Normative values of the Balance Evaluation System Test (BESTest), Mini-BESTest, Brief-BESTest, *Timed Up and Go Test and Usual Gait Speed* in healthy older Portuguese people

Sara Isabel Lebre de Almeida,[1] Alda Marques,[1-2] Joana Santos[1]

ABSTRACT

Objective: This study aimed to establish age and gender-related normative values for the Balance Evaluation System Test (BESTest), Mini-BESTest, Brief-BESTest, Timed Up and Go (TUG) test and Usual Gait Speed (UGS) for Portuguese healthy older people aged 60 to 89 years.
Design: An exploratory cross-sectional study was conducted.
Local: Portugal.
Population: Portuguese healthy older people aged 60 to 89 years.
Methods: Participants were recruited from the community. Socio-demographic, anthropometric and general clinical data were collected with a structured questionnaire based on the International Classification of Functioning, Disability and Health. Balance was assessed with the BESTest, Mini-BESTest and Brief-BESTest, mobility with the TUG and gait speed with the six meters UGS. Normative scores were reported by age decades (60-69; 70-79 and 80-89 years old) and gender.
Results: One hundred and thirteen healthy older people (75.8±8.9 years; 70.5% female) participated in this study. Mean scores for the BESTest (86.5±15.6; 82.6±14.5; 72.6±15.0), Mini-BESTest (22.4±6.3; 21.6±5.9; 16.2±6.2), Brief-BESTest (17.5±6.3; 16.0±6.0; 10.2±5.5) and UGS (122.3±46.8cm/s; 116.6±47.3cm/s; 73.8±32.6cm/s) decreased whereas TUG (8.9±2.8s; 9.5±4.0s; 16.8±5.3s) increased as age advanced. Female presented worse results than male. Mean scores of all measures were significantly different among age and gender groups (p<.05).
Conclusions: This study provides normative values of BESTest, Mini-BESTest, Brief-BESTest, TUG and UGS, which may contribute to develop tailored interventions to improve balance, mobility and gait speed in Portuguese healthy older people living in the community.

Keywords: Normative values; Balance; Mobility; Gait speed; Older people; Portugal.

INTRODUCTION

The older population is increasing worldwide and it is estimated that 35.7% of the Portuguese population will be older than 60 years old by 2050.[1] Falls, particularly fatal falls (i.e., falls that result in the person's death), are more common in older people than in younger population[2-3]. Falls have a substantial impact on the increase of morbidity and mortality rates, disability, fear of falling, social isolation, loss of independence and institutionalization.[2,4] Moreover, injuries related to falls in older people represent a substantial cost to health systems.[5] For all the-

1. Lab 3R – Respiratory Research and Rehabilitation Laboratory, School of Health Sciences, University of Aveiro (ESSUA), Aveiro, Portugal.
2. Institute for Research in Biomedicine (iBiMED), University of Aveiro, Aveiro, Portugal.

se reasons, falls have been considered a major public health problem worldwide.[2]

Balance, mobility and gait speed are major modifiable risk factors for falls.[6] These abilities are fundamental for older people to change body positions voluntarily, respond to postural adjustments automatically, react to external disturbances and to walk at different speeds.[7-8] Thus, balance, mobility and gait speed are key aspects for the daily life of individuals' functioning in the community.[9]

Balance is determinant for normal daily life.[7] I"t requires the integration of sensory information of the body position in relation to the surroundings and the ability to create appropriate motor responses to control the body movement.[7] It is known that the ability to maintain static and dynamic balance is usually affected in older people.[10] In order to assess balance comprehensively, Balance Evaluation Systems Test (BESTest)[11] and its short versions Mini-BESTest[12] and Brief-BESTest[13] have been proposed. Mobility is also an essential factor of active aging and consequently of quality of life to allow older people to continue living an independent and dynamic life.[14-15] It has been shown that impaired mobility is a predictor of physical disability and it is associated with falling, loss of independence, institutionalization and mortality.[16-18] The Timed Up and Go (TUG) test is a simple measure to assess individual's mobility since it includes standing, walking, turning and sitting, which are tasks frequently performed in daily life.[19] It is known that walking requires energy, movement control and support of multiple organ systems (heart, lungs, circulatory, nervous and musculoskeletal).[20] Therefore, gait speed has been considered a 'vital sign' and an indicator of well-being in older people since it has been shown to reflect health and global functioning among this population.[21-23] Thus, individuals' Usual Gait Speed (UGS) is relevant to their functioning in the community[9] and a strong predictor of a wide range of results in older adults,[21] especially risk of falling.[24]

To be able to interpret results with confidence from balance, mobility and gait speed measures, and consequently modify the risk of falling in the older population, normative data are required.[8,25-26] Normative data are specific for each population and national reality.[27-29] In addition, normative data are useful for: i) evaluating and comparing each individual's performance[26] within a population;[8] ii) establishing comparisons across different populations; and iii) evaluating the effectiveness of an intervention by comparing the individual performance before and after treatment.[26] Although there are studies presenting normative values for BESTest,[30] Mini-BESTest,[30] Brief-BESTest,[30] TUG[31] and UGS,[25] these are lacking for the Portuguese healthy older population. These hinder the interpretation of data and the development of tailored interventions.

Therefore, this study aimed to establish age-and gender-related normative values for the BESTest, Mini-BESTest, Brief-BESTest, TUG and UGS for the Portuguese healthy older people living in the community. We hypothesized that balance, mobility and gait speed scores decrease as age advances and differ between gender in the Portuguese healthy older population living in the community.

METHOD

An exploratory cross-sectional study was conducted. Ethical approval was obtained from the Ethics Committee (238/10-2014). Written informed consent was obtained from all participants (when eligible people could not read or write, but were willing to participate after receiving information about the study, the informed consent was explained and the finger print was collected instead of their signature).

Participants

Healthy older people living in the community (60-89 years old) were recruited from six day care centers, two gymnasiums and one senior university from Aveiro, Porto and Vila Real. A meeting was scheduled with the managers of each institution to explain the aims of the study. Each manager selected professionals to identify eligible participants.

A healthy and older population was recruited, considering the following definition: a healthy person is the one who fills a physical, mental and social well-being and not the one who just have absence of disease or infirmity.[32] Participants were included according to the following criteria: were 60 to 89 years old; were considered healthy, although they could have some comorbidities considering their age (e.g., high cholesterol and hypertension);[32] able to walk 6 m independently without a gait aid; understood the aims of the study;

were able to express opinions; demonstrated coherent speech and spatiotemporal orientation and accepted to participate voluntarily. People were excluded if they reported a history of dizziness or fainting and were taking any medication that could cause dizziness or impair balance (e.g., psychotropic medication); had been hospitalized in the last month; demonstrated signs of cognitive impairment or psychiatric (e.g., psychosis); presented a past or current history of significant musculoskeletal (e.g., severe osteoarthritis, rheumatoid arthritis, amputation, scoliosis), neurological (e.g., stroke, Parkinson) or cardiorespiratory disorders (e.g., myocardial infarction, heart failure, asthma, chronic obstructive pulmonary disease) presented significant musculoskeletal, neurological or respiratory disorders (e.g., amputation, scoliosis, stroke, asthma); if physical assistance to walk was necessary and showed signs of substances abuse (e.g., alcohol and drugs consumption).

Procedures

Data were collected between November 2014 and February 2015. Sociodemographic (age and gender), anthropometric (height, weight, body mass index, percentage of fat free mass) and general clinical (self-reported medication and common age-related comorbidities – e.g., hypertension and hyperlipidemia) data were collected with a structured questionnaire. This structured questionnaire was based on the International Classification of Functioning, Disability and Health Checklist (ICF-checklist) because it is a classification of health and health-related domains recommended by the World Health Organization.[33] Then, the BESTest instructions were read by one researcher[11] while a second researcher demonstrated the task to the participant. In order to ensure participant's safety, when he/she performed the task, the second researcher provided supervision. If the participant's attempt indicated an obvious misunderstanding of the instructions, another demonstration was given, and the participant was allowed a second attempt of the task, as recommended by the authors of the test.[11] The first researcher scored the tasks immediately after the participant's performance. After all testing performances, the scores of the Mini-BESTest, Brief-BESTest, TUG and UGS were based on the performance of the original BESTest tasks. A custom designed worksheet was used by the researchers to simultaneously record the BESTest and Mini-BESTest item scores. Each data collection was completed in 60-80 minutes.

Outcome measures

BESTest

The BESTest is a clinical balance assessment measure with 36 items grouped into six systems: biomechanical constraints, stability limits/verticality, anticipatory postural adjustments, postural responses, sensory orientation and stability in gait.[11] Each task is scored on an ordinal scale from zero (severe impairment) to three (no impairment).[13] The total score of the BESTest (108 points) is calculated with a percentage score (0-100%) and higher scores indicate better balance performance.[13] Although there are specific procedures for each task, participants were always tested without shoes or with flat heeled shoes and with comfortable clothes.[11] If they used a technical aid in some items, those were scored one category below.[11]

BESTest has been used in several populations such as healthy adults[30] people with sub-acute stroke,[34] cerebral stroke,[10] balance deficits,[13] Parkinson's disease,[35] peripheral neuropathy11 and vestibular dysfunction.[11] Excellent correlation has been found between BESTest and Berg Balance Scale (r=0.96; $p \leq 0.001$) in people with subacute stroke[34] and between BESTest and Functional Gait Assessment (r=0.882; p<0.001) in people with Parkinson's disease.[35] The BESTest has shown excellent interrater reliability (ICC=0.985) in people with and without multiple sclerosis.[13] Internal consistency of BESTest has also been shown to be excellent ($\alpha_{\text{Biomechanical constrains}}=0.83$; $\alpha_{\text{Anticipatory Postural Adjustment}}=0.87$; $\alpha_{\text{Postural Responses}}=0.86$; $\alpha_{\text{Sensory orientation}}=0.81$; $\alpha_{\text{Stability in gait}}=0.92$) with the exception of system "stability limits/verticality" that presented moderate consistency ($\alpha_{\text{Stability limits/verticality}}=0.62$).[35]

The BESTest has the advantage of identifying the balance systems that are affected/preserved, providing guidance for the development of a specific treatment or intervention.[10] However, as the BESTest has an administration time between 20 to 60 minutes[11,13] it is not often used in clinical practice.[36] Therefore, short versions, Mini-BESTest and Brief-BESTest which take less than half of the time to apply than BESTest,[37] have been proposed.

Mini-BESTest

The Mini-BESTest is a clinical balance assessment measure that consists of 14 items from the original BESTest, with four of the six systems: anticipatory postural adjustments, reactive postural control, sensory orientation and dynamic gait.[12,37] Each task is scored on a three-point scale (zero to two) and the total score is 28 points.[12,37] Better balance performance is indicated with higher scores.[12] The Mini-BESTest provides a total score for dynamic balance, being a useful shorter version of the BESTest.[12]

The Mini-BESTest has been used to test balance in people with multiple sclerosis, stroke, traumatic brain injury and vestibular disorders.[37] High correlation between the Mini-BESTest and TUG has been found in people with Parkinson's disease (r=–0.81; p<0.001) and in people with stroke (r=-0.89; p<0.001).[38] High interrater and test-retest reliability (ICC=0.995) has been reported for the Mini-BESTest in people with Parkinson's disease.[35] However, Mini-BESTest does not identify the six systems of the original BESTest[35] and therefore, the Brief-BESTest has been proposed.

Brief-BESTest

The Brief-BESTest consists of eight items of the original BESTest, one item for each system and two items (single-leg stance and functional forward reach) scored bilaterally.[13,39] Each task is scored on a four-point scale (zero to three) and the total score is 24 points. Higher scores indicate better balance performance.[13]

The Brief-BESTest has been used in multiple sclerosis,[13] Parkinson's disease,[39] stroke[39] and peripheral neuropathy.[39] Excellent correlation between the Brief-BESTest and Mini-BESTest has been found (r=0.94; p<0.001) in people with Parkinson's disease.[39] The Brief-BESTest has shown excellent interrater reliability (ICC=0.994) in people with multiple sclerosis.[13]

TUG

The mobility was assessed with TUG.[19] The TUG is a simple dynamic measure for identifying individuals who are at risk of falling.[19] In this study, participants were given verbal instructions to stand up from a chair, walk three meters at their comfortable speed, turn, walk back and sit down.[19,40] The TUG has been widely used in several populations such as in community dwelling elderly,[40] in people with vestibular disorders[41] or in people with hip osteoarthritis.[42] The TUG has a high correlation with functional mobility and gait speed (r=-0.81,-0.61; p<0.001) in frail older people.[43] The intra- and inter-rater reliability of TUG has been shown to be excellent in elderly populations (ICC=0.99).[43]

UGS

The UGS is measured over a relatively short distance.[44] There is heterogeneity in the measures of gait speed across studies however, the six meters distance is the most commonly used in aged studies.[45] In this study, each participant was instructed to walk at her/his comfortable speed in a six meters straight line without verbal encouragement.[44,46] The timing started to count after the researcher said 'Go' and when the participant foot touched the starting line and stopped to count after the participant foot touched the finishing line.[44] The UGS has shown to be highly correlated with the peak energy expenditure (p<0.001) in mid-to-late life population.[46] It has an excellent test-retest reliability (ICC=0.96-0.98) in healthy older people.[44] The UGS has been used to predict hospitalization,[47] declines in health and function[47] and falls[24] in older people.

Data analysis

Descriptive statistics [mean, standard deviation (SD) and 95% confidence intervals (CI)] were used to describe the sample characteristics and the test scores by age and gender. Age was categorized by decade: 60-69; 70-79 and 80-89 years old.[48] Graphic and statistical methods (Shapiro-Wilk tests) were applied to explore normality of the data distribution. To determine if balance, mobility and gait speed scores differed significantly among age decades and gender, Kruskal-Wallis and Mann-Whitney U tests were performed as data were not normally distributed. Normality of the data was assessed with the Kolmogorov-Smirnov test. However, to facilitate comparisons across studies[25,30-31] the mean and standard deviations were reported. When a statistically significant difference was found for age decades, multiple comparison tests were performed using the Bonferroni correction. The level of significance considered was .05. All statistical analyzes were conducted with Statistical Package for Social Sciences (SPSS) software (v. 22.0 for Windows, IBM Corporation, Armonk, NY,

TABLE I. Characteristics of participants (*n*=113)

Characteristic	Group	Age (years old)					
		60-69 (*n*=34)		70-79 (*n*=42)		80-89 (*n*=37)	
		M±SD (range)	*n*	M±SD (range)	*n*	M±SD (range)	*n*
Gender	Total	65.4±2.8 (60-69)	34	73.9±3.0 (70-79)	42	84.0±3.2 (80-89)	37
	M	65.2±2,2 (60-68)	13	74.6±3.6 (70-79)	15	83.1±2.9 (80-87)	7
	F	65.5±3,2 (60-69)	21	73.4±2.6 (70-78)	27	84.2±3.3 (80-89)	30
Weight (kg)	Total	71.8±13.4 (46-98)	34	71.4±13.9 (44-106)	42	67.1±11.8 (50-93)	37
	M	80.5±11.3 (60-98)	13	80.3±12.5 (55-98)	15	75.5±9.8 (60-93)	7
	F	66.5±11.8 (46-98)	21	66.7±12.5 (44-106)	27	65.1±11.4 (50-86)	30
Height (cm)	Total	161.3±9.9 (145-182)	34	161.2±9.4 (142-182)	42	159.0±10.6 (142-180)	37
	M	171.5±6.2 (162-182)	13	170.1±6.0 (160-182)	15	171.4±5.1 (165-180)	7
	F	155.0±5.4 (145-166)	21	156.3±7.1 (142-173)	27	156.1±9.3 (142-178)	30
BMI (kg/m²)	Total	27.2±3.5 (21-36)	34	26.8±4.6 (19-41)	42	26.1±3.5 (22-37)	37
	M	27.3±2.8 (23-33)	13	27.1±4.3 (20-35)	15	25.7±3.8 (22-33)	7
	F	27.2±3.9 (21-36)	21	26.7±4.8 (19-41)	27	26.2±3.5 (22-37)	30
FFM (%)	Total	33.1±6.3 (21-46)	34	35.4±7.4 (13-50)	42	36.1±6.4 (14-48)	37
	M	28.4±4.0 (21-35)	13	30.9±4.8 (23-41)	15	28.8±8.6 (14-42)	7
	F	36.0±5.7 (21-46)	21	37.9±7.6 (13-50)	27	37.8±4.4 (30-48)	30

BMI: Body Mass Index; F: Female; FFM: Free-fat mass Index; M: Male; M±SD: Media ± Standard Deviation.

USA) and plots created using GraphPad Prism version 5.01 (GraphPad Software, Inc., La Jolla, CA, USA).

RESULTS

One hundred and thirteen older people living in the community participated in the study (75.8±8.9 years old; *n*=78; 70.5% female). Thirty-four were between 60-69 years old, forty-two between 70-79 and thirty-seven between 80-89 years old. On average, participants were overweight (body mass index: male: 25.7-27.3kg/m^2; female: 26.2-27.2kg/m^2) and had a high fat-free mass (male: 29.4±5.4%; female: 37.5±6.0%). Table I shows the descriptive characteristics of the participants.

Table II shows the normative scores for the BESTest (total score and systems scores), Mini-BESTest, Brief-BESTest, TUG and UGS for each age group and according to the gender. Mean total and systems scores of the BESTest, Mini-BESTest and Brief-BESTest and UGS decreased whilst the TUG scores increased with age for both genders (Table II). Statistically significant differences across age decades (Figure 1) and between genders (Figure 2) were found for all measures (Table II). The only exception was the UGS score of the male older adults which did not change significantly as age increased.

Figure 1 represents graphically the statistically significant differences found across age decades for all measures. The BESTest mean score was statistically significant lower in participants with 80-89 years old than in participants with 60-69 years old (post hoc p<0.001) and 70-79 years old (post hoc p=0.003). The Mini-BESTest and the Brief-BESTest mean scores were also statistically significant lower in participants aged 80-89 years old than in those aged 60-69 years old (post hoc p<0.001) and 70-79 years old (post hoc p<0.001). The TUG mean score was statistically significant higher in participants aged 80-89 years old when compared to participants with 60-69 years old (post hoc p<0.001) and 70-79 years old (post hoc p<0.001). The UGS mean scores were statistically significant lower in participants aged 80-89 years old than in those aged 60-69 years old

TABLE II. BESTest, Mini-BESTest, Brief-BESTest, TUG and UGS Scores for the Portuguese population by age decade and gender (*n*=113)

Measure		Age						Kruskal-Wallis
		60-69 (*n*=34)		70-79 (*n*=42)		80-89 (*n*=37)		
BESTest		M±SD	95%CI	M±SD	95%CI	M±SD	95%CI	*p*
Total score	Total	86.5±15.6	81.1-92.0	82.6±14.5	78.1-87.1	72.6±15.0	67.5-77.6	<0.001
	M	96.9±2.0	95.4-98.4	91.4±7.5*	87.1-95.8	89.8±1.3*	87.7-91.8	0.015
	F	84.0±15.0	77.0-91.1	79.1±14.6	73.3-84.9	70.0±14.0	64.7-75.2	<0.001
Biomechanical Constraints	Total	86.3±16.4	80.6-92.0	75.4±17.8	69.9-80.9	64.4±18.7	58.1-70.8	<0.001
	M	95.2±8.5	89.4-100.8	87.7±9.8	81.8-93.6	75.2±20.0	56.8-93.6	0.040
	F	84.3±15.6	77.0-91.6	71.8±16.9	65.2-78.5	62.2±17.6	55.6-68.8	<0.001
Stability Limits/Verticality	Total	80.7±16.9	74.8-86.6	74.8±18.1	69.2-80.5	59.5±19.0	53.1-65.9	<0.001
	M	89.6±10.4	82.6-96.6	78.8±11.4	70.0-87.6	70.6±13.3*	56.7-84.6	0.019
	F	77.6±16.8	69.8-85.5	72.3±16.6	65.7-78.9	56.2±17.7	49.6-62.8	<0.001
Transitions/ Anticipatory	Total	82.0±19.8	75.1-88.9	77.9±19.5	71.2-84.0	57.4±20.6	50.4-64.4	<0.001
	M	91.9±9.1	85.8-98.0	90.3±9.8	84.0-96.5	72.2±22.5*	48.6-95.8	0.044
	F	79.2±21.2	69.2-89.1	74.1±21.1	65.7-82.4	54.1±18.7	47.1-61.1	<0.001
Reactive	Total	78.3±29.7	67.9-88.6	73.9±34.0	63.4-84.5	52.5±34.6	40.8-64.2	<0.001
	M	91.9±26.8	73.9-109.9	90.1±26.4*	74.8-105.3	76.2±26.2*	52.0-100.4	0.036
	F	71.9±29.6	58.1-85.8	65.8±35.5	51.8-79.9	47.6±34.0	34.9-60.3	0.025
Sensory Orientation	Total	82.0±23.2	73.9-90.0	79.8±21.7	73.1-86.6	57.4±27.0	48.3-66.6	<0.001
	M	97.0±4.6	93.9-100.0	82.5±13.0	82.5-97.5	86.7±7.3*	79.0-94.3	0.043
	F	78.3±20.8	68.6-88.1	76.3±22.4	67.4-85.2	53.1±26.3	43.3-63.0	<0.001
Stability in Gait	Total	85.±20.3	78.5-92.6	81.8±21.9	74.9-88.6	63.5±24.0	55.4-71.6	<0.001
	M	89.0±23.0	75.1-102.9	87.3±23.6*	74.2-100.4	75.5±19.3	57.6-93.4	0.023
	F	83.1±19.1	74.2-92.0	78.7±20.7	70.5-86.8	61.3±24.3	52.2-70.3	<0.001
Mini-BESTest	Total	22.4±6.3	20.2-24.6	21.6±5.9	19.7-23.4	16.2±6.2	14.1-18.2	<0.001
	M	24.1±6.5	20.2-28.1	23.9±5.7*	20.7-27.0	20.3±5.4*	15.3-25.3	0.033
	F	21.2±6.0	18.4-24.1	20.3±5.7	18.1-22.5	15.2±6.1	12.9-17.5	<0.001
Brief-BESTest	Total	17.5±6.3	15.3-19.7	16.0±6.0	14.1-17.8	10.2±5.5	8.4-12.1	<0.001
	M	19.1±6.6	15.1-23.0	18.4±6.0*	15.1-21.7	14.3±4.2*	10.4-18.2	0.019
	F	16.4±6.0	13.6-19.3	14.6±5.6	12.4-16.8	9.3±5.4	7.3-11.3	<0.001
TUG	Total	8.9±2.8	7.9-9.9	9.5±4.0	8.2-10.7	16.8±13.7	12.3-21.4	<0.001
	M	6.9±1.2	6.0-7.7	7.5±1.2	6.8-8.2	13.4±5.9	7.9-18.8	0.003
	F	9.1±2.2	8.1-10.1	9.6±3.2	8.3-10.8	14.2±5.7	12.0-16.4	<0.001
UGS	Total	122.3±46.8	105.9-138.6	116.6±47.3	101.9-138.6	73.8±32.6	62.9-84.7	<0.001
	M	129.4±37.1	105.9-153.0	121.3±39.1	98.7-143.9	94.3±36.1	61.0-127.7	0.176
	F	113.1±46.5	91.9-134.2	107.4±37.1	92.8-122.1	69.0±30.5	57.7-80.4	<0.001

BESTest: Balance Evaluation System Test; CI: Confidence Interval; F: Female; M: Male; M±SD: Mean ± Standard Deviation; TUG: Timed Up & Go; UGS: Usual Gait Speed; *$p<0.05$

(post hoc $p<0.001$) and 70-79 years old (post hoc $p<0.001$).

Figure 2 shows the statistically significant differences across gender that was found for all measures. The

BESTeste, Mini-BESTest, Brief-BESTest and UGS mean scores were statistically significant higher and TUG mean score lower in male (p<0.05).

DISCUSSION

This study provides normative values of the BESTest, Mini-BESTest, Brief-BESTest, TUG and UGS for the Portuguese healthy older population living in the community. It was shown that the BESTest, Mini-BESTest, Brief-BESTest and UGS scores decreased and TUG scores increased with age, regardless of gender. These data can guide health professionals to interpret balance (BESTest, Mini-BESTest and Brief-BESTest), mobility (TUG test) and gait speed (UGS) scores and develop tailored interventions to prevent falls.

Previous studies have assessed balance with BESTest, Mini-BESTest and Brief-BESTest in healthy older individuals.[11,30,49-51] However, these data came from small samples. Moreover, data regarding these measures have never been reported by age decades and gender in the healthy older Portuguese population. The mean scores previously reported for the healthy population between 70 and 80 years old ranged from 62.0±10.5 to 85.4±6.0 for the BESTest and from 17.7±2.2 to 21.0±3.1 for the Mini-BESTest.[30,51] Similar values have been found in this study. Only one study, conducted in Canada, aiming to establish normative values for the BESTest, Mini-BESTest and Brief-BESTest in the healthy older population has been reported.[30] The proposed normative values were higher for the BESTest (60-69: 91.4±3.4; 70-79: 85.4±6.0; 80-89: 79.4±10.6), Mini-BESTest (60-69: 24.7±2.2; 70-79: 21.0±3.1; 80-89: 19.6±4.2) and Brief-BESTest (60-69: 20.5±2.2; 70-79: 18.8±3.3; 80-89: 15.0±4.7) than the ones found in this study.[30] Several reasons might explain these differences such as the different sample sizes per age group (being our sample bigger). Another explanation could be the fact that the average Portuguese population is much shorter than the Canadian population.[30,52] Simple anthropometric reasons might influence differences in balance results across populations.[52] This reinforces the importance of proposing balance normative values for each population.

The TUG test has been used to assess mobility of several populations,[19,40-43] namely of the healthy older people living in the community.[31] The mean scores of the TUG reported for the healthy population ranged from 7.73±2.7s to 9.67±2.8s for people between 70 and 78 years old[40,51] which are similar to the results found in this study. Similar results per gender were also found for 60-69 (male: 8±2s; female: 8±2s) and 70-79 (male: 9±3s; female: 9±2s) age groups.[31] However, for the 80-89 age group, our results were higher than the ones previously reported (male: 10±1s; female: 11±3s).[31] A possible explanation is the short length of the legs of the Portuguese population,[52] especially in the oldest population, leading to the need to walk more steps and consequently spending more time to go through the same distance.[53] The higher percentage of fat free mass found in this group of the Portuguese population may also contribute to explain this finding.[54-55] Data from the UGS also confirmed these results. In fact, the Portuguese population presented a slightly slower UGS than values previously reported in several countries (male: 60-69: 133.9; 70-79: 126.2; 80-99: 96.8 / female: 60-69: 124.1; 70-79: 113.2; 80-99: 94.3).[25] This is of concern especially in the oldest female group where results (69±30.5cm/s) were found to be near or below the cut offs proposed (0.6m/s or 0.8m/s)[21,47,56] for poor health and function and values higher than 0.8m/s have been found to predict better life expectancy.[20] Nevertheless, these slight differences can also be explained by the lack of uniform protocol to measure UGS, which could be helpful for health professionals in clinical practice.[57] The standardization of the UGS could help to define cut offs for comparison studies and communication between health professionals.

A considerable increase in the variation of balance, mobility and gait speed scores with age, as shown in Table II and Figure 1, was found. This has been previously reported.[30-31] The greater variation among balance scores in the older age groups can be explained by the health changes related with age.[58-60] Motor (strength, flexibility, and coordination) and sensory (vision, self-perception, and vestibular function) abilities have been shown to deteriorate with age.[58] This has impacts on the dynamic balance of people (reactive and limits of stability systems).[59-60] Decrease of walking speed, reduced physical dexterity, latency of phasic contractions of lower-limb muscles, decrease of muscle mass and number and function of motor units and increase of reaction time[31,40,61-63] have also been found to affect mobility and gait speed in the oldest people. Therefore, similarly to this study, increase of the TUG mean scores[31,40] and decrease UGS[31] with age, have been reported.

The findings of this study may be used as reference values by health professionals when assessing balance comprehensively, mobility and gait speed in Portuguese older people living in the community. This knowledge may also inform health professionals to tailor interventions targeted to the needs indentified. Therefore, the normative data presented is a reference by which clinicians can: i) evaluate and compare each individual's performance within the Portuguese older population; ii) develop tailored interventions for preventing falls; iii) evaluate the effectiveness of an intervention by comparing individuals' performance before and after treatment; and iv) establish comparisons across different populations.

Limitations and future directions

Some limitations of this study need to be acknowledged. This study was conducted in a Portuguese healthy older population living in the community in the North and Center regions of Portugal and therefore, our findings may not be applicable to other populations or people living in different contexts (e.g., people living in a residential home) or regions of the country. Moreover, the findings only cover a relatively small convenience sample within an age range between 60-89 years old. Normative data outside this age range are still not available. Another limitation is that participants were included and excluded based on their health self-report. Although detailed assessment was conducted participants could have been unaware of some health conditions that could affect the results. Therefore, medical examination during the screening process may be considered in future studies. However, stricter criteria would have decreased external validity of our findings. Finally, we did not focus on patients with common chronic diseases nor did we exclude them (e.g., diabetes) and therefore, it is possible that this may have affected the results. Nevertheless, we believe this has been minimized by the comprehensive assessment conducted to all participants and inclusion of only those that followed the inclusion criteria.

Nevertheless, this study may enhance the utility of comprehensive balance, mobility and gait speed measures for professionals to screen people and develop tailored interventions for preventing falls in Portuguese healthy older people living in the community.

CONCLUSIONS

The present study provides normative values for the BESTest, Mini-BESTest, Brief-BESTest, TUG and UGS for Portuguese healthy older people living in the community aged 60-89 years old. Our findings showed that balance, mobility and gait speed decreases as age increases and are significantly worse in females.

The normative data provided by age decades and gender will allow more widespread use of these measures and may enhance the utility of comprehensive balance, mobility and gait speed measures for health professionals to screen people and develop tailored interventions for preventing falls in Portuguese healthy older people living in the community.

Acknowledgements

The authors are grateful to all institutions and participants for taking part in the study. This work was supported in part by the Portuguese Foundation for Science and Technology (FCT – Fundação para a Ciência e a Tecnologia), through iBiMED – Institute for Research in Biomedicine (UID/BIM/04501/2013).

REFERENCES

1. United Nations. World population ageing, 1950-2050. Washington: UN; 2002. ISBN 9789210510929
2. World Health Organization. Falls: fact sheet. Geneva: WHO; 2012 [updated 2016 Sep]. Available from: http://www.who.int/mediacentre/factsheets/fs344/en/
3. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing. 2006;35 Suppl 2:ii37-ii41.
4. Boyé ND, Lieshout EM, Van Beeck EF, Hartholt KA, Van der Cammen TJ, Patka P. The impact of falls in the elderly. Trauma. 2012;15(1):29-35.
5. Schuffham P, Chaplin S, Legood R. Incidence and costs of unintentional falls in older people in the United Kingdom. J Epidemiol Community Health. 2003;57(9):740-4.
6. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. Maturitas. 2013;75(1):51-61.
7. Sturnieks DL, St George R, Lord SR. Balance disorders in the elderly. Neurophysiol Clin. 2008;38(6):467-78.
8. Rothstein JM, Echternach JL. Primer on measurement: an introductory guide to measurement issues featuring the American Physical Therapy Association's standards for tests and measurements in physical therapy practice. Pennsylvania: American Physical Therapy Association; 1993. ISBN 9780912452920

9. Vermeulen J, Neyens JC, van Rossum E, Spreeuwenberg MD, de Witte LP. Predicting ADL disability in community-dwelling elderly people using physical frailty indicators: a systematic review. BMC Geriatr. 2001;11:33.
10. Rodrigues LC, Marques AP, Barros PB, Michaelsen SM. Reliability of the Balance Evaluation Systems Test (BESTest) and BESTest sections for adults with hemiparesis. Braz J Phys Ther. 2014;18(3):276-81.
11. Horak FB, Wrisley DM, Frank J. The Balance Evaluation Systems Test (BESTest) to differentiate balance deficits. Phys Ther. 2009;89(5):484-98.
12. King L, Horak F. On the Mini-BESTest: scoring and the reporting of total scores. Phys Ther. 2013;93(4):571-5.
13. Padgett PK, Jacobs JV, Kasser SL. Is the BESTest at its best? A suggested brief version based on interrater reliability, validity, internal consistency, and theoretical construct. Phys Ther. 2012;92(9):1197-207.
14. World Health Organization. Global age-friendly cities: a guide. Geneva: WHO; 2007. ISBN 9789241547307
15. Webber SC, Porter MM, Menec VH. Mobility in older adults: a comprehensive framework. Gerontologist. 2010;50(4):443-50.
16. Hirvensalo M, Rantanen T, Heikkinen E. Mobility difficulties and physical activity as predictors of mortality and loss of independence in the community-living older population. J Am Geriatr Soc. 2000;48(5):493-8.
17. Rubenstein LZ, Powers CM, MacLean CH. Quality indicators for the management and prevention of falls and mobility problems in vulnerable elders. Ann Intern Med. 2001;135(8 Pt 2):686-93.
18. Von Bonsdorff M, Rantanen T, Laukkanen P, Suutama T, Heikkinen E. Mobility limitations and cognitive deficits as predictors of institutionalization among community-dwelling older people. Gerontology. 2006;52(6):359-65.
19. Viccaro LJ, Perera S, Studenski SA. Is timed up and go better than gait speed in predicting health, function, and falls in older adults? J Am Geriatr Soc. 2011;59(5):887-92.
20. Studenski S, Perera S, Patel K, Rosano C, Faulkner K, Inzitari M, et al. Gait speed and survival in older adults. JAMA. 2011;305(1):50-8.
21. Abellan van Kan G1, Rolland Y, Andrieu S, Bauer J, Beauchet O, Bonnefoy M, et al. Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. J Nutr Health Aging. 2009;13(10):881-9.
22. Fritz S, Lusardi M. White paper: "Walking speed: the sixth vital sign". J Geriatr Phys Ther. 2009;32(2):46-9.
23. Abellan van Kan G, Rolland Y, Bergman H, Morley J, Kritchevsky S, Vellas B. Frailty assessment folder people in clinical practice: expert opinion of a Geriatric Advisory Panel. J Nutr Health Aging. 2007;12(1):29-37.
24. Verghese J, Holtzer R, Lipton RB, Wang C. Quantitative gait markers and incident fall risk in older adults. J Gerontol A Biol Sci Med Sci. 2009;64(8):896-901.
25. Bohannon RW, Andrews AW. Normal walking speed: a descriptive meta-analysis. Physiotheray. 2011;97(3):182-9.
26. Mitrushina MN, Boone KB, Razani LJ, D'Elia LF. Handbook of normative data for neurophsychological assessment. 2nd ed. New York: Oxford University Press; 2005. ISBN 9780195169300
27. Freitas S, Simões MR, Alves L, Santana I. Montreal Cognitive Assessment (MoCA): normative study for the Portuguese population. J Clin Exp Neuropsychol. 2011;33(9):989-96.
28. Hopman WM, Towheed T, Anastassiades T, Tenenhouse A, Poliquin S, Berger C, et al. Canadian normative data for the SF-36 health survey. CMAJ. 2000;163(3):265-71.
29. Ferreira LN, Ferreira PL, Pereira LN, Oppe M. EQ-5D Portuguese population norms. Qual Life Res. 2014;23(2):425-30.
30. O'Hoski S, Winship B, Herridge L, Agha T, Brooks D, Beauchamp MK, et al. Increasing the clinical utility of the BESTest, mini-BESTest, and brief-BESTest: normative values in Canadian adults who are healthy and aged 50 years or older. Phys Ther. 2014;94(3):334-42.
31. Steffen TM, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. Phys Ther. 2002;82(2):128-37.
32. World Health Organization. WHO definition of health, 2003. Geneva: WHO.
33. World Health Organization. International classification of functioning, disability and health (ICF). Geneva: WHO; 2001.
34. Chinsongkram B, Chaikeeree N, Saengsirisuwan V, Viriyatharakij N, Horak FB, Boonsinsukh R. Reliability and validity of the Balance Evaluation Systems Test (BESTest) in people with subacute stroke. Phys Ther. 2014;94(11):1632-43.
35. Leddy AL, Crowner BE, Earhart GM. Utility of the Mini-BESTest, BESTest, and BESTest sections for balance assessments in individuals with Parkinson disease. J Neurol Phys Ther. 2011;35(2):90-7.
36. Sibley KM, Straus SE, Inness EL, Salbach NM, Jaglal SB. Balance assessment practices and use of standardized balance measures among Ontario physical therapists. Phys Ther. 2011;91(11):1583-91.
37. Franchignoni F, Horak F, Godi M, Nardone A, Giordano A. Using psychometric techniques to improve the Balance Evaluation Systems Test: the mini-BESTest. J Rehabil Med. 2010;42(4):323-31.
38. Bergström M, Lenholm E, Franzén E. Translation and validation of the Swedish version of the mini-BESTest in subjects with Parkinson's disease or stroke: a pilot study. Physiother Theory Pract. 2012;28(7):509-14.
39. Duncan RP, Leddy AL, Cavanaugh JT, Dibble LE, Ellis TD, Ford MP, et al. Comparative utility of the BESTest, mini-BESTest, and brief-BESTest for predicting falls in individuals with Parkinson disease: a cohort study. Phys Ther. 2013;93(4):542-50.
40. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther. 2000;80(9):896-903.
41. Whitney SL, Marchetti GF, Schade A, Wrisley DM. The sensitivity and specificity of the Timed "Up & Go" and the Dynamic Gait Index for self-reported falls in persons with vestibular disorders. J Vestib Res. 2004;14(5):397-409.
42. Arnold CM, Faulkner RA. The history of falls and the association of the timed up and go test to falls and near-falls in older adults with hip osteoarthritis. BMC Geriatr. 2007;7:17.
43. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-8.

44. Peters DM, Fritz SL, Krotish DE. Assessing the reliability and validity of a shorter walk test compared with the 10-Meter Walk Test for measurements of gait speed in healthy, older adults. J Geriatr Phys Ther. 2013;36(1):24-30.
45. Graham JE, Ostir GV, Kuo YF, Fisher SR, Ottenbacher KJ. Relationship between test methodology and mean velocity in timed walk tests: a review. Arch Phys Med Rehabil. 2008;89(5):865-72.
46. Schrack JA, Simonsick EM, Ferrucci L. The relationship of the energetic cost of slow walking and peak energy expenditure to gait speed in mid-to-late life. Am J Phys Med Rehabil. 2013;92(1):28-35.
47. Studenski S, Perera S, Wallace D, Chandler JM, Duncan PW, Rooney E, et al. Physical performance measures in the clinical setting. J Am Geriatr Soc. 2003;51(3):314-22.
48. Garfein AJ, Herzog AR. Robust aging among the young-old, old-old, and oldest-old. J Gerontol B Psychol Sci Soc Sci. 1995;50(2):S77-87.
49. Jones KD, Horak FB, Winters-Stone K, Irvine JM, Bennett RM. Fibromyalgia is associated with impaired balance and falls. J Clin Rheumatol. 2009;15(1):16-21.
50. Beauchamp MK, Sibley KM, Lakhani B, Romano J, Mathur S, Goldstein RS, et al. Impairments in systems underlying control of balance in COPD. Chest. 2012;141(6):1496-503.
51. Yingyongyudha A, Saengsirisuwan V, Panichaporn W, Boonsinsukh R. The Mini-Balance Evaluation Systems Test (Mini-BESTest) demonstrates higher accuracy in identifying older adult participants with history of falls than do the BESTest, Berg Balance Scale, or Timed Up and Go Test. J Geriatr Phys Ther. 2016;39(2):64-70.
52. Arezes PM, Barroso MP, Cordeiro P, Costa LG, Miguel AS. Estudo antropométrico da população portuguesa. Lisboa: Instituto para a Segurança, Higiene e Saúde no Trabalho; 2006. ISBN 9789728321994
53. Kang HG, Dingwell JB. Separating the effects of age and walking speed on gait variability. Gait Posture. 2008;27(4):572-7.
54. Mainenti MR, Rodrigues EC, Oliveira JF, Ferreira AS, Dias CM, Silva AL, et al. Adiposity and postural balance control: correlations between bioelectrical impedance and stabilometric signals in elderly Brazilian women. Clinics. 2011;66(9):1513-8.
55. Hida T, Harada A. Fall risk and fracture. Diagnosing sarcopenia and sarcopenic leg to prevent fall and fracture: its difficulty and pit falls. Clin Calcium. 2013;23(5):707-12.
56. Cesari M, Kritchevsky SB, Penninx BW, Nicklas BJ, Simonsick EM, Newman AB, et al. Prognostic value of usual gait speed in well-functioning older people: results from the Health, Aging and Body Composition Study. J Am Geriatr Soc. 2005;53(10):1675-80.
57. Studenski S. Bradypedia: is gait speed ready for clinical use? J Nutr Health Aging. 2009;13(10):878-80.
58. Lord SR, Sherrington C, Menz HB. Falls in older people: risk factors and strategies for prevention. Melbourne: Cambridge University Press; 2001. ISBN 0521589649
59. Andrade LP, Stella F, Barbieri FA, Rinaldi NM, Hamanaka AY, Gobbi LT. Efeitos de tarefas cognitivas no controle postural de idosos: uma revisão sistemática [Effects of the cognitive tasks in the postural control of elderly: a systematic revision]. Motricidade. 2011;7(3):19-28. Portuguese
60. Pereira VV, Maia RA, Silva SM. The functional assessment Berg Balance Scale is better capable of estimating fall risk in the elderly than the posturographic Balance Stability System. Arq Neuropsiquiatr. 2013;71(1):5-10.
61. Larsson L, Grimby G, Karlsson J. Muscle strength and speed of movement in relation to age and muscle morphology. J Appl Physiol Respir Environ Exerc Physiol. 1979;46(3):451-6.
62. Samson MM, Crowe A, de Vreede PL, Dessens JA, Duursma SA, Verhaar HJ. Differences in gait parameters at a preferred walking speed in healthy subjects due to age, height and body weight. Aging (Milano). 2001;13(1):16-21.
63. Callisaya ML, Blizzard L, Schmidt MD, McGinley JL, Lord SR, Srikanth VK. A population-based study of sensorimotor factors affecting gait in older people. Age Ageing. 2009;38(3):290-5.

CONFLITO DE INTERESSES

As autoras declaram não ter conflitos de interesses.

COMISSÃO DE ÉTICA

Estudo realizado após parecer favorável da Comissão de Ética da Unidade de Investigação em Ciências da Saúde: Enfermagem Escola Superior de Enfermagem de Coimbra.

ENDEREÇO PARA CORRESPONDÊNCIA

Alda Marques
E-mail: amarques@ua.pt

Recebido em 12-06-2016
Aceite para publicação em 27-02-2017

RESUMO

VALORES NORMATIVOS DO *BALANCE EVALUATION SYSTEM TEST* (BESTEST), *MINI-BESTEST, BRIEF-BESTEST, TIMED UP AND GO TEST* E *USUAL GAIT SPEED* EM PESSOAS IDOSAS PORTUGUESAS SAUDÁVEIS

Objetivo: O objetivo deste estudo é estabelecer valores normativos relacionados com a idade e o género para o *Balance Evaluation System Test (BESTest), Mini-BESTest, Brief-BESTest, Timed Up and Go* (TUG) *test* e *Usual Gait Speed* (UGS) para a população idosa Portuguesa, saudável, entre os 60 e os 89 anos.

Tipo de estudo: Realizou-se um estudo transversal exploratório.

Local: Portugal.

População: Pessoas idosas Portuguesas, saudáveis, com idades entre os 60 e os 89 anos.

Métodos: Os participantes foram recrutados na comunidade. Os dados sociodemográficos, antropométricos e de informação clínica geral foram recolhidos através de um questionário estruturado baseado na Classificação Internacional de Funcionalidade, Incapacidade e Saúde. O equilíbrio foi avaliado com os *BESTest,* o *Mini-BESTest* e o *Brief-BESTest*, a mobilidade com a TUG e a velocidade da marcha com os seis metros da UGS. Os valores normativos foram reportados por décadas de idade (60-69; 70-79 e 80-89 anos) e por género.

Resultados: Cento e treze pessoas idosas saudáveis (75,8±8,9 anos; 70,5% feminino) participaram neste estudo. A média do BESTest (86,5±15,6; 82,6±14,5; 72,6±15,0), *Mini-BESTest* (22,4±6,3; 21,6±5,9; 16,2±6,2), *Brief-BESTest* (17,5±6,3; 16,0±6,0; 10,2±5,5) e UGS (122,3±46,8cm/s; 116,6±47,3cm/s; 73,8±32,6cm/s) diminuíram, enquanto a média da TUG (8,9±2,8s; 9,5±4,0s; 16,8±5,3s) aumentou com o avançar da idade. O sexo feminino apresentou piores resultados. A média de todas as medidas foi significativamente diferente entre grupos de idade e género (p<,05).

Conclusões: Este estudo fornece valores normativos para o *BESTest, Mini-BESTest, Brief-BESTest,* TUG e UGS, que podem contribuir para o desenvolvimento de intervenções específicas para melhorar o equilíbrio, mobilidade e velocidade da marcha em pessoas idosas Portuguesas, saudáveis, que vivem na comunidade.

Palavras-chave: Valores normativos; Equilíbrio; Mobilidade; Velocidade da marcha; Pessoas idosas; Portugal.