Title: Further validation of the Balance Outcome Measure for Elder Rehabilitation

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ABSTRACT

Objective: To determine the concurrent validity of the Balance Outcome Measure for Elder Rehabilitation (BOOMER) with both the Berg Balance Scale and gait speed.

Design: Prospective cohort study

Setting: Two geriatric rehabilitation units

Participants: Elderly adults (n = 134) admitted to inpatient rehabilitation.

Intervention: Not applicable.

Main Outcome measures: The BOOMER consists of timed static stance feet together eyes closed, Functional Reach, step test and the Timed Up and Go test. Validity was determined using Spearman’s correlation coefficient comparing with the Berg Balance Scale and gait speed on admission and discharge. Responsiveness of the BOOMER was compared with the Berg Balance Scale and gait speed for the change scores between admission and discharge using Spearman’s correlation coefficient.

Results: The BOOMER demonstrated high to very high correlation with the Berg Balance Scale at admission ($\rho = 0.91; p < 0.01$) and discharge ($\rho = 0.89; p < 0.01$), and with gait speed at admission ($\rho = 0.67; p < 0.01$) and discharge ($\rho = 0.68; p < 0.01$). Change scores between admission and discharge for the BOOMER and Berg Balance Scale displayed moderate correlation ($\rho = 0.55; p < 0.01$), while those between the BOOMER and gait speed displayed only fair correlation ($\rho = 0.33 p <0.01$).

Conclusion: The BOOMER appears to be a valid measure of the standing balance construct as it demonstrated high correlation with another measure of balance, and moderate correlation with a measure of a related construct (gait speed). The BOOMER maybe a worthwhile alternative for more complex multi-item balance measures.

Key words: Validation studies, Balance and Postural Control, Aged, Geriatric Assessment, Rehabilitation
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<th>List of Abbreviations</th>
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<td>BBS</td>
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<td>Berg Balance Scale</td>
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<td>BOOMER</td>
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<td>Balance Outcome Measure for Elder Rehabilitation</td>
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<td>Confidence Interval</td>
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<td>Mini Mental State Exam</td>
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<td>Standard Deviation</td>
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<td>TUG</td>
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The Berg Balance Scale (BBS) is one of the most common and easily recognized measures of balance used in rehabilitation. It was originally developed to objectively measure balance in older adults. The scale comprises 14 items of static balance and functional tasks, and performance is determined using a five-point scale. Scores range from 0 to a maximal score 56 with scores over 50 representing good balance. The measure has been extensively investigated, and has been shown to have excellent psychometric properties of internal consistency, validity and reliability in people with neurological conditions including stroke and spinal cord injury. In addition, the BBS has been validated for use across a variety of clinical settings including acute care, rehabilitation and residential aged care and in different countries.

Despite the widespread use of this popular tool it is not without its limitations. It can typically take 10 to 20 minutes to administer which may be time-consuming in a busy clinical environment or may place a significant demand on patients especially if frail or unwell. Another limitation to the usefulness of the BBS in clinical settings is the limited knowledge about what a score or change in score actually indicates. For example, a score of 45 has been proposed to indicate a falls risk in community dwelling older adults, but even in this patient group cut-off scores ranging from 42 to 52 have been reported. Cut-off scores also vary for different settings and patient groups further limiting the clinical utility of the scale. In addition, the minimum clinically important difference has been demonstrated to vary depending on balance score and patient group.

Gait speed is frequently used as an indicator of overall functional ability in both clinical practice and research and is regarded as a valid, sensitive and reliable measure. It has been used with a variety of population groups across various settings. Reduced gait speeds have been associated with impairments such as reduced muscle strength, activity limitations and participation restrictions as well adverse outcomes and mortality. This suggests that gait speed has the potential to be of significance in many clinical settings, and provides a useful comparative measure in geriatric assessment.

The Balance Outcome Measure for Elder Rehabilitation (BOOMER) was specifically developed for use in rehabilitation and domiciliary settings with older adults, to be time and resource efficient, to adequately reflect the standing balance construct and be valid and sensitive to change. The BOOMER comprises four commonly used clinical measures; the
step test, the Timed Up and Go (TUG), Functional Reach (FR) and static stance feet together eyes closed; which were selected by an expert panel of physical therapists to be representative of the essential domains of the standing balance construct (static, dynamic, function). Performance on each of these four measures is then converted to a five-point ordinal scale, 0 to 4 with 4 representing good balance performance, resulting in a total score out of 16. The BOOMER has demonstrated high levels of internal consistency (Cronbach $\alpha > .87$) and has good validity with the motor component of the Functional Independence Measure and the Modified Elderly Mobility Scale. However, its validity against the BBS and other measures of physical function such as gait speed, has not been investigated. This study aims to examine the concurrent validity of the BOOMER with the BBS and with gait speed throughout the rehabilitation period and its responsiveness for change in performance between admission and discharge. We hypothesized that the BOOMER would be valid when compared to the BBS and gait speed.

METHOD

A prospective cohort study was conducted at two geriatric rehabilitation units in Southeast Queensland, Australia. Participants were people admitted consecutively for rehabilitation over a six month period. Measures were taken on admission and discharge. University and Hospital Human Research Ethics Committees approved this study. All participants had medical clearance to participate in this study.

To be included in this study, participants had to be admitted for rehabilitation that included a physical therapy component, able to follow simple instructions and be medically stable. Patients were excluded if they were unable to walk due to a medical condition such as paraplegia or tetraplegia, had a lower limb amputation and did not have a prosthesis or were unable to follow instructions. Demographic information obtained included age, gender, primary diagnosis, prior indoor walking aid and residential status prior to hospital admission. Discharge data collected included length of stay, indoor walking aid and residential status. Clinical information collected included the Mini Mental State Exam (MMSE) and the Functional Independence Measure (FIM). All participants received a multidisciplinary comprehensive rehabilitation program targeting their physical and cognitive impairments prescribed by their respective rehabilitation teams.
Each participating site involved in this study included all specified outcome measures routinely as a component of patient admission and discharge physical therapy assessment. A sample size of 102 was determined to be required to have a high level of correlation at 0.05 level of significance and 80% power. Each site was asked to collect data from consecutive patients admitted to their units who met the inclusion and exclusion criteria for approximately a six month period; with participant numbers to be reviewed at this time. Each site identified a study coordinator who was responsible for all data collection at that site ensuring that all measures were conducted according to standardised testing procedures detailed in a written study protocol, provided to all staff involved. In addition, all physical therapists (six) involved in the data collection were provided with training on all measures. On completion of the six-month data collection period, data was de-identified and sent to one investigator for data entry and analysis.

The primary outcome measures were the BOOMER, BBS and gait speed. Participants completed all four components of the BOOMER; the step test, TUG, FR and static stance with eyes closed. Performance for each component was recorded and then converted to the 5-point ordinal scale (0 to 4) of the BOOMER (Table 1). If participants were unable to complete any component, the BOOMER score for that component was recorded as 0. For the step test, the BOOMER score was based on the average of 2 trials (1 with each foot) and the TUG was performed at a comfortable pace. Participants completed 2 practice trials for the FR followed by 1 test trial which was recorded. In the static stance test, feet were together with eyes closed and 3 trials were performed; however, if the participant scored the maximum on the first trial, 30 seconds, then the two subsequent trials automatically scored 30 seconds giving a maximum total of 90 seconds. The total of the three trials was then converted to the BOOMER score (Table 1). Individual component scores were combined to provide an overall BOOMER score out of 16. Gait speed was measured using a 10 m walk test which included a moving start and finish.

**Data analysis**

Descriptive statistics were used to determine the mean and range of scores of all measures at admission and discharge and mean (95% CI) of the change in scores between admission and discharge for all measures. Differences in scores between admission and discharge were compared using paired t-test for parametric and Wilcoxon signed-ranks test for non-parametric data. To determine concurrent validity between the BOOMER with the BBS and...
gait speed throughout the rehabilitation period, that is, at admission and discharge, Spearman’s correlation coefficient was used. In addition, the responsiveness of the BOOMER to detect change in performance between admission and discharge was validated against the BBS and gait speed for the change scores between admission and discharge using Spearman’s correlation coefficient. A clinically meaningful result was determined by investigators a priori, as achieving a correlation coefficient of at least 0.7 which has been suggested to demonstrate evidence of validity between measures of a similar construct. All statistical analyses were conducted using SPSS v 17.0 and significance set at p < 0.05.

RESULTS

One hundred and thirty-four participants from two geriatric rehabilitation units in Southeast Queensland (Australia) were included in this study. Participant characteristics are presented in Table 2. No discharge data was available for seven participants due to being transferred to another facility due to an acute medical illness (4) or death (3). BOOMER, BBS, gait speed and FIM scores at admission and discharge from rehabilitation are presented in Table 3. On admission 15 (11%) participants were unable to complete any component on the BOOMER, scoring 0 and 18 were unable to complete the 10 m walk test. At discharge, two participants scored 0 on the BOOMER and three were unable to complete the 10 m walk test. By discharge from rehabilitation, BBS scores improved an average (95% CI) 9 (8 to 11) points (p<0.01), BOOMER scores had improved 3 (2 to 4) points (p<0.01) and gait speed had improved 0.19 (-0.56 to 0.87) m/s (p<0.01). The BOOMER demonstrated high to very high correlation with the BBS at admission (ρ = 0.91; p < 0.01) and discharge (ρ = 0.89; p < 0.01) and with gait speed at admission (ρ = 0.67; p < 0.01) and discharge (ρ = 0.68; p < 0.01). Change scores between admission and discharge for the BOOMER and BBS displayed moderate correlation (ρ = 0.55; p < 0.01) while those between the BOOMER and gait speed displayed only fair correlation (ρ = 0.33 p <0.01). Scatter plots illustrating the relationship between BOOMER scores with BBS scores and gait speed are presented in Figure 1.

DISCUSSION

The BOOMER appears to be a valid measure of the standing balance construct, demonstrating high correlation alongside a commonly used measure of balance, the Berg Balance Scale and with another construct, gait speed. The BOOMER has some clinical advantages over the BBS. The BOOMER takes approximately five minutes to complete, relative to 10 to 20 minutes for...
the BBS, making it particularly suitable for assessing balance in busy clinical settings or when
patients are frail or unwell.

Standing balance is a complex construct, evident by the number of tools available to
clinicians. Single-item tests offer the advantage of being quick to administer in a busy clinical
environment but provide limited information on the entire balance construct. Multi-item tests,
such as the BBS, can provide detailed information of many of the domains that comprise the
balance construct. However, these can be complicated, time consuming to administer or place
a physical burden on the patient. The BOOMER is a multi-item tool that is not time
consuming and provides information on the essential domains of the balance construct
including static balance and functional mobility.

The clinical utility of assessment tools is important to consider as this can affect use in
clinical practice. Tools need to be resource and time efficient and provide clinicians with
meaningful information. Gait speed has the advantage of being useful across a wide range of
conditions, abilities and sensitive enough to detect small changes. The BBS, like any
ordinal measure, has been demonstrated to suffer from floor and/or ceiling effects as well as
lack meaningful interpretation of change scores, particularly across diagnostic groups and
functional levels. In the current study the BOOMER was valid against both the BBS and gait
speed at admission and discharge providing us with confidence that BOOMER provides
clinicians with robust information. Further investigation is required of the BOOMER in
different settings, across varying functional levels and diagnostic groups. This would also
assist in determining the potential for the BOOMER to demonstrate floor and/or ceiling
effects. In addition, further research is required to ensure reliability of the BOOMER,
although this is anticipated due to the sound psychometric properties of the component items.

The ability of an assessment tool to be responsive, that is, detect change over time is another
important issue for clinicians when choosing an outcome measure. The minimum clinically
important difference for the BOOMER has previously been demonstrated to be a score of
three. In the current study, participants improved an average of three points between
admission and discharge, again suggesting that this was a clinically significant improvement.
Certainly a statistically significant difference was found between admission and discharge
scores on all measures (p < 0.01). The minimum clinically important difference for the BBS,
at least for people after stroke, has been suggested to be a score of six, though there was
limited agreement between clinicians’ opinion and this change score. A recent study adds support to the idea that a change of six points on the BBS indicates a clinical improvement, demonstrating that the minimum change score ranged from five to seven points depending on the initial score in a group of older adults. In the current study, the BBS score improved nine points, giving us confidence that participants in the current study clinically improved their balance.

The relationship between BOOMER and gait speed however appears to be more complex. The change in gait speed between admission and discharge was not statistically significant with an average (95% CI) 0.19 (-0.56 to 0.87) m/s recorded in the current study. A closer look at this relationship (Figure 1) does suggest that the relationship is reasonably flat perhaps up until a midrange score of for example, 8. However, for higher BOOMER scores, gait speed appears to increase more. Perhaps one reason for this finding is that different constructs are being measured; that is, balance and walking ability. Although these constructs are related with gait speed shown to be associated with balance performance in older adults and in those with stroke; other factors, such as lower limb muscle strength, may well contribute to gait speed and walking ability. Another possibility is the influence the use of walking aids may have made to the gait speed measure. When people present with reduced balance, clinicians will frequently prescribe a walking aid to improve safety in functional tasks including walking. In the current study, a high proportion of participants (78%) either did not use a walking aid or only used a single point stick, prior to hospital admission. However, by the time of discharge from rehabilitation, 50% of participants used some type of wheeled walker as their indoor mobility aid. This suggests that balance was still a major impairment for these participants and it is possible that the use of a walking aid enhanced their gait speed compared to not using a walking aid.

Study Limitations

This study is not without its limitations. Participants in the current study were patients undergoing rehabilitation within two rehabilitation units and had a range of diagnoses, though nearly 50% were recovering from some type of orthopaedic condition. Length of stay within the rehabilitation units was short, averaging 16 days. These findings, therefore, may not be applicable to a cohort of elderly people requiring more intensive or longer rehabilitation, for those with specific diagnoses such as stroke or for those living in the community.
CONCLUSIONS

In conclusion, the BOOMER is a valid measure of the standing balance construct, demonstrating high correlation with the BBS and gait speed in this group of elderly patients undergoing inpatient rehabilitation. Further research is required to investigate the BOOMER in additional settings, such as in a busy clinical environment or when patients might be frail or unwell, for example, an acute care or residential aged care setting. In addition, the relationship between BOOMER score and functional ability or discharge destination should also be investigated.
REFERENCES


Table 1. Scoring for BOOMER components.

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<tr>
<td>Step Test (average)</td>
<td>Unable</td>
<td>&gt; 0 and = 5</td>
<td>&gt; 5 = 8</td>
<td>&gt; 8 = 12</td>
<td>&gt; 12</td>
</tr>
<tr>
<td>TUGT (secs)</td>
<td>Unable</td>
<td>&gt; or = 30</td>
<td>&lt; 30 to = 20</td>
<td>&lt; 20 to = 10</td>
<td>&lt; 10 secs</td>
</tr>
<tr>
<td>FR (cms)</td>
<td>0</td>
<td>&gt; 0 = 15</td>
<td>&gt;15 = 20</td>
<td>&gt; 20 = 30</td>
<td>&gt; 30</td>
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<tr>
<td>Static Standing (eyes closed) (secs)</td>
<td>Unable</td>
<td>&gt; 0 to = 30</td>
<td>&gt; 30 to = 60</td>
<td>&gt; 60 to &lt; 90</td>
<td>90 secs</td>
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Table 2  Characteristics of participants (mean, SD or n, %).

<table>
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<th>Characteristic</th>
<th>Participants</th>
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<tr>
<td>Age (yr), mean (SD)</td>
<td>78 (11)</td>
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<tr>
<td>Males, n (%)</td>
<td>50 (37)</td>
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<tr>
<td>MMSE (0 to 30), mean (SD)</td>
<td>26 (4)</td>
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<td>Diagnosis, n (%)</td>
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<tr>
<td>Stroke</td>
<td>16 (12)</td>
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<tr>
<td>Other neurological condition*</td>
<td>17 (13)</td>
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<tr>
<td>Elective orthopaedic</td>
<td>18 (13)</td>
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<tr>
<td>Other orthopaedic†</td>
<td>30 (22)</td>
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<tr>
<td>Cardiac</td>
<td>13 (10)</td>
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<tr>
<td>Other set diagnoses combined‡</td>
<td>43 (30)</td>
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<td>Aid before admission, nothing or single point stick, n (%)</td>
<td>104 (78)</td>
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<tr>
<td>Living arrangements before admission, community dwelling, n (%)</td>
<td>126 (94)</td>
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<tr>
<td>Admission FIM score (0 to 135), mean (SD)</td>
<td>91 (15)</td>
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<tr>
<td>Discharge FIM score (0 to 135), mean (SD)</td>
<td>106 (13)</td>
</tr>
<tr>
<td>Length of stay (days), mean (SD)</td>
<td>16 (8)</td>
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*Refers to neurologic conditions other than stroke (eg, Parkinson’s disease).
†Refers to orthopedic diagnoses that were not elective, for example, fractured neck of femur.
‡A merged category including the categories of amputation, spinal cord injury, arthritis, pain, musculoskeletal, major multiple trauma, pulmonary, and burns.
Table 3  Mean (range) scores at admission and discharge. Mean (95% CI) difference between the discharge and admission scores, representing improvement.

<table>
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<tr>
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<th>Admission</th>
<th>Discharge</th>
<th>Difference (Discharge minus admission)</th>
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<tr>
<td>Berg Balance Scale (0 to 56)</td>
<td>33 (0 to 56)</td>
<td>42 (3 to 56)</td>
<td>9 (8 to 11)</td>
</tr>
<tr>
<td>BOOMER (0 to 16)</td>
<td>8 (0 to 16)</td>
<td>11 (0 to 16)</td>
<td>3 (2 to 4)</td>
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<td>Gait speed, m/s</td>
<td>0.64 (0.11 to 1.67)</td>
<td>0.82 (0.24 to 1.63)</td>
<td>0.19 (-0.56 to 0.87)</td>
</tr>
<tr>
<td>Functional Independence</td>
<td>91 (43 to 120)</td>
<td>106 (61 to 125)</td>
<td>14 (11 to 16)</td>
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Figure 1. Scatter plots for BOOMER scores with Berg Balance Scale score and gait speed at (a) admission, (b) discharge and (c) the difference between admission and discharge.