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# SENSITIVITY AND SPECIFICITY OF INDIVIDUAL BERG BALANCE ITEMS COMPARED WITH THE TOTAL SCORE TO PREDICT FALLS IN COMMUNITY DWELLING ELDERLY INDIVIDUALS

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## ABSTRACT

***Background:*** Falls are a major problem in the elderly leading to increased morbidity and mortality in this population. Scores from objective clinical measures of balance have frequently been associated with falls in older adults. The Berg Balance Score (BBS) which is a frequently used scale to test balance impairments in the elderly ,takes time to perform and has been found to have scoring inconsistencies. The purpose was to determine if individual items or a group of BBS items would have better accuracy than the total BBS in classifying community dwelling elderly individuals according to fall history.

***Method:*** 60 community dwelling elderly individuals were chosen based on a history of falls in this cross sectional study. Each BBS item was dichotomized at three points along the scoring scale of 0 – 4: between scores of 1 and 2, 2 and 3, and 3 and 4. Sensitivity (Sn), specificity (Sp), and positive (+LR) and negative (-LR) likelihood ratios were calculated for all items for each scoring dichotomy based on their accuracy in classifying subjects with a history of multiple falls. These findings were compared with the total BBS score where the cut-off score was derived from receiver operating characteristic curve analysis.

***Results:*** On analysing a combination of BBS items, B9 and B11 were found to have the best sensitivity and specificity when considered together. However the area under the curve of these items was 0.799 which did not match that of the total score (AUC= 0.837). A, combination of 4 BBS items - B9 B11 B12 and B13 also had good Sn and Sp but the AUC was 0.815. The combination with the AUC closest to that of the total score was a combination items B11 and B13. (AUC= 0.824). hence these two items can be used as the best predictor of falls with a cut off of 6.5 The ROC curve of the Total Berg balance Scale scores revealed a cut off score of 48.5.

***Conclusion:*** This study showed that combination of items B11 and B13 may be best predictors of falls in the elderly with a cut off of 6.5.

***Key Words:*** Elderly, geriatric, balance, falls, Berg Balance Scale, diagnostic tests, test and measures

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## INTRODUCTION

In 2011 5.5% of the entire Indian population was estimated to be individuals above 65 years of age as per the Central Intelligence Agency(CIA) world factbook.[1] The problems faced by this segment of the population are numerous owing to the social and cultural changes that are taking place within the Indian society. The major area of concern is the health of the elderly with multiple medical and psychological problems.[2]

Falls are one of the major problems in the elderly and are considered one of the "Geriatric Giants". Recurrent falls are an important cause of morbidity and mortality in the elderly and is the second most common cause of death in India.[2] One half to two thirds of falls occur in or around the patient's home.[3]

Falls can be defined as an event which results in a person coming to rest unintentionally at a lower level, other than as a result of dizziness, fainting, sustaining a violent blow, loss of consciousness or other overwhelming external factors[4].

Balance impairments is one of the intrinsic risk factors of falls and is a complex process involving the reception and integration of sensory inputs and the planning and execution of movement to achieve a goal requiring upright posture. It plays a key role in differentiating a faller from a non-faller. Balance is defined as the ability to control the centre of gravity over the base of support in a given sensory environment.[5]

Many standard tests to measure key components of balance are available but perhaps the most commonly used FUNCTIONAL tool to assess balance in these populations is the Berg Balance Scale.

The Berg Balance Scale (BBS) was developed by Berg and co-workers [6,7,8] and is used as an objective measure of static and dynamic balance abilities. The BBS was originally developed for use with elderly populations with stroke in the acute rehabilitation setting. BBS has also shown to be a useful tool on predicting falls in the elderly[9, 10] and evaluating changes in patients undergoing physical therapy.[11]

One of the limitations of the interpretation of the total BBS score may lie in the scoring of the individual BBS items. Kornetti et al [12] performed a rating scale analysis of BBS in the elderly and found that the score associated with success on an individual item varies among the BBS items. "Success" in this context refers to performing the defining task for a particular BBS item based on the operational definitions described by the developers of the BBS. The lack of a consistent score across items that indicates success may result in differential weighting of individual BBS items in the total score and may explain some of the variability seen in total BBS scores used as fall screening measures.

Also there has been limited analysis of individual BBS items relative to fall risk in older adults. Kornetti et al[12] found that a total BBS score of 45 was associated with an increased probability of succeeding on items alternating foot on stool (B12), stand on one leg (B14), turn and look behind (B10), and stand with feet together (B7) while Chiu et al [13] through logistic regression analysis, found picking up an object from the floor and stand on one leg contributed most to the discriminative ability of the BBS in identifying older adults with a history of single falls. They also found that the items (B9) and (B12) are useful for discriminating older adults with multiple falls. Although these individual items have been associated with fall risk, the relevance of individual scores on those items remains unclear. In other words, there may be a critical pivot score on individual items that is most closely related to risk of falls and that, if identified, would allow for simpler, dichotomized scoring of items. Additionally, if these optimal pivot scores could be identified, the clinical usefulness of the BBS as a fall screening tool may be improved.

In the clinical setting, where time is at a premium and patient fatigue is a concern, the 15–20 minutes required to complete the BBS may limit its usefulness. This practical concern, in addition to the scoring system variability issues and variable accuracy in detecting fall risk, may limit the utility of the BBS as a screening tool for falls. Identifying a cluster of BBS items and understanding the association of these items to fall history may lead to a more accurate and efficient way for assessing fall risk.

The objective of this study was to determine sensitivity and specificity of each item in classifying individuals according to fall history and also to determine if individual items or a combination of BBS items would have greater overall accuracy than the total BBS, based on their sensitivity and specificity.

## METHODS

**Inclusion criteria**: 60 adults above 65 years, both male and female with an ability to follow commands and walk independently (with or without an assistive device) were chosen from Nagarbhavi Village area Bangalore as part of the sample.

**Exclusion Criteria:** Institutionalised individuals were not considered in this study in order to achieve baseline data with no bias. Subjects with auditory / visual impairments, any major neurological or musculoskeletal disorders were excluded from the study.

**Procedure**: The study was approved by the Institutional ethical committee of Padmashree Institute of Physiotherapy. The study design was a cross sectional study. Subjects were chosen based on a score above 25 on the Mini mental scale and on the inclusion exclusion criteria set. Informed and written consent from each concerned patient was taken.

Basic assessment includes self-reported fall history of the past 6 months and demographic data including age, gender, height, weight, body mass index, use of medication and co-morbid conditions, including the use of assistive devices were noted.

The Berg Balance Scale (14 items with a total score of 56) was then used to assess balance of each individual. The total BBS score as well as scores of each item in the BBS was recorded for each individual.

The sensitivity and specificity of each item across three different pivot points was analyzed. The positive and negative likelihood ratios and positive and negative predictive values were also analyzed. Statistical analysis was performed by SPSS (version 17) for windows; α value was set at 0.05. Descriptive statistics was used to analyse Mean, SD and Range of demographic variables.

Items with sensitivity above 0.9 and specificity above 0.3 were considered for further investigation. Analysis of individual BBS items was performed to identify the individual BBS items with the highest Sn and Sp relative to classifying participants by fall history (history of multiple falls vs one or no falls). We dichotomized subjects based on scoring of each BBS item using three different pivot points on the scoring scale: between the score of 1 and 2, 2 and 3, and 3 and 4. Sensitivity was analysed at each pivot point as a measure to detect the ability of each item to assess the occurrence of falls including individuals who have fallen. Similarly specificity was analyzed at each pivot point as the ability of each item to exclude individuals who did not fall.

Positive likelihood ratios was analyzed as the ratio of probability that a BBS cut off point would positive if there was a self-reported fall to the probability of cut off of BBS would be positive if there was no self-reported fall. Negative likelihood ratios were analyzed as the ratio of probability that a BBS cut off point would be negative if there was a self-reported fall to the probability of cut off of BBS would be negative if there was no self-reported fall.

ROC curve analysis on the BBS total score using fall status (falls v/s no falls) as the dichotomous outcome to determine the usefulness of the total BBS in classifying people according to fall history was performed. Similar analysis of the best combination items was also performed. Microsoft Excel was used to generate the necessary tables and graphs.

## RESULTS:

The study included a total of 60 participants.

**Table 1:** Descriptive Statistics for demographic and background variables

| | All subjects | Subjects with no falls | Subjects with falls |
|---|---|---|---|
| **Number** | 60 | 42 | 18 |
| **Age(y) mean ±SD (range)** | 70.53± 4.88 (65-84) | 69.33 ± 4.66 (65-84) | 73.33 ± 4.27 (66-82) |
| **BBS mean (range)** | 43.03( 24-55) | 45.54(26-55) | 37.16(24-48) |

Data are mean ±standard deviation with range in brackets.

Since none of the items at pivot points 1&2 and 2&3 met the criteria set for sensitivity and specificity with regard to falls, they were not considered for further analysis

**Table 2:** The Sensitivity and Specificity of individual BBS items dichotomized at Pivot points 3&4

| ITEM | TP(a) | FP(b) | FN ( c ) | TN(d) | A+C | B+D | Sn | Sp | Sn 95% CI | Sp 95 %CI |
|---|---|---|---|---|---|---|---|---|---|---|
| **B1** | 14 | 13 | 4 | 29 | 18 | 42 | 0.78 | 0.69 | 0.5479-0.91 | 0.0374-0.3788 |
| **B2** | 6 | 3 | 12 | 39 | 18 | 42 | 0.33 | 0.92 | 0.1628-0.5625 | 0.8099-0.9754 |
| **B3** | 0 | 0 | 18 | 42 | 18 | 42 | NA | 1 | 0-0.1759 | 0.9162 |
| **B4** | 15 | 16 | 3 | 26 | 18 | 42 | 0.43 | 0.62 | 0.6078-0.9416 | 0.598-0.8225 |
| **B5** | 15 | 21 | 3 | 21 | 18 | 42 | 0.43 | 0.5 | 0.6078-0.9416 | 0.3553-0.6447 |
| **B6** | 17 | 34 | 8 | 1 | 18 | 42 | 0.94 | 0.02 | 0.4841-0.8279 | 0.0051-0.1453 |
| **B7** | 18 | 38 | 0 | 4 | 18 | 42 | 1 | 0.1 | 0.8241-1 | 0.0377-0.2207 |
| **B8** | 18 | 40 | 0 | 2 | 18 | 42 | 1 | 0.05 | 0.8241-1 | 0.0132-0.1579 |
| **B9** | 18 | 29 | 0 | 13 | 18 | 42 | 1 | 0.31 | 0.8241-1 | 0.1907-0.4603 |
| **B10** | 4 | 6 | 14 | 36 | 18 | 42 | 0.22 | 0.88 | 0.09-0.4521 | 0.7216-0.9328 |
| **B11** | 18 | 25 | 0 | 17 | 18 | 42 | 1 | 0.4 | 0.8241-1 | 0.2704-0.5551 |
| **B12** | 17 | 25 | 1 | 17 | 18 | 42 | 0.94 | 0.4 | 0.7424-0.9901 | 0.2704-0.5551 |
| **B13** | 18 | 26 | 0 | 16 | 18 | 42 | 1 | 0.38 | 0.8241-1 | 0.25-0.5319 |
| **B14** | 18 | 41 | 0 | 1 | 18 | 42 | 1 | 0.02 | 0.8241-1 | 0.0042-0.1232 |

Table 2 shows the sensitivity and specificity of individual BBS Items Dichotomized at pivot points 3&4. The items that yielded a sensitivity and specificity above 0.9 and 0.3 respectively when seen together were, B9, B11, B12 and B13.

**Table 3:** The sensitivity and specificity of combination of BBS Items dichotomized at pivot points 3 & 4

| ITEM | TP (A) | FP (B) | FN (C) | TN (D) | (A+C) | (B+D) | Sn | Sp | Sn 95 %CI | Sp 95 %CI |
|---|---|---|---|---|---|---|---|---|---|---|
| **B11 + B9** | 18 | 20 | 0 | 22 | 18 | 42 | 1 | 0.52 | 0.8241-1 | 0.3772-0.66 |
| **B11 + B12** | 17 | 23 | 1 | 19 | 18 | 42 | 0.94 | 0.45 | 0.7424-0.9901 | 0.3122-0.60 |
| **B11+ B13** | 18 | 21 | 0 | 21 | 18 | 42 | 1 | 0.5 | 0.8241-1 | 0.3553-0.64 |
| **B9+ B11+ B12+B13** | 17 | 16 | 1 | 26 | 18 | 42 | 0.94 | 0.62 | 0.7424-0.9901 | 0.4681-0.75 |

Table 3 shows the sensitivity and specificity of combination of BBS Items dichotomized at pivot points 3 & 4. B11+B9 showed a sensitivity of 1 and specificity 0.52. B11+ B12 showed a sensitivity of 0.94 and specificity 0.45. B11+B13 showed a sensitivity of 1 and specificity 0.5. The combination of all 4 items showed a sensitivity of 0.94 and specificity of 0.62.

**Table 4:** The Area under the curve, standard error, level of significance and confidence interval for combination of BBS items dichotomized at pivot points 3&4.

| Variable | AUC | SE | p value | Confidence interval |
|---|---|---|---|---|
| **B9+ B11** | 0.799 | 0.056 | 0.001 | 0.689-0.909 |
| **B11+ B12** | 0.808 | 0.057 | 0.001 | 0.696-0.920 |
| **B11+B13** | 0.824 | 0.053 | 0.001 | 0.719-0.929 |
| **B9+ B11+ B12+ B13** | 0.815 | 0.55 | 0.001 | 0.707-0.923 |
| **Total score** | 0.837 | 0.51 | 0.001 | 0.736-0.938 |

Table 4 shows the Area under the curve, standard error, level of significance and confidence interval for combination of BBS items dichotomized at pivot points 3&4. The Area under the curve for the total score was found to be 0.837 with a standard error of 0.51 and 0.001 level of significance. The confidence interval was found to be 0.736-0.938. The Area under the curve closest to that of the total score was found among B11+B13 combinations with a value of 0.824 and standard error 0.51. The level of significance was 0.001 with a confidence interval of 0.736-0.938.

**Table 5:** The likelihood ratios for 4 BBS items and their combinations at Dichotomized Pivot points 3 & 4

| Item | Positive LR | Negative LR |
|---|---|---|
| **B9** | 1.448(1.183-1.773) | 0 |
| **B11** | 1.680(0.309-2.156) | 0 |
| **B12** | 1.587(1.207-2.086) | 0.137(0.02-0.955) |
| **B13** | 1.615(1.274-2.048) | 0 |
| **B11 + B9** | 2.1(1.529-2.884) | 0 |
| **B11 + B12** | 1.725(1.282-2.321) | 0.123(0.018-0.849) |
| **B11+ B13** | 2(1.478-2.706) | 0 |
| **B9+ B11+ B12+B13** | 2.48(1.659-3.704) | 0.090(0.013-0.612) |

Table 5 shows the likelihood ratios for 4 BBS items and various combinations at Dichotomized Pivot points 3 & 4. The positive likelihood ratios for the 4 items ranged from 1.448-0.680 and the negative likelihood ratios ranged from 0- 0.137. The positive likelihood ratios for the combinations ranged from 1.725- 2.48.

**Figure 1:** The ROC curve of total Berg balance Scale scores with fall status as outcome

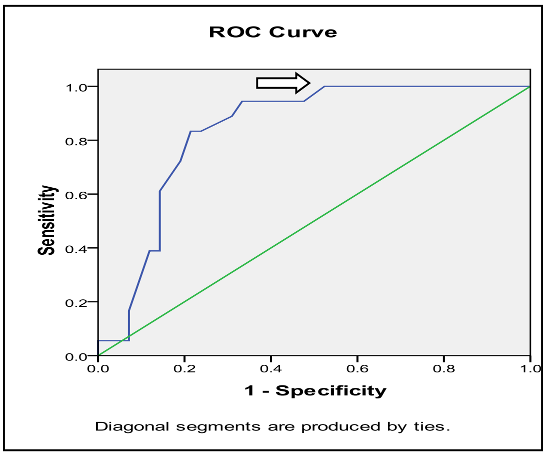

Figure 1 shows the ROC curve of total Berg balance Scale scores with fall status as outcome (faller's v/s non fallers). The arrow indicates the optimal single cut-off score of 48.5 with a sensitivity of 1 and specificity of 0.48 indicating that individuals with a score less than equal to 48 can be classified as fallers while individuals with a score more than equal to 49 can be classified as non-fallers.

**Figure 2:** The ROC curve of B11 + B13 combination with fall status as outcome (faller's v/s non fallers)

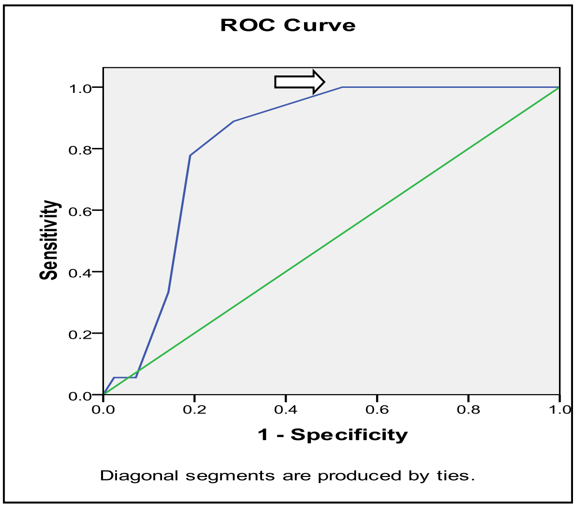


Figure 2 shows the ROC curve of B11 + B13 combination with fall status as outcome (faller's v/s non fallers). The arrow indicates the optimal single cutoff score of 6.5 with a sensitivity of 1 and specificity of 0.48 indicating that individuals with a score less than equal to 6 can be classified as fallers while individuals with a score more than equal to 7 can be classified as non-fallers.

## DISCUSSION

In the present study an attempt has been made to analyse individual items of the BBS in elderly individuals and to find the association with fall history using a dichotomized scoring system in order to eliminate some of the ambiguities of the scoring system.

30 %( 18 out of 60 individuals) of the population in the present study had a history of falls. This is in contrast to 17%[13,] 35% [10] and 50% [14] of fallers in other studies of community dwelling elderly individuals. The sample was relatively low functioning with a mean BBS score of 43.03, however more than half of the population was able to ambulate independently in the community without the need for an assistive device.

Various authors have published and discussed a number of articles stating that the BBS can be used as a valid and reliable tool to predict falls in other populations[1516,17,18] However in the elderly, several studies of fall risk using the BBS based on defined cut off scores have demonstrated mixed results. Muir et al, using dichotomous scoring based on the standard cut off of 45 and other higher scores derived from receiver operating characteristic (ROC) curves, found the BBS to be only moderately effective for identifying older adults who fell, with sensitivities ranging from 0.25 to 0.69.

Chiu et al found B14, B9 and B12 to be the best predictors of falls[19] while Kornetti found B11 B13, B10 and B6 to be closely related to fall history. In 1996 Chou et al found that the first 7 items of the BBS were sufficient to predict falls in stroke subjects. [20] However Alzayer et al, in their study proved that B11, B12, B13, B14 were the items on BBS that could predict falls in stroke patients.[21]

In the present study an attempt was made to find a critical pivot score on individual items that is most closely related to risk of falls and when identified would allow for simpler dichotomized scoring of items. This study in accordance with that performed by Alzayer et al found that a dichotomized scoring system using the pivot points between 3 & 4 yielded the highest sensitivity and specificity compared to other pivot points [21]. This may be partly due to the fact that majority of the subjects were self independent in ambulation .Also a cut off of 3-4 represents the most challenging performance on each task. Although studies in the past have been performed to find the association of individual items with fall risk, the relevance of individual scores on these items remains unclear. Kornetti et al performed a rating scale analysis and found that the score associated with success on an individual item varies among the 14 BBS items and is based on the operational definitions delineated by the developers.

In items B11 and B12 the different between the scoring of 3 to that of 4 is a matter of performing the task faster. B9 deals with the ability to perform the task independently, while in B13 the individual has to hold a posture for a period of time. Hence the efficacy of these items at these scoring pivot points in accurately classifying participants according to fall history management may be due in part to these clear scoring definitions.

In contrast to earlier studies [22], the present study indicates that B11 was the item with the single highest sensitivity and specificity in identifying those with a history of multiple falls. The difference for this variation may be due to the independently ambulant characteristic of majority of the subjects in the present study.

On analyzing a combination of BBS items B9 and B11 were found to have the best sensitivity and specificity when considered together. However the area under the curve of these items was 0.799 which did not match that of the total score (AUC=0.837). A combination of 4 BBS items - B9, B11, B12 and B13 also had good Sn and Sp but the AUC was 0.815. The combination with the AUC closest to that of the total score was a combination items B11 and B13. (AUC= 0.824). Hence these two items were considered as the best predictor of falls.

The ROC curve of the Total Berg balance Scale scores with fall status as outcome (faller's v/s non fallers) revealed a cut off score of 48.5 to distinguish fallers from non-fallers. This is in contrast to older studies wherein cut-offs of 45 and 40 were proven to help distinguish fallers from non-fallers. A reason for the difference in these cut off may be non- uniformity in the scoring system across the 14 items. ROC curve analysis of combination of Items B11 and B13 revealed a cut off score of 6.5 out of 8 to help differentiate fallers from non-fallers. This minimization will help save time in analysis of risk fall in elderly individuals and also help overcome the hurdle experienced by the lack of consistency in the cut-off of the total score. Since the balance assessment in elderly has now been limited to 2 items (based upon best ability to predict falls) the ambiguities that arose in the total score cut off can be overcome.

## LIMITATIONS AND FUTURE SCOPE OF STUDY

Some of the limitations in this study indicate that the results should be interpreted with caution. The sample size chosen was relatively small as it was a preliminary study. The Sample was assessed under varying environmental conditions which could lead to variation in the analysis. Also the sample was relatively low functioning which could lead to a bias in interpreting the results. Since the fall history was collected based on subjects' recall of the past six months there could be an error in data collection. It is suggested that similar studies be performed with institutionalized elderly individuals. Various subsets of the BBS can be matched to the group's functional level to more accurately identify fall risk and prospective studies can be performed to test the interpretation of this present study.

## CONCLUSION

The objective of this study was to determine if individual items or a combination of BBS items would have greater overall accuracy than the total BBS, based on their sensitivity and specificity. Individual item analysis showed that using selected BBS items may be as useful and accurate in classifying people based on fall history as using the total BBS score which would improve efficiency. A dichotomous approach to scoring may eliminate some of the scoring variability and ambiguity and seems to hold promise as a system that could be used to measure fall risk but these exploratory results need to be investigated prospectively.

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