ORIGINAL ARTICLE

Comparison between balance assessment instruments for adult and elderly women in the community

Comparação entre instrumentos de avaliação do equilíbrio em mulheres adultas e idosas da comunidade

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ABSTRACT

Objective: To compare two balance assessment instruments, BESTest and Baropodometry, for women and to verify the influence of age, comorbidities and sight on balance. **Method:** Cross-sectional, quantitative study conducted with adult women (50 to 64 years old) and elderly women (65 years old and older). Balance was assessed by a baropodometric platform and the Balance Evaluation Systems Test (BESTest). T test, Anova with Bonferroni correction, and Linear Regression were applied to analyze the data, and statistical significance was set at p <0.05. **Results:** 156 women participated in the study, 54 adults (59 years ± 3.93) and 102 elderly women (71 years ± 4.8). BESTest evidenced that adult women performed better (p <0.01) than older women in the categories biomechanical constraints, transitions and anticipations, sensory orientation, gait stability and total score. There was a relationship between BESTest and self-reported comorbidities in the elderly group in items such as biomechanical restrictions, transitions / anticipations and total score categories (p <0.01). Baropedometry identified alterations of latero-lateral displacement with eyes closed between both groups (p=0.01), and the elderly presented worse performance. However, such tools had little relation to each other, and their association ranged from 5 to 11%. **Conclusion:** BESTest and baropedometry were effective in detecting differences between the balance of adult and elderly women but had a low association with each other. It is suggested that they should be adopted as complementary and not substitutable evaluations in the physiotherapist's clinical practice.

Keywords: Postural Balance, Aged, Women

RESUMO

Objetivo: Comparar dois instrumentos de avaliação do equilíbrio, BESTest e Baropodometria, em mulheres da comunidade e verificar a influência da idade, comorbidades e visão no equilíbrio. **Método:** Estudo tranversal, analítico, realizado com mulheres adultas (50 a 64 anos) e idosas (a partir dos 65 anos). O equilíbrio foi avaliado por uma plataforma baropodométrica e com o Balance Evaluation Systems Test (BESTest). Aplicou-se teste T, Anova, Bonferroni e Regressão Linear utilizando o Software SPSS 23.0, adotando-se p<0,05. **Resultados:** Participaram 156 mulheres sendo 54 adultas (59 anos ± 3,93) e 102 idosas (71 anos ± 4,8). O BESTest verificou que as mulheres adultas apresentaram melhor desempenho (p<0,01) em relação à idosas nas categorias restrições biomecânicas, transições e antecipações, orientação sensorial, estabilidade de marcha e escore total. Houve relação entre o BESTest e o autorrelato de doenças no grupo de idosas nas categorias restrições biomecânicas, transições/antecipações e escore total (p<0,01). A baropodometria identificou alteração do deslocamento latero-lateral com olhos fechados entre os grupos (p=0,01), sendo que, as idosas apresentaram pior desempenho. Todavia, as ferramentas supracitadas apresentaram pouca relação entre si, tendo sua associação variando entre 5 e 11%. **Conclusão:** O BESTest e a baropometria foram capazes de detectar diferenças entre o equilíbrio de mulheres adultas e idosas, porém apresentam baixa associação entre si. Sugere-se que sejam adotadas como avaliações complementares e não substituíveis na prática clínica do fisioterapeuta.

Palavras-chave: Equilíbrio Postural, Idoso, Mulheres

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INTRODUCTION

Changes in the Aging Index is a reality. It is understood that in 2043, the population proportion of elderlies will rise to 25%, whereas those with 14 years of age will be about 16.3%.[1] Balance alterations evolves as decades of life elapse, such that the base for postural support is unchanged, however the stability limits for balance itself are reduced.[2]

There are several issues involved with balance reduction such as aging itself, sedentarism, history of diseases and falls.[3] Currently, balance is stratified into four items: static balance, pro-active balance (anticipated reactions), and reactive balance (capacity to apply strategies after balance disturbances).[4]

The ideal balance measurement requires assessments on all items and applying established evaluations that measures some or only one of them, as Timed Up and Go that is limited within dynamic balance or Romberg test that is limited within static balance, for instance.[5]

The Balance Evaluation System Test (BESTest) is the only clinical assessment that evaluates postural response towards external disturbances and the vertical postural perception. This evaluation tool is validated for elderly population; however, it is not widely used among active elderly women.[6,7]

Another evaluation tool for corporal balance in its different items is the analysis of center of gravity and pressure measures. The baropodometry can be used for such measurements, with good reliability (ICC>0.7).[8] Balance assessment among elderly is common, however the best assessment tool for measuring corporal balance of elderly healthy women is still a gap in the specialized literature.

OBJECTIVE

The objectives of this study are to compare two tools for evaluating corporal balance, BESTest and Baropodometry, in a population of adult and elderly women to understand the influence of comorbidities and visual acuity towards balance.

METHODS

This is a cross sectional study that was conducted at the Mobility Laboratory Dr. Cláudio de Almeida at the State University of Goiás (UEG – Universidade Estadual de Goiás, Brazil), Sports Campus. This study was approved by the Ethics Review Board UFG (reg. no. 741.298/2019) and the participants were included after signing the Informed Consent Form (ICF).

Women who participated in physical activities at the Third Age Open University Program (Programa Universidade Aberta a Terceira Idade – UNATI) of UEG campus Goiânia were invited. The authors included women with 50 years of age or older, with independent gait, with a score of at least 14 in the Mini Mental State Examination (MMSE),[9] considering their educational level.

Eight women were excluded due to use of assistive devices, self-report of incapacitating pain, history of injury or fracture in lower limbs 6 months preceding inclusion, severe osteoporosis and uncontrolled arterial hypertension.10

The included participants were grouped as adults (50 to 59 years of age), and elderly (above 60 years of age), once previous studies demonstrates balance alterations since early middle age,[11,12,13] therefore it is possible to observe the first evidences of balance alterations in advance.

A sample size estimation was defined with at a website,[14] in which we set standard deviation of 3.4, difference of 4.3 points between both groups, power of 99% and alpha (Type I error) of 5% for the total score of BESTest, according to the results of O'Hoski et al.[6] The sample size was estimated with 46 participants, 23 individuals for each group.

The assessments were conducted by an experienced and trained physiotherapist. At first, there was an anamnesis for demographical data (age and body mass index, BMI), self-report of falls in the 12 months preceding the evaluation, comorbidities, and shoe size. After the anamnesis, the participant was evaluated by the MMSE, the BESTest, and baropodometry. It all was concluded in a single visit of about 1 hour and 30 minutes.

The BESTest is composed of 27 items and stratified into six categories (Chart 1) that evaluates different aspects of corporal balance. The evaluation was applied according to the original protocol proposed by Horak, Wrisley, and Frank.[15] The partial scores are standardized to percentages in which 100% means the best performance in each category. The total score is the sum of all partial scores.

Chart 1. Description and characterization of BESTest 6 categories

Biomechanical Constraints	Feet deformities inspection and/or self-report of pain, center of mass alignment, lower limbs strength, trunk stability, ankle range of motion, ability to sit and rise from the floor
Stability limits / Vertically	Lateral inclination, seating for both sides, return and realignment to vertical position, functional reach towards anterior and lateral foot
Anticipatory postural adjustments	Sit and stand from a chair, stand on the toes without support, unilateral support, touch a degree with both feet alternatively, (8 times), 2kg halter elevation with shoulder flexion at 90º and elbow extension
Postural Responses	Verify the capacity to recover balance after external disturbances, which is done by the evaluator in all directions
Sensory Orientation	Sensory orientation by maintaining erect posture with opened and closed eyes on a foam and on a ramp
Stability in Gait	Stability during gait with speed changes, sudden pauses, changes of direction, deviating and passing obstacles

The BESTest evaluation requested several objects to be carried: a chair with lumbar support and arm rest, a chair without arm rest, a 3kg halter, a 10º inclination ramp, a medium density foam, measuring tape, a step, obstacles (in this study, two shoeboxes), chronometer and a tape to mark distances on the ground.

The static baropodometry of the distance from the center of gravity to the center of pressure, as well as the latero-lateral and antero-posterior displacements of the center of pressure was carried out with a podobarometer platform Foot Work® (Arkipelago, Brasil). This device is equipped with quartz sensors and data is captured at a frequency of 150Hz and transmitted and stored into a laptop.

The participants were requested to be barefoot, in orthostatic position and without support, with both feet on parallel bases for sixty seconds.[16] The displacement measurements are described as centimeters and greater distances mean reduced postural balance.

The Statistical Package for the Social Sciences (SPSS) 23.0 was the software used for statistical analysis. Normality was tested with Shapiro-Wilk test and the group comparisons between adults and elderlies were tested with Student's T-test. ANOVA and Bonferroni, as post hoc, were used to compare pathology groups (self-report of no pathologies, one or two pathologies or more than 3 pathologies).

Linear regression was applied with BESTest results as dependent variable and balance items as independent variables in other three different groups, the adults, the elderlies, and the whole sample combined. Statistical significance was achieved whenever $p<0.05$ for all analysis. This study met the ethical principles of the Helsinki Declaration[17] and the Brazilian regulations.

RESULTS

A total of 156 women were included in this study. Their characteristics are described in Table 1, as well as the stratification into adults (50 to 64 years of age) and elderly (above 65 years of age).

Table 1. Characterization of age (years), weight (kg), height (cm), body mass index (BMI), and history of falls in the preceding 12 months of adults (n=54) and elderly (n=102)

	Mean (SD)				p [a]
	Adults		Elderly		
Age	59,3 (±3,93)		71,8 (±4,80)		0,001
Weight	67,16 (±10,58)		64,9 (±12,68)		0,258
Height	1,56 (±0,06)		1,55 (±0,07)		0,366
BMI	27,38 (±3,95)		26,8 (±5,02)		0,475
MMSE	27,25 (±3,16)		27,06 (±3,42)		0,656
History of falls	**Absolute**	**Percentile**	**Absolute**	**Percentile**	
	20	37%	30	29,10%	0,335

** Student's T-test; SD, standard deviation; BMI, body mass index; MMSE, Mini Mental State Examination*

In the adult group, 35.2% did not have comorbidities, 50% reported one or two pathologies, and 14.8% reported three or more pathologies, whereas among the elderly they reported 18.6%, 60.8%, and 20.6%, respectively, therefore, without significant differences between both groups. Regarding the pathology characterization, 56.1% was systemic arterial hypertension, 14.6% diabetes, 7.6% glaucoma, 2.5% pulmonary diseases, and 45.2% was other diseases. 80% of the participants reported history of surgery.

The general results of balance assessment with BESTest and baropodometry is described in Tables 2 and 3, respectively. When the covariable age is considered, except for limits of stability and postural responses, significant differences were found in all categories of BESTest. Regarding the history of diseases, biomechanical constraints, anticipatory postural adjustments, and total score was significantly different between both groups.

The baropodometry results evidenced a significant difference between age and latero-lateral displacement with closed eyes (p=0.01), what suggests this is direction to be the first to undergo alterations with the aging process.

The combination of balance evaluations demonstrated there is a significant correlation between the variables, however this is week. Among the adult women, there was correlation between postural responses and antero-posterior displacement with closed eyes, gait and distance between COP and CG in the left side with opened and closed eyes explaining 11% and 5% of this correlation, respectively.

Among the elderly, weak correlations were found in almost all items of BESTest, especially in anticipatory postural adjustments and postural responses. There were associations between the variables of both assessments, however their strength ranged from 3% to 16% (Table 4).

There is evidence that postural responses and total score of BESTest is inversely correlated with the results of displacements in the baropodometry, i.e. greater scores in these categories at BESTest produced lower oscillations in static baropodometry, with a variation range of 11% to 16% (Table 4).

Table 2. Comparison of performance between both groups (adult and elderly) and self-report of comorbidities

BESTest categories	Adults (≤ 64 years)	Elderly (≥ 65 years)	p[a]	Self-report of number of comorbidities: None	1 – 2	3 or more	p[b]	Simple effect[c]
Biomechanical Constraints	85,92 (±11,03)	78,88 (±14,32)	**0,001**	88,59 (±9,29)	81,19 (±12,16)	72,17 (± 17,17)	**0,001**	**0 ≠ 1-2, 0 ≠ 3, 1-2 ≠ 3**
Stability limits / Vertically	84,82 (±12,95)	81,18 (±12,2)	0,08	85,2 (±10,43)	82,02 (±12,97)	80,13 (±13,47)	0,23	NA
Anticipatory postural adjustments	86,93 (±11,11)	78,37 (±14,13)	**0,001**	87,42 (±11,67)	80,02 (±13,98)	77,39 (±13,43)	**0,001**	**0 ≠ 1-2, 0 ≠ 3**
Postural Responses	87,43 (±13,95)	83,76 (±18,36)	0,20	88,59 (±17,08)	84,63 (±15,23)	81,6 (±21,36)	0,24	NA
Sensory Orientation	86,41 (± 9,15)	81,36 (±11,46)	**0,01**	84,56 (±12,31)	83,44 (±10,35)	80,23 (±10,76)	0,25	NA
Stability in Gait	96,03 (± 5,45)	91,59 (±10,38)	**0,001**	94,86 (±5,79)	93,20 (±9,81)	90,64 (±10,6)	0,18	NA
Total Score	88,16 (±6,13)	82,89 (±7,7)	**0,001**	88,39 (±5,6)	84,38 (±7,07)	80,92 (±9,08)	**0,001**	**0 ≠ 1-2, 0 ≠ 3**

[a], Student's T-test; [b], Anova One-Way; [c], significative single effects: Bonferroni; NA, not applicable; Statistical significance whenever p<0.05

Table 3. Performance at baropodometry with opened and closed eyes within each group (adults and elderly), and stratified by number of self-reported comorbidities

		Distance from CG to COP (cm)*				Displacement (cm)*			
		Right	p	Left	p	Antero-posterior	p	Latero-lateral	p
Opened Eyes	Adults	12, 52 (±2,02)	0,14[a]	13,65 (± 2,26)	0,11[a]	1,93 (±0,8)	0,12[a]	1,45 (±1,37)	0,28[a]
	Elderly	11,97 (± 2,31)		13,08 (± 1,99)		2,15 (±0,84)		1,68 (±1,18)	
	No comorbidities	11,96 (±2,24)		13,68 (±1,8)		2,12 (±0,96)		1,53 (±1,13)	
	1 or 2 comorbidities	12,25 (±2,26)	0,81[b]	12,96 (±2,04)	0,79[b]	2,07 (±0,8)	0,95[b]	1,55 (±1,07)	0,51[b]
	3 or more comorbidities	12,19 (±2,25)		13,77 (±2,52)		1,53 (±1,13)		1,84 (±1,81)	
Closed Eyes	Adults	12,39 (±2,12)	0,21[a]	13,71 (±2,24)	0,11[a]	1,79 (±0,76)	0,48[a]	0,91 (±0,37)	**0,01[a]**
	Elderly	11,92 (±2,26)		13,13 (±2,09)		1,88 (±0,65)		1,12 (0,63)	
	No comorbidities	12,0 (±2,27)		13,58 (±1,92)		1,86 (±0,93)		1,01 (±0,49)	
	1 or 2 comorbidities	12,09 (±2,24)	0,94[b]	13,07 (±2,08)	0,21[b]	1,84 (±0,57)	0,93[b]	1,06 (±0,59)	0,89[b]
	3 or more comorbidities	12,2 (±2,15)		13,79 (±2,6)		1,89 (±0,73)		1,03 (±0,56)	

*CG, center of gravity; COP, center of pressure; * Results in mean and standard deviation; [a], Student's T-test; [b], One-way ANOVA*

Table 4. Linear regression analysis of BESTest categories and baropodometry oscillations among adult and elderly women (p<0.05)

	BESTest categories and baropodometry oscillations	p	R	Adjusted R^2
ADULTS	Postural Responses x APD CE	0,008	-0,356	0,11
ELDERLY	Stability limits / Vertically x LLD OE	0,045	-0,199	0,03
	Anticipatory postural adjustments x DCG-COP Right OE	0,004	-0,285	0,072
	Anticipatory postural adjustments x LLD OE	0,019	-0,232	0,044
	Anticipatory postural adjustments x DCG-COP Right CE	0,001	-0,334	0,102
	Anticipatory postural adjustments x APD CE	0,032	-0,212	0,036
	Anticipatory postural adjustments x LLD CE	0,021	-0,228	0,043
	Postural responses x LLD OE	**0,000**	**-0,410**	**0,16**
	Sensory orientation x DCG-COP Right OE	0,001	-0,317	0,092
	Sensory orientation x DCG-COP Right CE	0,002	-0,302	0,083
	Stability in gait x LLD OE	0,01	-0,254	0,055
	Total Score x DCG-COP Right OE	0,08	-0,260	0,058
	Total Score x LLD OE	**0,000**	**-0,409**	**0,16**
	Total Score x DCG-COP Right CE	0,04	-0,279	0,069

LLD, latero-lateral displacement; DCG-COP, distance between center of gravity and center of pressure; APD, antero-posterior displacement; CE, closed eyes; OE, opened eyes

DISCUSSION

The BESTest evidenced that balance of elderly women had significant deficit in all categories, except for Stability limits and postural responses, when compared to adult women. Regarding the number of comorbidities, biomechanical constraints and reduction of performance during anticipatory postural adjustments were affected.

The baropodometry analysis identified greater oscillation in static balance of elderly women when compared to adult women, specifically regarding latero-lateral displacement of center of pressure performed with closed eyes.

The evaluation tools, even though they assess balance according to different aspects, were efficient to characterize balance under different aspects of age and presence of comorbidities. However, the analysis of this study does not allow to test superiority between both evaluation methods, what suggests they are not exclusive. The BESTest analyzes different aspects of balance (static, dynamic, anticipatory, and reactive), whereas baropodometry evaluates the static bipodal posture.

In our study, the aging process and concomitant pathologies influenced balance as measured by BESTest. The presence of comorbidities induces fragility and debilitation to this population,[18] and BESTest has shown that greater number of comorbidities produces worse body posture and corporal alignment. Therefore, their capacity to use strategies to prevent alterations and postural control is reduced, what was shown in the total score and the partial scores of BESTest.

The items Postural Responses and Stability Limits were not influenced by age. McCrum et al.[19] described that postural responses may be used as a classification of elderly who are fallers and non-fallers. In our study, most of the sample was of non-faller elderly women, what may have influenced the item Postural Response not to change. Piirtola and Era[20] report elderly fallers need more steps as reactive strategy for balance when compared to non-fallers.

Regarding baropodometry, we found greater latero-lateral misplacement of the center of pressure when performed with closed eyes in the elderly group when compared to the adults.

Wingert and Foo[21] suggest that sight is compensatory to possible deficits of somatosensory and vestibular system, and that elderly subjects undergo loss of proprioception and kinesthesia of hip when compared to middle aged adults, especially with closed eyes, as the hip joint is responsible for most of the latero-lateral oscillation.

These authors also reported that better proprioception results in better performance measured by the mini-BESTest. The strategies for antero-posterior and latero-lateral balance control are different and autonomic, as exceeding oscillations, especially latero-lateral, are the cause of most cases of falls among the elderly.[20] Adaptation and disturbances in a movent plane do not necessary transfer and benefit stability control in other movement planes.[22]

Therefore, our study found alterations in the latero-lateral plane at the expense of the antero-posterior. We emphasize that the antero-posterior oscillation is indispensable, primarily as an ankle strategy to grant gait progression, whereas the latero-lateral oscillation requires hip and trunk strategies,[23] which is used either during gait or for maintaining the still bipodal posture.

The item postural responses was the only variable that had moderate correlation, with 16% of interaction, with the latero-lateral displacement. The specialized literature evidence that both, postural response and latero-lateral displacement, are directly associated with balance and falls, even being capable to predict them.[24,25] In this regard, in our study there was no strong correlation, once most of the participants are non-fallers.

Our results indicated that Anticipatory Postural Adjustments was the subsystem with greater deficit in our study. This item, therefore, must be the aspect to be stimulated among active women during their transition to the third age for a pro-active balance. The importance of this factor is applied directly in interventions that improve anticipatory responses which are closely associated with falls due to stump or slips whenever the efficiency of anticipatory and reactive mechanisms is compromised.[26] In this regard, this issue can be improved by neuroplasticity of task repetitions, with 91% of success in gait stability.[3]

Marques et al.[10] verified that the BESTest was more efficient to describe frail and pre-frail elderly than center of pressure variables, suggesting that, even though they are complimentary, the BESTest was more economically advantageous in the daily clinical practice, what was confirmed in our study.

A physical rehabilitation program for improving balance among women in between age groups, low count of falls and physically active may benefit from static and dynamic exercises, predicted instabilities and unexpected external disturbances in the antero-anterior and latero-lateral direction specially, identified primarily sensitized in our study.

Professionals should also consider all sensory systems and propose interventions that motivate the integrated use of visual, somatosensorial, and vestibular information. Balance dynamic activities may include change of direction, gait on different surfaces, and rotational movements that interact trunk and hips.

Our study identifies the need to broaden the use of BESTest versions and to test its short versions, such as MiniBESTest and Brief-BESTest for evaluating balance of women, once a disadvantage of BESTest is the long time required to be applied. Also, we suggest it is necessary to apply dynamic experiences of baropodometry with simulation of balance situations as well as to control the level of physical activity.

CONCLUSION

BESTest could detect differences of balance between adult and elderly healthy active women in all categories, except limits of stability and postural response. The self-report of comorbidities indicated that worst balance scores regarding biomechanical constraints, anticipatory postural adjustments, and the total score. Baropodometry identified significant differences of balance deficit in the latero-lateral displacement over the center of pressure when subjects have eyes closed. Both evaluation tools are helpful for balance analysis, however whenever possible they are complementary and not exchangeable.

After evaluating balance categories, we suggest that physiotherapy interventions should provide external disturbances so that the patient develops and adapts their balance strategies to maintain their body within the support of the lower limbs, what may avoid consequent falls and comorbidities, especially among elderly women.

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