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Original Article

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Concurrent Validity of the Seven-Item BBS-3P with Other Clinical Measures of Balance in a Sample of Stroke Patients

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Purpose: The aim of this study was to investigate if the 7-item Berg balance scale (BBS) 3-point, which is a short form of the BBS (SFBBS), has compatible psychometric properties in comparison with the original BBS, and also to study the concurrent validity using a 10-meter walk test (10 mWT) and a timed up and go test (TUG), which are widely used with SFBBS in clinical settings.
Methods: A total of 255 patients who had experienced stroke participated in this cross-sectional study. We used results obtained from 188 patients who completed both 10 mWT and TUG. The three levels in the center of the BBS were collapsed to a single level (i.e., 0-2-4) to form the SFBBS. The concurrent validity was assessed by computing the Spearman coefficients for correlation among outcome measures and in between each outcome measure and the SFBBS. As there were four outcomes, the corrected p-value for significant correlation was 0.013 (0.05/4).
Results: Spearman coefficients for correlations and evaluation instruments for concurrent validity revealed significantly high validity for both of SFBBS and BBS ($r = 0.944$). 10 mWT and TUG were -0.749 and -0.770 respectively, which are in the high margin and are statistically significant ($p > 0.000$).
Conclusion: SFBBS has sound psychometric properties for evaluating patients with stroke. Thus, we recommend the use of SFBBS in both clinical and research settings.

Keywords: Balance, Psychometric properties, Validity, Stroke

INTRODUCTION

Keeping balance is a critical factor for daily activities.[1,2] Balance system is complicated due to multivariate factors such as vision, vestibular sense, proprioceptive sense, muscular strength and reaction time.[3] Diminished balance is a key predictor for falling[4] and it generally means reduced balance and insufficient mechanism for balance needed for preventing falling,[5] Loss of balance that leads to instability makes patients with neurological disorders more prone to serious damages such as loss of functional independence, reduced daily activities, limited involvement, and high risk of falling.[6]

To provide a precise understanding with regards to balance, a standardized evaluation of balance is essential in order to assess the effectiveness of intervention after neurological injury.[7] To utilize the balance test effectively in clinical settings, an instrument should have significant psychometric properties, and it should not be lengthy to administer.[7,8] Various assessments exist, but there is no one measurement that can be used to evaluate every aspect of the entire population in a specific setting.[9] However, due to multidimensional properties of the balance system, it is not useful to design only a single balance assessment capable of predicting a person's risk for falling and minimize the ceiling and floor effect at the same time.[10]

The Berg balance scale (BBS)[11] is a test with five different scoring scales. This instrument is widely used to evaluate balance function in elderly people and in patients with stroke.[12,13] BBS has been previously proven to be significant for use for psychoanalysis (including having high inter-rater reliability, high concurrent validity, and sat-

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isfactory responsiveness).[12,13] However, Chou et al.[14] mentioned that several factors limit the use of BBS. First, BBS takes 20 minutes to complete; such a procedure is not convenient in daily clinical use. Patients with stroke and those who cannot take a test for a long time may also have a hard time completing the procedure.[15] Especially, for an inexperienced tester, this will be more difficult. Thus, in order to increase the availability of BBS, we suggest that BBS be simplified.[14] Even though there is scarce evidence, some researchers insist that test with four or five scoring systems are better instruments (e.g. for the testing of balance) than those with three scoring systems in the aspect of psychometric properties.[16] However, some documents suggest that the higher scoring systems do not always indicate better psychometric properties.[17,18]

BBS takes approximately 20 to 30 minutes to complete, with the exact timing depending upon sense, movement and perceptional function of the subject.[19] However, the 7-item Berg balance scale 3 point (7-Item BBS-3P), which is a condensed version of BBS, only takes approximately about 10 minutes (www.rehabmeasures.org). This is because 7-Item BBS-3P contains only half of the items of BBS.[14] When we use a relatively simple and easy predictive model of falling, we can find out if an individual is at high risk and persuade him or her to be involved in a prevention program.[1] For these reasons, 7-Item BBS-3P is a much faster and more comfortable instrument that requires less time and effort than BBS does. Thus, this method can be used as a screening tool. This is deemed to be an ideal attempt to simplify the process of the test and retain the psychometric properties at the same time.

Recently, in South Korea, Park et al.[20] and An et al.[21] compared the concurrent validity of the 7-Item BBS-3P test with previous studies. However, these are mainly focused on evaluating the activities of daily living (ADL), rather than on the assessment of balance. Furthermore, in clinical settings, 10-meter walk test (10 mWT), timed up and go test (TUG), functional reach test and single limb stance test are preferred than FMA, as these assessment tools are considered to be gold standards in clinical settings.[22] Even though there are various articles about comparing BBS and SFBBS, there has been no research done regarding correlation among the assessment tools, which are often used in clinical settings. The purpose of this study is to see if 7-item Berg balance scale 3-point, which is a short form of BBS (SFBBS), has compatible psychometric properties in comparison with the original BBS, and also to study the concurrent validity using a 10-meter walk test (10 mWT) and a TUG, which are widely used with SFBBS in clinical settings.

METHODS

1. Subjects

Four subjects were selected by using G*Power program 3.1.9.2 for Mac,[23] based on its use the previous studies,[14] with an effect size of p = 0.99, (1-β) 95% confidence level, and a level of significance 0.05 for analysis on a correlation analysis. However, this value is deemed to be less than a real number of subjects, due to the significantly high level of correlativity (r = 0.99) quoted by Chou et al. Actually, in this study, since culture and research settings are different among different countries, we selected 16 subjects based on a correlativity of 0.5, and selected 225 subjects in total, since it was reported that the sample size for examination of assessment tools should be more than 5 times greater than the minimum number of items.[24] Among all of subjects, only 188 subjects completed 10 mWT and TUG, so only their results were used in this article.

We selected subjects based on following conditions: first, patients with balance disorder due to neurological injury; second, those who can walk 10 meters without any support device, third, those without any cardiovascular or musculoskeletal diseases; forth, those who can comply with instructions given by therapist and also those who score over 24 in the mini-mental status examination-Korean version (MMSE-K), and fifth, those who voluntarily agree to participate in the study after being given the explanation, including the aim and outline of the study. In addition, we also notified subjects that any of the data or documents would not be used for other purposes except for this study. Furthermore, we explained to the subjects about the confidentiality and cancellation policies for participating in the study.

2. Measurement tools and methods

1) BBS

BBS consists of 14 items, and was originally designed to screen elderly patients who are at risk for falling. BBS is divided into three different sections: sitting, standing, stepping.[11,13] Each section's score ranges from zero to four (five scales), and BBS' total score ranges from 0 to 56. The psychometric properties of this test are regarded to be sufficient for testing patients with stroke.[12,13,25]

2) SFBBS

SFBBS is the simplified version of the original BBS. The five scales (0-1-2-3-4) of BBS are condensed into three scales in SFBBS. Although the score system of the original test was used in this study, the third and fourth scale (2 points and 3 points) are excluded, which implies that the middle score was given to subjects who achieved the second easiest level but who could not complete the most difficult task. Since SFBBS-3P and the original BBS are considered to have compatible psychometric properties, we used both the original BBS and SFBBS-3P in this study to develop the simplified measure and brief test. In the study, when using data obtained from SFBBS-3P, we documented 0-2-4 levels instead of five levels of the original test. The seven items that are used in this study are, reaching forward with an outstretched arm, standing with eyes closed, standing with one foot in front, turning to look behind, retrieving an object from floor, standing on one foot, and moving from sitting to standing. The full possible score is 28 points.[14]

3) TUG

TUG is for evaluating functional dynamic shift done by subjects. Subjects sit on a chair with upper limb support, stand up and walk at a steady speed for 3 meters, and then come back to the same chair.[26] The longer it takes them to finish the test, the lower the patients' functional ability is scored. This test has significantly high inter-rater reliability and intra-rater reliability, which are r = 0.99 and r = 0.98, respectively.[27,28] The measurement was performed in triplicate and the mean was retained.

4) 10 mWT

In 10 mWT, raters measure the time during which the subjects walk, and evaluate their ability to walk. Subjects are asked to walk for a total length of 14 meters. The first 2 meters and the last 2 meters are considered to be adjustment time for acceleration and deceleration, respectively. Thus, the middle 10 meters without the first and last 2 meters are measured.[29,30] If the recorded time is long, it means that the subject's ability to walk is diminished. High speed refers to ICC = 0.97, and low speed refers to 0.94,[31] with regards to test-retest reliability. The intra-rater reliability of the test is ICC = 0.97-1.00,[32,33] and inter-rater reliability is 0.998,[34] which indicates a significantly high reliability. The measurement was performed in triplicate and the mean was retained.

3. Data analysis

We carried out an analysis of frequency and a descriptive statistic analysis in order to interpret the general information collected about subjects. Also, we used Spearman correlation coefficient to identify correlation between BBS, SFBBS, 10 mWT, and TUG, and to measure concurrent validity. Furthermore, the degree of correlation in regards to the correlation coefficient was interpreted as poor or absent ($r < 0.25$), fair ($r = 0.25$-0.49), moderate-to-good ($r = 0.5$-0.75), or good-to-excellent ($r > 0.75$).[35] When the test was carried out repetitively, we applied Bonferroni adjustment and adjusted the alpha level in order to minimize type 1 error.[35] The p-value, which was adjusted in regards to significant correlation, was 0.013 (0.05/4). Mac SPSS ver. 22.0 (IBM, Armonk, NY, USA) was used for statistical analysis of the collected data.

RESULTS

General information of subjects in the study and the average and standard deviation (SD) of shown in Table 1. The average age of subjects was 58.45 (SD 13.37) years. Male patients accounted for 64.7% of the total number of subjects, and subjects who had any form of brain infarction took up 52.2%. Also, the percentage of subjects who used support device was 24.7%, and that of subjects who wore ankle foot orthoses was 11%. And, participants of outcome

Table 1. Demographic and clinical characteristics of participants (n = 255)

	Value, mean ± SD
Age (year)	58.45 ± 13.37
Gender (%)	
Male	165 (64.7%)
Female	90 (35.3%)
Side of hemiplegic	
Left	120 (47.1%)
Right	119 (46.7%)
Bilateral	16 (6.3%)
Type of Stroke	
Ischemic	133 (52.2%)
Hemorrhagic	122 (47.8%)
Weight (kg)	64.10 ± 9.42
Height (cm)	165.66 ± 7.86
MMSE-K	26.56 ± 2.40
Use of assistive device	62 (24.7%)
Use of AFO	28 (11%)

MMSE-K: mini-mental states examination-Korean version, AFO: ankle foot orthosis, SD: standard deviation.

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Table 2. Outcome measures score of participants (n=255)

	Value, mean±SD
Berg balance scale	45.14±7.54
Short form Berg balance scale	19.81±4.56
10 meter walk test (n=188)	16.19±11.07
Timed up and go test (n=188)	17.61±12.28

SD: standard deviation.

Table 3. Concurrent validity of scores for the balance measures

	BBS	SFBBS	10 mWT	TUG
BBS	1	0.944*	-0.796*	-0.816*
SFBBS		1	-0.749*	-0.770*
10mWT			1	-0.922*
TUGT				1

Correlation coefficients with 95% confidence intervals were obtained using Spearman rank correlation. The CIs are given where significant correlations were found, *p<0.000.
BBS: original 5 level (0-1-2-3-4) Berg balance scale, SFBBS: simplified 3 level (0-2-4) short form Berg balance scale, 10 mWT: 10-meter walk test, TUG: time up and go test.

measures scores shown in Table 2. The average score of BBS was 45.14 (SD 7.54), and that of SFBBS was 19.8 (SD 4.56).

Concurrent validity

In comparison with SFBBS, Spearman coefficient with assessment tool for concurrent validity shows that the values of BBS, 10 mWT, TUG are 0.944, -0.749, and -0.770, respectively, which are all statistically significant (p<0.000) (Table 3).

DISCUSSION

Through a measure that has sound psychometric properties, both clinicians and researchers are able to monitor and manage balance performance and the status of patients who have had a stroke. The results of this study show similar concurrent validity with 10 mWT and TUG in both SFBBS and the original BBS, which strongly suggests SFBBS is psychometrically similar to the original BBS.

Recent studies[17,36] revealed that increasing the scoring levels does not directly lead to the enhancement of psychometric properties of the measure. These results imply that three scoring levels are sufficient in order to evaluate balance performance for patients with stroke, and thus, tests that have more than three scales should be considered for simplification. There are many ways to reduce the scoring levels from 5 to 3. For example, in the score system with 0-1-2-3-4, we can put middle three levels into one scale or make the lowest two levels into one and the highest two levels into one, respectively. In this study, the middle scale might be considered as "partially completing one item", with the lowest score meaning "not being able to carry out the task" and the highest score meaning "accomplishing the task completely". When the lowest scale and the highest scale are summed, the ceiling and floor effect of the measure will increase. For this reason, we used SFBBS, in which the middle scales are put into one. Chou et al.[14] who developed 7-time BBS, recommended the use of the 7-item BBS-3P in clinical and research settings because it has sound psychometric properties that are similar to those of the original BBS, and the procedure for administering it is simple and short.

The score range of the simplified 3 scale measure is identical to that of the original measure (e.g., SFBBS: 0-2-4; original BBS: 0-1-2-3-4), and this benefits the comparison of the SFBBS and the original BBS. Both in clinical and research settings, since scores of the SFBBS are linearly transformed into a score range as that of the original BBS, the psychometric properties of the SFBBS are not changed and thus, it is possible to convert both assessment tools into a 0-1-2 scoring system of each item. In addition, Wang et al.[12] demonstrated that a simplified scoring system showed similar responsiveness to that of the original assessment and that SFBBS showed sensitivity to important changes, as the original BBS also did. According to previous studies,[17,37] from the perspective of psychometric properties, up to 7 items (e.g., standing unsupported and shifting from one chair to another) in the original BBS were found to be redundant because their application did not provide any additional psychometric information.

Park et al.[20] and An et al.[21] articles were designed to identify correlations between the modified Bathel index (MBI), the Fugl-Meyer assessment (FMA) and the postural assessment scale for stroke (PASS). Through this research, inter-rater and intra-rater reliability were confirmed. For this reason, in our study, the inter-rater and intra-rater reliability of data that was obtained from the simplified measures was not calculated. However, research on test-retest reliability demonstrated good reliability (ICC=0.99)[14,38] and satisfactory internal consistency (Cronbach's alpha=0.96)[14] for patients with stroke. Furthermore, Intra-rater reliability was 0.97 at ICC=0.79[21,39] and inter-rater reliability was 0.96 at ICC=0.83[20,39] as reported in previous research. For this reason, in this study, we conducted re-

search on validity except for reliability.

In the research on validity for patients with stroke,[14] the correlation between the original BBS and SFBBS retained high concurrent validity (r= 0.99). Moreover, scores for all of the SFBBS exhibited equivalent and high convergent validity with scores for the BI (r= 0.84-0.86) and with scores for the FMA (r= 0.66-0.68).[14] In domestic research, the study on comparing the original BBS with SFBBS showed r= 0.92[21] and 0.93,[20] which are consistent with our study. Moreover, research on patients with hip/knee arthroplasty, not with neurological disorders, resulted in r= 0.97 and 0.92,[40] which also correspond to our study. Furthermore, we verified concurrent validity with 10 mWT and TUG for the first time in the application of SFBBS, and we found that in comparison with SFBBS, 10 mWT (r= -0.749) and TUG (r= -0.770) are in high correlation.[35] On the basis of these results, SFBBS is considered to reflect the ability of dynamic balancing, including static balancing.

In comparison with the original BBS, this study improved the text with respect to three different aspects. Firstly, the total number of test items are reduced to half. Secondly, the scoring system was simplified to three score levels, so that possibility of inconsistency during the evaluation dropped to half. Lastly, SFBBS requires a smaller number of assessment tools, for example, in SFBBS, there is no "placing alternate foot on stool" item, so that there is no need to have that device on-hand. Overall, all of these improvements lead to a reduction in time required to complete the test, which can be finished in 10 minutes, whereas the original BBS usually needed 20 to 30 minutes to finish. These advantages reduce the possibility of incomplete collection of data and enhance the efficiency of the test. Furthermore, it is highly recommended to use SFBBS instead of the original BBS in the that scores of subjects using SFBBS showed excellent agreement with those achieved using the original BBS,[14] and it is mentioned that the SFBBS is especially useful when the time available for the test is not enough, such as at follow-up or when the subjects are too weak to stand lengthy examinations.

This study had a few limitations. In order to minimize the effects of spontaneous recovery of the disease on the results of the study, patients with chronic stroke were primarily chosen to be our subjects in the study. Future research to may be needed on the clinical utility of SFBBS as to the average duration of the disease and with regards to examining subjects who have decreased balance due to general musculoskeletal disorders. In addition, since items affecting the ability of balancing are various, it is necessary to look for items that are redundant in other sections in order to increase clinical utility and reduce the redundancy of the assessment items and relevance with several assessment tools, including recognition items. In conclusion, SFBBS has sound psychometric properties to be used for testing patients with stroke, and is deemed to be sufficiently useful. The study has added these results strengthen the evidence that the SFBBS is valid to be used in the stroke rehabilitation. Therefore, we recommend the use of SFBBS in either a clinical or a research setting.

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