ORIGINAL ARTICLE

Psychometric Properties of the Berg Balance Scale in a Community-dwelling Elderly Resident Population in Taiwan

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Background/Purpose: To investigate the psychometric properties (acceptability, internal consistency reliability, interrater reliability, construct validity) and identify the most challenging items of the Berg Balance Scale (BBS) for elderly people living in the community.

Methods: A total of 268 community-dwelling adults 65 years of age or older volunteered to participate in this study. Each subject's performance was assessed with the BBS, timed up and go (TUG) test, and usual gait speed. For testing interrater reliability, the other 68 community-dwelling older adults who met the criteria were also recruited.

Results: The BBS demonstrated good internal consistency reliability (Cronbach's $\alpha = 0.77$), good interrater reliability ($ICC_{2,1} = 0.87$), and moderate correlation with the TUG and usual gait speed (Spearman's $\rho = -0.53$ and 0.46, respectively). The BBS score of the mobility/IADL (instrumented activities of daily living) able group was also significantly higher than that of the disabled group. Among all items on the BBS, tandem stance (item 13) and one-legged stance (item 14) were found to be the most challenging items for the subjects in the sample.

Conclusion: The results of this study suggest that the internal consistency reliability, interrater reliability, and construct validity of the BBS are adequate for measuring balance in community-dwelling older adults. Among all items in the BBS, the tandem stance and one-legged stance are the most challenging items. Further study of their applicability for screening use in the community is warranted. [*J Formos Med Assoc* 2006;105(12):992–1000]

Key Words: Berg Balance Scale, community, older adults, psychometric testing

Balance deficits in elderly adults can arise from the process of aging, such as age-related changes associated with the sensory system (vestibular, visual, somatosensory) or diseases such as cerebrovascular accident, arthritis, peripheral neuropathies, or disuse due to immobility.[1] Balance is maintained when all the forces acting on the body are balanced so that one's center of gravity is controlled within the base of support in static postures, during movement, and when responding to external disturbances.[2,3] Balance can be broken down into three aspects: steadiness (the

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ability to maintain a given posture with minimal extraneous movement or sway), symmetry (equal weight distribution between the weight-bearing components), and dynamic stability (the ability to move within a given posture without loss of balance).[4] According to Berg and coworkers, balance deficit is identified as the individual having difficulty in changing positions, maintaining balance in more challenging positions (such as positions with a smaller base of support or higher center of gravity) or in more challenging situations (such as an increased range of motion or speed of movement).[2,5] Individuals with balance deficit may require assistance or more time to complete daily activities; thus, they reduce the speed of performing a daily task (i.e. achieve a lower number of repetitions per unit of time), exhibit greater postural sway, and encounter a greater threat to their safety.[2,4] Research has shown impaired balance to be a major factor associated with falls,[6–8] future disablement,[9] institutionalization, or even death[10,11] in older adults. Therefore, balance performance in the older individual deserves special attention from medical professionals and researchers. If the balance deficits of older adults can be identified early, health care professionals will be able to develop effective strategies to prevent subsequent decline in physical function.

A psychometrically sound balance assessment instrument is useful in documenting the balance performance of independent older adults, monitoring changes, and identifying those at an early phase of deterioration and in need of intervention as early as possible. The Berg Balance Scale (BBS) was originally developed to assess balance performance in geriatric persons or geriatric patients.[1] It has been widely used in elderly adults with various balance deficits.[12–22] The BBS can be easily administered in community settings, and its application to the assessment of balance performance in community-dwelling older adults has been suggested.[23–25] Although the reliability and validity of the BBS have been shown to be satisfactory in geriatric patients,[1,26–28] the psychometric properties of the BBS have rarely been examined in elderly, community-dwelling residents,[29–31] and never in a Taiwanese community-dwelling older population. A number of studies have reported a ceiling effect when the BBS was applied in community-dwelling older adults.[29–31] Because psychometric properties are sample-dependent,[32] the psychometric characteristics of the BBS in diverse populations of community-dwelling elderly residents need to be examined.

The use of the most challenging items in the BBS, such as the "tandem stance", "one-legged stance", "alternating foot", and "look behind" items, have been suggested for assessment of balance performance in community-dwelling older adults.[29–31] Those challenging items of the BBS have not been similarly identified in other international populations with different cultures and lifestyles. The challenging items identified would help clinicians and researchers better understand older adults' balance decline sequence and guide screening and intervention programs. Thus, the purposes of this study were to examine the psychometric properties of the BBS in older community-dwelling residents in Taiwan and to identify the most challenging items on the BBS for this population. The specific aims of this study were to: (1) investigate the acceptability of the BBS by reporting its score distribution (mean/mode score, minimal and maximal score), as well as ceiling and floor effects; (2) examine the internal consistency reliability (Cronbach's α) of the BBS; (3) examine the interrater reliability of the BBS; (4) examine the construct validity of the BBS; and (5) identify the more challenging items for community-dwelling older adults in Taiwan from item response profiles.

Methods

Subjects

To identify older adults' balance deficits early, subjects were recruited from five community centers in Hualien, Taiwan, through local advertisements. Volunteers who met the inclusion/exclusion criteria were asked to participate in this study. The

inclusion criteria were: (1) age ≥ 65 years; (2) living independently in the community; (3) independent in self care activities (eating, dressing, bathing, getting in and out of bed, using the toilet);[33] and (4) able to follow instructions in order to perform the tests required in this study. Due to safety concerns, the exclusion criteria were unstable high blood pressure or heart disease. However, no one was excluded by these exclusion criteria.

Procedure

Subjects signed the institutional review board-approved informed consent form prior to being approached by the tester in this study. Each subject was first interviewed to obtain his/her demographic information, personal background information, medical history, exercise habits (e.g. frequency, duration, and types of exercise), self-perceived health status (healthier, same, less healthy), and ability to perform tasks in the mobility-related functions domain[34,35] and instrumented activities of daily living (IADL) domain.[36] Subjects were asked if they were able, needed help, or were unable to perform the tasks in the mobility-related functions domain (to walk several blocks and to walk up and down stairs) and IADL domain (preparing meals, shopping, doing light housework, taking medication, using transportation, using the telephone, handling finances). Older adults who reported at least one "need help" or "unable" to perform were categorized into the "disabled" group, whereas those who could perform all items independently were considered to belong to the "able" group.

Subjects then underwent the three performance-based evaluations, the BBS, timed up and go (TUG) test, and usual gait speed, in a predetermined random order. One trained tester (physical therapist) who was not cognizant of the purposes of this study performed all the measurements. Subjects were allowed one practice trial for the TUG to ensure they fully understood the task before they were asked to perform the test twice. For the TUG and usual gait speed, the response measures were the means of the two trials. Before administering the BBS, the rater read the standardized instructions of each item on the BBS and then was trained in administering the BBS by an experienced physical therapist who has routinely used the BBS. The rater also practiced using the BBS on geriatric patients in clinics for 1 month to become familiar with the rating criteria and verbal instructions. Prior to the study, the rater rated five older adults simultaneously with the experienced physical therapist to clarify and ascertain the scoring criteria.

For the interrater reliability, another two raters (a physical therapist and an occupational therapist) rated older adults' balance performance using the BBS individually. Half of the older adults were first rated by rater A and then by rater B, whereas the other half was rated by rater B first and then by rater A. The raters who administered the test were blinded to each other's results. Before administering the BBS, the two raters read the standardized instructions for each item on the BBS and then practiced on each other to familiarize themselves with the rating criteria and verbal instructions. The two raters then rated four community-dwelling older adults simultaneously but individually (two received verbal instructions from rater A and the other two received verbal instructions from rater B) to clarify possible disagreements on the BBS scoring.

Instrumentation

The BBS assigns an integer score between 0 (poorest) and 4 (best) to the performance of each of 14 different tasks.[26] These tasks assess older adults' balance performance in common everyday life activities, progressing from stable positions to position changes and finally to upright positions with various maneuvers to challenge balance (e.g. eyes closed, feet together, picking up object, turning, alternate stepping, and narrowed base of support).[26] These tasks were standing unsupported, sitting unsupported, moving from sitting to standing, moving from standing to sitting, transferring weight, standing unsupported with eyes closed, standing unsupported with feet together, reaching forward, picking up an object from the floor, turning to look behind, turning

360°, alternately placing the feet on a step, maintaining a tandem stance, and standing on one leg. All items were coded the same way, i.e. a higher score means better performance. Each item had standard criteria for scoring based on the individual's performance. The lowest score for the entire scale is 0; the highest is 56.

Previous studies have shown the interrater reliability (intraclass correlation coefficient, ICC = 0.98[1] or $r_s = 0.88$[37]) and test–retest reliability ($ICC_{(2,1)} = 0.98$)[38] of the BBS in various elderly populations to be high. BBS scores also showed moderate correlation with Dynamic Gait Index (Spearman's $\rho = 0.67$)[39] and center-of-pressure measures of body sway during still and perturbed standing (Kendall coefficient of variance = −0.40 to −0.67).[38] The BBS score can discriminate between elderly people who are prone to falling and those who are not prone to falling.[37,39] A cut-off score of 45 on the BBS is relatively good for identifying people who are not prone to falling (specificity of 90%).[40]

The TUG assesses an individual's functional mobility.[41] This test records the time (in seconds) required for a subject to stand up from a chair, walk 10 feet forward, turn around, return to the chair, turn around, and sit down. Timing of the test begins at the word "go" and stops when the subject sits back down on the chair. The longer the time needed, the worse the performance. Its intratester and intertester reliability have been reported as high (ICC = 0.92–0.99)[41–43] and its test–retest reliability has been found to be acceptable (ICC = 0.56) in a group of community-dwelling older adults.[43] Its construct validity has been examined through correlations with gait speed (Pearson's $r = 0.75$), postural sway ($r = -0.48$), and the Barthel Index ($r = -0.79$).[41,42,44]

Gait speed was the strongest predictor of self-perceived physical function in the elderly, both in the community and in nursing homes,[45] and has been associated with falling in elderly individuals.[46] Subjects walk straight across a 50-foot distance twice consecutively at their usual speed as a tester records the time with a stopwatch. The speed (meters/second) of this walking was calculated and the mean of two trials was used for data analysis. Gait speed has been shown to be a reliable and valid measure of the ability to walk in older adults (> 60 years of age).[47] The test–retest reliability of usual speed was high ($ICC_{(2,1)} = 0.94$) in hemiparetic individuals after stroke,[48] and the interrater and intrarater reliability have also been reported as high (ICC = 0.90–0.96) in normal adults (age, 20–79 years) and in post-stroke individuals.[49,50] Gait speed has good predictive validity as being the strongest independent predictor of self-reported physical function in community-dwelling and nursing home residents.[45]

Data analysis

The subjects' demographic data and characteristics were examined using descriptive statistics. The psychometric properties of the BBS were tested through evaluation of its acceptability, internal consistency reliability, interrater reliability, and construct validity.

The acceptability of each scale was determined by its score distribution;[51] the mean score should be near the scale midpoint, or the scores should be symmetrically distributed around the midpoint of the scale, and the ceiling and floor effects should be < 15% of the subjects.[52] The internal consistency reliability of the BBS was examined using Cronbach's α. A Cronbach's $\alpha > 0.7$ indicates that a test is adequate for group comparison.[53] The interrater reliability of the BBS was examined by the ICC. An ICC value > 0.75 indicates good reliability.[54]

The construct validity of the BBS was tested by: (1) the relationship of the BBS with the TUG and usual gait speed using Spearman's ρ correlation coefficient to determine convergent validity of the BBS and; (2) by comparing the BBS score difference between the mobility/IADL able and disabled group using Mann–Whitney tests to determine the discriminant validity of the BBS.

The profiles of responses from the older adults' performances on each item of the BBS were also examined, and the most challenging items in the

BBS were identified by the score distribution in each item.

Results

A total of 359 older adults were approached. Of these, 82 subjects were younger than 65 years, and nine declined to participate due to time constraints, leaving 268 subjects who met the selection criteria and completed all the tests. In the sample, 149 (55.6%) were males and 119 (44.4%) were females; the mean age was 73.8 ± 5.18 years (range, 65–90 years). Slightly more than two-thirds (67.9%) of the subjects reported two or more comorbidities. Vision problems (72.8%), high blood pressure (42.9%), and arthritis (23.9%) were the three medical complaints most often reported. The most commonly used assistive devices were dentures (82.5%) and eyeglasses (55.6%). Almost half of the subjects (47.2%) in the sample perceived themselves as being as healthy as others of the same age; 37.3% believed that they were healthier than others in the same age group. About four-fifths (78%) of the subjects exercised daily. Only 29.1% ($n = 80$) and 10.8% ($n = 29$) of the subjects reported that they needed help in performing at least one item in the mobility-related function domain and IADL domain, respectively. Further descriptive data on the subjects are presented in Table 1.

Table 1. Characteristics of the study participants ($n = 268$)*

Age (yr)	73.84 ± 5.2
Body mass index (kg/m^2)	24.48 ± 3.2
Gender (male/female)	149/119
Education ($n = 264$)	
Illiterate	30 (11.4)
Elementary school	126 (47.7)
Junior high school	41 (15.5)
Senior high school	39 (14.8)
College and above	28 (10.6)
Marital status ($n = 267$)	
Not married	3 (1.1)
Married	218 (81.7)
Widowed	46 (17.2)
Living arrangements ($n = 267$)	
Alone	32 (12.0)
With family/friends	235 (88.0)
Comorbidity	
High blood pressure	115 (42.9)
Diabetes	43 (16.0)
Heart disease	50 (18.7)
Arthritis	64 (23.9)
Vision problems	195 (72.8)
Hearing problems	44 (16.4)
Number of comorbidities ($n = 266$)	
0	13 (4.9)
1	73 (27.2)
2	90 (33.6)
3	60 (22.4)
≥ 4	32 (11.9)
Self-perceived health status ($n = 267$)	
Healthier	100 (37.3)
Same	126 (47.2)
Less healthy	30 (11.2)
Don't know	11 (4.1)

**Data presented as mean ± standard deviation or n (%).*

For the interrater reliability, 68 community-dwelling older adults who met the inclusion and exclusion criteria were asked for their consent to participate. There were 32 males and 36 females. There were 80.6% of the older adults who reported the same or healthier health status compared with those of the same ages. The majority of these participants (73.2%) exercised daily. The percentages of having comorbidities were: high blood pressure 46.5%; diabetes 18.3%; heart disease 21.1%; arthritis 31.0%.

Acceptability of the BBS

The distribution of the BBS scores in the sample was negatively skewed, with a mean of 53, which is far above the midpoint of the scale (28). The mode was 56, the highest possible score. One third of the subjects in the sample attained the highest score (Table 2).

Reliability

The internal consistency reliability of the BBS in the sample was acceptable, with a Cronbach's α

Table 2. Descriptive statistics for the Berg Balance Scale (BBS), timed up and go test (TUG), and usual gait speed (UGS)

	BBS	TUG (s)	UGS (m/s)
Mean ± standard deviation	53.3 ± 4.1	8.6 ± 1.8	1.3 ± 0.2
Mode	56.0		
Median	54.0		
Minimal	23.0	5.0	0.3
25%	52.0	7.3	1.1
50%	54.0	8.2	1.3
75%	56.0	9.4	1.4
Maximal	56.0	14.8	2.2
Ceiling effect	$n = 89$ (33.2%)		
Floor effect	$n = 0$ (0%)		

of 0.77. The interrater reliability of the BBS was good, with $ICC_{(2,1)} = 0.87$ ($p < 0.0001$).

Construct validity

Spearman's ρ correlation coefficients of the BBS with the TUG and usual gait speed were −0.53 ($p < 0.01$) and 0.46 ($p < 0.01$), respectively. The negative relationship between the BBS and TUG indicates that individuals with better balance performance (i.e. higher scores in the BBS) also performed better in general mobility (i.e. requiring less time to complete the TUG). The positive relationship between the BBS and usual gait speed indicates that older adults who scored higher on the BBS also walked faster.

The BBS could discriminate community older adults with and without mobility/IADL disability. The BBS scores for the mobility able and disabled groups were 53.9 ± 2.7 and 48.6 ± 6.7, respectively. The BBS scores for the IADL able and disabled groups were 53.6 ± 2.9 and 47.8 ± 8.0, respectively. The results indicated that the able group significantly outperformed the disabled group ($p < 0.0001$).

Item response profile

Table 3 shows that, except for items 8, 13 and 14, more than 90% of the subjects in the sample attained the highest score of 4 for the items on the BBS. The percentages of subjects scoring 4 for items 8, 13 and 14 were 80.6%, 51.9% and 49.6%, respectively. On item 8, 99% of the subjects in the sample scored either 3 or 4. Only on items 13 and 14 were the scores evenly distributed among 0, 1, 2 and 3.

Further analysis revealed that the total scores of these two items also demonstrated significant differences between the mobility/IADL able and disabled groups ($p < 0.0001$). Sum scores of both items 13 and 14 for mobility able and disabled groups were 6.2 ± 2.0 and 3.5 ± 2.9, and sum scores of both items 13 and 14 for IADL able and disabled groups were 6.4 ± 1.8 and 3.7 ± 2.7, respectively.

Discussion

This study examined the psychometric properties of the BBS in a community-dwelling older adult population in Taiwan. Two major findings emerged. The first is that the psychometric properties of the BBS in Taiwan are supported by our results. The internal consistency reliability of the scale was adequate for the purpose of group comparison.[53] The interrater reliability was good. The high interrater reliability of the BBS was also found in other studies in older adults,[55] in different populations such as stroke patients,[56,57] and in adults with learning disability.[58] These observations well support the interrater reliability of the BBS. Moderate associations were observed

Table 3. Item analysis of the Berg Balance Scale ($n = 268$)

	Level of scoring (frequency)					α if item is deleted
	0	1	2	3	4	
Item 1: sitting to standing	0	1	1	20	247	0.7479
Item 2: standing unsupported	1	0	0	5	262	0.7540
Item 3: sitting unsupported	0	0	0	5	263	0.7671
Item 4: standing to sitting	0	0	0	15	253	0.7588
Item 5: transfers	0	0	0	19	249	0.7573
Item 6: standing with eyes closed	1	0	0	12	255	0.7568
Item 7: standing with feet together	1	1	0	10	256	0.7438
Item 8: reaching forward with outstretched arm	0	0	3	49	216	0.7427
Item 9: retrieving object from floor	1	0	0	3	264	0.7570
Item 10: looking over left and right shoulder	1	1	5	16	245	0.7566
Item 11: turning 360°	1	0	8	6	253	0.7446
Item 12: placing alternate foot on stool	1	1	0	7	259	0.7465
Item 13: standing with one foot in front	25	11	31	62	139	0.7741
Item 14: standing on one foot	19	35	36	45	133	0.7760

between the BBS and two other tests that measure similar aspects of older adults' functional mobility performance, the TUG and the usual gait speed. The BBS also demonstrated its ability to discriminate between older adults with and without mobility/IADL disability. These findings support the internal consistency reliability, inter-rater reliability and construct validity of the BBS for assessing balance in community-dwelling older adults in Taiwan.

The second major finding is that of a ceiling effect when testing community-dwelling older residents. A close examination of the item response profiles revealed that most items in the BBS are too easy for community-dwelling older adults and that the tandem stance (item 13) and one-legged stance (item 14) were the most difficult items; furthermore, their response profiles were different from those of other items on the BBS scale. Previous studies have also found the tandem stance, one-legged stance, alternating foot, and look behind tasks to be the most difficult items in the BBS.[29–31] The first three cited are the most difficult activities for relatively healthy community-dwelling older adults.[29] Based on the results of the current study, the two most challenging items were the tandem stance and one-legged stance. Item 14 of the BBS (standing on one leg) was able to discriminate older community-dwelling fallers from non-fallers.[31] In a study testing the BBS in a community-dwelling veteran population referred for balance deficits, the authors reported that subjects who passed the tandem stance and at least two of the three marker items (alternating foot, stance on one leg, look behind) had a low probability of falling, since they had total scores above the cut-off of 45 for fall risk.[30] These findings might indicate that older adults experiencing an early stage of balance decline start from having difficulty maintaining the center of gravity in a static standing (upright) posture with a narrowed base of support (one leg or tandem stance) among these 14 items in the BBS.

The generalization of the results of this study may be limited to the study sample population and should not be applied to those who are homebound or those living in institutions. A psychometrically sound balance assessment instrument is needed to document and monitor the balance performance of community-dwelling older adults so that those at an early stage of decline can be identified and timely intervention can be provided. Future studies should examine the applicability and usefulness of these two tests (one-legged stance and tandem stance) in identifying community-dwelling older residents who are in

the early stage of balance decline. The results of this study may shed light on the aspect of early balance deficit in Taiwanese community-dwelling elderly residents. This information may help clinicians better understand the mechanisms of early balance decline in older adults and could be used to guide future development of screening or intervention programs for balance deficits in community-dwelling elderly residents.

The internal consistency reliability, interrater reliability, and construct validity of the BBS in measuring balance performance in a Taiwanese community-dwelling older population were supported in this study. Our results suggest that the one-legged stance (item 13) and tandem stance (item 14) are the tasks most challenging to this population. Further study of their applicability for screening use in the community is warranted.

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