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RESEARCH

Calf circumference: clinical validation for evaluation of muscle mass in the elderly

Circunferência da panturrilha: validação clínica para avaliação de massa muscular em idosos

Circunferencia de la pantorrilla: validación clínica para evaluación de masa muscular en mayores

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ABSTRACT

Objective: To validate calf circumference as a technology for assessing muscle mass in the elderly. **Method:** Cross-sectional study with 132 elderly people from Goiânia, Goiás, Brazil. Decreased muscle mass was determined by the skeletal muscle mass index (IME) using Dual Energy X-Ray Absortometry (DEXA). The cutoff circumferences (CC) cutoff points to indicate muscle mass decrease were estimated by ROC curve, sensitivity, specificity and accuracy. **Results:** The most accurate cut-off points for detecting decreased muscle mass in the elderly were 34 cm for men (sensitivity: 71.5%, specificity: 77.4%) and 33 cm for women (sensitivity: 80.0%; specificity: 84.6%). **Conclusion:** CC can be used as a measure for early identification of muscle mass decrease in routine evaluations of the elderly in primary care.
Descriptors: Sarcopenia; Anthropometry; Body composition; Geriatric Nursing; Primary Health Care.

RESUMO

Objetivo: Validar a circunferência da panturrilha como tecnologia de avaliação de massa muscular em idosos. **Método**: Estudo transversal com 132 idosos de Goiânia, Goiás, Brasil. A diminuição de massa muscular foi determinada pelo índice de massa muscular esquelética (IME) por meio da Absorciometria por Raios-X de Dupla Energia (DEXA). Os pontos de corte da medida de circunferência da panturrilha (CP) para indicar diminuição de massa muscular foram estimados por meio de curva ROC, sensibilidade, especificidade e acurácia. **Resultados**: Os pontos de corte com melhor acurácia para detecção de massa muscular diminuída em idosos foi 34 cm para homens (sensibilidade: 71,5%; especificidade: 77,4%) e 33 cm em mulheres (sensibilidade: 80,0%; especificidade: 84,6%). **Conclusão**: A CP pode ser utilizada como medida para identificação precoce de diminuição de massa muscular em avaliações de rotina de idosos na atenção primária.
Descritores: Sarcopenia; Antropometria; Composição Corporal; Enfermagem Geriátrica; Atenção Primária a Saúde.

RESUMEN

Objetivo: Validar la circunferencia de la pantorrilla como tecnología de evaluación de masa muscular en mayores. **Método**: Estudio transversal con 132 mayores de Goiânia, Goiás, Brasil. La disminución de masa muscular fue determinada por el índice de masa muscular esquelética (IME) por medio de la Absorciometría por Rayos-X de Dupla Energía (DEXA). Los puntos de corte de la medida de circunferencia de la pantorrilla (CP) para indicar disminución de masa muscular fueron estimados por medio de curva ROC, sensibilidad, especificidad y precisión. **Resultados**: Los puntos de corte con mejor precisión para detección de masa muscular disminuida en mayores fue 34 cm para hombres (sensibilidad: 71,5%; especificidad: 77,4%) y 33 cm en mujeres (sensibilidad: 80,0%; especificidad: 84,6%). **Conclusión**: La CP puede ser utilizada como medida para identificación precoz de disminución de masa muscular en evaluaciones de rutina de mayores en la atención primaria.
Descriptores: Sarcopenía; Antropometría; Composición Corporal; Enfermería Geriátrica; Atención Primaria a la Salud.

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INTRODUCTION

Human aging is accompanied by changes in body composition that include progressive decrease in muscle mass[1], termed sarcopenia in 1989 by Rosenberg[2].

Currently, sarcopenia is conceptualized as a syndrome, characterized by the gradual and generalized loss not only of muscle mass, but also of muscle strength and function[3]. Studies in different global settings show that sarcopenia has a high prevalence[4-5] and increases the occurrence of disability[6].

In the context of nursing practice in the care of the elderly, the evaluation of muscle mass and sarcopenia is poorly described[7-8], although several nursing diagnoses are related to the event of muscle weakness and muscular alterations, either in the taxonomy of NANDA-International[9], or in the terminology of CIPE®[10].

In the NANDA-I taxonomy[9], the term decreased muscle mass is only mentioned in the Impaired Physical Mobility Diagnosis. However, the term musculoskeletal injury can be considered as a proxy for decreased muscle mass and is described in seven diagnoses of the activity and rest domain: impaired transfer ability, impaired mobility, impaired physical mobility, impaired bed mobility, impaired wheelchair mobility, self-care deficit syndrome, and ineffective respiratory pattern.

Sarcopenia was incorporated as a related factor of four diagnoses in the NANDA-I edition 2015-2017[9]: frail elderly syndrome, frail elderly syndrome risk; get up injured and sit down injured.

The determination of decreased muscle mass was termed pre-sarcopenia[3]; thus, it is necessary to evaluate the other parameters to establish the presence of sarcopenia: assessment of muscle strength and function[3,11].

Despite its importance in clinical nursing practice in the care of the elderly, the evaluation of muscle mass is a challenge in the health services, since its determination requires high cost exams such as magnetic resonance imaging and computed tomography[11-12]. Extensive epidemiological studies[5,13-16] used Dual Energy X-Ray Absortometry (DEXA) as a reference method to estimate muscle mass, and this method was recommended by the European Consensus of Sarcopenia[3] and for use in scenarios of clinical practice[12,17]. However, despite its accuracy and accuracy, in developing countries, such as Brazil, its use is expensive both in primary and secondary care services.

As a result, anthropometric measures are recommended[18] as alternative measures for assessing muscle mass and early identification of sarcopenia in clinical practice and primary health care settings[12,19], due to the low cost and ease of obtaining. Among them, calf circumference (CC)[19] has been used in recent studies with the objective of measuring muscle mass and estimating the prevalence of sarcopenia[20-22], predicting disability[23-24], mortality(24-25) and need for care[26], as well as for determining cut-off points of decreased muscle mass in the elderly population[27-31]. Although the results demonstrate that CC has a good ability to predict muscle mass decrease, the different cutoff points available in the literature - 31 cm to 35 cm in women[27-31]; 33 cm to 34 cm in men[28-31] - hinder clinical judgment and therapeutic decision making by the professional in clinical practice.

Considering the possibility of applying calf circumference as a low cost and affordable care technology for evaluation of muscle mass in the elderly, especially in primary care services, the overall objective of this study was to validate calf circumference as a mass evaluation technology in the elderly. As specific objectives, the study sought to verify the prevalence of decreased muscle mass according to DEXA and CC, as well as to analyze the predictive capacity of calf circumference in identifying muscle mass and to identify cutoff points in the elderly population.

METHOD

Ethical aspects

This research is nested in a matrix study, "Validation of Anthropometric Indicators for Assessment of the Nutritional Status of Elderly", approved by the Research Ethics Committee of the Federal University of Goiás. The elderly respondents signed the Informed Consent Term, confirming the consent participate in the study.

Kind of study

In order to evaluate the proposed objectives, a secondary analysis of data from the main research was carried out. The main objective of this study was to analyze the health and nutrition conditions of elderly users of the Primary Health Care System (SUS) of Goiânia.

Study scenario and data source

In the matrix study, 418 elderly individuals were randomly selected, with probabilistic and proportional sampling to the nine sanitary districts of the city of Goiânia. This sample is representative of the elderly users of Primary Care in this municipality[32]. For the present study, a sub-sample of 132 elderly subjects was randomly selected. They performed the DEXA exam, recommended as a reference in estimating muscle mass in the elderly. The circumference of the calf was also evaluated, as well as other anthropometric measures and the application of a standardized and pre-tested questionnaire.

Collection and organization of data

The data were collected in a clinic specialized in diagnostic imaging, between July and August 2009, by a team previously trained. It should be noted that data from the 2009 period were analyzed because it is a broad population-based study whose results, already analyzed, together with the continuous updating of the literature on the different diagnostic methods of muscle mass, led us to evaluate the circumference of the calf as a method for evaluation of muscle mass in the elderly, emphasizing its application in nursing practice. The clinic in question was selected considering the cost of the examination, methodological quality in performing the DEXA exam, location and adequate space to accommodate the elderly at all stages of data collection. To this end, the research objectives were first communicated and clarified by telephone to the elderly, and, agreeing to participate, they were also advised about the care in the standardized preparation for DEXA: absolute fasting of at least 4 hours before the test; do not consume alcohol or foods containing caffeine in the 24 hours before the test; not exercise within the 12 hours prior to

the test; urinate 30 minutes before the test; nor to use diuretics within 24 hours of the test[13,17]. The elderly were transported from their homes to the site of the research in a safe vehicle, accompanied by one of the researchers.

The muscular mass was obtained by means of DEXA, using Lunar DPX-MD PLUS, software version 7.52.002 DPX-L, calibrated daily. Muscle mass was defined by the Appendicular Muscle Mass (MMA), which is estimated by the sum of the fat-free mass of the arms and legs. The decrease in muscle mass was defined by the Appendicular Muscle Mass Index (IMMA), ratio between MMA and height squared[3,15]. The cutoff point for low muscle mass was 7.26 kg/m^2 in men and 5.45 kg/m^2 in women[15].

Calf circumference (CC) was measured with inelastic tape with the elderly in the upright position, feet 20 cm apart, at the maximum circumference in the plane perpendicular to the longitudinal line of the calf[33]. The measurement was performed in a standardized way[33], with three measurements to obtain the average of three measurements, using inelastic tape for all circumferences. The researcher who collected these measurements was duly trained according to the technique of Habicht (1994)[34] to calculate the technical error of the measurement in order to achieve appropriate accuracy and accuracy for the quality of scientific research data.

Data analysis

The data were analyzed in the software STATA/SE version 12.0®. The descriptive characteristics of the sample were expressed as means and standard deviation, analyzing the mean differences by means of the t test, at a significance level of 5%. In order to analyze the correlation between anthropometric variables and MMA, the Pearson correlation was used, considering a strong correlation r> 0.70. The Receiver Operating Characteristic (ROC curve) was used to analyze the sensitivity and specificity variation of different CC values in relation to the low muscle mass diagnostic criteria by DEXA[35]. The total area under the ROC curve and 95% CI for CC were identified according to the criterion of low muscle mass, according to sex. An area under the ROC curve above 0.70 was considered satisfactory[35]. Subsequently, the cut-off points for calf circumference were identified, with respective values and confidence intervals of sensitivity, specificity and accuracy. Values indicated through the ROC curve are cut-off points that should promote a more adequate balance between sensitivity and specificity. The cut-off points for screening of diminished muscle mass were those with the best balance between sensitivity and specificity for CMB, CB and CC, with minimum values of 60%, in addition to a higher accuracy score[35].

RESULTS

A total of 132 elderly individuals, 60.6% females, with a mean age of 69.9 years (± 6.6) and 39.4% males, mean age of 70.5 years (± 6.7) . The mean MII was 7.5 (± 0.8) in men and 6.2 (± 0.7) in women (p = 0.000). The prevalence of decreased muscle mass was higher in men (40.4%, p = 0.006) and in the very elderly (33.3%, p = 0.748). Mean values of BMI, WC and CC were lower in elderly with low muscle mass, with statistically significant differences. MMA had a mean correlation with BMI (r = 0.44), WC (r = 0.51) and WC (0.56), although it presented p <0.05 (Table 1).

The sensitivity and specificity of the CC cut-off points available in the literature are described in table 2. In women, a better accuracy is found for the cut-off point 31 cm; however, there is a very low sensitivity (40%). The cutoff point of 33 cm shows good accuracy and a better balance between sensitivity (80%) and specificity (87%). The prevalence of muscle mass decreased according to this cutoff point in women was 25.9%. Among men, the two cutoff points, both 33 cm and 34 cm, presented a median accuracy, but the 34 cm showed a better balance between sensitivity and specificity (66.7% and 77.4%, respectively). The prevalence of muscle mass decreased according to this cutoff point in men was 30.8%. The prevalence according to the other cutoffs analyzed is different, since it has a lower accuracy to identify the decreased muscle mass in the elderly.

Table 1 – Description of the sample and prevalence of Decreased Muscle Mass measured by Dual Energy X-Ray Absortometry (DEXA) according to sex, age range and anthropometric variables, Goiânia, Goiás, Brazil

Variables	Sample (%)	Decreased Muscle Mass		Correlation	*p*
		Yes n = 36 (27.3%)	No n = 96 (72.7%)		
Sex					0.006§
Male	52 (39.1%)	21 (40.4%)	31 (59.2%)	-	
Female	81 (60.9%)	15 (27.3%)	65 (81.2%)	-	
Age group					0.748§
60-69	69 (51.9%)	17 (24.6%)	52 (75.4%)	-	
70-79	51 (38.3%)	15 (29.4%)	36 (70.6%)	-	
≥80	13 (9.8%)	4 (33.3%)	8 (66.7%)	-	
Weight	67.6 (±14.2)	60.2 (±13.9)	70.6 (±13.1)	0.64*	0.001ʃ
Height	1.59 (±0.08)	1.61 (±0.79)	1.58 (±0.84)	0.47*	0.034ʃ
BMI (kg/m^2)	26.7 (±5.2)	22.8 (±3.8)	28.2 (±4.9)	0.44*	0.003ʃ
WC (cm)	93.7 (±13.7)	86.8 (±12.9)	96.3 (±13.2)	0.51*	0.000ʃ
CC (cm)	34.7 (±3.15)	32.2 (±2.5)	35.7 (±2.7)	0.57*	0.000ʃ

*Note: § Pearson's chi-square test; ʃ Student T test; * p <0.005 in the Pearson correlation; BMI: Body Mass Index; WC: Waist Circumference; CC: Calf Circumference.*

Table 2 – Prevalence of decreased muscle mass and predictive ability to identify muscle mass in the elderly of cutoff circumferences cutoffs available in the literature, according to sex, Goiânia, Goiás, Brazil, 2010, N = 132

Cutting points	Prevalence	Sensitivity (CI 95%)	Specificity (CI 95%)	PPV* (%)	NPV** (%)	Accuracy (%)
			Male (n = 52)			
33 cm	16 (30.8)	57.1 (34.0-78.1)	87.1 (70.2-90.4)	75.0	75.0	75.0
34 cm	21 (40.4)	66.7 (43.0-85.4)	77.4 (58.9-90.4)	66.7	77.4	73.1
			Female (n = 80)			
31 cm	9 (11.0)	40.0 (16.3-67.7)	96.9 (89.3-99.6)	75.0	96.9	86.2
33 cm	21 (25.9)	80.0 (51.9-95.6)	87.6 (77.2-94.5)	60.0	95.0	86.2
34 cm	37 (45.7)	93.3 (68.0-99.8)	66.1 (53.3-77.4)	38.8	97.7	71.2

*Note: * PPV: Positive Predictive Value; ** NPV: Negative Predictive Value.*

Table 3 – Performance of cutoff circumferences cutoff points obtained by means of the Receiver Operating Characteristic curve for the detection of decreased muscle mass in the elderly according to sex, Goiânia, Goiás, Brazil, (N = 132)

			Men	
	Cutoff (cm)	Sensitivity (%)	Specificity (%)	Accuracy (%)
Best point	33.7	76.2	67.7	71.1
Option 1	34	71.4	77.4	75.0
Option 2	35	80.9	64.5	71.1
Option 3	36	85.7	48.4	63.4
Option 4	37	95.2	38.7	61.5
			Women	
	Cutoff (cm)	**Sensitivity (%)**	**Specificity (%)**	**Accuracy (%)**
Best point	32.8	73.3	89.2	86.2
Option 1	33.0	80.0	84.6	83.7
Option 2	34.0	93.3	58.4	65.0
Option 3	32.0	46.7	93.8	85.0
Option 4	31.0	46.7	96.9	87.5

*Note: * ROC curve (Receiver Operating Characteristic Curve); CC: Calf Circumference*

As for the best cut points obtained by the ROC curve, it can be seen in table 3, in men and women, that the best values were 33.7, cm and 32.8 cm respectively. However, because they are fractional values, the cut points 34 cm in men and 33 cm in women were those that presented better sensitivity, specificity and accuracy (Table 3).

DISCUSSION

The prevalence of decreased muscle mass according to DEXA was high, which is consistent with studies that also used DEXA performed in the United States[14,36] and China[37]. Studies in Brazil found a prevalence of 13.5% in men[38] and 3.7% in women[5], and a global prevalence of 17%[5].

Revision study[4] identified that the mean cutoff points for muscle mass through DEXA vary from 5.72 kg/m^2 to 8.81 kg/m^2 in males and 4.23 kg/m^2 at 7.36 kg/m^2 in women, resulting in prevalences varying from 5.2% to 54.4% in men and from 2.6% to 40.5% in women. These discrepancies found in the prevalence of decreased muscle mass can be attributed to the different diagnostic criteria proposed for its estimation. The most common cut-off point in the literature was that proposed by Baumgartner et al[14], which uses the appendicular muscle mass index, calculated by the sum of the fat-free mass in the upper and lower limbs, divided by the square of the height estimated by the DEXA, whose cut-off point for men is 7.26 kg/m^2 and for women 5.45 kg/m^2.

Although more recent studies have shown cutoff points for CP with better sensitivity and specificity[28-30], two recent studies were found in the Netherlands[20] and Mexico[22] that assessed the prevalence of sarcopenia using the cutoff point of 31 cm of CC for estimation of decreased muscle mass, whose sensitivity in the present study (40.3%) and in the original study (44.3%) [27] was low. In the study with Mexican elderly women, the prevalence of sarcopenia using IMME as measured by DEXA and CC was, respectively, 14.6% and 11%[2]. In the Netherlands[20], men and women with cognitive disabilities, living in long-term

institutions, were analyzed and 17% of the participants had decreased muscle mass. It should be emphasized that men and women were included, and the cut-off point of 31 cm had been established for women[27]. Therefore, the results may not represent the actual prevalence in men.

In the present study, the 33 cm cutoff point for females and 34 cm for males has a greater capacity to predict decreased muscle mass. The first study to analyze the predictive capacity of CC was performed in French women[27] and the suggested cutoff point was 31 cm, whose sensitivity (44.3%) and specificity (91.4%) were similar to that found in this study. More recent studies have been conducted with men and women in Turkey[31], Japan[28] and Brazil[30]. In these studies, the elderly were also analyzed in the community and the reference method used was DEXA[28,30], except for Turkey[31], which used electrical bioimpedance. In these three studies, cut-off points in men and women presented close values (33 cm to 34 cm). Sensitivity and specificity values in men varied, respectively, from 61% to 89% and from 72% to 76%[28,30-31]. In women, sensitivity ranged from 78% to 100% and specificity ranged from 72% to 76%[28,30-31].

In spite of the amplitude of the variations in these studies and in the present investigation, the proximity of the cut points found indicates that there is good accuracy in identifying the decreased muscle mass, except for the 31 cm point, which presented low sensitivity (44.3%); the others have a good balance between sensitivity and specificity, with a higher specificity value.

Diagnostic tests with high specificity can avoid unnecessary interventions and bring less physical, financial and emotional repercussions due to an incorrect diagnosis of sarcopenia[35]. On the other hand, the low sensitivity of the CP cutoff point may make it an inadequate tool for the screening of sarcopenia in the elderly.

Thus, the use of CP with a cutoff point of 33.0 cm or 34.0 cm implies a higher probability of correctly diagnosing elderly patients with decreased muscle mass.

The possibility of identifying elderly patients with reduced muscle mass through CP is reinforced by studies that have evaluated their ability to predict mortality[23-24] and disability[24-25] and need for care[26]. In Taiwan, the decrease in CP[26] increased the risk of death in men by 1.30 (RR: 1.22-1.71) and in women by 1.38 (RR: 1.15-1.48) . Although studies[23-26] have shown that decreased CP increases the likelihood of decreased muscle mass, a study with elderly in Mexico[24] showed that CP increase (> 38 cm) had an independent association with disability, suggesting that the fat tissue may still impact muscle function.

Other studies[14,39] have also developed proposals with SC to track sarcopenia, but the measure is dependent on other variables. One of them, carried out in Japan[39], developed a proposal for the screening of sarcopenia, including, in addition to CP, muscle strength and age of the elderly. From a clinical practice point of view, this may not be an easy way to assess sarcopenia in developing country contexts, as the dynamometer is not usually available.

On the other hand, SC can be used in clinical practice and in primary care settings by different health professionals, requiring only a tape measure and training for this verification. Considering the adverse health outcomes of the elderly, this evaluation can be included in the routine evaluation of the elderly in primary care and, once changed, both the nurse and other health professionals can intervene or propose a more accurate evaluation of the body composition.

Limitations of the study

Despite their contributions, one of the limitations of this study is the cutoff point used for the definition of decreased muscle mass according to DEXA. It is a value obtained from a young American population[14] that does not have the same standard of living nor the health conditions of the Brazilian population. However, the studies presented here[27-28,30] that analyzed the predictive capacity of CP and proposed cut-off points also used this parameter, which facilitates comparisons of results. One possible limitation refers to errors inherent in anthropometric measures, since body changes related to aging, such as increased body fat deposition[40] and loss of skin elasticity, render these measures vulnerable to errors. To avoid this kind of bias, the following precautions were taken: single anthropometrist, training, standardization and analysis of interobserver technical error. Other care refers to the spectrum of the subjects, a fundamental condition for validation studies, that is, the tests were performed in a population that uses Primary Care, a population that proposes to apply the anthropometric measures later.

Contributions to the area of nursing, health or public policy

In nursing clinical practice, this measure can be performed during the physical examination of the elderly at different levels of health services, directing the clinical judgment and increasing the probability of a correct diagnostic decision and adoption of preventive measures, considering that in some situations the nurse diagnoses or establishes associations using taxonomies, from a subjective perception of the decrease of muscular mass.

CONCLUSION

This study validated and identified calf circumferential cutoff points for decreased muscle mass using DEXA as a reference. In the studied population, the cutoff points of 33 cm in females and 34 cm in males presented better predictive capacity of decreased muscle mass. In addition, the estimated prevalence of decreased muscle mass, according to these cutoff points, was similar to that identified by DEXA, which demonstrates the good accuracy of CP.

The evaluation of calf circumference can therefore be a useful technology in the clinical practice of nurses in both the identification and follow-up of muscle mass reduction, in the follow-up of body losses and in the early identification of sarcopenia. Thus, it is recommended to use it in clinical practice contexts in primary care using the values of 33 cm in women and 34 cm in men for screening of decreased muscle mass.

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