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Analysis of agreement of assessment tools of body balance in the elderly

Análise da concordância entre instrumentos de avaliação do equilíbrio corporal em idosos

Aline H. Karuka[1,2], José A. M. G. Silva[3], Marcelo T. Navega[1,2,3]

Abstract

Background: The diagnosis of clinical parameters associated with falls in the elderly has become a major challenge for the scientific community. Despite the existence of several tools aiming to assess body balance in the elderly, it is still scarce the number of studies that have investigated and discussed the agreement between different methods. **Objective:** To analyze the correlation between tests used to assess the body balance in the elderly. **Methods:** This was a cross-sectional, observational study conducted with 30 healthy female community-dwelling elderly volunteers with different levels of physical conditioning. The Functional Reach Test (FRT), the Berg Balance Scale (BBS), the Timed Up and Go (TUG) and the Performance-Oriented Mobility Assessment of Balance (POMA) were used. The data analysis was performed by using the Spearmam's rank correlation coefficient, with a significance level of 5% ($p \leq 0.05$). **Results:** There was positive and moderate correlation between the FRT and BBS ($r=0.4845$, $p=0.0067$), between FRT and POMA ($r=0.4136$, $p=0.0231$), and between BBS and POMA ($r=0.6088$, $p=0.0004$). **Conclusion:** The tests are complementary since they showed specific and distinct limitations. It is reasonable, therefore, to use these instruments together to get better assessment of elderly body balance.

Keywords: geriatric assessment; physical therapy; body balance.

Resumo

Contextualização: Diagnosticar os parâmetros clínicos associados com as quedas em idosos tornou-se um grande desafio para a comunidade científica. Apesar da existência de diversos instrumentos direcionados à avaliação do equilíbrio corporal em idosos, ainda é escasso o número de trabalhos que investigaram e discutiram a concordância entre os diversos métodos. **Objetivo:** Analisar a correlação entre alguns testes usados para avaliar o equilíbrio corporal no idoso. **Métodos:** Tratou-se de um estudo transversal, observacional, realizado com 30 voluntárias idosas comunitárias, hígidas, com diferentes níveis de condicionamento físico. Foram utilizados o Teste de Alcance Funcional Anterior (TAF), a Escala de Equilíbrio de Berg (EEB), o teste *Timed Up and Go* (TUG) e o Teste de Equilíbrio de Tinetti (*Performance Oriented Mobility Assessment - POMA*). A correlação dos dados foi realizada por meio da aplicação do Coeficiente de Correlação de Spearman, com nível de significância de 5% ($p \leq 0,05$). **Resultados:** Observou-se correlação positiva e moderada entre o TAF e a EEB ($r=0,4845$; $p=0,0067$), entre o TAF e a POMA ($r=0,4136$; $p= 0,0231$), entre a EEB e a POMA ($r=0,6088$; $p=0,0004$). **Conclusão:** Os testes são complementares, dado que se mostraram com particularidades e limitações distintas. Torna-se razoável, portanto, a aplicação conjunta desses instrumentos para melhor avaliar o equilíbrio de idosas.

Palavras-chave: avaliação geriátrica; fisioterapia; equilíbrio corporal.

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[1] Musculoskeletal Assessment Laboratory, Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Marília, SP, Brazil
[2] Faculty of Philosophy and Science, UNESP, Marília, SP, Brazil
[3] Institute of Bioscience, UNESP, Rio Claro, SP, Brazil
Correspondence to: Marcelo T. Navega, Faculdade de Filosofia e Ciências – Departamento de Educação Especial, Avenida Hygino Muzzi Filho, 737, CEP 17525-900, Marília, SP, Brasil, e-mail: navegamt@marilia.unesp.br

Introduction

The aging process of the population is a global phenomenon[1,2]. In developed countries, especially in European countries, the elderly population has been growing gradually. In absolute numbers the total population in 1980 was 121.3 million, being more than 4.9 million older than 65 years, and 0.6 million older than 80. The expectation for 2020 is that the total population will be of 233.8 million, being 18.9 million over 65 year-old and 3.1 million over 80 year-old. Brazil presents one of the most acute processes of population aging among the most populous countries[2]. Brazil will be the sixth oldest population in the world in 2025, in contrast to the 16th place that the country ranked in 1960[3], a factor that increases the scientific community's concern in performing studies towards elderly people.

An important aspect to be studied in the elderly is falls. They are treated as highly relevant epidemiological, social and economic factor in the whole world as it is the most common type of accident among the elderly[4]. A fall is characterized as a serious risk since it can potentially lead to complications, such as hypoactivity, social isolation, depression, institutionalization, reduces the quality of life[5-7], loss of confidence, dependence in basic functional activities and even death[8]. It is noteworthy that both the incidence and severity of falls increases considerably after the sixth decade of life, tripling the rates of hospitalization of the elderly after 65 years[3].

It is estimated that the fall is the cause of about 90% of hip fractures in the elderly, impairment that has a high morbidity and mortality. Fractures from falls account for approximately 70% of accidental deaths in people over 70 years[9]. Besides the serious consequences for health and independence of these patients, falls result in an increase of admission to health services, reaching 20,000 admissions per year in some countries. This increased use of services causes a proportional increase in health costs for the country. The costs post falls are higher than US$ 4,500 per year for each patient[3].

The balance of the body decreases along with aging process[10], being one of the functions most affected in this process. It is estimated that the prevalence of balance complaints in the elderly population over 65 year-old reach 85%[11]. Balance is a complex process that involves the reception and integration of sensory input, the planning and execution of movements to control the center of gravity on the support base, being conducted by the postural control system, which integrates information from the vestibular system, visual receptors and somatosensory system[12].

With aging, this system becomes deficient and may eliminate several steps in the postural control, reducing the compensatory capacity of the system, leading to an increase in instability[13]. As the balance depends on multiple sensory inputs, any failure in one of the involved systems can cause postural imbalance and consequently falls[12]. Given those considerations, it is clear the importance of body balance assessment in the elderly, as once the deficit is identified; preventive actions can be taken as early as possible, avoiding therefore the risk of falls in this population.

With the goal to diagnose the clinical parameters to predict of the risk of falls in the elderly, several instruments were developed for assessment of postural control. Among the clinical tests to evaluate the body balance, the most commonly used and established in the literature are the Functional Reach Test (FRT), the Berg Balance Scale (BBS), the test "Timed Up and Go" (TUG), and Tinetti Balance Test (Performance Oriented Mobility Assessment - POMA)[11,14], that are validated in the original language and have good reliability[11]. Due to the several instruments aimed to predict the risk of falls in the elderly, this study aimed to investigate and discuss the correlation between the instruments as well as to discuss the pros and cons of each method of evaluation.

Methods

The study was approved by the Ethics Committee involving human subjects of the Faculty of Philosophy and Sciences of the Universidade Estadual Paulista "Julio de Mesquita Filho" (UNESP), Marília, SP, Brazil (Protocol 1355/2010). The procedures were started after the participants signed the consent form, in accordance with Resolution 196/96 and its supplementary of the Brazilian National Health Consul.

This was an observational cross-sectional study with the sample selected by convenience. The sample consisted of 30 healthy female community-dwelling elderly volunteers, with different physical fitness levels, aged from 61 to 74 years, residents of the city of Marilia, SP, Brazil. We excluded volunteers who had neurological diseases, such as stroke, Parkinson's disease; vestibular impairment; uncorrected visual problems; paralysis of any etiology; orthopedic alterations such as amputations, fractures, history of ankle sprain in the last six months, inability to remain standing upright without the use of walking support device, pain on abduction and/or flexion of the shoulders, less than 90° of shoulder abduction or reduced range of motion of the elbows and scores below 18 points in the Mini Mental State Examination (MMSE)[15]. The tests were carried out in places with good lighting, flat and smooth ground and according to the individual convenience for each volunteer.

Initially, an anamnesis was performed, in which personal data were provided and a brief physical examination with anthropometric data (body weight, height, body mass index (BMI), length of arm and right foot) was performed, which could be used to normalize the data whenever necessary. After the anamnesis, the test for cognitive assessment (MMSE) was applied. Tests for measuring body balance were performed by a single assessor and applied randomly through a simple drawing for each volunteer. For each test, the instructions were given and the tasks do be performed were demonstrated, without the need of a previous training of the volunteer.

Mini Mental State Examination (MMSE)

In order to assess cognitive functions, the MMSE was applied[16]. This instrument consists of seven categories, being each one designed with the objective to assess specific cognitive functions. They are: temporal orientation, spatial orientation, registration of three words, attention and calculation skills, recall of the three words, language and visual-constructive praxis. The MMSE score ranges from zero to 30 points, being lower values indicating possible cognitive impairment. MMSE values <18 indicate the presence of dementia of mild severity; 10 <MMSE <18 moderate dementia and MMSE <10 severe dementia[16].

Berg Balance Scale (BBS)

Translated by Miyamoto et al.[17], this scale is widely used mainly to determine risk factors for loss of independence and falls in the elderly. The scale assesses the balance in 14 common items to daily life. Each item has an ordinal scale of five alternatives ranging from 0 to 4 points, being the maximum score 56 points. The points are based on the time in which the position can be maintained, the distance that the arm is able to reach forward and the time to complete the task[18]. The lower the score achieved, the greater is the risk of falling. However, the relationship between the score achieved with the result of fall is not linear, as a small variation in the points may indicate a large difference in risk of falls[19].

Different cutoff scores are described in the literature to discriminate elderly fallers and non-fallers: Berg et al.[20] propose 45 points; Chiu, Au-Yeung and Lo[21] suggested 47 points and Shumway-Cook et al.[22] 49 points. According to these authors, higher scores indicate normal balance and scores equal to or below that cutoff scores indicate the risk of falls. Shumway-Cook and Woolacott[19] suggest that, between 53-46 points, there is low to moderate risk of falls, and scores below 46 points indicate high risk of falls.

Functional Reach Test (FRT)

The FRT determines how far that the elderly are able to move within the limits of anterior stability. It is widely used to identify the risk of falls. A tape measure is attached to the wall, parallel to the floor, and positioned in the height of the volunteer's acromion. The barefoot subject is positioned with the feet comfortable, parallel, perpendicular to the wall and near the beginning of the tape measure. With the wrists in neutral position, arms straight and shoulder in 90° of flexion, the volunteer is instructed to perform a forward bend without touching the tape measure, then, the displacement on the tape measure should be verified.

The test result is represented by the average, after three attempts, of the difference between the initial and final position recorded on the tape measure. Displacements smaller than 15 cm indicate frailty and risk of falls[20,23,24]. Gai et al.[25] however, reported that elderly with functional reach smaller than or equal to 17 cm are 13 times more likely to fall.

Timed Up and Go test (TUG)

The TUG test aims to assess the mobility and the functional balance. The test quantifies the functional mobility, in seconds, by the time that the participant takes to perform the task of rising from a chair (support of approximately 46 cm in height and arms of 65 cm in height), walk 3 meters, turn around and go back toward the chair and sit again[26].

In order to be tested by the TUG, the elderly is instructed to begin the test from a starting position of sitting upright with the back leaning against the chair. The timing begins after the starting signal and stopped only when the elderly are positioned again into the starting position, sitting with the back against the chair.

Bischoff et al.[27] suggested that the performance of the test within 10 seconds is the time considered normal for healthy, independent adults without risk of falls; values between 11-20 seconds is expected for frail or disabled elderly, with partial independence and with low risk of falls; above 20 seconds suggests that the elderly presents important deficit of physical mobility and risk of falls. The same authors determine a performance of up to 12 seconds as normal time to perform the test for the community-dwelling elderly.

Tinetti Scale (Performance Oriented Mobility Assessment - POMA)

The Tinetti Scale was translated into Brazilian-Portuguese and validated in Brazilian population by Gomes[24].

This scale is divided into two parts: one that evaluates the balance, and the other evaluates the gait. It consists of a scale of 22 tasks, being 13 of them are part of the balance scale, and the other 9 of the gait assessment part. Similarly to the Berg Balance Scale, the Tinetti Balance Scale consists of several tasks representative of daily living activities, which are evaluated through observation by the examiner. The Performance Oriented Balance Assessment can be classified into three categories: normal, adaptive and abnormal, with the corresponding scores of 3, 2 and 1, respectively. The Performance Oriented Gait Assessment can be classified into two categories: normal and abnormal, corresponding to scores 2 and 1, respectively. The Performance Oriented Balance and Gait Assessments make a total score of maximum 39 and 18 points, respectively (being the maximum score of 57 points in the sum of the two scales). The cutoff scores that represent risks of falls for the POMA-Brazil have not yet been described in literature. The scores recently reported correspond to the Tinetti Scale, which originally has 14 tasks (eight on the balance scale and six to the gait assessment), being the score ranging from 0 to 28 points. Scores below 19 points and between 19 and 24 points represents, respectively, a high and moderate risk of falls[28].

Statistical analysis

For statistical analysis, the program *GraghPad Prism 5* was used. To analyse the data distribution, the *Shapiro-Wilk* test was used. The Spearman's correlation test was used to assess correlations between the balance tests. To interpret the data, the significance level of 5% ($p \leq 0.05$) was set.

Results

The sample consisted of 30 elderly women, mean age 67.93 (SD 3.90) years (max: 74 years and min: 61 years), presenting BMI of 29.16 (SD 4.53) kg/m² (max: 41.03 kg/m² and min: 20.73 kg/m²) and MMSE score of 27.27 (SD 2.32) (max: 30 points and min: 19 points).

The results of the performance of FRT, BBS, POMA and TUG are shown in Table 1.

Table 2 shows the classification with regards to the risk of falls and/or mobility/functional independence of participants according to the cutoff scores of BBS TUG and FRT as proposed by different authors.

Table 3 represents the correlations between the tests TUG, POMA, BBS and FRT.

Table 1. Results obtained in FRT, BBS, POMA e TUG.

	Mean±Standard Deviation	Min - Max
Measure of Functional Reach Test (cm)	30.11±5.12	21-37.17
BBS score	53.87±1.61	50-56
POMA score	37.9±1.09	36-39
Timed Up and Go (s)	10.67±2.2	8-19

cm=centimeters; s=seconds; FRT=Functional Reach Test; BBS=Berg Balance Scale; POMA=Performance Oriented Mobility Assessment; TUG=Timed Up and Go.

Table 2. Classification of participants with regards to the risk of falls and/or mobility (functional independence) in accordance with the cutoff of BBS, TUG and FRT.

	Categorias	n	%
BBS (Shumway-Cook and Wollacott[19])	56-54 points (no risk for falls)	19	63
	53-46 points (low to moderate risk for falls)	11	37
	<46 points (hight risk for falls)	0	0
BBS (Shumway-Cook et al.[22])	≤49 points (risk for falls)	0	0
	>49 points (no risk for falls)	30	100
BBS (Chiu, Au-Yeung and Lo[21])	≤47 points (risk for falls)	0	0
	>46 points (no risk for falls)	30	100
BBS (Berg et al.[20])	≤45 points (risk for falls)	0	0
	45 points (no risk for falls)	30	100
TUG (Podsiadlo and Richardson[26])	≤10 s (preserved functional independence)	15	50
	Between 11-20 s (functional independence partially preserved)	15	50
	>20 s (compromised functional independence)	0	0
TUG (Bischoff et al.[27])	≤12 s (execution within the expected time)	27	90
	>12 s (execution above the expected time)	3	10
FRT (Duncan et al.[23])	≤15 cm (risk for falls)	0	0
	>15 cm (no risk for falls)	30	100
FRT (Gai et al.[25])	≤17 cm (risk for falls)	0	0
	>17 cm (no risk for falls)	30	100

n=number of participants; %=percentage; BBS=Berg Balance Scale; TUG=Timed Up and Go; FRT=Functional Reach Test.

Table 3. Results of Spearman correlation between FRT, BBS, POMA and TUG test.

	r	p
BBS and POMA	0.60	<0.01*
BBS and TUG	-0.30	0.10
FRT and BBS	0.48	<0.01*
FRT and POMA	0.41	0.02*
FRT and TUG	-0.24	0.18
POMA and TUG	-0.21	0.25

FRT=Functional Reach Test; BBS=Berg Balance Scale; POMA=Performance Oriented Mobility Assessment (Tinetti test); TUG=Timed Up and Go. * Statistically significant.

Discussion

Several tests have been developed with the aim of functionally evaluate the body balance and to establish the parameters for identifying elderly with increased risk of falls[14]. Figueiredo, Lima and Guerra[11] identified the most used instruments for analyzing functional balance in the international and national level. Based on this study[11], four tests were selected: FRT, TUG, BBS and POMA. These tests were selected because of its wide applicability in the clinical-scientific context as these testes have psychometric characteristics of ease to use, such as low cost, validity in the original language, good reliability, easier understanding, reduced time to perform the tests and they are in the public domain.

The elderly group assessed in this study showed a moderate positive correlation between the scores of BBS and POMA (r=0.60; p<0.01), indicating that the two scales are directly proportional, both have characteristics that predict the risk of falls and the risk of functional decline. The positive correlation between the scales is due to the fact that many tasks assessed by the Berg Scale are also proposed during the performance of the POMA scale (balance while sitting, standing and standing in one foot, sitting and standing). Corroborating the present study, Silva et al.[29] in assessing balance, coordination and agility of 61 elderly, aged from 60 to 75 years, alocated into two groups (resistive physical exercise and control group), found a significant positive correlation between BBS and POMA for the experimental group (r=0.57; p<0.01) and for the control group (r=0.82; p<0.01).

There was a statistical significant and moderate correlation between the instruments FRT and BBS (r=0.48; p<0.01), indicating that for some participants of this study, the greater the anterior reach achieved, the higher is the scores on the BBS. In this study, all participants had results above the cutoff scores described in the literature to discriminate elderly fallers and non-fallers, represented by functional reach greater than 15 cm[23] and 17 cm[25] and scores above 45[20], 47[21] and 49 points[22] in the BBS. It can be said therefore, that the results of the two scales are equivalent with regards to the measurement of the risk of falls; both indicated normal balance for the assessed population. However, it should be emphasized that despite the equivalence relationship mentioned, the performance of one test does not replace the other. The FRT is an assessment tool that identifies the dynamic changes of postural control and only assesses the movement in one direction (anterior displacement of the trunk). The BBS is a functional assessment of the balance performance, based on representative activities of daily living, evaluating the stable and anticipatory postural control through the interaction of different force vectors[30].

The moderate correlation found between FRT and POMA (r=0.41; p=0.02) indicates a trend that the higher the functional reach achieved, the higher is the score in the POMA. However, the lack of description in the literature for scores indicative of falls for the POMA-Brazil, restricts the comparison between the indicative of the risk of falls between the FRT and the POMA. Gai et al.[25] conducted a descriptive study with 83 elderly women, which aimed to identify factors associated with the presence of falls into a group of independent and autonomous elderly women. The participants were submitted to the FRT and to the POMA. The results showed that the body balance condition presented by the elderly women, assessed by the POMA and by the FRT, showed an association with the occurrence of falls, indicating that these two tests are efficient tools to predict risk of falls.

In this study, there was no statistical significant correlation between the TUG and the BBS tests. However, according to the cutoff scores proposed by Podsiadlo Richardson[26] for the TUG, and by Shumway-Cook and Wolacott[19] for BBS, it was found that 67% of equity of the risk of falls between the two scales: 40% of participants performed the TUG with time equal to or less than 10 seconds and scored between 54 and 56 points in the BBS, as an indication of the normal balance and low risk of falls; 27% of the participants performed the TUG with time between 11 and 20 seconds and had a score between 53 and 46 in BBS. These results suggest a low to moderate risk of falls. If we consider the cutoff scores proposed by Berg et al.[20], Chiu, Au-Yeung and Lo[21] and Shumway-Cook et al.[22] for BBS, 45, 47 and 49 points, respectively, and the time of 12 seconds as a cutoff for the TUG to consider the elderly performance within the expected time[27], it can be said that there is 90% agreement between the two tests to predict risk of falls, as all elderly women had a score above 49 points in the BBS, and 27 of those performed the TUG in time equal to or less than 12 seconds, results that indicate the absence of the risk of falls.

As observed in the correlation between the BBS and TUG, no correlation was found between the POMA and the TUG. An important issue to be raised is that the POMA scale is indicated

for people with more severe motor impairment, which have a higher risk of falls[31]. A study evaluating healthy elderly or with a younger age that present an intact motor function measured by the POMA scale can result in high rate of ceiling effect. In the present study, the mean age of participants was 67.93 ± 3.90 years, 63% of the sample consisted of elderly women between 60 and 69 years and 37% of elderly women between 70 and 79 years. A ceiling effect in the POMA scale for this population occurred in 12 volunteers (40%). In the BBS and FRT scales, maximum performance was also observed in some volunteers.

Among the instruments used to evaluate balance, it should be emphasize the advantage of BBS and POMA in relation to others, since they evaluate many different aspects of balance and need few types of equipment to be administered. However, the time required to administer these tests are longer compared to the TUG and the FRT. With regards to the psychometric properties of the scales, it is noteworthy that both the BBS and the POMA assess the body balance in situations that represent the daily living activities, such as standing position, standing up, leaning forward, turning, among others. However, the BBS shows better details to describe and classify the performance of each proposed task, as each activity can be scored on five quality levels; otherwise, the POMA scale allows score in three sublevels for each task. A disadvantage of both scales is the low specificity with regards to the elderly with better functional capacity; as there are limitations in the scoring with regards to a more subtle balance changes, leading to the ceiling effect in the score. From this study, we can say that the POMA is even more susceptible to this effect than the BBS, as it showed ceiling effect in 40% of participants; in contrast with 17% of the sample presented the highest score in the BBS.

The advantages of the FRT are reflected in the feasibility and to the lower time required to be administered; it is sensitive to changes as a result of balance training, however only assess the movement in one direction - forward. The TUG, unlike the other tests, has the characteristic of assessing balance and functional mobility through a dynamic activity. It has the advantage that it can be administered quickly, with minimal equipment.

This study has limitations related to the homogeneity of the study population, which has contributed to the low variability between the scores obtained during the execution of the proposed functional scales, which may have contributed to the fact that the correlation values between the tests varied from moderate to weak.

Conclusion

The data from this study allow us to conclude that the assessment tests of the elderly balance, BBS, TUG, POMA and FRT, are complementary, given that they did not showed a strong correlation and presented distinct peculiarities and limitations. It is reasonable, therefore to apply these instruments together to better assess balance of elderly.

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