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Factors related to falls in active women over 50 years old: associated clinical and functional aspects

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Abstract

Falling is a public health problem as it results in physical, psychosocial and economic damage. Identifying factors related to the risk of falling in a given population allows for the development of more specific preventive activities. The objective of this study was to associate clinical and functional characteristics with the recent history of falls in middle-aged and elderly women. A total of 152 physically active women participated in the study, 50 of whom have reported one or more falls in the last twelve months. Self-reported clinical comorbidities and motor functionality were verified using the 30" Chair Stand Test (30CST) and the Balance Evaluation System Test (BESTest). Spearman correlation and a logistic regression analysis with the forward stepwise method were applied, considering p≤0.05. Age was inversely correlated with all BESTest items. Independent variables that were predictors of past falls were: number of comorbidities (p=0.017), performing 8 repetitions or less in the 30CST (p=0.036), having a score of 86.7% (13 points) or less in BESTest I (p=0.038), with a score of 73.3% (11 points) or less in BESTest V (p=0.050). There was an association between a history of falls and changes in muscle strength of the lower limbs and postural balance, related to biomechanical restrictions and sensory orientation in women in the study's age group. It is concluded that, women over 50 years old, physically active, with a history of falls, demonstrate that the number of comorbidities and the lower motor performance are factors associated with the risk of falling.

Key words: Health of the Elderly. Adult Health. Postural balance. Muscle strength.

INTRODUCTION

Falling is a public health problem, since 17% of the population over 55 years old reports having fallen during the last year and, after a decade of life, this number can increase to up to 60%[1,2]. It is characterized as a serious event among the elderly, as it results in both physical and tissue damage, injuries, fractures and functional decline, as well as psychosocial damage, such as increased dependence and fear of falling, isolation and loss of autonomy[3].

Elderly people who have muscle weakness, vertigo, gait and balance disorders, foot problems, visual, auditory, cognitive and sensory deficits, are more susceptible to falling[4–8]. The 30" Chair Stand Test (30CST) and the Balance Evaluation System Test (BESTest) are tools aimed at tracking these disorders and predicting the risk of falling in this population[9–11].

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Being a woman is considered a risk factor for falling, justified by the presence of a higher risk of tripping and a higher frequency of falls when compared to men of the same age group[1,12–15]. Women make up the largest portion of the Brazilian and world population[16], such facts endorse the motivation to carry out studies focused exclusively on this population.

The 30CST performance is a useful indicator in the diagnosis of disability in elderly populations, and it is simple, practical and quick to be carried out in research and clinical care center[s17]. This test provides an indirect measurement of strength and functionality of the lower limbs, which allows it to be potentially associated with measures to prevent falls in the elderly9.

BESTest is a broad, reliable and valid tool for assessing balance in the elderly[18]. The several sections of tests, when analyzed together, allow to associate and identify factors related to the risk of falling in the elderly[19]. This test allows the evaluator to perform static and dynamic analyses that reflect the individual's stability.

Performing physical exercises minimizes the risk and the history of falls in the elderly[20] but does not completely prevent its occurrence. The fall and the factors associated with this event in women starting from 50 years old, in transition to elderly life, who have the habit of performing regular physical activity, has been rarely addressed in the literature. This is because, it is believed that this age group is minimally affected by the risk of falling, as well as being protected by the practice of exercises, widely spread as a fundamental preventive factor.

Thus, there is a gap in the literature of evidence from tests that are sensitive in screening for the risk of falling in this population. It is believed that BESTest, both in the individual interpretation of its sections and in its final sum, and the 30CST aim to identify the presence of functional deficits related to falls in an age group considered to be at a low risk of falling[15].

Thus, the objective was to associate clinical and functional characteristics to the recent history of falls in middle-aged and elderly women active in the community.

METHODOLOGY

Cross-sectional analytical study, unpaired control case, carried out at the Movement Laboratory of Dr. Cláudio de Almeida Borges, installed at the College of Sports - ESEFFEGO, at Goiás State University (UEG), from January 2016 to December 2017.

A sample calculation was made for logistic regression, considering 4 independent variables (covariates k) and a proportion (p) of 32.5% of fallers, obtained from the study by Santos et al. (2013)17. The formula n=10k/p suggested by Long (1997)[21] was used to guarantee a power of 80% and an alpha error of 5%. The minimum sample for this study should be 124 participants, where n=(10*4)/0.325.

The sample selection included women enrolled in the UEG Open University Program (UNATI). They were included in the study under the following criteria: a score greater than or equal to 17 regardless of the influence of education on the Mini Mental State Examination (MMSE)[22,23] and the signed informed consent form (ICF).

Exclusion criteria were the use of lower limb prostheses (or endoprostheses), the report of acute crises of vertiginous syndromes close to the date of the assessment and the use of alcoholic drinks up to 24 hours prior to data collection[24].

The MMSE was applied to track cognitive losses, resulting in a score of a maximum of 30 points. Higher score values indicate higher cognitive performance. The cutoff of 24 points was suggested for people with over 9 years of education and 17 points for those with less

education[22].

The following instruments were used for motor assessment: anamnesis, 30CST and BESTest.

The anamnesis provided identification data (age, date of birth, sex and telephone number), anthropometric data on weight, height, body mass index (BMI), which physical exercises were performed during that period (type of physical activity and how long ago it was performed), history of falls in the last twelve months, use of legal and illegal drugs, use of medication and surgical history.

The 30CST indirectly assesses strength and resistance of the lower limbs by recording the number of executions of sitting and rising from a chair for 30 seconds, without using the upper limbs. The number of repetitions performed was recorded and corresponded to the final score, being directly proportional to the individual's functional performance. A score less than or equal to 9 indicated dependence on the performance of daily activities, since the score above this cutoff point was interpreted as a synonym for functional independence[17].

BESTest verifies postural balance through 27 items covered in 6 different sections: Biomechanical Restrictions, Stability/Vertical Limits, Anticipatory Postural Adjustments, Postural Responses, Sensory Guidance and Stability During Marching. To interpret the data, each item had a score ranging from 0 to 3, with 3 being the best performance. Each section had its score, which was transformed into a percentage. The maximum score was 118, also transformed into a percentage, with higher percentage values indicating a better balance[11].

All quantitative variables were assessed by the Kolmogorov-Smirnov test, to test the normality of the data distribution. Only age results showed normal distribution, as shown in table 1.

To prove correlation between age, 30CST and BESTest (association between quantitative variables), Spearman's correlation was used, appropriate for non-normal distributions.

To better define which independent variables would be associated with the faller's status (dependent variable), a logistic regression analysis was performed using the forward stepwise method (conditional), considering independent variables as all other qualitative and quantitative variables. Logistic regression is the most appropriate statistical technique, since the distribution of most independent variables and the number of falls (dependent variable) was not normal, which makes multiple linear regression unfeasible. The forward stepwise method introduces the significant independent variables in each step, adjusting the logistic regression model, in order to obtain the equation with better predictive capacity and eliminating non-significant variables.

In order to improve the logistic regression technique, as recommended by Fávero et al. (2009)25, the scaling motor variables were transformed into categorical ones: for the 30CST and all BESTest sections (including total value), several cutoff scores were established, with values that varied from the score immediately above the minimum value to the score immediately less than the maximum value. For example, in the case of BESTest I, the cutoff points ranged from 6 points (40%) to 14 points (93.3%); in the 30CST, 6 to 20 repetitions, and so on. In this transformation of the variables, if the participant had a value equal to or less than the cutoff point, she was classified as having a risk of falling, respectively, and vice versa.

The ethical and legal aspects of Resolution 466/127 were strictly followed, the project was presented and approved by the Research Ethics Committee (CEP) of the Federal University of Goiás (UFG), according to opinion No. 741.298/2014.

RESULTS

The sample consisted of 152 women, 50 of whom reported having fallen once or more in the previous twelve months and 102 did not report the occurrence of this event. Regardless of the report of falling, the selection and distribution of the sample sought homogeneity related to age and body mass index (BMI) among the participants. All performed at least one exercise or regular physical activity at least twice a week, such as gymnastics, walking, weight training, Pilates, water aerobics, volleyball or yoga, some had not yet finished the first month of practicing the activity, while others had already done it on average for four years. The homogeneity between groups is shown in Table 2.

Age was inversely and significantly correlated with all BESTest items, suggesting that the older the age, the worse the performance on this postural balance scale (Table 3). BESTest is probably sensitive to the physiological changes of aging in this physically active female population. There was a weak significant correlation between the 30CST and BESTest items I and VI, indicating that greater functional power of the lower limbs correlates with better balance performance related to biomechanical restrictions and stability during gait. Correlations whose ρ (Spearman's Rho) has a value between 0.1 and 0.29 had a weak effect size, and a value between 0.3 to 0.49 had a moderate effect size[26].

According to the logistic regression, in the studied population, only the following independent variables are predictors of previous falls: number of comorbidities (concomitant diseases), performing 8 repetitions or less in the 30CST, having a score of 86.7 % (13 points) or less on BESTest I, and score 73.3% (11 points) or less on BESTest V (Table 4). The other variables were excluded from the equation, through the conditional method, as they have no statistical significance. The logistic regression equation explains 20.2% of the data, according to R^2 Nagelkerke.

The equation for calculating risk in the studied population, derived from logistic regression, is P=

$$\frac{1}{1+e^{-logit}}$$

logit=-2,310+(0,368*QDR)+(1,252*TSL)+(0,951*B_I)+(0,853*B_V)

- P is proportion;
- NDR is the number of diseases reported (the exact number);
- 30CST is the classification of the individual as incapable when she had a 30CST value ≤ 9 (value to be assigned in the equation: 1), or as capable if she had a 30CST value > 9 (value to be attributed in the equation: 0);
- B_I is the classification of equilibrium by BESTest I with values ≤ 13 (value to be assigned in the equation: 1) or values > 13 (value to be assigned in the equation: 0);
- B_V is the classification of equilibrium by BESTest V with values ≤ 11 (value to be assigned in the equation: 1) or values > 11 (value to be assigned in the equation: 0).

Proportions above 0.2863 (cut-off point) are likely to predict previous falls with 68% sensitivity and 59.8% specificity in this population. It is possible to use this regression in Microsoft Office Excel® using the following formula (without copying quotes), which must be pasted in the spreadsheet cell: "=1/(1+((POTÊNCIA(EXP(1);(-((-2,31)+(0,368*QDR)+(1,252*30CST)+(0,951*B_I)+(0,853*B_V)))))))".

Table 1- Tests of normality of the distribution of variables (Goiânia-GO, February - August 2017)

VARIABLE	p value*	Distribution	VARIABLE	p value*	Distribution
Age	0.200	Normal	30CST	<0.001	Not normal
BMI	0.036	Not normal	BESTest I	<0.001	Not normal
MEEM	<0.001	Not normal	BESTest II	<0.001	Not normal
Time of physical exercise	<0.001	Not normal	BESTest III	<0.001	Not normal
Number of types of physical activity practiced	<0.001	Not normal	BESTest IV	<0.001	Not normal
Number of reported diseases	<0.001	Not normal	BESTest V	<0.001	Not normal
Number of reported surgeries	<0.001	Not normal	BESTest VI	<0.001	Not normal
Number of falls in the last 12 months	<0.001	Not normal	BESTest total	<0.001	Not normal

* Kolmogorov-Smirnov test

Table 2- Distribution of the values of age, BMI, MMSE and time of physical exercise, among participants with and without a history of fall (s) (Goiânia-GO, February - August 2017)

	NO FALL HISTORY					WITH FALL HISTORY					
	Mín	Q1	Med	Q3	Max	Min	Q1	Med	Q3	Max	P value
Age (years)	50.0	63.0	68.0	73.0	85.0	50.0	61.8	67.5	72.3	80.0	0.677
BMI (kg/m2)	18.9	23.9	26.2	29.2	44.1	15.4	24.8	27.1	30.0	41.7	0.210
MEEM (score)	12.0	27.0	29.0	29.8	30.0	21.0	25.8	28.0	29.0	30.0	0.161
Physical exercise time (months)	0.0	6.0	24.0	81.0	348.0	0.0	12.0	42.0	99.0	240.0	0.329

Legend: Min.: Minimum; Max.: Maximum; Q1: first quartile; Q3: third quartile; Med: median.
* Significance in the Mann-Whitney test, for comparison of non-normal distributions

Table 3- Correlations between age, 30CST and BESTest (Goiânia, GO, February - August 2017)

VARIABLE	Correlation test	Age	30CST
30CST	Spearman's Rho p value (bilateral)	-0.115 0.160	1.000 .
BESTest I (%) **Restrições biomecânicas**	Spearman's Rho p value (bilateral)	***-0.229*** 0.005	***0.167*** 0.040
BESTest II (%) **Limites da estabilidade/ verticalidade**	Spearman's Rho p value (bilateral)	***-0.199*** 0.014	0.106 0.195
BESTest III (%) **Ajustes posturais antecipatórios**	Spearman's Rho p value (bilateral)	***-0.326*** <0.001	0.132 0.106
BESTest IV (%) **Respostas posturais**	Spearman's Rho p value (bilateral)	***-0.201*** 0.013	-0.028 0.735
BESTest V (%) **Orientação sensorial**	Spearman's Rho p value (bilateral)	***-0.170*** 0.037	-0.022 0.789
BESTest VI (%) **Estabilidade durante a marcha**	Spearman's Rho p value (bilateral)	***-0.219*** 0.007	***0.158*** 0.051
BESTest (%) **Total da pontuação**	Spearman's Rho p value (bilateral)	***-0.401*** <0.001	0.126 0.122

Significant correlations in bold and italics.

Table 4- Logistic regression using the historical variable of previous falls (Goiânia, GO, February – August 2017)

VARIABLES IN THE EQUATION				MODEL SUMMARIZATION	
Variable	**B**	**Wald**	**p-value**	R^2 Nagelkerke	0.202
History of falling	-0.713	17.055	<0.001*		
Number of reported diseases	0.368	5.676	0.017	TABELA DE CLASSIFICAÇÃO	
30CST rating ≤ 8	1.252	4.381	0.036	Sensibilidade 68,0%	
BESTest I ≤ 86.7	0.951	4.287	0.038	Especificidade 59,8%	
BESTest V ≤ 73.3	0.853	3.843	0.050	Acurácia 62,5%	
Constant	-2.310	23.821	<0.001	Ponto de corte 0,2863	
	Step 4	**X^2**	**p-value**	**CURVA ROC**	
OMNIBUS TESTS OF MODEL COEFFICIENTS	Step	23.875	<0.001	***Area***	***p-value***
	Block	23.875	<0.001	0.717	<0.001
	Model	23.875	<0.001		

* The regression equation is statistically significant.

DISCUSSION

It is known that BESTest is valid to differentiate adult who fall from those who do not fall, in a population over 50 years old[27]. In this study, in the population of middle-aged or elderly women who perform regular physical exercises, there was an association between the previous history of falling in the previous twelve months and the alteration of the muscular strength of the lower limbs and the postural balance related to biomechanical restrictions and sensory orientation assessed respectively by the 30CST, BESTest section I and V tests. It is possible that these independent variables are capable of predicting a greater chance of future falls, although the analysis was not performed.

It can be seen that the cutoff point of the 30CST for predicting falls in this study, of 8 repetitions, is slightly lower than the score proposed by Santos et al. (2013)17, to predict that an elderly woman is functionally dependent in basic activities of daily living (9 repetitions).

The variation of motor actions and reactions that an individual may present during the execution of a task is indicative of his performance and can be defined as motor variability. The interpretation of motor variability is dependent on the function evaluated; for example in new tasks, the greater the variation, the better the indication of learning and the establishment of preferences for execution, as the motor experience will be more intense in the face of the new challenge. In usual daily and functional activities, the lower the motor variability, the greater the energy savings and the better efficiency will be at the end of the task[28].

The participants who reported not having fallen during the previous year demonstrated less motor variability, that is, greater efficiency in the repetitions, reactions and adaptations required in section I of the BESTest, reflecting on a skeletal muscle performance superior to the participants with a previous history of falling. The increase in body sway on the support base can be referred to as the increase in motor variability in balance assessments, showing a direct relationship with the incidence of falls in the elderly[29].

Sensory orientation, evaluated in section V of the BESTest, describes the interactions of the sensory system that the participant has; this system being one of the factors that affect postural control, resulting in instabilities for daily functions18. The modified clinical test of sensory interaction in the balance (mCTSIB) is part of the evaluation proposed in section V of BESTest. However, it also has an independent application capable of identifying, for example, that osteoporotic elderly women with a history of falls in the last 12 months have worse balance and postural control in relation to osteoporotic women without the same record[30].

BESTest sections II, III, IV and VI were not able to differentiate women with a history of falling from those without a history of falls. Below, some clinical tests similar to the tasks described in the aforementioned BESTest steps are described in order to broaden the understanding of the assessment objective of each subcategory of that test.

The previous functional reach test, present in section II of BESTest as functional reach forward, was applied in the study by Campos, Vianna and Campos (2013)[31], and they also did not significantly correlate with the occurrence of falls in an elderly population predominantly female and healthy.

Regarding the anticipatory postural adjustments evaluated in section III of BESTest, the items “stand on one leg” and “alternately

place the feet on a step", are similar to tests carried out within the BERG Balance Scale. Both the BESTest and BERG Balance Scale are capable of identifying risk of falling in institutionalized older adults[32]. Strong scientific evidence associated with their respective applications in samples that practice physical activity and live independently in the community had not yet been found.

Considered part of postural control, balance compensates for internal and external disturbances through postural responses, ensuring stability[33]. Section IV of BESTest assesses these postural responses and corresponds to a series of external stimuli applied to the individual by the evaluator, similar to the one performed in a dynamic computerized posturography. It is possible to distinguish elderly fallers from non-fallers by means of dynamic computerized posturography[34]. However, in this study, the postural responses in section IV of BESTest did not discriminate the sample in relation to the history of falls, considering that women are physically active.

Stability During March is the title of section VI of the BESTest and describes an application protocol similar to the Timed Up and Go[35] and Tinetti Balance Test (Performance Oriented Mobility Assessment - POMA)[36]. Karuka, Silva and Navega (2011)[37] analyzed the agreement between the Previous Functional Reach Test, the BERG Balance Scale, the Timed Up and Go test and the Tinetti Balance Test for the study of body balance in the elderly. They concluded that these aforementioned tests are complementary and need to be applied together to better assess balance in elderly women.

It is believed that BESTest's proposal is to bring together the neuromusculoskeletal elements already described in the literature as influencing balance and proposing, in a single assessment instrument, the combination of these different tests described, in a single component. Thus, the clinical needs for better investigation of the balance function in the elderly are met.

This study exposes possibilities of continuity and replication, given the number of instruments mentioned that have similar purposes with peculiar characteristics and the growing need for optimization and accuracy during clinical investigations of the motor behavior of people transitioning to an elderly life; addressed here as starting from fifty years old. The broad age spectrum observed in the results was a limitation of the study.

CONCLUSION

The number of reported diseases and the level of strength and balance, detected by the study instruments, are independent variables associated with the recent history of falls in middle-aged and elderly women active in the community.

It is suggested that, when applying and interpreting the BESTest, the examiner considers the values obtained in each section, not only the final total score, to evaluate women starting from 50 years of age. It is possible, that these independent variables can also predict future falls in this population; however, it is necessary that prospective studies be carried out to confirm this hypothesis.

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