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Original Article

Accuracy of Berg balance scale to predict falls among community elderly dwellers

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ABSTRACT

Background & Aim: Berg balance scale (BBS) is one of the most applied tests to identify high-risk elderly people for fall. Fall is a common health problem among community senior citizens. A diagnostic test to identify high-risk elderly people can prevent or alleviate falls. The purpose of this study was to determine the accuracy of BBS to predict falls among elderly community dwellers.

Methods & Materials: This cross-sectional study was conducted among elderly community dwellers in Shahroud, Semnan Providence, Iran. In this study, 1312 elderly individuals were registered for the study, 455 of them were randomly selected as qualified participants. This study is a validity investigation on BBS among elderly community dwellers. To validate the BBS, researchers assessed validity, specificity, positive and negative predictive values, positive likelihood ratio (LR+) and negative LR (LR−).

Results: The findings of this study showed that 243 subjects were male, and 212 subjects were female. The mean age of subjects were 71.45 ± 9.25 years. This study showed sensitivity and specificity of 0.63 and 0.97, respectively. According to the findings of the study, LR+ and LR− were calculated as 9.57 and 0.39, respectively.

Conclusion: The results of the study are in harmony with the hypothesis to design the test, i.e. BBS have the acceptable accuracy to identify high-risk community elderly people for falls. However, other influential factors such as personal and environmental variables are necessary to consider for prediction of falls.

Introduction

Falls is one of the most common health problems among elderly community dwellers and bring a lot of burden to individual and family (1, 2). Falls are not only associated with morbidity and mortality in the older population but are also linked to poorer overall functioning, low quality of life (3) and early admission to hospital (4). It is estimated that one-third of elderly people aged 65 and above experience falls annually, and it exceeds 50% among elderly persons 85 years old and above (5, 6). Fall is known to be multifactorial (7-9) and has been explored by many researchers in different disciplines (10). The causes of fall has been categorized as extrinsic (medications, environmental hazards) and intrinsic (disease which cause impaired balance) factors (11, 12).

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Impaired balance has been correlated with an increased risk for falls (9) and a resulting increase in the mortality rate of elderly persons who are prone to falling compared with those who are not prone to falling (13). A reliable and valid clinical measure for balance abilities increases the health professionals' ability to predict who is at risk for falls (9, 14-16). Several clinical tests have been introduced to predict falls among elderly people (15, 17). Most of the test to predict falls is based on subjects' balance and postural abilities. Several researchers have measured balance abilities using platform. It is believed that increasing age produce and increase sway. However, there is a lot of controversy on the differential efficacy of sway test to predict falls among elderly people. While some researchers emphasized on the value of platform (18), Berg et al., concluded that it is not sensitive enough to differentiate those elderly individuals prone to falls from others (19, 20). It has been documented that there is low (if any) correlation between falls and sway speed. Another test to predict falls was sensory organization balance test (21). It has been extensively applied to measure balance (21, 22). This test is designed to assess balance abilities during six conditions of altered vision and altered support surface (23). The Berg balance scale (BBS) has been approved as a valid measure for predicting falls in a variety of patient populations with different medical diagnoses (9, 24-26). In addition moderate to high reliability has been established for the BBS within a variety of settings and diagnoses (9, 25-29). It has been well documented that BBS is significantly related to other functional assessment tests including Barthel index, timed up and go test. Moreover, Riddle and Stratford (30) concluded BBS is a sensitive and specific test for predicting falls among community elderly dwellers. In fact sensitivity and specificity of a test are essential characteristics of a test to apply it for subjects. In spite of accepted values of BBS to predict falls among elderly individuals, some researchers have proposed reluctance about its power to predict falls. Also, most of the researches have been conducted on Western populations. Few studies have conducted BBS as falls predictor test in Iran. Azadi et al. (2003) assessed the validity of BBS among institutional patient in a limited sample size (24). Another study found that the Persian version of the BBS has excellent inter-rater reliability and internal consistency for the assessment of multiple sclerosis patients when applied in clinics (29). In addition, in a recent study, Salavati et al. (2012) found an acceptable levels of intra and inter-rater reliability with a moderate internal consistency and high validity were demonstrated for the Persian version of BBS (31). However, validity and specificity of the test has not been evaluated among community elderly dwellers in Iran. Moreover, none of the previous studies has evaluated the positive predictive value (PPV) and negative predictive values (NPV) of the BBS. This study is designed to evaluate the accuracy of BBS for falls among Iranian elderly community dwellers.

Methods

This cross-sectional study was conducted among elderly community dwellers in Shahroud, Semnan Providence, Iran. The subject of the study was recruited from a large-scale community-based study on falls. Elderly subjects in population (N = 1312) were assessed for inclusion criteria of the study. To estimate a sample size, three numbers are needed, where estimate of the expected proportion (p), desired level of absolute precision (d) and confidence level e.g. 1.96 for 95% confidence level (Z).

The sample size formula was as follows:

$$n = \frac{Z^2 p(1-p)}{.d^2} = \frac{(1.96)^2 \times 0.35(1-0.65)}{0.045^2} = 430$$

Attrition among elderly subjects was predictable. So, researchers added a few participants. Participants of the study were randomly selected from the population. Subjects who were in the age of 60 and above, able to walk independently for at least 10 m indoors or outdoors, with or without walking aids were included in the study. Registered subjects with severe physical or mental disabilities (mini-mental state examination ≤ 18) and those who were confined to bed were excluded from the study.

All selected subjects (n = 455) were categorized in groups of fallers and non-fallers based on a self-reported falls during the last 12 months at the date of data collection. This study applied WHO's definition of falls as an unexpected event in which participant unintentionally comes to rest on the floor or ground or other lower level not due to intrinsic factors such as seizure or stroke.

All subjects and/or their family members were informed about the goals of the study and they signed the informed consent. They were assured that all the information shared in this study would be kept confidential. The instrument used in this study was BBS. Azad et al. (2011) assessed the reliability of the Iranian version of the BBS in patients with multiple sclerosis. The researchers found that the Kappa scores for BBS varied from 0.7 to 1.0 interclass correlation coefficient for the BBS's sum score was excellent (intraclass correlation coefficient = 0.99 with 95% confidence interval, 0.98-0.99). Moreover, they found strong internal consistency within the BBS's sum score (Cronbach alpha = 0.9) (29). The BBS assesses balance and risk for falls through direct observation of the participant's performance by general practitioners in health centers. The scale contains 14 static and dynamic activities related to everyday living. The items include simple mobility tasks (e.g. transfers, standing unsupported and sit-to-stand) and more difficult tasks (e.g., tandem standing, turning 360°, and single-leg stance). The items of BBS are scored on a scale of 0-4. A score of 0 is considered as inability to do the task, and a score of 4 means that the participant is able to complete the task based on the criterion that has been assigned to it. The maximum total score on the test is 56 and indicates best balance status. The BBS takes 15 (±5) minutes to complete. This easy to do test is performed using minimal equipment (chair, stopwatch, ruler, and step) and can be done in any average size room.

To validate the BBS, researchers assessed validity, specificity, PPV and NPV, positive likelihood ratio (LR+,) and negative LR (LR−). Sensitivity refers to the accuracy of a test to identify subjects with positive results, so it is called as true positive rate. Specificity measures the proportion of negatives which are correctly identified as such, so it is usually called as true negative rate. The LR+ is calculated as ($\text{LR+} = \frac{\text{sesitivity}}{1-\text{specificity}}$) and the LR− is calculated as ($\text{LR}- = \frac{1-\text{sesitivity}}{\text{specificity}}$). A LR of >1 indicates the test result is associated with the disease. A LR of < 1 indicates that the result is associated with absence of the disease (32). All data were collected and analyzed by SPSS version 19. The data were assessed by calculation of skewness which was ±1, indicating the normality of the data.

Results

All data were collected and analyzed by SPSS version 19. The data were assessed by calculation of skewness, which was ±1, indicating the normality of the data. The results of this study showed that of 455 subjects of the study, 243 were male (53%) and 212 were female (47%). The average age of the participants was 71.45 ± 9.25 years. The number of subjects living in urban and rural areas were 241 person (53%) and 214 person (47%), respectively. History of falls during the last 12 months among subjects of the study was reported in 152 (33%) elderly people. Other demographic results of the study are summarized in table 1.

Table 1. Determinants of balance disorders and BBS

Variables	Berg balance scores			P value
	BBS ≥ 20	21 > BBS ≥ 40	41 > BBS ≥ 56	
Age > 70 years (n = 199)	74	92	33	0.02
History of fall (n = 148)	47	79	25	0.03
Polypharmacy (>4 medication) (n = 351)	38	181	32	0.09
IADL (n = 73)	30	21	22	0.40
ADL (n = 102)	42	41	19	> 0.01
Visual disturbances (n = 247)	51	132	64	0.30
Muscular weakness (n = 388)	142	173	73	> 0.01
Vestibular balance disorders (n = 43)	21	15	7	> 0.01
Physical disturbances (orthopedic and sensory (n = 223)	51	131	41	0.30

IADL: Instrumental activity of daily living, ADL: Activity of daily living, BBS: Berg balance scale

Results of this study showed that subjects reported some chronic health problems related to falls. A total number of 455 elderly people participated in this study, 223 subjects were suffering from neurologic and orthopedic problems such as arthritis (n = 101) vertebral surgery (n = 13), lumbar fractures (n = 11), stroke (n = 90) and Parkinson disease (n = 8). Balance status were assessed as good (not prone to falls) in 303 subjects (67%). In addition, 338 (75%) elderly individuals did not use any walking aids at the time of the study.

Chi-square test was applied to assess the association of participants' demographic variables to their Berg balance scores. According to the finding of the study older age, history of previous falls during the last 12 months, dependency in activity of daily living, muscular weakness and vestibular balance disorders (vertigo) were significantly related to their balance scores.

Table 2 shows the results of elderly subjects' BBS with and without history fall. In addition, sensitivity, specificity, predictive values (PPV and NPV) and LR (LR+ and LR−) were calculated. The results are summarized in table 2.

Table 2. LR and predictive values of BBS

Subjects	Prone to falls	Not-prone to falls
Faller	136	78
Non- Faller	16	225
Sensitivity = 136/(136 + 78) = 0.63		
Specificity = 225/(225 + 16) = 0.93		
PPV = 136/(136 + 16) × 100 = 89%		
NPV = 225/(225 + 16) × 100 = 78%		
LR+ = (136 × 241)/(225 × 16) = 9.57		
LR− = (78 × 241)/(225 × 214) = 0.39		

PPV: Positive predictive value, NPV: Negative predictive value, LR+: Positive likelihood ratio, LR−: Negative likelihood ratio, BBS: Berg balance scale

Results of this study showed the sensitivity of 0.63, which means that the BBS can identify 63 out of 100 subjects who will fall. In addition, the specificity of the test was calculated as 0.93, which can be interpreted as the accuracy of the test to identify 93% of elderly who are not susceptible for fall. To calculate the predictive value of BBS, PPV and NPV of the test were assessed. PPV of the BBS suggests the probability of low BBS among elderly people who fall. In this study, the PPV of the BBS was calculated as 89%, which means that 89 out of 100 subjects with low BBS will fall. Similarly, NPV of the BBS indicates that elderly people with higher BBS will not probably fall. Therefore, based on the results of this study NPV of the BBS was 78%, which means that 78 out of 100 subjects with high BBS will not fall. However, both PPV and NPV of a test are under the influence of prevalence of a given phenomenon. To remove the influential effects of prevalence from the accuracy of a test, LR+ and LR− were applied. According to the findings of the study, LR+ and LR− were calculated as 9.57 and 0.39, respectively. LR+ is well above 1, and LR− is close to zero, which indicates accuracy of the BBS to predict falls.

Discussion

BBS as a valid and reliable test to assess postural balance has been applied in a variety of the case including patients suffering from stroke, Parkinson disease and multiple sclerosis (17, 25, 30, 33-36). The focus of attention in the most previous literature has been on patients with the special medical condition. However, this study recruited elderly subjects living in the community. In addition, no previous study has evaluated LR of BBS to predict falls among Iranian elderly community dwellers. Moreover, some previous studied were done on small sample size (37).

Among covariates of falls studied in this research, older age (> 70 years old), history of falls during the last 12 months, dependency, muscle weakness, imbalance due to auditory system were significantly associated with fall. Consistent with most previous literature and findings of investigations, the results of this study supports the accuracy of BBS to evaluate and predict falls among elderly individuals. Also, the prevalence of falls in this study was 33% which similar to world-wide estimates of falls (23-35%) (1, 2, 5, 6, 12). This study showed sensitivity and specificity of 0.63 and 0.97, respectively. Moreover, LR+ and LR− were calculated as 0.89% and 0.78%, which indicate the predictive value of the BBS for falls. This finding of the study supports the application of BBS as a predictor for falls among community elderly dwellers. In addition, LR+ and LR− which are independent to the prevalence of the disease (falls) strongly showed the accuracy of the BBS. Salavati et al. 2012 found that Persian version of BBS had interclass correlation coefficients (95% confidence interval) of 0.93 (0.87-0.96) and 0.95 (0.92-0.97) were obtained for inter and intra-rater reliability, respectively (31). In addition, Bogle Thorbahn and Newton (1996) found the specificity of 53% for BBS (9); however, no other study calculated the likelihood of the test.

A well-reputed study concluded that BBS is not an appropriate test when used as a dichotomous (faller/non-faller) scale with a cutoff point score (26). Therefore, in this study, researchers did not use graphic methods of showing receiver operating characteristic curve to estimate the cutoff point of the BBS. There are some limitations for this study to be acknowledged. Researchers relied on subjects self-report of falls, which may be subjected to false reports. In addition, this study did not consider some other covariates of falls such as subjects' home assessment. It is recommended that any prediction of falls for elderly people will be more accurate, if it is accompanied by other intrinsic and extrinsic factors of falls.

BBS has been investigated for sensitivity and specificity in different languages. This study was the first investigation to use LR+ and LR−, which is independent to incidence of falls.

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