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Mini-BESTest cutoff points for classifying fallers and non-fallers female older adults

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HIGHLIGHTS

- We examined the accuracy of the Mini-BESTest for identifying falls in older women.
- We established the Mini-BESTest cutoff scores for fallers in different age groups.
- The Mini-BESTest is a highly accurate tool for identifying falls in older Brazilian women.
- The Mini-BESTest cutoff score to classify the fallers was 26 for 65-69 years old.
- The Mini-BESTest cutoff score to classify the fallers was 24 for 70+ years old.

ABBREVIATIONS

AUC	Area under the ROC curve
Mini-BESTest	Mini-Balance Evaluation Systems Test
MMSE	Mini-Mental State Examination
PD	Parkinson's disease
ROC	Receiver operating characteristic
-LR	Negative likelihood ratios
+LR	Positive likelihood ratios

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BACKGROUND: The Mini-Balance Evaluation Systems Test (Mini-BESTest) is an efficient screening tool healthcare professionals use to predict the risk of falls in older adults. However, the Mini-BESTest cutoff scores to classify fallers and non-fallers were established using men and women in the same sample. Considering the higher number and prevalence of falls in older women, it is important to know the Mini-BESTest accuracy and the cutoff score specifically for this population.
AIM: We examined the capability and accuracy of the Mini-BESTest for identifying fallers and non-fallers female older adults without neurological impairments and established the cutoff scores according to different age groups.
METHOD: Eighty-one female older adults were classified into fallers (n=40) and non-fallers (n=41) groups according to their retrospective history of falls in the last 12 months. Fallers and non-fallers were divided into three age groups according to the following ranges: 65-69 years, 70-74 years, and 75+ years. We used the receiver operating characteristic (ROC) curves to determine the relative performances of the Mini-BESTest score for classifying participants with and without a history of falls.
RESULTS: The Mini-BESTest is a good and highly accurate tool for identifying female Brazilian fallers and non-fallers. The Mini-BESTest cutoff scores established to classify fallers and non-fallers female older adults in the different age groups were 26 points for 65-69 years and 24 points for 70-74 years and 75+ years.
INTERPRETATION: The Mini-BESTest is an important tool that health professionals in clinical practice can use to estimate the risk of falls for older Brazilian women.

KEYWORDS: Older women | Falls | Accuracy | Sensitivity | Specificity | Mini-BESTest

INTRODUCTION

Falls are a major health problem among older adults worldwide and have been recognized as the second leading cause of accidental or unintentional injury deaths in the older population [1,2]. Indeed, approximately one-third of individuals aged over 65 years are reported to fall each year, with a greater risk for women, becoming even more recurrent with increasing age [1,3,4]. In Brazil, a recent population-based study reinforced this prevalence showing that 25.1% of older adults (60-75 years or older) reported at least one fall in the last 12 months, with a higher prevalence among older women (30.2%) than older men (18.4%) [5]. Previous studies have also evidenced that older women do not have just an increased risk of falls but experience more falls than men [1,3,4-7], showing a worse quality of balance[8,9,10] and a greater perception of their risk of falling than men [10].

Studies have evidenced that, after an initial fall, older adults have a higher risk of falling again [6,7]. The occurrence of a first fall is a predictor of future falls [6,11], and these falls may result in fractures [12], frequent injury-related hospitalizations, physical disability, reduced functionality, less independence, fear of new falls, loss of the ability to perform daily living activities, poor quality of life, reduced survival of those who experienced falls, burdens on caregivers and society as a whole [13,14]. Falls represent a leading cause of hospital admission in older adults leading to substantial healthcare costs [2,4]. Thus, avoiding the first fall can contribute to maintaining functional independence since roughly half of older adults fall recurrently after the first fall [1,6], which can help decrease health care costs and, ultimately, death in older adults [6,15]. These severe consequences and the adverse impacts of falls emphasize the need to identify and

classify older people at risk of falls, apply an appropriate clinical assessment tool with specific cutoff scores, and then select appropriate prevention strategies [14,16].

The literature on falls epidemiology and risk factors for falls among older adults has grown considerably in recent decades[3,7,17,18,19]. Many factors, including female gender, advancing age, cognitive deficits, reduced physical activity level, and obesity, have been associated with a higher risk of falling [20]. Thus, screening is essential to identify these factors associated with an increase in the number of falls in older people [3,7].

Balance and gait deficits are other significant predictors of falls in older adults [1,21,22]. Studies have suggested to healthcare professionals the Mini-Balance Evaluation Systems Test (Mini-BESTest) as an efficient screening tool to identify older adults with higher fall risk and assess the components of the postural control system, functional balance and gait stability responsible for the occurrence of falls in older adults [14,15,23]. The literature contains cutoff scores for the Mini-BESTest for individuals with Parkinson's disease (PD) [24,25], individuals with stroke [26], and healthy older adults [14,15].

Yingyongyudha and colleagues [14] compared the areas under the receiver operating characteristic (ROC) curves of the Mini-BESTest, BESTest, Berg Balance Scale, and Timed Up and Go Test to identify older adults with a history of falls without neurological problems. The authors suggested a single score of 16 (out of 28) as the cutoff score for the Mini-BESTest for identifying older adults with a history of falls. In addition, the sample was composed of male and female community-dwelling older adults in Thailand. However, whether these values would be generalizable to the Brazilian population, specifically for female older adults with different chronological ages, is unknown. For the Brazilian people, Magnani et al.[15] also analyzed the areas under the ROC curves of the BESTest and Mini-BESTest to identify the reference values of these tests to identify fallers in community-dwelling Brazilian older adults of different age groups (60-102 years). Their results showed that the cutoff scores to identify older adults with fall risk according to the Mini-BESTest in different age groups were 25 points for 60-69 years of age, 23 points for 70-79 years of age, 22 points for 80-89 years of age, and 17 points for 90 years of age or older. However, although in a lower number, this study also included males in the sample and generalized the same cutoff scores for both genders. Considering the higher number and prevalence of falls in female older adults and the lack of specific cutoff scores for Brazilian older women, it is essential to know the Mini-BESTest accuracy and the cutoff score specifically for this population. Therefore, we examined the capability and accuracy of the Mini-BESTest for identifying fallers and non-fallers female older adults without known neurological impairments. Based on this, we established cutoff scores for classifying Brazilian fallers and non-fallers female older adults in age groups 65-69 years, 70-74 years, and 75+ years. This knowledge is fundamental for an appropriate clinical application of the Mini-BESTest for fall prevention and balance rehabilitation in this population.

METHODS

Participants

Eighty-one female older adults volunteered for this study. They were identified as fallers if they experienced a fall in the 12 months preceding the data collection. We used the fall definition proposed by Beauchet et al. [27] "as unintentionally coming to rest on the ground, floor, or other lower level". Participants signed the informed consent form approved by the local ethics committee. Before the Mini-BESTest [15,28,29] assessment, the participants were screened by filling out a questionnaire to check their history of falls, health status, physical activity level (Modified Baecke Questionnaire)[30], cognitive functions (Mini-Mental State Examination, MMSE)[31,32], and anthropometric parameters. We included community-dwelling older adults who could walk independently without using any assistive device (cane or walker). Participants were excluded if they had a stroke, neurological disease, or other diseases that could compromise their stability.

Procedures

The Mini-BESTest assesses functional balance, specifically the transitions/anticipatory postural control, reactive postural control, sensory orientation, and gait stability. The Mini-BESTest comprises fourteen tests with a maximum score of 28 points. For each test, the score varies from 0 (the lowest functional level) to 2 (the highest functional level).

Statistical analyses

Data were analyzed considering the entire sample and separate age groups: 65-69 years, 70-74 years, and 75+ years. The receiver operating characteristic (ROC) curves were used to determine the relative performances of Mini-BESTest scores for classifying participants with and without a history of falls. The accuracy of the Mini-BESTest for discriminating participants with and without a history of falls was assessed using the area under the ROC curve (AUC). An AUC value of 0.9 and greater indicates high accuracy, between 0.7 to 0.9 indicates moderate accuracy, between 0.5 to 0.7 indicates low accuracy, and 0.5 and less indicates a result due to chance [14,33]. The cutoff point was defined by selecting the best score between high sensitivity and high specificity [34]. Sensitivity and specificity values were used to calculate positive and negative likelihood ratios according to methods used in previous studies [35,36]. Positive likelihood ratios

(+LR) were calculated as Sensitivity/1 − Specificity. Negative likelihood ratios (-LR) were calculated as 1 − Sensitivity/Specificity. A positive likelihood ratio (+LR) and a negative likelihood ratio (-LR) were also calculated for each age group. An +LR higher than 5 and an -LR lower than 0.2 indicate that the test is useful due to its high probability of correctly identifying participants with and without a history of falls, but LR values very close to 1.0 indicate that the test is useless, as the probability of correctly and incorrectly identifying participants with a history of falls is the same [14,34]. A likelihood ratio of 1.0 means the true-positive and false-positive (or true-negative and false-negative) rates are the same, making the test results useless [31]. For this reason, a +LR indicates the clinical usefulness of a positive test result: the larger the +LR value above 1.0, the more valuable the positive result. The −LR indicates the usefulness of a negative test result: the smaller the value below 1.0, the more valuable the negative result [35,36]. We provided the power for the ROC curves analyses based on the calculator available at http://riskcalc.org:3838/samplesize/ [37]. The power calculation determined that the minimum sample size was 18 for an AUC of 0.95 (3 fallers and 15 non-fallers) and 25 for an AUC of 0.99 (4 fallers and 21 non-fallers) participants. These values were obtained with an alpha level of 0.05 (2-tailed), a power of 0.8, a null hypothesis of AUC ≤ 0.5, and a prevalence (ratio of positive cases/total sample size) of 0.16 (i.e., +LR = 13.01 and total sample size = 81) [37].

Using the data of the entire sample, we ran a multiple regression analysis (stepwise method) with the number of falls as the dependent variable. The following independent variables were included in the regression analysis: age, height, body mass, MMSE, Mini-BESTest, and physical activity level. For all analyses, the significance level was set at p≤0.05.

RESULTS

Entire sample

Participants were divided into two groups based on their retrospective history of falls: non-fallers (n=41) and fallers (n=40). Table 1 presents the data for both groups. Except for the Mini-BESTest, no statistical difference existed between groups for all other variables assessed. The Mini-BESTest score was smaller for the fallers than for the non-fallers. For the entire sample, 51.2% did not fall in the last six months, 18.6% felt once, 16.3% felt twice, and 14.0% felt three or more times.

Table 1. Mean and standard deviation (in parentheses) of the assessed variables for non-fallers and fallers across age groups.

Variables	Non-Fallers (n=41)	Fallers (n=40)	p-value
Age (years)	72.1 (4.6)	73.8 (5.0)	0.125 [a]
Body Mass (kg)	64.7 (12.4)	67.3 (12.2)	0.343 [a]
Height (m)	1.56 (0.06)	1.54 (0.06)	0.176 [a]
Mini-Mental State Exam (score)	28.1 (1.7)	26.9 (3.1)	0.072 [b]
Mini-BESTest (score)	26.5 (1.8)	19.6 (3.4)	**≤0.0001** [b]
Physical Activity Level (score)	5.1 (2.4)	4.9 (2.5)	0.688 [a]
Number of Falls	---	2.2 (1.7)	---

[a] One-way ANOVA; [b] Mann-Whitney Test; Bolded p-values indicate statistical significance.

The ROC curve analysis indicated a high accuracy in classifying fallers from non-fallers, as the area under the curve was higher than 0.9 (Figure 1A and Table 2). Both sensitivity and specificity were high, and the cutoff point for the Mini-BESTest to classify fallers from non-fallers was 24 points (Table 2).

Table 2. Parameters of the receiver operating characteristic (ROC) curve for the Mini-BESTest as a classifier of older adults with a history of falls.

Groups	AUC	95% CI	p-value	Sensitivity (%)	Specificity (%)	+LR	-LR	Cutoff Point
All sample	0.97	0.93-1.00	**≤0.0001**	95	93	13.01	0.05	24
65-69 y	1.00	1.00-1.00	**≤0.0001**	100	100	--- [a]	0.00	26
70-74 y	0.99	0.96-1.00	**≤0.0001**	92	93	13.78	0.08	24
75+ y	0.95	0.88-1.00	**≤0.0001**	100	85	6.49	0.00	24

AUC: area under the curve; CI: confidence interval; +LR: positive likelihood ratio; -LR: negative likelihood ratio; [a] It was not possible to compute as the denominator was zero; Bolded p-values indicate statistical significance.

The regression analysis identified age (β=-0.046; p=0.029) and Mini-BESTest (β=-0.235; p≤0.0001) as predictors for the number of falls (R^2=0.57). Based on β, Mini-BESTest exhibited a larger predictive power than age for multiple falls risk. Thus, the smaller the Mini-BESTest score, the higher the risk of multiple falls (Figure 2).

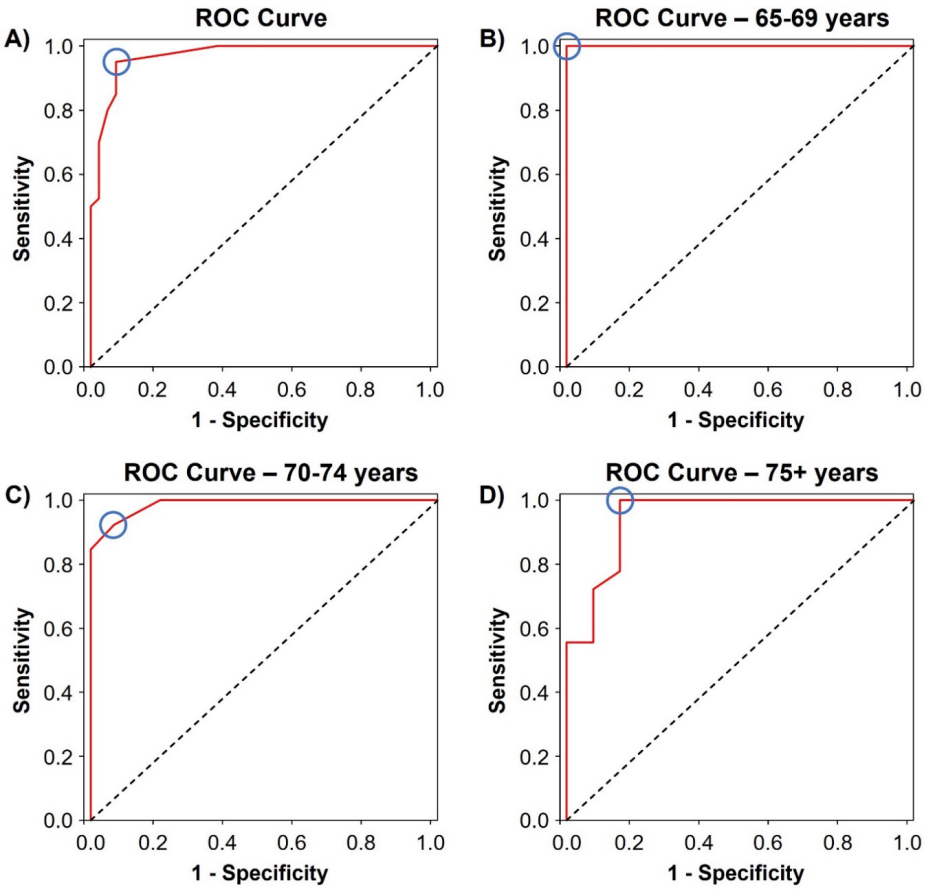

Figure 1. Receiver operating characteristic (ROC) curves for the entire sample (A), 65-69 years (B), 70-74 years (C), and 75+ years (D). The dashed diagonal line in each ROC curve indicates the reference line. The blue circle indicates the cutoff point.

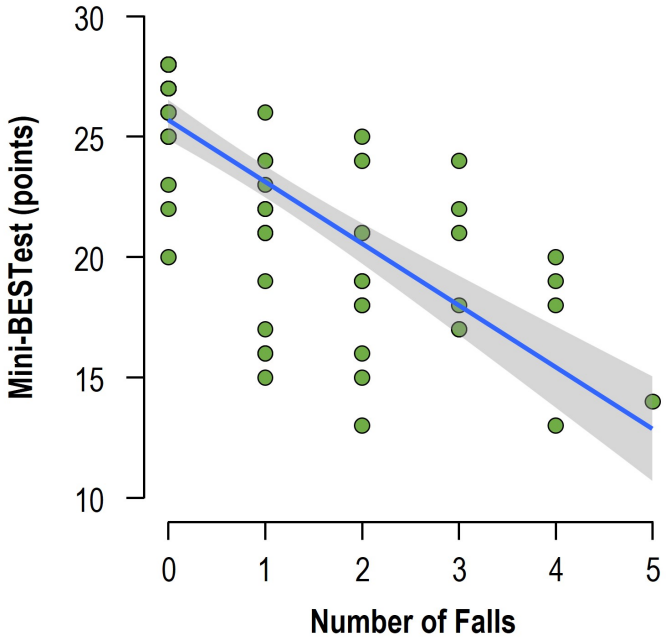

Figure 2. Scatterplot of the number of falls and the Mini-BESTest score for the entire sample. The blue line indicates the regression line. The shaded area corresponds to the confidence interval (95%).

Age groups

Table 3 exhibits the data of all three age groups. For all age groups, the Mini-BESTest score differed between fallers and non-fallers, with smaller scores for the fallers. Fallers were heavier than non-fallers for the 65-69 age group. For the 75+ age group, fallers scored smaller than non-fallers in the Mini-Mental State Exam.

Table 3. Mean and standard deviation (in parentheses) of the assessed variables for non-fallers (NF) and fallers (FA) separated by age groups.

Variables	65-69 y			70-74 y			75+ y		
	NF (n=13)	FA (n=9)	p-value	NF (n=15)	FA (n=13)	p-value	NF (n=13)	FA (n=18)	p-value
Age (years)	67.5 (1.6)	66.9 (1.4)	0.390[b]	71.3 (1.3)	72.3 (1.3)	0.061[b]	77.8 (2.8)	78.3 (2.4)	0.291[b]
Body Mass (kg)	65.4 (12.9)	79.3 (12.9)	**0.022**[a]	67.5 (14.3)	65.3 (10.0)	0.646[a]	60.8 (8.9)	62.8 (9.7)	0.570[a]
Height (m)	1.58 (0.08)	1.55 (0.05)	0.298[a]	1.55 (0.04)	1.54 (0.05)	0.397[a]	1.55 (0.05)	1.55 (0.07)	0.768[a]
Mini-Mental State Exam (score)	28.5 (1.2)	26.4 (3.2)	0.105[b]	27.4 (2.1)	28.2 (1.4)	0.369[b]	28.7 (1.4)	26.2 (3.8)	**0.027**[b]
Mini-BESTest (score)	27.6 (0.5)	20.5 (3.6)	**≤0.0001**[b]	26.5 (1.5)	19.5 (2.9)	**≤0.0001**[b]	25.5 (2.2)	19.2 (3.6)	**≤0.0001**[b]
Physical Activity Level (score)	4.3 (1.4)	4.4 (2.2)	0.944[a]	5.9 (2.8)	5.3 (3.3)	0.611[a]	4.9 (2.7)	4.8 (1.9)	0.952[b]
Number of Falls	---	2.9 (3.0)	---	---	2.3 (1.2)	---	---	1.8 (0.9)	---

[a] One-way ANOVA; [b] Mann-Whitney Test; Bolded p-values indicate statistical significance.

The ROC curve analysis indicated a high accuracy for all three age groups in classifying fallers from non-fallers, as the area under the curve was higher than 0.9 (Figures 1B-D and Table 2). Both sensitivity and specificity were high, and the cutoff point for the Mini-BESTest to classify fallers from non-fallers was 26 points for 65-69 y and 24 points for the other two age groups (Table 2).

DISCUSSION

This study reinforces that the Mini-BESTest is an effective and accurate tool for identifying fallers and non-fallers female older adults without known neurological impairments [14,15]. As proposed in our second aim, we could establish cutoff scores for classifying fallers and non-fallers Brazilian female older adults in different age groups (65-69 years, 70-74 years, and 75+ years). The ROC curve results indicated a high accuracy in classifying fallers from non-fallers female older adults, as the AUC was higher than 0.9 with high sensitivity (95%) and specificity (93%). These findings aligned with previous studies that observed the Mini-BESTest has a high [14] and moderate accuracy [15] in identifying older adults with a history of falls.

The Mini-BESTest cutoff points obtained in the current study to classify fallers from non-fallers female older adults differed from those reported in the literature. Our findings showed that the cutoff point for the Mini-BESTest to classify women between 65-69 as a faller was a score of 26 points with high accuracy (AUC 1.00), sensitivity (100%), and specificity (100%). The cutoff score among female older adults of 70-74 years (0.99 AUC, 92% sensitivity, and 93% specificity) and 75+ years (0.95 AUC, 100% sensitivity, and 85% specificity) was 24 points for both groups. Yingyongyudha et al. [14] found that the Mini-BESTest was the most accurate tool for identifying older adults with a history of falls since it had the highest accuracy (85%) with a cutoff score of 16 points. In Yingyongyudha's study [14], the Mini-BESTest showed a high AUC (0.84), sensitivity (85%), and specificity (75%), but the cutoff score was lower than found in a study with patients with stroke (0.64 AUC, 64% sensitivity, 64.2% specificity and cutoff score of 17.5 points) [26] and patients with PD (0.75 AUC, 79% sensitivity, 67% specificity and cutoff score of 19 points) [25], and much lower than we observed in our study. The disparity between these findings [14,25,26] and our findings could be due to differences in the population groups studied and the impairments underlying the falls that may be different. In Yingyongyudha's study [14], the sensitivity, specificity, and AUC of the Mini-BESTest were higher than in other studies [25,26] and lower than in our study. This discrepancy could arise from age differences, methods of classifying participants with a history of falls, and whether the falls histories were obtained retrospectively [14,26] or prospectively [25]. The disparity between Yingyongyudha's study [14] and our study could also be due to the population groups studied (Thailand older men and women [14] and Brazilian older women in the present study) and age differences (60-96 years old [14] and 65-80 years old in the present study).

Similarly, Magnani et al. [15] suggested that the Mini-BESTest is a good tool for predicting fall risk over six months in community-dwelling Brazilian older adults between 60-102 years old. They found that cutoff values vary for different age groups, with a cutoff score of 25 points for older adults 60-69 years of age (0.68 AUC, 58% sensitivity, and 74% specificity) and a cutoff score of 23 points for older adults 70-79 years of age (0.74 AUC, 66% sensitivity and 73% specificity). However, our Mini-BESTest cutoff scores for the Brazilian female older adults differed from that reported by Magnani's study [15], with an increase of one point. This one-point difference is not

clinically meaningful, considering that a change of 1.5-4.5 points for the Mini-BESTest may be clinically important [38]. However, a previous study [10] assessed the psychometric properties of Mini-BESTest in Spanish in community-dwelling older adults (65-89 years old) and found that total scores obtained by women at Mini-BESTest were significantly lower than those reached by men, suggesting that older women had a worse quality of balance and a greater perception of their risk of falling than men. In this way, this one-point difference might indicate the differences between men and women in the performance and scores of the Mini-BESTest [10]. These differences can be associated with factors such as the heterogeneity of their sample, which included men and women, the difference in age groups division, the nature of the fall report (retrospective in the present study and prospective in their study), and the period of fall assessment occurrence (12 and 6 months, respectively). In addition, the cutoff score was chosen by selecting the score that provided the best balance between high sensitivity and high specificity. We found a positive likelihood ratio (+LR) more than 5 (+LR 13.01) and a negative likelihood ratio (-LR) less than 0.2 (-LR 0.05), indicating that the Mini-BESTest is helpful due to its high probability of correctly identifying participants with and without a history of falls.

In our study, age was a fall predictor. This is already well established in the literature since the fall prevalence in older women increases with age [1,3,4]. This significant influence of age on the risk of falling in women might be due to a higher prevalence of age-related risk factors among women, such as declines in physical, sensory, and cognitive function [3,20], and increased predisposition to muscle mass and bone density loss [5,16], as well as an increase in the number of comorbid conditions [3,19]. However, the Mini-BESTest exhibited a larger predictive power than age, indicating that the smaller the Mini-BESTest score, the higher the risk of multiple falls. Other studies also found that the Mini-BESTest strongly predicts fall in different populations, but no more than age [14,15,25]. Mak et al. [25] observed that the Mini-BESTest score is an independent predictor of future recurrent falls in patients with PD, revealing that the recurrent fallers had significantly lower Mini-BESTest scores than non-recurrent fallers. In addition, Magnani et al. [15] observed that the Mini-BESTest values were negatively associated with fall prediction, indicating that a 1-point reduction in the Mini-BESTest increased the odds of falls by 14% in older adults 60-69 years and by 33% in older adults 70-79 years. These authors concluded that the Mini-BESTest is a good tool for predicting fall risk in older adults of different ages and health statuses. In agreement with these previous studies [14,15,25], we also observed a smaller Mini-BESTest score for the fallers than non-fallers female older adults, confirming its predictive power to discriminate female older adults with and without a history of falls.

The Mini-BESTest is suitable as a screening clinic tool for health professionals to identify female older adults at risk of falls and, based on this, tailor fall prevention programs for this population. Fallers female older adults typically have deficits in anticipatory postural adjustments (i.e., postural transitions such as moving from sitting to standing or standing to sitting, rising to toes, and standing on one leg – right and left) [14], postural responses, sensory orientation, and dynamic stability during gait [3,4,14,16,22]; therefore, fall prevention programs or balance rehabilitation that targets these specific areas would be helpful to prevent future falls in female older adults in different age groups. Considering that the Mini-BESTest appropriately and accurately measures all these domains of dynamic balance, its application can help health professionals identify the main problems that can be addressed in an intervention program.

This study has some limitations: The fall data were collected retrospectively, which is more susceptible to recall problems and bias. In addition, the sample did not include older women with 80+ years.

CONCLUSION

The Mini-BESTest is a good and highly accurate tool for classifying fallers and non-fallers community-dwelling older Brazilian women in different age groups. The Mini-BESTest cutoff scores correctly classified fallers and non-fallers female older adults of varying age groups (65 to 69, 70 to 74, and 75 years of age or older). Our findings reinforce that the Mini-BESTest is an essential clinical tool that health professionals should use to evaluate the risk of falls in older females.

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