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Analysis of anthropometric indicators used in the nutritional assessment of active elderly in the city of Macaé, Rio de Janeiro, Brazil

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ABSTRACT

Introduction: Body composition changes related to aging alter the capacity of predicting risk through anthropometric parameters. **Objective:** To discuss methodological aspects of anthropometry in active elderly based on associations between Body Mass Index (BMI) and other nutritional indicators. **Methods:** Cross-sectional study with active elderly from Macaé, Rio de Janeiro, Brazil (2014/2015). Nutritional status was described according to the BMI (Nutritional Screening Initiative, 1994). Linear regression analysis was performed: the outcome variable was BMI and the dependent ones were circumferences of waist, hip, neck, calf, arm and waist-to-hip ratio (WHR). **Results:** We assessed 173 people (55.5% female; median 71 years old). Calf and neck circumferences and WHR presented low R^2 value. Among women, hip (R^2=0.825) and waist circumferences (R^2=0.729) individually explained much of the variation in BMI; and among men, waist (R^2=0.759) and arm circumferences (R^2=0.741) performed better. The cut-off points for waist circumference corresponding to the critical BMI value (27 kg/m^2) were 87.9 and 96.8 cm, respectively for women and men. In multiple analysis, the association of waist, hip and arm circumferences with BMI remained significant. **Conclusion:** Circumferences traditionally used to assess adults had higher linear association with BMI than specific indicators for elderly people. The body composition of active elderly can be more similar to adults' than that of elderly with other profiles. The waist circumference cut-off points established for adults may not be suitable for elderly populations. We suggest testing the cut-off points obtained by this study on other groups of active elderly.

Keywords: nutrition assessment; anthropometry; body mass index; aged; health profile; Brazil.

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INTRODUCTION

In recent decades there has been an increase in the number of older adults in Brazil due to the demographic transition process[1]. This growth reinforces the need to assess health and nutrition conditions of this population, especially in contexts of social vulnerability, as occurs in several Brazilian regions[1,2]. Thus, it is essential to have adequate methodological resources to generate information about elderly health and nutrition profile and the distribution of associated diseases in order to support public policies and actions targeted at the elderly population in the country[2].

Anthropometry is indicated for the nutritional assessment of communities, mainly because it is a relatively simple and effective method for nutritional screening and surveillance, allowing early action and preventing disease and death[3]. Elderly nutritional surveillance is relevant because aging is accompanied by weight redistribution among body compartments and areas, which includes lean mass reduction and concomitant fat mass accumulation, especially in the abdominal and intramuscular regions[4,5].

These aging physiological particularities, however, may reduce the ability of anthropometric indicators to estimate body compartments and, consequently, affect their correlation with health risks associated with changes in body composition[6-8]. Thus, different from the more solid epidemiological view on anthropometric methods in adults[9,10] and children[11], the use of anthropometry in the elderly is not fully established in the literature[6,12].

Even for traditional indicators such as body mass index (BMI), widely recognized for its high correlation with adiposity and risk of morbidity and mortality in groups of individuals aged 20 years or more, there is still no international standardization of cut-off points for the elderly[9,12]. On the national level, there is also a lack of evidence supporting the generalization of BMI cut-offs for the elderly[7,8]. Therefore, the Brazilian Ministry of Health currently adopts the Nutrition Screening Initiative (NSI)[13] reference regarding BMI classification for the elderly in the country. On the other hand, the World Health Organization (WHO) recommends using the same classification applied to adults[9].

Concerning the use of waist circumference as an indicator of cardiovascular risk, there is also no theoretical consensus on specific cut-off points for the elderly population[10]. Furthermore, the use of neck circumference instead of waist circumference to classify this risk in the elderly is a current discussion. This is because, compared to central fat deposits estimated by waist circumference, there may be a greater independent correlation between fat accumulated in the neck region and cardiovascular risk[14].

As a complementary anthropometric measurement to assess muscle mass in the elderly, the WHO recommends calf circumference. However, the relevance of applying the WHO calf cut-off point in the elderly in Brazil is debatable[15,16], since it was determined based on a restricted sample[17].

The state of the art of nutritional assessment of the elderly indicates, therefore, open margins for research. Hence, the present article aims to discuss methodological aspects of anthropometric assessment of the elderly based on the associations between BMI and other nutritional indicators applied to a group of active elderly in the city of Macaé, Rio de Janeiro, Brazil.

METHOD

This is a cross-sectional study, with a quantitative approach. We evaluated 173 individuals of both sexes, aged 60 years or older. Data collection was conducted between 2015 and 2016, within the scope of the research and extension project "Aging, Nutrition, and Health Promotion" (*Envelhecimento, Nutrição e Promoção da Saúde* – ENUSA), at the Universidade Federal do Rio de Janeiro, Macaé Campus.

In agreement with the nomenclature used by the WHO[18], the understanding of "active" adopted in this study is not based on the level of physical activity, but on the fact that they are elderly who participate in social and citizenship activities daily. ENUSA participants were active because they attended social integration initiatives in the municipality of Macaé. That is, they were not institutionalized, hospitalized or bedridden, and had preserved functional capacity. One of these initiatives was the Senior Guard Program, in which the participants received training and remuneration to act as a community helper, guiding the population in public places, such as squares and schools. Another initiative was located in a senior citizen center, a space for the promotion of health and quality of life through individual and collective health care, courses, workshops, and gymnastics. It was not necessary to calculate a sample because all the participants of the initiatives were invited to voluntarily participate in the research.

According to anthropometrics protocols standardized by the WHO[9], trained researchers measured body weight (kg), height (cm), waist circumference (cm), hip circumference (cm), calf circumference (cm), and arm circumference (cm). Following the method described by Ben-Noun and Laor[19], the neck circumference was also assessed. The measurement was taken at the midpoint of the neck and, in men, immediately below the biggest laryngeal prominence. All measurements were taken twice, except for weight. Weight was measured on an Omron® portable digital scale, with a 150 kg capacity and 0.1 kg precision. Height was obtained with a portable stadiometer with 0.1 cm accuracy.

Body circumferences were measured with an inextensible inelastic tape, and accuracy of 0.1 cm. Waist circumference was assessed at the midpoint between the lower border of the last rib and the iliac crest, at the mid-axillary line, in the end of exhalation. Hip circumference was measured in the horizontal plane, at the largest perimeter in the gluteal region. Calf circumference was measured with the individual seated with the leg bent at a right angle, and the tape positioned around the largest perimeter. The arm circumference was measured on the non-dominant side, at the median point between the acromion and the olecranon, with the arm relaxed and parallel to the body[9].

BMI was calculated by dividing weight (kg) by squared height (m^2), and waist-to-hip ratio (WHR) by dividing waist circumference by hip circumference. BMI was classified following the NSI[13] cut-off points adopted by the Brazilian Ministry of Health[3].

To describe the participants, we also analyzed education, family income, type of housing, and whether the individuals resided with other people.

The digital data were compared to the physical forms and submitted to typing quality control. Statistical analysis was performed using the Statistical Package for the Social Science® (SPSS), version 21.0. The normality of the variables was verified by visual inspection. We carried out descriptive analyses, including calculation of measures of central tendency (mean and median) and dispersion (standard deviation, interquartile range, and percentiles) of continuous variables; and relative frequencies of categorical variables. We performed the t-student test and analysis of variance (ANOVA) to verify differences between means and the chi-square ($\chi 2$) test to differences between proportions.

Simple and multiple linear regression analyses were performed, with BMI as the outcome variable. Age, WHR, and waist, hip, neck, calf, and arm circumferences were the independent variables. The coefficient of determination (R^2) was calculated to quantify the variation in BMI explained, individually and jointly, by such anthropometric indicators. In all analyses we considered statistical significance level of 5% ($p<0.05$).

In the regression equations resulting from the relationship between waist circumference and BMI, the value 27 kg/m^2, referent to overweight in the elderly[3], was applied as an indicator of increased risk for cardiovascular problems. The waist circumference values corresponding to this BMI cut-off point were used to classify the individuals in terms of waist adequacy.

The research project was approved by the Research Ethics Committee of Faculdade de Medicina de Campos/Fundação Benedito Pereira Nunes: Certificate of Submission for Ethics Appreciation nº. 45743015.5.0000.5244, from July 5, 2015, under Opinion nº. 1.138.759. The participants signed an Informed Consent Form.

RESULTS

Among the 173 participants, 55.5% were female (n=96). The mean age was 71.2 years. Men were, on average, 4.2 years older than women ($p<0.001$). In respect to social aspects, the median of schooling was 5 years (ranging from 0 to 16 years), 80.9% (n=140) of the participants lived with other people and 80.8% in their own house. Among the 162 individuals with information on family income, approximately 62% received three or more minimum wages (Table 1).

The means (±standard deviation) and medians (interquartile range) of the anthropometric variables are described in Table 2. The means for height, BMI and arm circumference were statistically different between sexes. The average BMI among women, 29.0 kg/m² (5.5), was higher than among men, 25.6 kg/m² (3.8) ($p<0.001$). In addition, the mean waist circumference of the women was high and equivalent to that of the men.

The prevalence of overweight, the most frequent nutritional problem in the group, was higher among females: 59.4% versus 39.0% ($p=0.008$) (Table 3). It is noteworthy that the prevalence of thinness was equal to 12.1%, and higher in males: 18.2% versus 7.3% ($p=0.029$).

In simple linear regression for males, waist circumference ($R^2=0.759$) presented the best fit with BMI, followed by arm circumference. Among women, the best explanatory variable for BMI was hip circumference ($R^2=0.825$), followed by waist circumference ($R^2=0.729$). Among men, WHR, neck and calf circumferences individually showed R^2 values around 0.5 in relation to BMI. Among women, these measures also had R^2 close to 0.5, but the WHR was less than 0.1 (Table 4).

The regression equations resulting from the relationship between waist circumference (WC) and BMI were BMI = -10.258 + 0.424 (WC) for women, and BMI = -3.020 + 0.310 (WC) for men. The WC values that, in these equations, corresponded to the BMI of 27 kg/m^2 were 87.87 cm and 96.84 cm for women and men, respectively. When using these values to classify the participants, 65.6% of women and 36.4% of men presented waist circumference inadequacy (Table 3). Among women, the waist circumference in the 90th percentile was equal to 105.71 cm, and among men, 107.61 cm.

In multiple regression analysis, a model was built with combined sexes, and separate models by sex. The best model to explain BMI in both sexes included arm circumference (AC), waist circumference (WC), and hip circumference (HC), resulting in the equation: BMI = -19.723 + 0.325 (AC) + 0.130 (WC) + 0.251

Table 1: Sociodemographic characteristics of active elderly (n=173) from the municipality of Macaé, RJ, Brazil, 2015.

Variables	Men	Women	Total
	years - mean (SD)		
Age	73.5 (6.0)	69.3 (5.5)	71.2 (6.1)
Education	5.4 (3.6)	5.2 (3.3)	5.3 (6.1)
	%		
You live with someone	89.6	74.0	80.9
Family income[a]			
1 minimum wage	4.5	4.1	4.3
2 minimum wages	37.1	30.1	34.0
3 minimum wages	37.1	31.5	34.6
>3 minimum wages	21.3	34.2	27.2
Housing Type			
Own	85.7	76.8	80.8
Rented	11.7	15.8	14.0
Ceded	0	6.3	3.5
Another	2.6	1.1	1.7

SD = standard deviation; [a]n=162

Table 2: Anthropometric characteristics of active elderly (n=173) from the municipality of Macaé, RJ, Brazil, 2015.

Variables	Men (n=77)		Women (n=96)		Total (n=173)	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Weight (kg)	69.3 (11.5)	68.1 (62.0-77.4)	67.6 (13.2)	66.6 (57.6-77.8)	68.4 (12.4)	67.5 (59.0-76.8)
Height (m)	1.60 (0.10)[a]	1.66 (1.60-1.68)	1.50 (0.10)	1.52 (1.49-1.57)	1.58 (0.85)	1.58 (1.52-1.65)
BMI (kg/m²)	25.6 (3.8)[a]	25.7 (23.0-28.4)	29.0 (5.5)	28.4 (24.8-32.1)	27.5 (5.1)	27.0 (23.7-30.4)
Waist circumference (cm)	92.3 (10.6)	92.2 (86.4-100.4)	92.6 (11.1)	92.4 (83.6-100.6)	92.4 (10.8)	92.2 (84.6-100.4)
Hip circumference (cm)	96.9 (6.6)	97.6 (92.9-100.5)	103.7 (10.7)	103.4 (95.1-109.3)	100.7 (9.7)	99.8 (93.9-105.5)
WHR	0.95 (0.07)	0.94 (0.91–1.00)	0.89 (0.06)	0.89 (0.89-0.94)	0.92 (0.07)	0.92 (0.87-0.97)
Neck circumference (cm)	38.2 (3.4)	37.8 (36.0-40.4)	35.2 (3.0)	35.1 (33.0-36.6)	36.5 (3.5)	36.2 (34.0-38.7)
Arm circumference (cm)	29.2 (3.2)[a]	29.2 (26.8-31.2)	31.5 (4.3)	30.6 (27.8-35.3)	30.5 (4.0)	30.2 (27.4-33.2)
Calf circumference (cm)	36.2 (3.4)	36.1 (34.2-38.3)	36.5 (3.9)	36.3 (34.1-38.8)	36.4 (3.7)	36.2 (34.1-38.5)

SD: standard deviation; IQR: interquartile range; BMI: body mass index; WHR: waist-to-hip ratio.
[a] difference in means between the sexes was statistically significant.

Table 3: Classification of nutritional status according to anthropometric variables of active elderly (n=173) from the municipality of Macaé, RJ, Brazil, 2015.

Parameter	Men (n=77)			Women (n=96)			Total (n=173)		
	Thin	Adequate	Overweight	Thin	Adequate	Overweight	Thin	Adequate	Overweight
	%								
BMI (kg/m²)	18.2[a]	42.9	39.0[a]	7.3	33.3	59.4	12.1	37.6	50.3
	Adequate		Inadequate	Adequate		Inadequate	Adequate		Inadequate
	%								
Waist circumference (cm)	63.6		36.4	34.4		65.6	47.4		52.6

BMI (NSI): Body Mass Index according to The Nutrition Screening Initiative (1994).
[a]Difference in proportions was statistically significant between the sexes.

Table 4: Regression equations and determination coefficients obtained by bivariate linear regression between body mass index and other anthropometric variables of active elderly (n=173) from Macaé, RJ, Brazil, 2015.

Equations	R	R²	p-value
Women			
BMI = -1.911 + 0.979(AC)	0.77	0.59	0.001
BMI = -4.,865 + 0.926(CC)	0.66	0.43	0.001
BMI = -17.316 + 1.315(NC)	0.70	0.50	0.001
BMI = -10.258 + 0.424(WC)	0.85	0.73	0.001
BMI = -19.444 + 0.467(HC)	0.91	0.83	0.001
BMI = 19.008 + 11.134(WHR)	0.13	0.02	0.204
Men			
BMI = -3.390 + 0.993(AC)	0.86	0.74	0.001
BMI = -0.673 + 0.726(CC)	0.66	0.43	0.001
BMI = -5.570 + 0.806(NC)	0.72	0.52	0.001
BMI = -3.020 + 0.310(WC)	0.87	0.76	0.001
BMI = -15.525 + 0.421(HC)	0.74	0.55	0.001
BMI = -8.316 + 35.664(WHR)	0.68	0.46	0.001

AC: arm circumference; BMI: Body Mass Index; CC: Calf circumference; NC: Neck circumference; WHR: Waist-to-hip ratio; WC: Waist circumference.

(HC) (R^2=0.855). Together, these same variables explained 87.9% of the BMI in females, according to the equation BMI = - 20.585 + 0.197(AC) + 0.155 (WC) + 0.279 (HC). In the male model, the hip circumference was not statistically significant (p=0.652) and its removal did not reduce the predictive power. The equation found for men was BMI = -6.930 + 0.182 (AC) + 0.538 (WC) (R^2=0.848). Age was also tested with the anthropometric variables but was not statistically significant.

DISCUSSION

The group studied is characterized, in general, by a high prevalence of overweight and increased cardiovascular risk. Regarding nutritional classification according to BMI, the profile of the participants is similar to that observed in Brazil, where overweight and obesity are the most prevalent nutritional problems. Notably, in population-based surveys in Brazil[20,21], overweight is more prevalent in females, like in this group.

Regarding the evaluation of waist circumference, the percentile distribution was similar between the sexes, which is especially relevant considering that, in women, a smaller measurement indicates cardiovascular risk. The prevalence of waist circumference inadequacy was higher among women, as observed in other local surveys with active elderly Brazilians. In both sexes, the prevalence of inadequacy found here was higher than in these studies[7,22], even though we used a specific classification, whose cut-off points for inadequacy are higher than those recommended by the WHO[9].

The arm circumference is usually used to evaluate the reduction of muscle mass, especially in hospitalized and institutionalized elderly. However, in this and other studies with active elderly[24,25], arm circumference medias were high. The arm circumference also had a high determination coefficient, mainly among men, a group in which this indicator was able to individually explain 74% of the BMI variation. This finding suggests that the participants in this study possibly had important subcutaneous fat reserve in the brachial region, which was well captured by this perimeter. Considering the relatively high age of the participants, one could expect a decrease in arm circumference accompanied by fat centralization[9]. However, the findings suggest that the redistribution process of body compartments may be delayed, possibly due to the active functional capacity.

By active functional capacity, we do not necessarily refer to exercising regularly or integrating the labor force. It is not a quantitative approach to the level of physical activity, but the recognition of the importance of autonomy and independence to increase life expectancy and quality[18]. Moreover, given the housing situation, the presence of cohabitants, and the family income, the participants cannot be considered socioeconomically vulnerable.

Calf circumference has been recognized as a more sensitive indicator than arm circumference and other measures to detect muscle loss in older adults due to its more direct relationship with the somatic protein compartment[9,16]. Its high sensitivity has been described in some studies with Brazilian elderly[15,16]. In this reasearch, however, calf circumference averages were high in both sexes, which cannot be explained by adiposity, since the linear association of this indicator with BMI was low. It is possible that, as a group, the participants did not have enough muscle loss to be detected in perimetry, which also suggests a less pronounced process of redistribution of body compartments.

As for cardiometabolic risk classification in the elderly, neck circumference has been highlighted as a possible alternative to waist circumference because it is easy to measure and there is evidence that the brown adipose tissue in the neck region has a greater independent correlation with cardiovascular risk markers than central fat deposits[14]. However, neck circumference presented low linear association with BMI in this group, despite the high mean BMI and waist circumference observed, consistent with excess adiposity. Although neck circumference explained little of the variation in total adiposity, the metabolic activity of neck fat may be relevant to increased metabolic risk, the detection of which would require analysis of factors other than anthropometry.

Waist circumference, traditionally applied in adults, was the most pertinent indicator to estimate adiposity in both sexes in this group. The study by Sampaio and Figueiredo[4] endorses the view that the association between BMI and waist circumference, observed in adults, remains in the elderly population. In general, hip circumference is not applied alone as an indicator, but it assesses a region that accumulates fat, especially in women. In this sex, the linear association between hip circumference and BMI was high. However, this strong association individually observed between waist and hip circumferences with BMI was lost with the construction of the WHR, which did not prove to be a good indicator of excess adiposity. This finding is congruent with a recent systematic review that pointed waist circumference as a better predictor of metabolic syndrome in the elderly than WHR[26]. It also corroborates the indication of the WHO[10] to use waist circumference as an indicator of cardiovascular risk in the elderly.

Waist circumference alone was able to explain more than 70% of the variation in BMI in both sexes. However, the waist circumference cut-off points calculated for this group were 9.84% and 3% higher than those recommended by the WHO[9,10], for women and men, respectively. This difference suggests that the waist circumference point at which there is an increased risk of morbidity and mortality may be higher in the elderly than in adults.

The association of BMI with the risk of disease and death is well recognized[27], as well as it is the ability of waist circumference to discriminate visceral adiposity[28]. However, the discussion about applying the same BMI cut-off points used in adults to elderly populations is current. For example, meta-analysis studies have shown that the BMI range traditionally considered overweight in adults would be associated with a lower risk of death in the elderly[29]. However, waist circumference cut-off points for elderly populations have not been frequently questioned, and the classification recommended by the WHO for the elderly does not differ from that applied to adults[9]. As the considerations made in the literature regarding BMI cut-off points in the elderly[12], it would also be necessary to discuss waist circumference limit values to identify cardiovascular risk in this age group.

The relevance of this discussion lies in the fact that small differences in cut-off points can directly interfere in the nutritional diagnosis of populations and in public health decision making, resulting in the inclusion or exclusion of thousands of people in actions designed in response to an identified demand. In the case of Brazil, the adoption of the BMI classification proposed by the NSI[13] makes the cut-off point to determine overweight more tolerant (27 kg/m^2) than that recommended by the WHO (25 kg/m^2), which can interfere in the screening of people to be included in food and nutrition programs. Although the Brazilian Ministry of Health does not indicate waist circumference to assess central obesity in the elderly, it is commonly applied in epidemiological studies and clinical practice, and the available cut-off points are those of the WHO, which do not distinguish between adults and the elderly[9].

Regarding the evaluation of populations, the results of this study raise a broader reflection on the use of different anthropometric indicators for adults and active elderly populations, concerning both the choice of measurement and the range of adequacy. It is not about questioning the clinical sense of applying the indicators, because in the individual level, it is recommended to use BMI in association with some measure that expresses the distribution of body fat. The point is the pertinence of these indicators to assess risk in the population level, in which particular cases are diluted in the collective. This discussion is important because the group of individuals aged 60 years or more, categorized as "elderly" based on chronological criteria, is heterogeneous and encompasses different functional and physiological conditions[12]. Even among active elderly, the level of physical activity - which is closely related to body composition[30] - can vary widely, from individuals with reduced participation in work and leisure activities to those who practice sports. Furthermore, among Brazilian adults, a population stratum in which functional impairments are not frequent, the prevalence of physical inactivity is high in all age groups[31].

Thus, a question that arises is: in terms of body composition, elderly groups, not extremely longevous, functionally active and participating in daily social life, differ from adult populations to the point of requiring specific anthropometric indicators? The present findings suggest that although the evaluated individuals are elderly from a chronological point of view, in terms of body composition, they may, as a collective, not differ markedly from adult groups. Furthermore, as age was not statistically significant in the multiple model, functional capacity may be more determinant of body composition than age in community-dwelling, functionally active elderly.

However, the question raised requires a complex answer that is certainly beyond the scope of this study. It would be necessary to analyse the causal association of anthropometric indicators with risk of illness and death in probabilistic samples of Brazilian elderly of different functional and age profiles. Another limitation of this study is the exclusive use of BMI as the outcome variable. This index estimates the total adiposity - whose increase is associated with higher morbidity and mortality, but it does not distinguish body compartments, as it happens in the measurement of body fat by bioelectrical impedance or dual absorption X-ray (DEXA)[12]. In this sense, possible developments of this study would be to replicate the set of analyses, considering the body fat percentage, measured by gold standard methods, as the outcome variable. Besides, it would be interesting to verify the applicability of the waist circumference limit values obtained here in other groups of Brazilian elderly.

Considering the high burden of chronic diseases associated with overweight that currently press the Brazilian Health System, further studies should be conducted to evaluate anthropometric methods accessible for the nutritional diagnosis of Brazilian elderly. This study suggests that, in the anthropometric assessment of active elderly, waist circumference - historically applied in nutritional assessment of adults - and arm circumference perform better in measuring adiposity than neck circumference. In conclusion, the available cut-off points to identify cardiovascular risk by waist circumference may not be fully appropriate for active elderly, and result in poor planning of actions in public health aiming at this population.

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