Comparison of the Berg Balance Scale and Fullerton Advanced Balance Scale to predict falls in community-dwelling adults

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Abstract. [Purpose] The purpose of this study was to investigate and compare the predictive properties of Berg Balance Scale and Fullerton Advanced Balance Scales, in a group of independently-functioning community-dwelling older adults. [Subjects and Methods] Ninety-seven community-dwelling older adults (male=39, female=58) who were capable of walking independently on assessment were included in this study. A binary logistic regression analysis of the Berg Balance Scale and Fullerton Advanced Balance Scale scores was used to investigate a predictive model for fall risk. A receiver operating characteristic analysis was conducted for each, to determine the cut-off for optimal levels of sensitivity and specificity. [Results] The overall prediction success rate was 89.7%; the total Berg Balance Scale and Fullerton Advanced Balance Scale scores were significant in predicting fall risk. Receiver operating characteristic analysis determined that a cut-off score of 40 out of 56 on the Berg Balance Scale produced the highest sensitivity (0.82) and specificity (0.67), and a cut-off score of 22 out of 40 on the Fullerton Advanced Balance Scale produced the highest sensitivity (0.85) and specificity (0.65) in predicting faller status. [Conclusion] The Berg Balance Scale and Fullerton Advanced Balance Scales can predict fall risk, when used for independently-functioning community-dwelling older adults.

Key words: Berg Balance Scale, Fullerton Advanced Balance scale, Receiver operating characteristic

INTRODUCTION

Falls are the leading cause of health hazard and functional limitation in the elderly people over (>65 yrs)1). Fall-related injuries such as fractures, musculoskeletal pain, and traumatic brain injury reduced independent activity and quality of life2). However, falls may be prevented if the risk factors are identified through early precise assessment, and if interventions designed to reduce the fall risk are implemented3). Thus, valid and reliable clinical assessment methods are needed to identify the fall risk, and to serve as a tool for evaluating outcomes following intervention in clinical setting4). Performance-based assessment tools that are sensitive to subtle changes in the balance ability and capable of classifying older adults at different levels of fall risk may prove especially useful5).

Among the clinical assessment tools, the Berg Balance Scale (BBS) is currently the most commonly used clinical test to assess balance ability in elderly. Several studies have found that the BBS can predict the fall risk in a community-dwelling older adults6). However, BBS has been shown to be less predictive because of a ceiling effect, which may occur if the participants can walk independently in the community6, 7).

The Fullerton Advanced Balance (FAB) scale was developed as a performance-based measure to assess the subtle changes
in a multiple dimension of balance ability. The FAB scale is recommended to predict the fall risk in higher-functioning older adults as it includes criteria to evaluate multiple dimensions of balance ability.

The purpose of this study was to investigate and compare the predictive properties of BBS and FAB scales relative to fall risk, in a group of independently-functioning community-dwelling older adults.

SUBJECTS AND METHODS

Ninety-seven community-dwelling older adults (male=39, female=58) who were capable of walking independently (without aid) during the assessment were included in this study. Exclusion criteria were: (1) history of any orthopedic injury or surgery within 3 months, (2) other disease and conditions that could influence standing and gait, (3) cognitive impairment that might impair the ability to communicate reliable information about fall status and frequency.

Prior to initiation of the study, all participants were sufficiently informed about the research procedure. They agreed to the publishing of their study data, and signed informed-consent forms. All participants completed a general characteristics questionnaire documenting their gender, age, and fall frequency. The participants were assessed randomly to investigate their balance function, using the BBS and FAB scale. Any criterion that was duplicated between the BBS and FAB scales was performed only once, and scored on each scale to minimize learning effect. Fall history was assessed by asking the participants how often they had fallen during the last 6 months, and 2 or more falls were considered to have a positive fall history. A fall was defined as any event that led to an unplanned, unexpected contact with a supporting surface, and excluded falls resulting from unavoidable environmental hazards, such as a chair collapsing.

For statistical analysis, SPSS Statistics version 18.0 (IBM Corp, Armonk, NY, USA) was used. Two statistical procedures were used to investigate the fall risk predictive properties of the BBS and FAB scale. Firstly, a binary logistic regression analysis was performed on the basis of the total BBS and FAB scores, to investigate a predictive model for fall risk. Secondly, a receiver operating characteristic (ROC) analysis was conducted to determine which total BBS and FAB scale cut-off score produced the optimal level of sensitivity and specificity. In determining optimal cut-off points, three methods have been generally used. Among of three methods, Youden index was used to measure the optimal cut-off value in present study. Youden index utilizes the maximum of vertical distance of ROC curve from the point (x, y) on diagonal line. This study was approved by the Kyungdong University Human Studies Committees.

RESULTS

The general characteristics of the participants are presented in Table 1. The results of the binary regression analysis revealed that a test of the full model was significantly reliable (N=97, $\chi^2=84.87$, p<0.001), and indicated that the total BBS and FAB scores were predictive of fall risk. The Hosmer-Lemeshow test, which used to formally evaluate the goodness-of-fit for logistic regression models, was nonsignificant (p=0.99), indicating that the assessed model was good. The overall prediction success rate was 89.7%, and the total BBS and FAB scores were significant (p<0.05) as a predictive variable for evaluating fall risk (Table 2). The BBS and FAB scales revealed similar accuracy in identifying fallers with two or more falls versus non-fallers, with the area under the ROC curve of 0.70 and 0.72 respectively. On the BBS, a cut-off score of 40-points

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Table 1. Demographic characteristics of the participants (mean ± SD)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Fallers (n=46)</th>
<th>Non-fallers (n=51)</th>
<th>Total (n=97)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>76.6 ± 4.0</td>
<td>71.5 ± 4.4</td>
<td>73.9 ± 4.9</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>158.2 ± 4.9</td>
<td>160.0 ± 5.5</td>
<td>159.2 ± 5.3</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>60.5 ± 5.6</td>
<td>62.7 ± 5.7</td>
<td>51.7 ± 5.7</td>
</tr>
<tr>
<td>Falls</td>
<td>2.4 ± 0.7</td>
<td>0.7 ± 0.5</td>
<td>1.46 ± 1.0</td>
</tr>
<tr>
<td>Total BBS score</td>
<td>35.4 ± 5.3</td>
<td>49.6 ± 5.7</td>
<td>42.3 ± 8.6</td>
</tr>
<tr>
<td>Total FAB score</td>
<td>17.0 ± 5.4</td>
<td>29.9 ± 5.9</td>
<td>23.8 ± 8.5</td>
</tr>
</tbody>
</table>

BBS: Berg Balance Scale; FAB: Fullerton Advanced Balance scale

Table 2. Predicted probability of falling as a function of total BBS and FAB scale scores

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total BBS score</td>
<td>0.26</td>
<td>0.11</td>
<td>6.32</td>
<td>1</td>
<td>0.01</td>
<td>1.3</td>
</tr>
<tr>
<td>Total FAB score</td>
<td>0.2</td>
<td>0.1</td>
<td>4.03</td>
<td>1</td>
<td>0.04</td>
<td>1.22</td>
</tr>
<tr>
<td>Constant</td>
<td>-15.59</td>
<td>3.5</td>
<td>19.8</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

BBS: Berg Balance Scale; FAB: Fullerton Advanced Balance scale
provided optimal sensitivity (0.82) and specificity (0.67). Moreover, on the FAB scale, a cut-off score of 22-points provided optimal sensitivity (0.85) and specificity (0.65) (Table 3).

### DISCUSSION

This study aims to investigate and compare the predictive properties of BBS and FAB scales in a group of independently-functioning community-dwelling older adults. The total BBS and FAB scores are a predictive measure of the fall risk among independently-functioning older adults. Specifically, for each point increase in the total BBS and FAB scores, there is a 30% and 22% increase (respectively) in the likelihood of older adults being non-fallers. As the optimal cut-off score of 40-points provides optimal sensitivity and specificity on the BBS, good sensitivity (82%) but poor specificity (67%) was observed. A previous study has proposed a cut-off score of 49 out of 56, with sensitivity of 77% and specificity of 86%5). The BBS specificity value in that study is higher than in our present study, because the participants in the previous study were comprised of older adults with higher levels of functioning. On the FAB scale, the optimal cut-off score of 22-points yields optimal sensitivity and specificity: a good level of sensitivity (85%), but poor level of specificity (65%) is evident. Another study has suggested a cut-off score of 25 points; however that study has only considered 5 criteria on the FAB scales to evaluate the possible cut-off score11). Schlenstedt et al.11) have reported lower sensitivity (67%) and specificity (58%) values obtained using the FAB scale, than those in the present study. This is because Schlenstedt et al.11) focus on the Parkinson’s patient.

In conclusion, the BBS and FAB scales are a predictive of fall risk when used with independently-functioning community-dwelling older adults. This study has several limitations. Firstly, data are obtained from only one region, and so our results may not be generalized. Secondly, other psychometric properties such as muscle strength, medication, and fear of falling that may affect balance function in older adults have not been considered. Further studies are needed that include data from various regions, and take into consideration the other psychometric properties affecting the balance function.

### REFERENCES

3) Hernandez D, Rose D: Predicting which older adults will or will not fall using the Fullerton Advanced Balance scale. Arch Phys Med Rehabil, 2008, 89: 2309–2315. [Medline] [CrossRef]

### Table 3. Predictive values for the BBS and FAB scale

<table>
<thead>
<tr>
<th>Test</th>
<th>AUC</th>
<th>Cutoff score</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBS scale</td>
<td>0.7</td>
<td>≤40/56</td>
<td>0.82</td>
<td>0.67</td>
</tr>
<tr>
<td>FAB scale</td>
<td>0.72</td>
<td>≤22/40</td>
<td>0.85</td>
<td>0.65</td>
</tr>
</tbody>
</table>

AUC: area under the curve; BBS: Berg Balance Scale; FAB: Fullerton Advanced Balance scale