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Anthropometric indicators as screening instrument for falls in the elderly

Indicadores antropométricos como instrumento de triagem para quedas em idosos

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Abstract – Anthropometric indicators enable professionals for predicting risk of falls in the elderly; however, there is a gap in literature on reference values. This study analyzes anthropometric indicators such as screening tests for falls in the elderly. Cross-sectional population-based systematic sampling was conducted through a household survey and body composition assessment. Anthropometric measurements were performed using portable electronic scale and stadiometer. Bioimpedance device was used to measure body mass index, body fat and lean body mass. Falls were evaluated in the 12 months preceding the interview as a dependent variable. Discriminatory analysis was performed for falls through the ROC curve, sensitivity, specificity, positive and negative predictive values. Overall, 275 older adults participated in this study, whose prevalence of falls was 23.6%. The average body mass index was 27.8kg/cm² and 52.1% of individuals were overweight. Among older men, height (ROC=0.68; 95%CI 0.54-0.78) and lean body mass (ROC=0.63, 95%CI 0.58-0.76) were associated to the occurrence of falls. When considering cutoff of 52.2kg and 166cm, sensitivity was obtained in 75% and high negative predictive values (88.1% and 89.1% respectively). For women, lean body mass (ROC=0.61, 95%CI 0.30-0.49) and body mass (ROC=0.60, 95%CI 0.53-0.72) were relevant from the optimal cutoff point of 28.9% and 57.2kg/m². Lean body mass was more sensitive (63.2%) and body mass little more specific (64.3%), both with high negative predictive values (82.0% and 83.0%). The indicators used were able to discriminate older adults who have suffered from falls.

Key words: Anthropometry; Obesity; Older adults; ROC Curve; Sarcopenia.

Resumo – *Indicadores antropométricos instrumentalizam profissionais para predizer risco de quedas em idosos, entretanto, há lacunas de evidências na literatura sobre valores de referência. O objetivo foi analisar os indicadores antropométricos como testes de rastreio para quedas em idosos. Estudo com delineamento transversal de base populacional, amostragem sistemática, realizado por meio de inquérito domiciliar e avaliação da composição corporal. As medidas antropométricas foram aferidas por meio de uma balança eletrônica e estadiomêtro portátil. Utilizou aparelho de Bioimpendância para análise das medidas do índice de massa corpórea, gordura corporal e massa corporal magra. Adotou-se queda nos 12 meses anteriores à entrevista como variável dependente. Foi realizada análise discriminatória para quedas por meio da curva ROC, sensibilidade, especificidade, valores preditivos positivos e negativos. Participaram 275 idosos, cuja prevalência de quedas foi de 23,6%. O índice de massa corporal médio foi igual a 27,8kg/cm² e 52,1% estiveram em sobrepeso. Entre os homens idosos, a estatura (ROC=0,68; IC95%=0,54-0,78) e massa corporal magra (ROC=0,63; IC95%=0,58-0,76) foram associadas à ocorrência de queda. Ao considerar os pontos de corte 52,2kg e 166cm, obteve-se sensibilidade de 75% e altos valores preditivos negativos (88,1% e 89,1% respectivamente). Para as mulheres, a massa corporal magra (ROC=0,61; IC95%=0,30-0,49) e a massa corporal (ROC=0,60; IC95%=0,53-0,72) foram relevantes a partir do ponto de corte de 28,9% e 57,2kg/m². A massa corporal magra foi mais sensível (63,2%) e a massa corporal pouco mais específica (64,3%), ambos com altos valores preditivos negativos (82,0% e 83,0%). Os indicadores adotados foram capazes de discriminar idosos que sofreram quedas.*

Palavras-chave: *Antropometria; Curva ROC; Idoso; Obesidade; Sarcopenia.*

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INTRODUCTION

Senescence changes include progressive decrease in lean body mass and body fluids, increased amount of fat tissue[1], decreased muscle strength, potential deficiencies and functional limitations[2]. These age-related changes can make older adults susceptible to the occurrence of falls, which represent a major challenge to public health among long-lived individuals[1,2].

A positive energy and weight gain balance enables the development of sarcopenic obesity, which is characterized by loss of lean body mass and increased subcutaneous fat[3]. However, the role of changes in body composition as a risk factor for falls is still controversial. On the one hand, central adiposity can change the bodily center of balance and thus move it and on the other, fat mass accumulation in lower limbs favors sarcopenia[4].

Studies have indicated association between sarcopenia and risk of falls, given the reduced mobility and loss in physical performance[5,6]. Body mass reduction identification can be performed by complex measures such as Dual-energy X-ray absorptiometry (DEXA), imaging studies (computed tomography and magnetic resonance imaging) and electrical bioimpedance, or by simple measures such as skinfold thickness and limb circumference[7].

Anthropometric evaluation has been discussed as an essential tool in geriatric assessment to report on different body structure components, which are important risk factors for serious diseases, functional disorders and disabilities[8]. In determining the nutritional status of older adults, anthropometric measurements are used due to their simplicity, low cost and easy application[7,8].

Body mass index (BMI), for example, has been considered as a survival measure in this population[8]. However, in epidemiological studies, this measure is not a variable associated with risk of falls in this population[9-11]. Measures such as total body fat, lean body mass and fat mass are associated and little explored in investigations. For these indicators, portability, cost and handling make Bioelectric Impedance (BIA) an instrument to be used in both clinical practice and field research, since it does not require high degree of evaluator's ability, it is more comfortable, non-invasive, and can be used in obese individuals with good indication for home assessments[12,13].

There is a gap in literature on scientific evidence to justify the use of anthropometric indicators in professional practice as a screening measure of falls, especially regarding reference values[10], which may be useful in the implementation of prevention and intervention strategies in this population[13]. In this sense, the aim of this study was to analyze anthropometric indicators such as screening tests for falls in the elderly.

METHODOLOGICAL PROCEDURES

Participants

This is a cross-sectional population-based study with older adults, residents in the urban area of Cambé, PR, Brazil. The population consisted of a subgroup belonging to the "VigiCardio: Cardiovascular Diseases in the State of Paraná: mortality, risk profile, drug therapy and complications" project. Sample size calculation was performed considering the population defined by IBGE in 2007, the time when the city's population was 92,888 people, of which 33.1% aged 40 years or older (in baseline, 2010 Census data were not yet available). The StatCalc application of the Epi Info 3.5.3 program was used, adopting 3% margin of error, 50% outcome prevalence and 95% confidence level, which resulted in 1,066 subjects. There was an addition of 25% for losses and refusals, totaling 1,332 participants[14].

For the definition of respondents, a geographic map of the city with the division of urban areas by census tracts, neighborhoods, streets and blocks was used. The blocks of each sector were listed and the starting point of the route was randomly defined, opting for a sample interval of 1: 2 to ensure representativeness and to avoid concentration of respondents. In each household, eligible individuals were initially identified and in situations where more than one resident met the inclusion criteria for the interview, a new draw was performed for the participant selection[14].

The staff received training and the form was adjusted through a pilot study. Then, especially for the collection of anthropometric measurements and falls, 14 months after the VigiCardio interviews, individuals aged 60 years or more were reassessed in the date of first interview that remained alive. From the definition of the elderly in each household in the base study, 361 eligible subjects were detected.

Those who could not answer the questions of assessment tools, unable to perform physical examination procedures and limited to assume orthostatism (amputation, immediate postoperative period, limiting pain, dependence on a caregiver) were excluded. Sample losses were considered individuals that were not found after three visits, those who have moved and have not been located, who refused to participate and who were not found by inconsistency of records.

Thus, 86 individuals were not interviewed, 20 of which were not located, 12 refused to participate, 17 have moved, 3 were admitted to hospital and 34 were excluded due to contraindications for performing bioimpedance such as the use of pacemaker (14%), use of metallic prosthesis (68%) and limb swelling (18%). Overall, 275 older adults composed the final sample.

Data collection

Sociodemographic (age and sex) and clinical characteristics (drug use, number of self-reported diseases, pain in lower limbs) and falls in the last twelve months were obtained by a sample characterization survey. The definition of fall used was "an unintended event that results in changing the individual position to a lower level relative to the initial position"[5,6].

For body composition analysis, the Tetrapolar Bioelectric impedance device Maltron BF-906 Body Fat Analyzer BF-906 (BIA) was used. This single frequency device (50 kHz) does not measures reactance and measurements were taken in the right side of the body positioned in supine on a surface and tetra polar electrodes were placed on the dorsal surface of hand and foot on the metacarpal and metatarsal distal parts, respectively, and between the distal prominences of the radius and ulna in the wrist, medial and lateral malleolus in the ankle[23]. Individuals were instructed to remove all metal objects such as watch, bracelets, chains, and others; and in the last 24 hours, not to drink alcohol, consume caffeinated drinks and practice of intense physical activity; urinating thirty minutes before assessment and resting for five minutes before starting procedures. The following parameters were computed in the analyzer in order of appearance: ethnicity, gender, height, weight and age. The variables analyzed in the device were BMI, body fat percentage and lean body mass, fat mass weight, and lean body mass (kg).

Portable electronic scale and stadiometer were used to measure weight and body height, with accuracy of 100 grams and 0.1 cm, respectively. Portable electronic scale was label Plenna, model SIM 09190 with maximum capacity of 150kg. Participants were asked to wear light clothing and to take their shoes off. Individuals remained standing on the center of the scale platform and without support in hands. Height was measured in the standing position, facing back to the vertical surface of the device and the head was positioned in the Frankfurt plane, upper limbs relaxed along the trunk with palms facing thighs, heels together touching the vertical part of the stadiometer and medial edges apart. The movable part of the stadiometer was moved until it touched the vertex, with hair compression. BMI was automatically calculated by the BIA device when data were entered, using the following formula: [weight (kg) divided by the squared height (cm)]. For the classification of the specific nutritional status of individuals, the recommendations of Lipschitz[15] were used, considering cutoff points for underweight and overweight, respectively, BMI below 22 kg/m^2 and above 27kg/m^2.

Statistical analysis

Data were double entered in statistical database created in the Epi Info version 3.5.4 software. The sample was divided into two groups from records of previous falls (Yes and No) and descriptive analysis (dispersion and frequency) was carried out between groups. For continuous variables, the Student t-test for independent samples was applied, and for categorical variables, the Pearson's chi-square test and the Kolmogorov-Smirnov normality test were applied.

To assess the optimal cutoff point of variables BMI, lean and fat body mass, total body fat, fat body mass and lean body mass as tools for screening falls, areas under the ROC curve (Receiver Operating Characteristic), sensitivity , specificity, positive predictive value, negative predictive value and 95%CI were analyzed. In all tests, $p < 0.05$ was considered and statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) for Windows (version 20.0, SPSS Inc. ©, Chicago, Illinois).

RESULTS

The average age of participants was 67.2 (SD = 5.87) years, with predominance of individuals in the age range from 60 to 69 years, represented by 67.6% (n = 186) of the sample. The prevalence of occurrence of falls was 23.6%. The group that reported fall in the previous year was predominantly characterized by older women who reported higher number of diseases. The body mass index of both groups was equal to 27.8 (SD = 5.0) kg/cm^2 with 52.1% overweight, 37.5% eutrophic and 10.2% underweight. The characteristics of participants are shown in Table 1.

Table 1. Characterization data of individuals in relation to falls according to sociodemographic, clinical and functional variables, Cambé, PR 2012.

Variable	Falls						
	NO (n= 210)			YES (n= 65)			P
	Mean (±SD)	n	%	Mean (±SD)	n	%	
Age	66.8±5.73	-	-	68.7±6.12	-	-	0.024*
Sex							
Male	-	95	45.2	-	16	24.6	0.003*
Female	-	115	54.8	-	49	75.4	
Body Mass (kg)	70.04±14.60		-	71.04±11.89	-	-	0.614
Height (m)	1.60±0.09	-	-	1.57±0.09	-	-	0.057
Use of medications							
0 to 4	-	199	94.8	-	60	92.3	0.773
5 or more	-	11	5.2	-	5	7.7	0.623
Number of self-reported diseases	1.16±1.16	-	-	1.68±1.41	-	-	0.010*
Pain in MMII (yes)	-	90	42.8	-	38	58.5	0.032*

Note: SD: standard deviation; BMI: body mass index; * P <0.05.

Regarding the analysis of the accuracy of anthropometric indicators to discriminate falls, two indicators are statistically associated. For women, there is an area under the ROC curve for acceptable body mass (ROC = 0.61; 95%CI = 0.53-0.72; p = 0.01) and lean mass percentage (ROC = 0.60, 95%CI = 0.30 to 0.49; p = 0.03). Among men, height and lean body mass (kg) showed area under the ROC curve of 0.63 (95%CI = 0.54-0.78; p = 0.03) and 0.68 (95%CI = 0.58 to 0.76; p = 0.006), respectively, showing to be valid in diagnosing falls. Table 2 shows all values of area under the ROC curve, 95%CI and p-value of measured indicators.

The behavior of the areas under the ROC curve between height and lean body mass (gross weight in kg) in males can be seen in Figure 1A, showing that body height has a smaller percentage under the curve to discriminate falls in men. In Figure 1B, it was observed that for women, the areas under the ROC curve between body mass and lean body mass showed acceptable values of discriminatory power with statistical significance.

Sensitivity, specificity, positive predictive and negative predictive values and their respective cutoff points are shown in Table 3. Among men, it is clear that the best cutoff point was 52.2% for lean body mass, with better sensitivity and negative predictive value (75.0% and 89.1%) to identify falls, and 166 cm in height, equally sensitive (75.0%) and negative predictive (88.1%). In the group of older women, lean body mass was more sensitive (63.2%) and body mass was a little more specific (64.3%), both with high negative predictive values (82.0% and 83.0%, respectively).

Table 2. Comparison of areas under the ROC curves in relation to the anthropometric characteristics of BMI, body fat, lean body mass, body mass and height among elderly men and women, Cambé, PR 2012.

Fall indicators	Area	CI (95%)	P
		Men	
BMI	0.58	0.27-0.57	0,33
Total Body Fat	0.50	0.35-0.65	0,99
Lean Body Mass (%)	0.64	0.22-0.50	0,07
Fat Mass (%)	0.59	0.25-0.56	0,23
Body Mass	0.56	0.50-0.77	0,43
Height	0.68	0.54-0.78	0,03*
Lean Body Mass (kg)	0.63	0.58-0.76	<0,01*
		Women	
BMI	0.60	0.49-0.69	0,06
Total Body Fat	0.60	0.50-0.69	0,06
Lean Body Mass (%)	0.61	0.30-0.49	0,03*
Fat Mass (%)	0.60	0.50-0.69	0,07
Body Mass	0.60	0.53-0.72	0,01*
Height	0.46	0.37-0.56	0,46
Lean Body Mass (kg)	0.46	0.37-0.56	0,49

Note: 95%CI: 95% confidence interval; BMI: Body Mass Index; * P <0.05

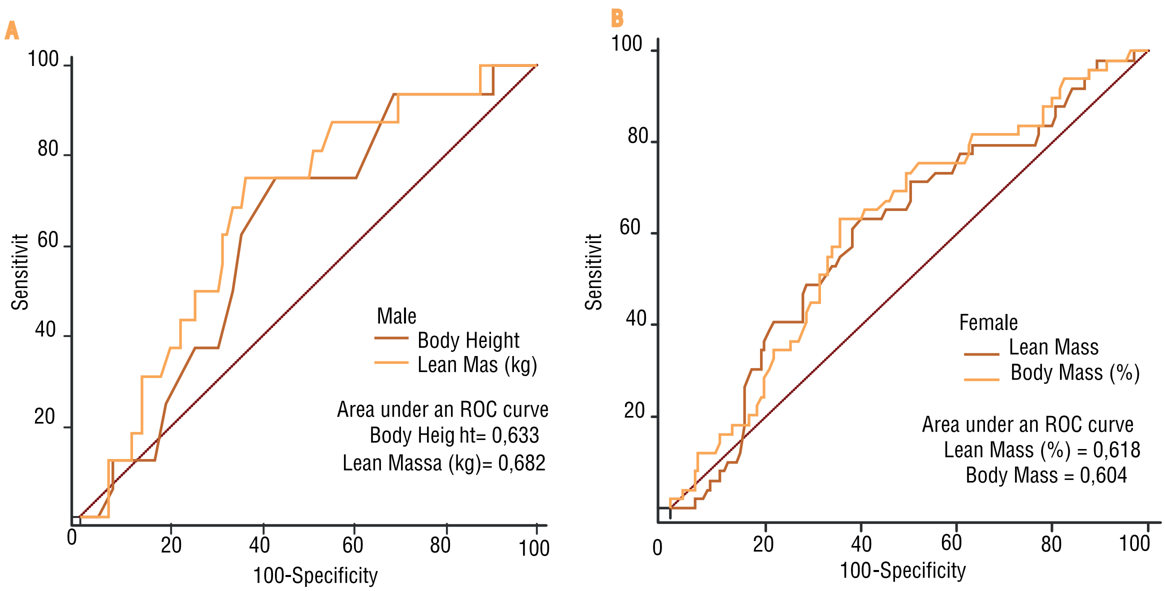

Figure 1. Areas under the ROC curves with their respective sensitivities and specificities of discriminant anthropometric indicators of falls in elderly men (A) and women (B), Cambé, PR 2012.

Table 3. Sensitivity, specificity, positive predictive value and negative predictive value regarding cutoff points of anthropometric indicators of obesity as discriminators of falls in elderly men and women, Cambé, PR 2012.

Fall Indicators	Cutoff Point	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
Men					
Height (cm)	>166	75.0%	57.2%	35.1%	88.1%
Lean Body Mass (kg)	>52.2	75.0%	63.5%	38.8%	89.1%
Women					
Lean Body Mass (%)	>28.9	63.2	60.0	36.0%	82.0
Body Mass	≤57.2	63.2%	64.3%	38.7%	83.0%

DISCUSSION

In this study, the hypothesis that anthropometric indicators contribute to the prediction of falls in the elderly was tested. The main finding of this study was prevalence of falls equal to 23.6%, statistically higher among women, in older individuals and who reported comorbidities. Body weight, height and use of medications were homogeneously represented. Height and gross weight of lean body mass among men were associated with the occurrence of the primary outcome and the percentage of lean mass and body weight was statistically significant among older women.

Sex categories were analyzed separately due to large differences in aging between men and women, particularly with regard to body composition and lean body mass. Previous studies indicate significant differences in the prevalence of falls in both sexes, with higher chances for older women[16,17]. Data obtained in this study are slightly lower than epidemiological population-based designs with prevalence of falls ranging from 28 to 42%[5,6] possibly due to a more pronounced muscle mass loss.

To compare the various anthropometric indicators and risk of falls, it was found that lean body mass, body mass and height are its best discriminators. The justification may be based on mass and muscle strength declines related to senescence.

In relation to lean body mass, there is still no consensus in literature on the concept, so the different formulas used reach different results. Bijlsma et al.[18] applied six different formulas to define low lean body mass. Comparatively, low lean mass among men aged 60-69 years varied from 0 to 31% and for those older than 70 years from 0 to 45%. Among women of these respective age groups, the prevalence of low muscle mass found ranged from 0 to 22% and from 0 to 26%. Adopting these distributions in the study population, the predetermined frequency of low lean mass in our study is compatible with percentages found by the authors[18].

The muscle mass measurement itself is of limited value for predicting the motor function of the individual's capacities. Type II muscle fibers (fast contraction) decrease in size[19], which contributes to the reduction in the muscle sectional area. In addition, there is muscle infiltration of adipose tissue, resulting from weight gain and/or the aging process. Thus, if the muscle has volume and weight, but without function quality, there are disorders in the health of these individuals such as sarcopenia, immobility and falls. Vilaça et al.[20] indicate that the quality of muscles in obese women (lean body mass divided by force) is lower than those of normal weight. Loss of mass with consequent loss of strength is directly related with reduced mobility and loss of physical performance, which contributes to the increased risk of falls[6].

Specific anthropometric measurements discriminate better the risk of falls than generalized proportional indicators[22]. Previous studies have suggested that BMI may not be the most ideal predictive of diseases in the elderly for being unable to assess the redistribution of age-associated body fat[11,13,20]. Thus, total body mass of muscle mass measurement can be directly related to functional capacity, which differs from results measured via DEXA in the investigation of Clark and Manini[23]. Analyzing our results, an older woman who has low lean body mass proportions and high body mass should be referred to multidisciplinary programs to improve body composition and prevent the risk of falls[22-24].

Possible memory bias should be considered, since individuals were asked about fall events in the year preceding the survey. However, the occurrence of falls found was similar to prospective studies that monitored this event by recall strategies. The population-based design of the study and the adoption of robust anthropometric measures using high-sensitivity electronic equipment, eliminating possible measurement bias stand out as positive points.

CONCLUSIONS

Indicators associated with the occurrence of falls among men were height and lean body mass percentage; among women were total body mass (kg) and lean body mass in percentage. These measures can be used in screening for falls in the elderly for showing better sensitivity and negative predictive values. These findings suggest the possibility of using anthropometry measures as an option to assess long-lived individuals through simple, reproducible and reliable criteria with high sensitivity, specificity and negative predictive value, at low cost, allowing greater scope in the monitoring of the nutritional and health status of this population.

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