Body composition changes and 10-year mortality risk in older Brazilian adults: analysis of prospective data from the SABE study

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Introduction

Aging related changes in body composition are associated with higher all-cause mortality risk[1,2]. However, most of the evidence comes from developed countries[1-3]. In addition, there are only few studies from developing countries using longitudinal data from nationally representative ageing cohorts. The social changes affecting Brazil in recent years had also impacted on health i.e. increases in the proportion of older adults, currently over 11%, and a growing number of overweight and obese Brazilians, over 51% of the population[4,5].

Epidemiological studies have demonstrated that being overweight and obese increases both morbidity and mortality risks in middle-aged and younger people, however, in older adults, this relationship is still not fully explained[6,7]. Recent debate indicates that overweight and obesity seemed to be associated with decreased mortality rates in older adults[8,9]. On the other hand, undernutrition remains a concerning condition in this age group since it can contribute to the development of functional limitations, disability and mortality[10].

The body mass index (BMI) is the most widely used anthropometric measure to investigate the association with mortality. However, BMI is not sufficient to explain the changes in body composition in later life. Therefore, other body composition measures, as well as those related to fat mass or muscle mass, could be better indicators for assessing mortality risk in this population[11,12]. Few studies have examined the association between fat or muscle mass and mortality[13]. In addition, different methods have been used to define body composition, such as bioelectrical impedance analysis, dual-emission X-ray absorptiometry and anthropometric measures. This last method being considered more accessible for use in developing countries[14]. Thus, the aim of the present study was to examine the associations between 10-year mortality risk with both BMI and body composition and whether these relationships are modified by age and gender using data from community-dwelling older Brazilian adults.

Methods

Study Population

We used data from two waves i.e. 2000 and 2010 of the SABE (Health, Well-being and Aging) study conducted in São Paulo, Brazil, involving a probabilistic sample of community-dwelling older adults aged 60 years and older. SABE is a multicenter survey with respondents from seven capital/major cities throughout the countries of Latin American and the Caribbean (LAC) that investigates the health and well-being of older adults[15].

The baseline sample was obtained from the 1995 Brazilian National Household Survey master sampling frame. The sampling process was conducted in two stages: the first, a probabilistic sample of 1,568 individuals, and the second, a further 575 individuals, to compensate the higher rate of male mortality and lower population density of the group aged 75 and older. At baseline, in 2000, information was collected on 2,143 individuals in the city of São Paulo/Brazil[15].

The data collection was performed in two steps. The first involved a household interview conducted by a single interviewer using a standardized questionnaire that included questions about the living conditions and health status proposed by the Pan American Health Organization (PAHO), translated and adapted for use in Brazil. The second step was a household visit by a pair of interviewers who collected anthropometric and physical performance measurements. Each questionnaire was reviewed by a specialized technical group. Detailed information about the sampling procedures and data collection process have been described elsewhere[15,16].

In 2010, the surviving participants from the 2000 cohort comprised 659 individuals. The reduction in participants occurred due to institutionalization, refusal, change of city and deaths. Our analytical sample comprised of 1,504 participants who had complete information on all variables investigated.

Mortality Follow-Up

Deaths assigned to all-cause were obtained from the data provided by the Fundação Sistema Estadual de Análise de Dados (the SEADE foundation) and Programa de Aprimoramento das Informações de Mortalidade (Program of Improvement of Information on Mortality, PRO-AIM), which are responsible for collecting and organizing data on deaths for the city of São Paulo, Brazil. The researchers of the SABE study identified the deaths occurring from 2000 to 2010 through a search based on name, sex, date of birth and address listed in the 2000 database.

BMI and Body Composition Assessment

The BMI (kg/m^2) was classified according to undernutrition = BMI $\leq$ 23 kg/m^2; adequate weight = BMI > 23 and < 28 kg/m^2; overweight = BMI $\geq$ 28 and < 30kg/m^2, and obesity, class I BMI $\geq$ 30 kg/m^2< 35kg/m^2, classes II and III $\geq$ 35kg/m^2. Body composition was determined through the following: waist circumference

(WC), waist hip ratio (WHR), triceps skinfold thickness (TSF), mid-upper arm circumference (MAC), calf circumference (CC) and arm muscle area (AMA), being categorized as high abdominal adiposity, when WC ≥ 94 for men and ≥ 80 for women and WHR ≥ 1 for men and ≥ 0.85 for women; <25th percentile for low body fatness and ≥ 25th percentile for adequate body fatness; adequate reserves of muscle mass, body fat, water, and bone when ≥ 25th percentile and < 25th percentile for inadequate reserves; low muscle mass when <31 cm and <25th percentile when ≥ 31 cm and ≥ 25th percentile, respectively, considering the percentiles of the same population.

Covariates

The following covariates were included in the analysis: sociodemographic characteristics (age in years, gender, marital status - married and not married, schooling years - 0 to 11 and 12 or more years, currently working - yes or no and income - > US$808, < 323.5 - US$ ≤808.70 and ≤ US$ 323.50); life style (weekly alcohol intake - none, once a week, two to six days a week, and every day, practice of physical activity - yes or sedentary); doctor diagnosed self-reported health conditions (hypertension, diabetes mellitus, cardiovascular diseases, lung diseases, stroke and cancer - yes or no), number of chronic diseases - none, one, and two or more, Mini mental state exam - ≤ 12 and > 12 points and Geriatric depression scale - < 6 and ≥ 6 points).

The SABE Survey was approved by the Ethics in Research Committee of the Faculty of Public Health of the University of São Paulo (control number 475,455) and the National Committee for Ethics in Research (CONEP) and all participants gave written informed consent prior to participation[15].

Statistical analyses

Means, standard deviations (continuous variables) and percentages (categorical variables) were reported for descriptive data at baseline.

Age and sex adjusted hazard ratios and their 95% confidence intervals were estimated for the association between nutritional status and body composition and death using Poisson regression estimates instead of Cox propoational hazards since the assumption of hazard proportionality was not found. The fully adjusted models were adjusted for a wide range of sociodemographic, lifestyle, physical health and mental health covariates. Statistical analyses were conducted using version 13.0 of STATA statistical software (Stata Corp, College Station, Texas). All p-values were 2-tailed ($p < 0.05$).

Data analysis was conducted using the "survey" command, which permits the incorporation of features related to the complex design of the sample, namely, disproportionate stratification, drawing in clusters and weighting. The weighting variable, created to examine the data, was defined by the inverse of the sampling fraction and adjusted so that the sample did not present distortions regarding age and sex.

Results

Over the 10 year- follow-up period, there were 769 deaths (40.2%), 48% in men and 34.6 % in women, with 30.6 % and 72.9 % from the 60-74y and ≥ 75y age groups, respectively. Mortality rates of 61.0 (95% CI 53.5 – 69.6) and 39.5 (95% CI 35.1- 44.6), were found for men and women respectively; and 34.3 (95% CI 30.2 – 39.1) and 111.8 (95% CI 102.9- 121.5) for the60-79 and ≥80y age groups respectively.

At baseline, the mean (SE) age was 69.3 (0.30) years for men and 68.4 (0.26) years for women. The mean anthropometrical variables by sex were: BMI 24.9 (0.16) and 27.2 (0.17) kg/m^2; WC 100.8 (2.84) and 100.7 (2.60) cm; WHR 0.97 (0.01) and 0.91 (0.001); AMA 38.9 (0.42) and 35.5 (0.34) cm^2; CC 35.4 (0.17) and 35.5 (0.13); STF 14.6 (0.28) and 25.9 (0.29) mm for men and women, respectively (data not shown).

The majority of the studied population were married, had low education, were not currently working, had a low income, did not have regular alcohol intake, had a sedentary lifestyle, and were not current smokers. Hypertension and having 2 or more diseases were the most common health conditions (Table 1). The mean values of weight, height, BMI, and body composition variables of elderly people who died were lower than the survivors (Table 2).

The total mortality rate was higher in individuals with low muscle mass (110.4), underweight (74.1), and low fat mass (66.6). In the Poisson regression analysis, statistically significant HRs for mortality were found for low muscle mass (HR: 1.88; HR: 1.33), underweight (HR: 1.53; HR: 1.29), and low fat mass (HR: 1.39; HR: 1.31) with and without adjustment, respectively ($p<0.05$). Some anthropometric variables such as high abdominal fat and inadequate muscle mass lost significance after adjustment (Table 3).

Considering gender differences, it was observed that men with low muscle and fat and inadequate body reserves had a higher mortality rate (136, 89.7 and 104.1, respectively) than women (98.8, 52.8 and 57.9, respectively). Based on the Poisson regression analysis, a statistically significant HR was found in men where extreme BMI classification (underweight –HR: 1.47; obesity I – HR: 1.66 and obesity II – HR: 1.91) was associated with mortality after adjustment, respectively ($p<0.05$), whereas for women, low muscle (HR: 2.13; HR: 1.45) and fat (HR: 1.34; HR: 1.31) mass were associated with mortality, with and without adjustment, respectively ($p<0.05$). In relation to BMI for women, underweight (HR: 1.34) was associated with mortality without adjustment and for obesity I (HR: 0.66) only with adjustment, $p<0.05$ (Table 4).
In relation to age group differences, a higher mortality rate was observed for those in the ≥80 y group with low muscle mass (HR: 168.7), inadequate body reserves (HR: 1.63), underweight (HR: 142.9), and low fat mass (HR: 140.7), when compared to the individuals in the 60 to 79y group. Considering the Poisson regression HR analysis, it was observed that the variables associated with mortality were the same between the age groups, with and without adjustment ($p<0.05$). WC was significantly associated only in the ≥80 y age group, demonstrating protection for mortality in the high risk categorization. The AMA lost significance after adjustment for both age group and gender (Tables 4 and 5).

Discussion

The results of this community-dwelling elderly cohort study demonstrated associations between underweight (<23kg/m^2), and low muscle and fat mass with all-cause mortality in 10-years. The highest mortality rate was observed in individuals with low muscle mass, independent of gender or age group. Moreover, no significant association was found between overweight/obesity and abdominal adiposity with mortality risk.

BMI and body composition differ according to age, gender, and race. Elderly individuals tend to lose water, muscle mass, and body fat[11]. Many factors are associated with these changes such as, the normal ageing process, physical activity level, functional capacity, nutrition, and chronic health conditions. Furthermore, the methods of measurement used, reference values, population characteristics, and consideration of confounding factors that might affect mortality risk make study comparisons difficult[17,18].

Undernutrition has frequently been reported as the nutritional condition with the most impact on the mortality risk in the elderly population[19]**.**This occurs due to multiple factors such as chronic diseases, polypharmacy, and psychosocial and physiologic alterations associated with aging[20]. Extreme BMI is associated with certain comorbidities. Underweight is associated with respiratory, cancer, depression, chronic kidney, and non-circulatory diseases, whereas excessive-weight is associated with hypertension, hyperlipidemia, heart disease, and diabetes[21]**.**

Moreover, it is also important to consider the possibility of reverse causality. Elderly individuals often lose weight as a result of a fatal illness and, as a consequence, mortality appears to be higher among people with low weight, however the real cause is the presence of the disease. To clarify this, it is necessary to evaluate whether low BMI is a result of disease-related weight loss or reflects a stable unmodified weight, each option having different prognostics[6]. In the present study the weight change was not analyzed, however the nutrition assessment was not limited to only one measure of BMI or weight, but also considered the body fat and muscle mass.

An association was not found between overweight and obesity with mortality in the elderly, which is consistent with the findings of several previous cohort studies, however when analyzed by gender, different behavior was found. It was observed that mortality in men was significantly associated with extreme BMI classification, 47% greater in those with underweight when compared to adequate weight (≥23 and <28 kg/m^2) and obesity, the risk being 60% and 90% higher as the obesity grade increased. In women, an association was observed between underweight and mortality in the unadjusted model (HR: 1.34, 1.05 - 1.70; 1.06, 0.80-

1.41).After full adjustment underweight did not remain significantly associated, however obesity grade I decreased the risk of mortality by 44%. This protective effect was lost with a BMI ≥35kg/m^2.

Some studies have found lower mortality associated with overweight and obesity[17].This supports the existence of a kind of obesity paradox. In the present study, in addition to other Brazilian cohort studies and many other cohort studies around the world, this effect has been mentioned, although the obesity paradox has not been proven[22]. The effect of the obesity paradox on mortality in the elderly, if present, may be modest. A possible explanation for this is that weight gain may indicate the absence of underlying wasting conditions or additional energy reserves that can be helpful to brain and muscle, able to be mobilized in the event of acute catabolic or chronic illness[23].

Considering the age groups, a greater mortality rate was found in the oldest group (≥80), therefore the underweight status presented greater risk in the youngest group (HR: 1.37,1.03-1.83). This phenomenon was also observed in PONCEs study where the mortality in patients aged 60–64 years was about 15-fold higher than in subjects of the general population, whereas for patients older than 84 years, mortality was only 3-fold higher[24]. This may be possible due to the fact that individuals who survive to old age may present characteristics that protect them from the adverse effects of ageing.

The association of abdominal and whole body adiposity with mortality in elderly people is unclear[25,13]. Abdominal adiposity assessed through both the WC and WHR has been reported as a risk factor for mortality in elderly individuals[11]. Nevertheless, our results did not support such findings, no significant association was verified between adiposity and mortality risk after adjustment for multiple indicators[1,11]. An inverse association between abdominal adiposity and mortality was observed in the oldest group. Higher abdominal adiposity in addition to whole body fat might be beneficial for survival in older persons ≥ 80 years[26]. Based on these considerations our results suggest that cut-off points for older individuals should be defined for WC and WHR values.

In addition, in the present study, the low fat mass identified by the TSF was associated with mortality risk with and without adjustments for gender and age groups. Our results suggest that fat mass may not have detrimental effects in advanced age, conversely to what is generally reported in middle age, in that the body stores contribute to the development of cardiovascular diseases and metabolic consequences[1,11].

In particular, circumferences of the extremities (CC and MAC) have been used in muscle mass assessment in elderly people[27,28]. However, the relationships between these variables and mortality are still inconsistent. Declines in muscle mass are associated with higher levels of cytokines and inflammatory markers. It has been hypothesized that loss of muscle mass is a physical sign of underlying inflammation related to a higher risk of mortality[8].

The majority of studies present results based on the MAC and CC values[27,28]. Despite this, the present study verified the muscle mass through AMA and observed that the variable was not associated with mortality after adjustment for potential confounders, in either sex or age group. Another study, also with older community-dwelling individuals, found results contrary to these[29].

Our results showed that the CC and MAC seem to be reliable indicators of muscle mass to predict mortality risk. The associations between CC and MAC with health outcomes and mortality have been investigated in several studies[27,28]. CC under 31 cm is associated with greater frailty, impaired physical function, and mortality among older individuals. Moreover, low CC and MAC have been proposed as an indicator of malnutrition in the elderly[17,30]. The present study also verified that low muscle mass through CC and inadequate reserves through MAC were associated with mortality risks with and without adjustments for gender and age groups. The mortality risk associated with low muscle mass could be due to the low levels of physical activity in the population studied.

The CC and MAC are particularly relevant to clinical practice as they are readily accessible, non-invasive, inexpensive, and relatively easy to measure (compared to weight and height measurements), particularly for frail or hospitalized individuals who require regular monitoring, and a healthcare provider would be able to assess muscle mass using only a tape measure. Furthermore, a decline in muscle mass is a condition of clinical importance in older persons, which needs to be identified early to prevent the development of sarcopenia and disabilities in this group[27-31].

This study has some limitations. First, we did not have data on specific cause of mortality in this population. Second, we did not consider recent weight changes of the participants. Third, individuals without data on anthropometric measures were excluded (n=), resulting in a younger and healthier sample. This could have led to an underestimation of the strengths of the observed associations.

The strengths of this study are the representative sample of the general Brazilian elderly population and the longitudinal design with a 10-year-follow-up. The relation between BMI and body composition with mortality may be different between institutionalized, hospitalized, and community-dwelling individuals, thus in the present study only elderly individuals living in the community were included. The use of easy-to-assess anthropometric measures enhances the potential applicability of the results to clinical and public health practices.

Conclusions

Our results suggest that underweight, low fat mass and low muscle mass were the anthropometric indices that most contributed to elucidate the mortality risk in Brazilian elderly people. It seems that the body composition performs a different role with regard to the risk of mortality considering gender and age. Further studies are needed to assess a possible protective role of high body fat in other elderly populations.

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Data availability

The SABE datasets used in this analysis are under license and are not publicly available based on a policy adopted by the SABE Survey.

Authors' contributions

MAR conceived the study. MAR and DAQSD performed the statistical analyses. MAR, DAQSD and CO drafted the first manuscript. MAR, YAOD, MFNM, CO and JLFS substantially contributed to the design of the study, and analyses and interpretation of these data; approved its final version; and critically revised the manuscript for important intellectual content.

Competing interests

None declared.

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Table 1 - Selected baseline characteristics of participants. The SABE (Health, Well-Being, and Aging) Study, Brazil, 2000.

Characteristics	**SABE (n=1,504)**
Sociodemographic variables	
Age	67.2 ± 0.19
Gender (female)	57.7 (n=861)
Marital status (married)	58.4 (n=802)
12 or more years of schooling	9.78 (n=125)
Currently working (yes)	27.7 (n=301)
Income	
>US$808	21.7 (n=264)
> 323.5 US$ ≤808.70	27.3 (n=403)
≤US$≤323.50	51.0 (n=771)
Lifestyle	
Weekly alcohol intake	
None	68.1 (1.056)
Once a week	19.7 (n=275)
Two to six days a week	6.2 (n=92)
Everyday	6.0 (n=81)
Sedentary lifestyle	73.5 (n=1,168)
Smoking	15.9 (n=205)
Health conditions	
Hypertension(yes)[1]	52.0 (n=797)
Diabetes (yes)[1]	17.4 (n=264)
Cardiovascular diseases (yes)	18.0 (n=303)
Lung diseases (yes)	10.2 (n=169)
Stroke (yes)	6.0 (n=96)
Cancer (yes)	3.1 (n=49)
Number of diseases[2]	
None	27.1 (n=384)
One	31.6 (n=466)
Two or more	41.3 (n=654)
Mini Mental State exam (≤ 12 points)	11.1 (n=232)
Geriatric depression Scale (≥ 6 points)	18.3 (n=234)

Note: Data are iven as mean ± SD or number and percentage. Means and proportions were alculated considering the weight of the sample. [1] Reported diagnosis for all diseases. [2] Hypertension, diabetes, cancer, osteoporosis, respiratory, cardiovascular, and osteoarticular diseases.

Table 2 – Characteristics of the included study sample, by 10-year mortality with BMI and body composition. The SABE (Health, Well-Being, and Aging) Study, Brazil, 2000.

Characteristics	**10-year Mortality**			
	Survived=735		**Died=769**	
	Mean (SD)	**95% CI**	**Mean (SD)**	**95% CI**
Weight	62.56 (0.49)	61.60 – 63.53	66.59 (0.44)	65.73 – 67.46
Height	1.57 (0.01)	1.56 – 1.58	1.56 (0.01)	1.56 – 1.57
BMI	27.20 (0.17)	26.86 – 27.54	25.36 (0.18)	25.00 – 25.70
WC	0.78 (0.15)	0.75 – 0.81	0.67 (0.17)	0.64 – 0.71
WHR	0.93 (0.01)	0.92 – 0.93	0.95 (0.13)	0.93 – 0.98
TSF	23.61 (0.36)	22.91 – 24.31	18.64 (0.34)	17.97 – 19.31
MAC	31.36 (0.14)	31. 10 – 31.63	29.08 (0.15)	28.78 – 29.38
CC	36.29 (0.13)	36.03 – 36.56	34.61 (0.16)	34.29 – 34.93
AMA	38.53 (0.39)	37.77 – 39.29	35.39 (0.38)	34.64 – 36.14

Note: Data are given as mean (M) ± SD or confidence interval calculated considering the weight of the sample.

Table 3 - Mortality rates and hazard ratios for 10-year mortality in Brazilians older adults, by body mass index, waist circumference, waist to hip ratio, triceps skinfold, mid-upper arm circumference, calf circumference and arm muscle area. The SABE (Health, Well-Being, and Aging) Study, Brazil, 2000-2010.

Variables	Mortality rate (95% CI)	Unadjusted HR (95% CI)	Full adjusted HR (95% CI)
Body mass index			
Adequate weight	42.9 (37.3 - 49.5)	1.00	1.00
Underweight	74.1 (63.3 – 86.8)	1.53 (1.30-1.79)	1.29 (1.07 – 1.55)
Overweight	45.9 (35.8 - 59.4)	1.07 (0.84-1.35)	1.11 (0.88-1.41)
Obesity I ($\geq$ 30 - <34 kgm^2)	40.2 (31.1 – 52.4)	0.96 (0.76-1.23)	0.98 (0.76 – 1.28)
Obesity II ($\geq$ 35 kgm^2)	31.5 (20.7- 49.8)	0.78 (0.53-1.15)	1.07 (0.72-1.61)
Waist circumference			
Adequate abdominal fat	58.6 (49.9-68.9)	1.00	1.00
High abdominal fat	43.9 (39.5-48.9)	0.81 (0.70-0.94)	0.96 (0.80 -1.14)
Waist to hip ratio			
Adequate fat	48.6 (42.4-55.8)	1.00	1.00
High fat	47.0 (41.9-52.9)	0.98 (0.85-1.13)	1.04 (0.87-1.23)
Triceps skinfold			
Adequate fat mass[a]	43.5 (39.3- 48.3)	1.00	1.00
Low fat mass[a]	66.6 (56.3- 79.0)	1.39 (1.19-1.61)	1.31 (1.10-1.55)
Mid-upper arm circumference			
Adequate	42.9 (38.7-47.6)	1.00	1.00
Inadequate	73.5 (62.1-87.2)	1.51 (1.30-1.75)	1.40 (1.17-1.66)
Calf circumference			
High muscle mass	44.3 (40.3-48.8	1.00	1.00
Low muscle mass	110.4 (87.5-139.1)	1.88 (1.60-2.19)	1.33 (1.08-1.64)
Arm muscle area			
Adequate muscle mass[a]	45.8 (41.7-50.4)	1.00	1.00
Inadequate muscle mass[a]	70.8 (55.3-90.9)	1.38 (1.14-1.68)	1.21 (0.96-1.59)

Note: Full adjusted model by age, gender, marital status, schooling, currently working, income, weekly alcohol intake, sedentary lifestyle, smoking, hypertension, diabetes, cardiovascular and lung diseases, stroke, cancer, number of diseases, Mini Mental State exam, and Geriatric depression Scale. [a] Percentile of the population studied. Cox regression-based test for equality of survival curves and Poisson regression analysis.

Table 4 - Mortality rates and hazard ratios for 10-year mortality in Brazilians older adults, by body mass index, waist circumference, waist to hip ratio, triceps skinfold, mid-upper arm circumference, calf circumference, arm muscle area and gender. The SABE (Health, Well-Being, and Aging) Study, Brazil, 2000-2010.

Variables	Men			Women		
	Mortality rate (95% CI)	**Unadjusted HR (95% CI)**	**Full adjusted HR (95% CI)**	**Mortality rate (95% CI)**	**Unadjusted HR (95% CI)**	**Full adjusted HR (95% CI)**
Body mass index						
Adequate weight	47.5 (38.8 - 58.5)	1.00	1.00	38.5 (32.1 – 47.2)	1.00	1.00
Underweight	96.9 (78.2 - 117.7)	1.72 (1.40-2.12)	1.47 (1.14-1.87)	56.5 (44.5 - 72.1)	1.34 (1.05-1.70)	1.06 (0.80-1.41)
Overweight	48.6 (32.8 - 73.5)	1.03 (0.72-1.46)	1.11 (0.78-1.57)	43.7 (31.9 - 60.6)	1.12 (0.82-1.53)	1.05 (0.76-1.45)
Obesity I (≥ 30 - <34 kgm^2)	82.8 (52.8 - 131.8)	1.49(1.07-2.09)	1.60 (1.14-2.23)	29.5 (21.7 - 40.8)	0.81 (0.59-1.11)	0.66 (0.46-0.95)
Obesity II (≥ 35 kgm^2)	77.2 (31.1-210.5)	1.47 (0.76-2.85)	1.91 (1.11-3.31)	25.8 (16.2 – 42.9)	0.71 (0.45-1.12)	0.80 (0.49-1.32)
Waist circumference						
Adequate abdominal fat	64.7 (53.4 - 78.6)	1.00	1.00	46.9 (35.0 - 63.3)	1.00	1.00
High abdominal fat	57.9 (48.3 - 69.5)	0.91 (0.75-1.11)	1.03 (0.84-1.28)	37.7 (33.1 - 43.1)	0.86 (0.66-1.11)	0.80 (0.59-1.09)
Waist to hip ratio						
Adequate abdominal fat	60.4 (51.5 – 71.0)	1.00	1.00	29.3 (22.6 – 38.6)	1.00	1.00
High abdominal fat	61.4 (48.7 – 78.0)	1.00 (0.81-1.23)	0.95 (0.76-1.18)	42.7 (37.4 – 44.9)	1.37 (1.06- 1.77)	1.09 (0.80-1.45)
Triceps skinfold						
Adequate fat mass[a]	54.5 (46.7-63.8)	1.00	1.00	36.2 (31.5- 41.6)	1.00	1.00
Low fat mass[a]	89.7 (70.6-114.3)	1.45 (1.19-1.78)	1.24 (0.97-1.59)	52.8 (41.7- 67.1)	1.34 (1.08-1.67)	1.31 (1.03-1.67)
Mid-upper arm circumference						
Adequate	53.8 (46.1-64.8)	1.00	1.00	35.3 (30.8-40.6)	1.00	1.00
Inadequate	104.1 (82.3-131.7)	1.63 (1.35-1.97)	1.38 (1.07-1.78)	57.9 (45.8-73.6)	1.46 (1.18-1.81)	1.41 (1.10-1.81)
Calf circumference						
Adequate muscle mass	57.8 (50.3 – 66.5)	1.00	1.00	35.3 (31.0- 40.2)	1.00	1.00
Low muscle mass	136 (91.0- 200.0)	1.72 (1.36-2.16)	1.13 (0.85-1.50)	99.8 (74.4- 133.9)	2.13 (1.72-2.62)	1.45 (1.07-1.96)
Arm muscle area						
Adequate muscle mass[a]	57.1 (49.6-65.8)	1.00	1.00	38.2 (33.7-43.5)	1.00	1.00
Low muscle mass[a]	105.8 (75.0-149.5)	1.52 (1.21-1.92)	1.28 (0.95-1.72)	51.4 (33.6-72.8)	1.26 (0.95-1.69)	1.04 (0.72-1.47)

Note: Full adjusted model by age, marital status, schooling, currently working, income, weekly alcohol intake, smoking, sedentary lifestyle, smoking, hypertension, diabetes, cardiovascular and lung diseases, stroke, cancer, number of diseases, Mini Mental State exam, and Geriatric depression Scale. [a] Percentile of the population studied. Cox regression-based test for equality of survival curves and Poisson regression analysis.

Table 5 - Mortality rates and hazard ratios for 10-year mortality in Brazilians older adults, by body mass index, waist circumference, waist to hip ratio, triceps skinfold, mid-upper arm circumference, calf circumference, arm muscle area and age groups. The SABE (Health, Well-Being, and Aging) Study, Brazil, 2000-2010.

Variables	60 – 79 years			80 years and more		
	Mortality rate (95% CI)	Unadjusted HR (95% CI)	Full adjusted HR (95% CI)	Mortality rate (95% CI)	Unadjusted HR (95% CI)	Full adjusted HR (95% CI)
Body mass index						
Adequate weight	30.3 (24.8-37.4)	1.00	1.00	107.1 (94.5-121.5)	1.00	1.00
Underweight	51.2 (40.0-66.3)	1.58(1.21-2.06)	1.37 (1.03-1.83)	142.9 (124.1-164.4)	1.15 (1.04-1.27)	1.17 (1.01-1.35)
Overweight	36.1 (25.8-51.5)	1.18 (0.84-1.65)	1.18 (0.85-1.64)	94.9 (73.4-123.3)	0.93 (0.76-1.13)	0.93 (0.74-1.17)
Obesity I (≥ 30 - <34 kgm^2)	30.2 (21.1-44.3)	1.01 (0.71-1.45)	1.07 (0.75-1.55)	88.5 (67.7-116.6)	0.89 (0.74-1.08)	0.83 (0.65-1.06)
Obesity II (≥ 35 kgm^2)	21.7 (12.1-42.6)	0.76 (0.43-1.36)	1.03 (0.57-1.85)	130.4 (78.5-215.2)	1.08 (0.83-1.41)	1.18 (0.86-1.61)
Waist circumference						
No risk	41.2 (32.5-52.6)	1.00	1.00	141.3 (123.5-161.7)	1.00	1.00
High risk	32.0 (27.4-37.4)	0.81 (0.64-1.03)	0.99 (0.76-1.28)	99.8 (91.9-113.0)	0.83 (0.75-0.91)	0.84 (0.73-0.96)
Waist to hip ratio						
No risk	35.5 (29.4- 43.3)	1.00	1.00	126.4 (111.8-142.9)	1.00	1.00
Risk	33.3 (28.1- 39.9)	0.94 (0.75-1.17)	1.05 (0.84-1.34)	104.0 (93.1-116.3)	0.88 (0.81-0.98)	0.86 (0.74-0.99)
Triceps skinfold						
Adequate fat mass[a]	30.8 (26.5-36.0)	1.00	1.00	104.1 (94.5-114.7)	1.00	1.00
Low fat mass[a]	49.1 (38.6-63.2)	1.48 (1.17-1.88)	1.34 (1.04-1.73)	140.7 (119.5-165.4)	1.16 (1.05-1.28)	1.20 (1.05-1.38)
Mid-upper arm circumference						
Adequate	30.4 (26.2-35.5)	1.00	1.00	100.0 (90.8-110.1)	1.00	1.00
Inadequate	53.3 (42.0-68.2)	1.60 (1.27-2.02)	1.38 (1.06-1.79)	173.9 (148.2-203.4)	1.32 (1.21-1.44)	1.35 (1.18-1.55)
Calf circumference						
Adequate muscle mass	32.4 (28.3-37.2)	1.00	1.00	104.4 (95.3-114.4)	1.00	1.00
Low muscle mass	77.4 (52.1-116.6)	1.96 (1.46-2.64)	1.65 (1.15-2.36)	168.7 (137.3-206.2)	1.25 (1.12-1.39)	1.22 (1.05-1.42)
Arm muscle area						

Adequate muscle mass[a]	32.4 (28.2-37.4)	1.00	1.00	107.6 (98.4-117.6)	1.00	1.00
Low muscle mass[a]	53.3 (38.1-75.8)	1.49 (1.12-1.99)	1.17 (0.85-1.60)	157.2 (122.0-201.1)	1.23(1.08-1.41)	1.21(0.99-1.47)

Note: Full adjusted model by gender, marital status, schooling, currently working, income, weekly alcohol intake, smoking, sedentary lifestyle, smoking, hypertension, diabetes, cardiovascular and lung diseases, stroke, cancer, number of diseases, Mini Mental State exam, and Geriatric depression Scale. [a] Percentile of the population studied. Cox regression-based test for equality of survival curves and Poisson regression analysis.