stepping backward, and rise to toes, is effective in reducing fall risk.

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