Ability to evaluate physical performance tests to identify low muscle mass in middle-aged and older women

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Abstract

Objective: To verify the ability to evaluate physical performance tests in the identification of low muscle mass (MM) in middle-aged and old women. *Method:* This cross-sectional study was carried out with 540 middle-aged (40-59 years old) and old women (≥60 years old) in the municipalities of Parnamirim and Santa Cruz in the state of Rio Grande do Norte, Brazil. MM, handgrip strength, knee extension, and gait speed were evaluated. Low MM was defined by skeletal muscle mass index lower than the lower 20% for each age group. The following tests were used: Student's t, chi-square, ROC curve analysis to calculate the area under the curve, and cutoff point of each test in the discrimination of participants with low MM. $P<0.05$ and CI of 95% were considered. *Results*: For the middle-aged group, the handgrip and knee extension strength showed moderate sensitivity (71.6% and 72.5%, respectively) and specificity (59.4% and 56.0%, respectively) in the identification of low MM. For the old women, gait speed and handgrip strength showed good sensitivity (77.8% and 81.6%, respectively) and moderate specificity (51.4% and 64.5%, respectively). The discriminatory capacity of gait speed for middle-aged women and knee extension strength for old women were unsatisfactory. *Conclusion*: Muscle strength measurements are useful for low MM screening in middle-aged women, while handgrip strength and gait speed tests are useful for older women.

Keywords: Mass Screening. Women. Sarcopenia. ROC curve. Muscle strength.

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INTRODUCTION

Sarcopenia is a process known as age-related decrease in muscle mass (MM)[1], a condition affecting great part of the old people worldwide with an overall prevalence estimated at 17% for older Brazilians,[2] and 10% of the world's older population[3]. It can be clinically defined as a geriatric syndrome characterized by the progressive and generalized decline in muscle mass and function[4]. It is associated with several adverse health consequences[5]. It has been reported that its manifestation in old people increases the risk of mortality by 3.6 times, with this risk being increased to 4.4 in individuals aged 79 years or older. Sarcopenia also increases the risk of functional disabilities by 3 times and predisposes the old person to be 2.4 times more prone to suffering falls, in addition to increasing the length of hospital stay by 1.6 times[5].

During aging, there is a gradual process of loss of MM,[6] and a consequently a decrease in strength[7] that tends to accelerate in older ages[6], giving rise to the sarcopenia process. Said accelerated loss is shown to be associated with aging. It occurs at younger ages in women than in men, being observed in them during menopause[8], still in the middle-age. This contributes to making them more susceptible to physical limitations and disabilities at earlier ages compared to men[9]. However, although the sarcopenia process, associated factors, and diagnostic criteria are widely described in the literature for different populations, few studies proposed to investigate these aspects in younger populations, such as middle-aged women. In view of the association between sarcopenia and the occurrence of adverse outcomes, there is a concern that its occurrence is identified as soon as possible, so that it is possible to prevent the associated risks before the condition has been developed.

Different diagnoses of sarcopenia are reported in the literature, and there is a consensus in the literature that sarcopenia is only clinically important when associated with reduced muscle strength or function[1,10]. Thus, physical performance tests are widely used along with MM identification methods to identify the presence of sarcopenia in the old people[1,10] .

Handgrip strength and gait speed are the most used physical performance tests to classify sarcopenia in old people[1] . Said tests are simple and easy to apply, and can be used both in the research context and in clinical practice. However, the use of said measures to identify sarcopenia and its relation with low MM in younger populations, particularly in the middle-aged ones, is still not well established, and there is doubt whether said measures are useful to screen sarcopenia in this population. In turn, measuring the knee extension strength seems to be a useful method for assessing muscle strength in populations of different age groups, including middle-aged people[11] and old people[12]. However, its use as a screaning method for sarcopenia does not seem to be the focus of previous studies.

Knowing simple methods to allow screening sarcopenia is a challenge for professionals and researchers, especially in environments where the availability of resources is scarce, such as in rural areas or in those with difficult access to health technologies. Identifying valid methods for assessing low MM, and consequently for screening sarcopenia particularly in groups of middle-aged people can contribute to making it possible to detect sarcopenia early and implement more effective rehabilitation strategies. Thus, the present study aimed to assess the ability of simple physical performance tests to identify low MM in middle-aged and old women from a low-income population.

METHOD

The present study is a cross-sectional analytical observational study. It is part of an ongoing longitudinal research entitled *The influence of menopausal status and hormone levels on functionality, muscle strength and body composition: a longitudinal study.*

The study population comprises women aged 40 to 80 years living in the municipalities of Santa Cruz (RN) and Parnamirim (RN) located in the state of Rio Grande do Norte, Brazil. The sample initially comprised 568 women, 381 of whom evaluated between September 2014 and July 2015 in Parnamirim (RN), and 208 from April to August 2016 in the city of Santa Cruz (RN). The sample was obtained by convenience after disclosure of the research in Basic Healthcare Units and community centers in the municipalities, and comprised 434 middle-aged women (40 to 59 years old) and 134 women between 60 and 80 years old. Considering the prevalence of low MM of 20%, an area under the estimated curve of 0.68 with type I error of 5% and power of 80%, the minimum sample size required for the objective proposed in the present study would be 104 participants in each age group.

The inclusion criteria for the study were age between 40 and 80 years, be a resident in the cities of the study (Santa Cruz, RN or Parnamirim, RN), with no cognitive alterations identified by four or more errors in the Leganés Cognitive Test, and/or no neurological and degenerative diseases, fractures in the limbs or any other condition preventing or compromising data collection. Twenty-eight middle-aged participants were excluded from the study because they did not perform the electrical bioimpedance analysis, with the final sample being 540 women (406 between 40 and 59 years old, and 134 between 60 and 80 years old). The maximum sample age was limited to 80 years since after that age the prevalence of disability and cognitive impairment increases significantly[13] which makes it difficult to follow the data collection protocol with a low risk of bias.

Data was collected by trained interviewers (undergraduate and graduate students in physiotherapy) using a structured questionnaire developed for this study. For the training, specific instructions were given about applying the research questionnaires and standardizing the procedures. The entire investigation team also received printed material with instructions for consultation during data collection, if necessary. Data collection followed the standardized protocol, as described below.

Initially, data such as age (years), education (years of study), and family income (Brazilian real) was collected. Weight (Kg) and height (m) were also measured by the interviewers using a digital anthropometric scale and a stadiometer attached to it (WELMY®, W100H, model R-110), respectively.

The skeletal muscle mass (SMM) was evaluated by electrical bioimpedance with the portable body mass analyzer InBody R20®[14,15]. The device uses eight electrodes, two of which positioned on each foot, and two others on each hand. The equipment measures the bioimpedance in a segmented way at two frequencies - 20 kHz and 100 kHz - using an applied current of 250 μA.

For the evaluation, the volunteers were requested to wear light clothing, not to eat or exercise at least two hours before the test, and to go to the bathroom to empty the bladder prior to the analysis[15]. The women were positioned over the feet electrodes on the surface of the digital scale of the device, and were requested to hold the other electrodes that are attached to a bar. During the test - which lasts from forty seconds to one minute on average - the volunteer was requested to remain in the same position (upright) without making any movement nor talking.

From the assessment, the body composition was automatically calculated based on the prediction equations of the equipment manufacturer. For the present study, the appendicular Skeletal Muscle Mass (ASMM) measure was used to calculate the Skeletal Muscle Mass Index (SMMI), and consequently to assess the presence of low MM.

The SMMI was calculated by dividing the sum of the SMM of the four limbs in kilograms by the height in meters raised to the second power (SMMI = appendicular SMM / height^2). After obtaining the SMMI, women were classified according to the presence of low MM if they presented the SMMI below the 20th percentile of the sample according to the age group. A cutoff point of <6.07 kg/m^2 was considered for middle-aged women, and <5.51 kg/m^2 for old women. To evaluate the handgrip strength, a Saehan® hydraulic hand dynamometer was used, which provides a record of muscle strength in the unit of kilograms/strength (Kgf). A dynamometer was used in the dominant hand for the measurement, with the volunteer in the sitting position, with adducted shoulder in neutral rotation, elbow flexion at 90° with the forearm and wrist in neutral positions[16]. Sustained contractions of five seconds were requested, with an interval of one minute between measurements. The arithmetic mean of three consecutive measurements was considered[17].

The knee extension strength was assessed using a portable dynamometer (Hoggan® Health Industries, UT, USA), model MicroFET2, which records muscle strength in kilograms/strength (Kgf). The volunteers were seated on the assessment stretcher with their legs hanging down and hands on their thighs[12], and the dynamometer was positioned on the distal segment and anterior to the leg. After being positioned for the test, they were requested to give three maximum isometric contractions of five seconds, with an interval of one minute between measurements. The arithmetic mean of the three measures was used for the analysis.

Gait speed was assessed following the protocol of the *Short Physical Performance Battery* (SPPB)[18] adapted for the Brazilian population[19]. A space of four meters was marked with adhesive tape for the test, and the volunteer was asked to walk from the initial mark to the final mark in their usual gait. The examiner demonstrated it first, and stayed beside the volunteer during the test. Time was measured in two attempts, with the shortest time being used to calculate gait speed in meters per second.

Descriptive statistics for all variables were presented according to age groups, and the comparisons were analyzed using the Student's t-test (continuous variables) and the chi-square test (categorical variables). The means of the physical performance variables were presented according to the variable of low MM and the other covariates, and compared using the Student's t test.

The ROC (*Receiver Operating Characteristics*) curve analysis was used to calculate the area under the curve (AUC) and the cutoff point of each physical performance test that best discriminates participants with and without low MM. In all stages of the data analysis, $p<0.05$ and 95% CI were considered.

The study was approved by the Ethics and Research Committee of Universidade Federal do Rio Grande do Norte (Approval number: 1,875,802). The participants were previously informed about the objectives and procedures of the study. The study accepted participants who agreed and signed the Free and Informed Consent Form (ICF) according to resolutions 510/2016 and 466/12 of the National Health Council, which regulates research with human beings.

RESULT

Table 1 shows the characteristics of the sample stratified by age (40-59 years; 60-80 years). The final sample consisted of 540 participants, 406 of whom were middle-aged women and 134 were old women. The average age was 54.51 (±8.88) years.

The average in the physical performance tests according to the covariates and stratified by age can be seen in Table 2. In both middle age and old women groups, a significantly lower performance was observed in the tests for handgrip strength and knee extension strength of women presenting low MM compared to those who did not.

However, a significantly worse performance for gait speed was also seen in the group of old women. However, the same was not observed for middle-aged women.

The AUC values, cutoff points, sensitivity and specificity of physical performance tests on the ability to identify low MM in middle-aged and old women are shown in Table 3. For the middle-aged group, a cutoff point of 26.33kgf in the handgrip strength and 22.07kgf in the knee extension force showed moderate sensitivity (71.6% and 72.5%, respectively) and specificity (59.4% and 56.0%, respectively) in the identification of low MM.

In the group of old women, a cut-off point of 0.84 m/s in gait speed and 22.67Kgf in handgrip strength showed good sensitivity (77.8% and 81.6%, respectively) and moderate specificity (51.4% and 64.5%, respectively) in the prediction of low MM. The discriminatory ability of gait speed in middle-aged women and knee extension strength in old women was unsatisfactory.

Table 1. Sociodemographic, anthropometric characterization and body composition (N=540). Santa Cruz and Parnamirim, RN, 2018.

Variables	Groups		*p*-value
	Middle age (40-59 years)	Old women (60-80 years)	
	Mean (SD)	Mean (SD)	
Age	50.30 (±4.66)	67.26 (±5.99)	<0.001[a]
Weight (kg)	69.07 (±12.07)	65.71 (±12.96)	<0.001[a]
Height (m)	1.54 (±0.05)	1.51 (±0.06)	<0.001[a]
Years of education*	8.79 (±4.18)	5.00 (±4.29)	<0.001[a]
Average family income*	1,972.47 (±1,595.90)	2,124.18 (±1,833.92)	0.36[a]
SMMI (Kg/m^2)	6.80 (±0.89)	6.30 (±0.97)	<0.06
Variables	Groups		*p*-value
	Middle age (40-59 years)	Old women (60-80 years)	
	N (%)	N (%)	
Education			
Less than elementary school	146 (36.0%)	103 (76.9%)	<0.001[b]
Between elementary and high school	188 (46.4%)	18 (13.4%)	
More than high school	71 (17.5%)	13 (9.7%)	
Family income*			
<3 minimum wages	124 (30.6%)	34 (25.4%)	0.24[b]
≥3 minimum wages	281 (69.4%)	100 (74.6%)	
Low muscle mass			
No	235 (80.0%)	107 (79.9%)	
Yes	81 (20.0%)	27 (20.1%)	0.52[b]
Total	406 (75.2%)	134 (24.8%)	

BMI: Body mass index; SMMI: Skeletal Muscle Mass Index; a- *p*-value: Student's t test, b-*p*-value: Chi-square test; *1 lost value

Table 2. Average of physical performance tests according to the covariates stratified by age (N=540). Santa Cruz and Parnamirim, RN, 2018.

	Middle age (40-59 years)					
	Handgrip strength (Kgf) Mean (SD)	*p*	Knee extension force (kgf) Mean (SD)	*p*	Gait speed (m/s) Mean (SD)	*p*
Low muscle mass						
Yes	24.21 (±4.11)	<0.001	19.80 (±5.91)	<0.001	0.98 (±0.19)	0.39
No	27.46 (±5.26)		23.50 (±8.00)		1.00 (±0.17)	
	Old women (60-80 years)					
	Handgrip strength (Kgf) Mean (SD)	*p*	Knee extension force (kgf) Mean (SD)	*p*	Gait speed (m/s) Mean (SD)	*p*
Low muscle mass						
Yes	21.38 (±2.52)	0.001	16.44 (±5.53)	0.04	0.77 (±0.17)	0.02
No	24.75 (±4.85)		19.32 (±6.64)		0.86 (±0.19)	
	Full sample					
	Handgrip strength (Kgf) Mean (SD)	*p*	Knee extension force (kgf) Mean (SD)	*p*	Gait speed (m/s) Mean (SD)	*p*
Low muscle mass						
Yes	23.50 (±3.96)	<0.001	18.95 (±5.97)	<0.001	0.93 (±0.21)	0.06
No	26.79 (±5.29)		22.47 (±7.89)		0.96 (±0.19)	

Table 3. Areas under the ROC curves (AUC), cutoff points, sensitivity and specificity of physical performance tests on the ability to identify low muscle mass in middle-aged and old women. (N=540). Santa Cruz and Parnamirim, RN, 2018.

Performance tests	Middle age (40-59 years)			
	Cut-off point	Sensitivity	Specificity	AUC (95%CI)
HGS (Kgf)	26.33	71.6%	59.4%	0.68 (0.63-0.73)
Knee Extension Force (Kgf)	22.07	72.5%	56.0%	0.64 (0.59-0.69)
Gait Speed (m/s)	0.96	52.5%	59.3%	0.54 (0.49-0.59)
Performance tests	Old women (60-80 years)			
	Cut-off point	Sensitivity	Specificity	AUC (95%CI)
HGS (Kgf)	22.67	81.6%	64.5%	0.74 (0.66-0.81)
Knee Extension Force (Kgf)	22.09	92.6%	32.1%	0.62 (0.53-0.70)
Gait Speed (m/s)	0.84	77.8%	51.4%	0.64 (0.56-0.72)

HGS: Handgrip strength.

DISCUSSION

For a test to be considered suitable to detect a particular condition, it must have reasonably accurate sensitivity and specificity. Sensitivity will inform the test's ability to identify positive cases, that is, those who present the condition, while specificity will identify negative cases[20]. According to the results, the handgrip test has a good ability to identify low muscle mass (MM) in both middle-aged and old women. However, the results also showed low accuracy in gait speed tests for middle-aged women (low sensitivity and specificity), and knee extension strength for old women (low specificity) in the ability to detect low MM.

Thus, in the present study, handgrip strength was the one with the best ability to assess low MM, as it obtained good results of sensitivity and specificity for both age groups. Grip strength is considered a measure of global strength assessment[21], being widely used along with MM to define sarcopenia in different populations[1,10], in addition to being known as a good predictor of negative health outcomes[22].

In a 2015 review, Bohannon[22] addressed the clinical and prognostic value of grip strength, and identified the test as an important predictor of mortality, disability, complications and increased length of hospital stay, capable of providing information on nutritional status, MM, and general health status, supporting its routine use as a useful predictor in view of being a practical, valid, easy to measure, and reproducible method.

Regarding the knee extension strength, the results of the present study showed that this measure presents satisfactory results of sensitivity and specificity for identifying low MM only among the middle-aged group. For the group of old women, although the mean strength of knee extensors was significantly lower for those with low MM, this measure did not present good performance in relation to its accuracy as a predictor of low MM in this group. Knee extension strength is a measure closely related to lower limbs function in different everyday activities[12,23].

It is known that with aging there is a decrease in activities requiring the use of these members, which can result in a decrease in force[24]. Thus, the old women in the present study may have already reached such low levels of muscle strength that this test is no longer able to discriminate the sarcopenic old women from the non-sarcopenic ones, since both groups already present marked strength deficit of the lower limbs. As middle-aged women still preserve functional activities with the lower limbs to a greater degree by walking, running, and going up ramps and stairs in their daily lives, it is believed that they also have greater preservation of muscle strength in this segment. Thus, it is expected that the muscle weakness identified is better related to a condition of alteration of their normal health status, such as low MM, thus making this test more appropriate for the prediction of sarcopenia in middle-aged women.

In contrast to the knee extension force which had better discriminatory capacity for the middle-aged group, gait speed presented better low MM detection capacity in older women. Slow gait is the most consistent alteration related to aging, and it is influenced by a number of conditions occuring most commonly with aging, such as reduced muscle strength, balance, and postural stability, and increased fear of falling[25]. Thus, during the aging process, alterations in gait speed seem to occur at a more advanced stage in the process of changing the functionality of the lower limbs and at older ages, being hardly identified at earlier ages as in middle age[26]. Thus, it is possible that the differences in gait speed during middle age are not large enough to be detected among younger people, which makes this test inadequate for screening sarcopenia in this age group.

Although physical performance tests are considered practical and valid to detect the presence of sarcopenia in middle-aged and old women, few studies were found investigating the discriminatory capacity of these measures in the identification of sarcopenia[27,28]. Previous studies showed both similar and divergent results from the present study. In a study carried out by Looijaard et al.[28] in 2018, the authors investigated the capacity of isolated physical performance measures including gait speed and grip strength to identify sarcopenia in a population of 140 old outpatients. The study presented low precision values, concluding that these tests are not able to predict sarcopenia in the old person. The results found can be attributed to a high multimorbidity found in this population, which could have affected the performance measures.

The study by Pinheiro et al.[27] in 2015 using the chair stand test in a population of old women showed the good accuracy of the test, indicating its use as a good prediction tool to screen old women at risk of developing sarcopenia.

Like Pinheiro et al.[27], Fillippin et al.[29] carried out another study in 2017 showing good results for the physical tests in the detection of sarcopenia. In this study, the performance measure used to predict sarcopenia in a population of old people of both genders was the *Timed Up and Go* (TUG) test, which presented adequate sensitivity for the prediction of sarcopenia and screening of the condition.

The most accessible screening methods for low MM that are validated and described in the literature are based on algorithms, questionnaires, screening grid, and prediction equations, and it is not yet determined which of these tools is the best one to predict sarcopenia[30]. Identifying fast, low-cost, easy-to-apply methods and/or tools to identify individuals with low MM for sarcopenia definition is a major challenge for clinicians and researchers.

In this context, this study allowed the identification of simple physical performance tests with adequate precision to identify low MM, and consequently sarcopenia both in middle-aged women and in old women in a low-income population in northeastern Brazil. Said measures are easily applicable tools in different contexts, including basic health units, community centers, and the residence of the old person. Thus, by showing adequate validity standards for screening and early diagnosis of low MM, they can be used by health professionals and researchers when other more sophisticated diagnostic methods are not available. Similarly, due to the ease of use and low cost, these measures may be useful even in the assessment of sarcopenia in population-based health surveys. The identification of sarcopenia by validated measures is extremely important so that appropriate prevention and rehabilitation strategies can be based, thus reducing the risk of negative health events.

The present study has some limitations. The sample comprised only women in northeastern Brazil, which should be taken into account when inferring these results to other populations. Although the sample was created by convenience, the socioeconomic characteristics are similar to those of middle-aged and old women in the population of both cities of study, according to the demographic census data[31]. Another point that should be considered is the use of electrical bioimpedance to evaluate skeletal muscle mass and identify sarcopenia. Although it is not considered the gold standard method for this evaluation, it is a useful and reliable tool for body composition assessment, both in middle-aged populations[32] and in older people[33], being commonly used both in research and clinical practice. Finally, it should be considered that the results presented here may vary according to some characteristics of the sample. This becomes clear with the observation of the cutoff point of grip strength identified in the present study for the sample of old women which was higher than that presented by international consensus on sarcopenia[1,10], but similar to that of other international studies[34,35]. It is possible that some characteristics of the population such as the practice of physical activity, presence of comorbidities, and the body mass index influence the results found, and this should be the focus of future researches.

CONCLUSION

The results of the present study suggest that physical performance measures are useful for identifying low muscle mass (MM) in middle-aged and old women in a low-income population. However, the analysis of sensitivity and specificity of the measures showed that the results are different when taking into account the age group evaluated. For middle-aged women, the measurements of muscle strength, whether by handgrip strengh or knee extension, are useful for screening low MM, while among older women handgrip strength and gait speed tests were useful for this purpose. As these physical performance measures are low cost and simple to apply, they can be used in different environments and help professionals identify sarcopenia in women, enabling appropriate interventions for each group. Other studies are needed to evaluate the applicability of such measures in populations of different socioeconomic contexts.

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