Body mass index and measures of adiposity among elderly adults

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Keywords
Body mass index. Anthropometry. Obesity, diagnosis. Brachial perimeter. Skinfold thickness. Nutritional status. Adult health. Aging health.

Abstract

Objective
To evaluate the nutritional status of elderly persons and to compare the correlation between the body mass index (BMI=kg/m^2) with measures of adiposity and fat distribution among elderly and middle-aged adults.

Methods
Elderly persons (N=699; 60 years or older) and middle-aged adults (N=1,306; 40-59.9 years) participating in a population-based survey conducted in 1996 in the municipality of Rio de Janeiro were evaluated as to body mass index, arm, waist, and hip circumferences, skinfolds, and arm fat and muscle areas using standardized procedures. The cutoff points proposed by the World Health Organization for waist circumference, waist-to-hip ratio, and body mass index were used. Analyses were performed using the Spearman correlation coefficient and linear regression adjusted for age.

Results
About 50% of elderly subjects were classified as overweight and more than 50% of women in all age groups had waist circumference and waist-to-hip ratio outside the normal range. Among men, these percentages were about 40% for waist circumference and 20% for waist-to-hip ratio. Among elderly subjects, the partial correlation (adjusted for age) between body mass index and measures of adiposity (waist circumference, skinfolds, and arm fat area) ranged from 0.45 to 0.85 for men and 0.55 to 0.86 for women. Weight and waist circumference were the variables more strongly correlated with body mass index among both elderly persons and adults.

Conclusions
The prevalence of overweight among elderly persons was high for both men and women. Body mass index shows a similar relationship with adiposity regardless of ageing.

INTRODUCTION

The body mass index (BMI), expressed as the relationship between body mass in kg and stature in m^2, is widely used as an indicator of nutritional status due to its strong correlation with body mass (r≈0.80) and weak correlation with stature.

Among older adults, the use of the BMI is problematic in light of the decrease in stature, accumulation of fatty tissues, reductions in lean body mass, and decrease in the amount of body fluids.[1,3] Additionally, the use of the BMI in elderly persons is further complicated by the frequent presence of diseases and the lack of specific cutoff points for this age group. Thus, there has been an extensive discussion regarding the use of the BMI and the limits of normality to be adopted for studying overweight and obesity

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among the elderly.[16] A recent systematic literature review[5] supports a change in the cutoff points used for defining excess weight among elderly persons, with the adoption of a wider range of normality. Furthermore, although the cutoff points used for BMI are similar for men and women, there are differences in the risk of cardiovascular disease associated with the distribution of body fat between the sexes.[7]

In Brazil, there are no population-based studies with elderly persons that allow for an evaluation of the adequacy of BMI as a marker of adiposity. The present survey is aimed at evaluating the correlation between BMI and a number of indicators of adiposity and of body fat distribution among elderly subjects, comparing the results to those of middle-aged adults living in the city of Rio de Janeiro. We also evaluate the nutritional status of the elderly subjects.

METHODS

The study population comprised 699 subjects aged 60 years or older, who participated in the Health and Nutrition Survey of the municipality of Rio de Janeiro (*Pesquisa de Saúde e Nutrição do município do Rio de Janeiro* - PSN/RJ), conducted between 1995 and 1996.

A probabilistic sample was defined in two stages. In the first stage, 60 census sectors were drawn with probabilities proportional to the number of households per sector. In the second stage, 34 households were systematically drawn from within each sector. Sample size calculation assumed 30% prevalence of obesity among middle-aged and elderly adults. Losses among the elderly amounted to 9.4%. All participants signed a term of free informed consent.

Measurements were performed at the participant's home by previously trained examiners. A detailed description of the sampling process, losses, collection instruments, interviewer training, and measurement reliability was published elsewhere.[10]

Anthropometrical measurements analyzed included body mass (kg), stature (m), arm circumference (cm), waist circumference (cm), hip circumference (cm), tricipital skinfold (mm), and subscapular skinfold (mm). Arm circumference was measured using a standard World Health Organization (WHO) tape measure, with one millimeter precision. For the evaluation of body mass, we used a portable digital scale with a 0.1 kg precision and a 150 kg limit. Participants were weighed wearing light clothing and no shoes. Skinfold measurements were performed using plastic adipometers with 0.2 mm precision and 60 mm limit. The validity of this measure was determined by comparing it to the measure obtained using a Lange adipometer. During the initial stages of examiner standardization, anthropometrists carried out both measurements. The interclass correlation coefficient was 0.73.

For the measurement of waist circumference, a tape measure was placed around the smallest curvature between the ribs and iliac crest. For hip circumference, the tape was placed around the hips at the most protuberant area.

Arm circumference and tricipital skinfold measures were used for calculating arm fat area and arm muscle area.[16]

Body fat distribution was estimated based on waist-to-hip ratio (WHR) and waist circumference (cm). The cutoff points recommended by WHO[17] for WHR, waist circumference, and BMI (kg/ m^2) were used. BMIs below 18.5 kg/m^2 are considered as underweight, and BMIs equal to or greater than 25 kg/m^2 are considered as overweight.

Analyses were stratified by age group and sex, since the hypothesis of the inadequacy of BMI cutoff points for elderly persons may be related to differences in fat distribution related to sex and age.[5] A reduction in BMI with age among the elderly has been by WHO report in more than 10 countries.[16] The three age groups normally associated with modifications in nutritional status among elderly persons are 60-69, 70-79, and 80+ years. We therefore evaluated anthropometric indicators in these age groups. The trend towards reduction in mean indicators (p-value for linear trend) was evaluated considering age group as a continuous variable.

Following the descriptive analysis of anthropometric variables and the comparison of values obtained for adults and elderly persons, divided by sex, we evaluated the relationship between BMI and anthropometric measures using Spearman's coefficient correlation. By means of multiple linear regression we obtained the partial correlation coefficients (rp) adjusted for age. The association between BMI and anthropometric measurements for middle-aged adults (aged 40-59.9 years (N=1,306), from the same database) were compared to those obtained for older adults.

Variables with right-skewed distributions were normalized by log 10 transformation, and exponential transformation was used for the presentation of results.

Data were analyzed taking into account the com-

Table 1 - Mean and standard error (SE) for anthropometric indicators according to sex and age group.

	60-69,9 years		70-79,9 years		≥80 years		p of the trend
	Mean	SE	Mean	SE	Mean	SE	
Men							
Stature (m)	1.67	0.61	1.65	0.73	1.65	1.61	0.26
Body mass (kg)	70.5	1.00	67.6	1.25	65.5	1.92	0.04
Body mass index	25.2	0.32	24.5	0.42	24.0	0.64	0.21
Waist (cm)	89.9	1.08	90.1	1.28	90.5	1.94	0.95
Waist-to-hip ratio	0.93	0.01	0.94	0.01	0.96	0.03	0.43
Arm circumference (cm)	29.9	0.30	29.1	0.40	27.9	0.73	0.02
Tricipital skinfold (mm)	17.0	0.70	18.1	0.94	14.9	1.43	0.18
Subscapular skinfold (mm)	20.1	0.63	20.3	0.86	17.7	1.57	0.32
Arm fat area (cm^2)	23.1	0.97	23.8	1.28	19.3	1.89	0.13
Arm muscle area (cm^2)	49.0	1.17	44.7	1.40	43.8	2.20	0.03
Women							
Stature (m)	1.55	0.48	1.53	0.72	1.51	1.09	0.007
Body mass (kg)	63.7	0.84	60.2	1.02	57.3	1.54	0.0005
Body mass index	26.3	0.33	25.5	0.41	24.9	0.68	0.08
Waist (cm)	86.7	0.88	85.2	1.09	85.2	1.73	0.51
Waist-to-hip ratio	0.85	0.01	0.87	0.01	0.87	0.01	0.42
Arm circumference (cm)	30.0	0.30	29.2	0.35	28.4	0.68	0.05
Tricipital skinfold (mm)	25.0	0.59	23.1	0.75	22.5	1.16	0.05
Subscapular skinfold (mm)	23.4	0.62	21.9	0.74	18.6	1.10	0.0008
Arm fat area (cm^2)	33.3	0.96	30.1	1.15	28.7	1.78	0.03
Arm muscle area (cm^2)	39.8	0.78	39.2	0.93	37.1	1.85	0.39

plexity of the sampling process and expansion factors, using SUDAAN (Software for the Statistical Analysis of correlated data) software.[9]

RESULTS

Estimated means and standard errors for the anthropometrical indicators are presented in Table 1. All differences between sexes were statistically significant ($P<0.0003$). Among elderly men, body mass, arm circumference, and arm muscle area decreased as the age group increased, whereas among elderly women only WHR, arm circumference, and arm muscle area did not change with age.

The general proportion of underweight was 3.8% among men and 3.5% among women.

There was a greater proportion of overweight and inadequate fat distribution among women in all three elderly age groups. The prevalence of inadequate waist-to-hip ratio and waist circumference among women was approximately twice that of men. The prevalence of both overweight and inadequate waist perimeter among men decreased with age. This decrease was less marked among women, and the prevalence of inadequate WHR among women increased with age. The prevalence of inadequate WHR among women was as high as three times that of men in the 80+ years age group (Table 2).

There was an important negative correlation between BMI and stature among adult and younger elderly (60-69.9 years) women (Table 3). Measures of adiposity (waist circumference, tricipital skinfold, subscapular skinfold, and arm fat area) showed *r* values between 0.45 and 0.84 among men and 0.50 and 0.80 among women, indicating a reasonable correlation with BMI. Women of all age groups showed greater correlation between BMI and arm fat area and between BMI and tricipital skinfold. Values were also higher for the correlations between BMI and body mass, waist and arm circumferences, and arm fat area, exception made to the 80+ years group. Men showed greater correlation between BMI and subscapular skinfold, except in the 70-79.9 years group.

Partial correlation coefficients were very similar when elderly subjects are compared to adults (Table 4).

Table 2 - Prevalence of overweight according to body mass index (BMI), inadequate waist circumference, and inadequate waist-to-hip ratio among elderly subjects.

Age (years)		Overweight* BMI ≥25 kg/m^2		Inadequate waist circumference* Men ≥94 cm Women ≥80 cm		Inadequate waist-to-hip ratio* Men ≥1 Women ≥0.85	
	N	%	SE	%	SE	%	SE
Men	248	47.9	2.05	39.2	3.20	18.9	2.56
60-69.9	136	50.6	4.34	43.7	4.46	17.5	3.32
70-79.9	87	45.9	5.77	34.2	5.18	19.9	4.44
≥80	25	39.8	10.12	31.3	9.65	22.9	8.59
Women	385	54.6	2.05	65.9	2.50	54.1	2.62
60-69.9	211	58.7	3.46	67.2	3.33	52.3	3.55
70-79.9	130	51.4	4.56	64.3	4.36	54.0	4.41
≥80	44	44.9	7.67	65.2	7.59	63.6	7.89

Table 3 - Spearman's correlation (r) between body mass index and anthropometric variables among elderly persons and adults.

Age (years)	Stature r	Stature p*	Body mass R	Waist circ. r	Arm circ. r	Tricipital fold r	Subscapular fold r	Arm fat area r	Arm muscle area r
Men									
40-59.9	-0.07	0.07	0.85*	0.75	0.70	0.51	0.64	0.61	0.35
60-69.9	-0.01	0.86	0.86	0.73	0.62	0.38	0.63	0.49	0.33
70-79.9	-0.13	0.22	0.84	0.77	0.71	0.33	0.46	0.45	0.42
≥80	-0.24	0.24	0.80	0.71	0.84	0.45	0.55	0.56	0.65
Women									
40-59.9	-0.21	0.00	0.86	0.77	0.74	0.62	0.63	0.72	0.43
60-69.9	-0.20	0.003	0.86	0.76	0.70	0.62	0.52	0.70	0.48
70-79.9	-0.12	0.16	0.81	0.80	0.77	0.55	0.64	0.66	0.53
≥80	-0.21	0.17	0.78	0.51	0.73	0.69	0.50	0.76	0.44

*Other p-values <0.004

DISCUSSION

Sixty percent of the elderly subjects analyzed were women. This proportion is characteristic of the ageing process. Most subjects studied were in the 60-69.9 years age group. These findings are in agreement with census data for the same period. In agreement with data from national surveys, our data show a higher frequency of overweight than of underweight, especially among women, and the prevalence of underweight was lower than that observed for the whole country in 1989.[12]

The significance and impact of overweight among elderly persons are controversial issues, but seem to be less strong in terms of mortality than those observed for adults.[14] A study by Grabowski & Ellis[4] analyzing the association between obesity and mortality among American elderly persons found that this condition, when compared to underweight and normal weight, may be a protective factor against mortality.

Another controversial issue among the elderly is the possibility that BMI may not adequately reflect adiposity.[1] Moreover, the centralization of body fat seems to be a better predictor for complications in this group.[14] Changes related to gains in visceral or subcutaneous fat associated with ageing may be affected by both the initial amount of fat and by increases in body mass. These transformations occur differently in men and women, and genetic characteristics are predisposition factors for fat centralization.[8] Zamboni et al,[18] in an analysis of fat distribution in women from different age groups by computerized tomography, showed that ageing leads to the redistribution and internalization of abdominal fat, especially among women.[15] In the present study, elderly subjects showed progressive reduction in arm fat mass with age (Table 1), and an increase in centralization of body fat, especially among women (Table 2).

Waist circumference is an indicator of abdominal distribution of fat as well as of total body fat.[17] In the elderly subjects from Rio de Janeiro, we found a greater proportion of inadequacy among women than among men (Table 1), both in terms of WHR and waist circumference. Greater centralization of body fat among women was also found in the adult population of the municipality of Sao Paulo.[13] It should be noted that the point for measuring waist circumference recommended by WHO is the midpoint between the last rib and the iliac crest, which is slightly different from the one used in the present study.

Although the correlation between BMI and body

Table 4 - Regression coefficient (β) and partial correlation coefficient, adjusted for age, between body mass index and anthropometric measures.

Measure	Men β	Men rp	Women β	Women Rp
Elderly (60+ years)*				
Arm fat area	4.04	0.57	6.62	0.68
Arm muscle area	4.13	0.36	7.16	0.45
Subscapular skinfold	5.09	0.60	5.96	0.54
Tricipital skinfold	3.32	0.45	6.89	0.59
Body mass	0.28	0.85	0.23	0.86
Arm circumference	0.72	0.69	0.81	0.73
Waist circumference	0.23	0.75	0.29	0.77
Adults (40-59 years)*				
Arm fat area	4.56	0.64	7.07	0.69
Arm muscle area	3.50	0.30	6.12	0.42
Subscapular skinfold	5.95	0.66	6.74	0.62
Tricipital skinfold	4.05	0.54	7.30	0.60
Body mass	0.28	0.87	0.33	0.88
Arm circumference	0.48	0.58	0.59	0.65
Waist circumference	0.28	0.78	0.31	0.79

*All analyses showed p-values <0.01
rp: Partial correlation coefficient

mass was strong for men and women of all age groups, we found a strong correlation between BMI and stature. Among adult women and women in the 60-69.9 years group, this correlation between BMI and stature was negative, a very undesirable characteristic for this indicator.

The correlation between BMI and tricipital and subscapular skinfold measures in the adult population of the United States (First National Health and Nutrition Examination Survey) ranged from 0.61 to 0.76, showing good correlation between BMI and measures of adiposity.[2] In the present study, the corresponding correlations were weaker, especially regarding the tricipital fold among men. However, the instrument we used for this measurement was less precise, which may have resulted in lower correlation values.

Among elderly subjects, waist and arm circumference were strongly correlated with BMI. Arm perimeter has been suggested as a substitute indicator for BMI, or as an additional measure for evaluating the nutritional status of populations.[6]

The assumption that BMI measures adiposity with the same accuracy across all age groups may be an equivocal one. BMI and body mass values increase with age, while stature and lean mass decrease.[1,11] However, our findings show that BMI maintained a similar correlation with measures of adiposity in all age groups, which indicates that the relationship between BMI and adiposity remains similar, regardless of ageing. On the other hand, the correlation with tricipital skinfold among men decreased markedly between the middle-aged (40-59.9 years) and elderly groups, and, consequently, so did the correlation with arm fat area. Moreover, the studied population showed very similar percentages of overweight and adiposity across all age groups. Although markers of adiposity with greater validity and precision than those used in the present study are necessary in order to draw any conclusions regarding the validity of the use of BMI among elderly subjects, comparative analyses of elderly and adult subjects indicate that the BMI may be used as an indicator of adiposity in this age group, particularly for women.

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