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original article

Skeletal-muscle mass of São Paulo city elderly – SABE Survey: Health , Well-being and Aging

Massa muscular de idosos do município de São Paulo – Estudo SABE: Saúde, Bem-estar e Envelhecimento

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Abstract – The analysis of skeletal muscle mass (SMM) in older adults, either total-body skeletal muscle mass (TSMM) or appendicular skeletal muscle mass (ASMM), is important to monitor this component throughout aging. These values are more often associated with disability when adjusted for height, thus enabling the analysis of total muscle mass index (TMMI) and appendicular muscle mass index (AMMI). The objective of the present study was to present the standard mean and percentile values of TSMM, ASMM, TMMI, and AMMI of older adults from the city of São Paulo according to sex and age group. The sample consisted of 1,203 male and female older adults who participated in the 2006 cohort of the SABE Study: Health, Well-being and Aging, conducted in São Paulo, Brazil. The variables TSMM and ASMM were calculated using predictive equations, whereas their respective indexes were calculated using the ratio between the values of SMM and squared height (in kg.m-2). The means and standard deviations of TSMM in women and men 80 years old or younger and older than 80 years old were: 17.7±3.6, 14.4±3.2, 26.9±3.8, and 24.1±2.9 in kg, respectively. The values of ASMM were 14.4±2.1, 13.0±2.0, 21.0±2.8, and 19.4±2.3, respectively. When adjusted for squared height, the values of TMMI were 7.6±1.4, 6.3±1.2, 9.8±1.1, and 8.9±0.9 in $kg.m^{-2}$, and the values of AMMI were 6.1±0.7, 5.7±0.7, 7.6±0.8, and 7.2±0.7, respectively. All variables were correlated (r > 0.84). Men and the younger age groups had higher values of SMM, with statistical significance compared with their peers, and the differences between age groups were higher among women.

Key words: Aging; Anthropometry; Muscle mass; Muscle mass index; Sarcopenia.

Resumo – *A análise da massa muscular (MM) em idosos, seja total (MMT) ou apendicular (MMA), é importante para o acompanhamento deste componente ao longo do envelhecimento, sendo que estes valores são mais associados à incapacidade funcional quando ajustados pela estatura, possibilitando, assim, a análise dos índices de massa muscular total (IMMT) e apendicular (IMMA). O objetivo deste estudo foi apresentar valores normativos, expressos em médias e percentis, de MMT, MMA, IMMT e IMMA, de idosos do município de São Paulo, segundo sexo e grupos etários. A amostra foi composta por 1203 idosos de ambos os sexos, da coorte de 2006 do Estudo SABE: Saúde, Bem-estar e Envelhecimento, realizado no município de São Paulo, Brasil. As variáveis MMT e MMA foram identificadas a partir de equações preditivas, enquanto os respectivos índices, pela razão entre os valores de MM e altura, ao quadrado (em* $kg.m^{-2}$*). Os valores médios e os desvios-padrão de MMT, de mulheres e homens, com menos de 80 e 80 anos e mais, foram, em kg, 17,7±3,6, 14,4±3,2, 26,9±3,8 e 24,1±2,9, respectivamente, enquanto os valores de MMA foram 14,4±2,1, 13,0±2,0, 21,0±2,8 e 19,4±2,3, respectivamente. Quando ajustados pela altura, os valores de IMMT foram, em* $kg.m^{-2}$*, 7,6±1,4, 6,3±1,2, 9,8±1,1 e 8,9±0,9, e os valores de IMMA foram, 6,1±0,7, 5,7±0,7, 7,6±0,8 e 7,2±0,7, respectivamente. Todas as variáveis apresentaram alta correlação entre si (r>0,84). Homens e idosos mais jovens apresentaram maiores valores, com significância estatística, em relação aos seus pares e as diferenças entre os grupos etários são maiores entre as mulheres.*

Palavras-chave: *Antropometria; Envelhecimento; Índice de massa muscular; Massa muscular; Sarcopenia.*

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INTRODUCTION

Muscle mass (MM) is a body component that accounts for approximately 35% of total body weight in young adults[1]. However, as a consequence of aging, its percentage can be reduced by 40%[2]. Such reduction combined with reduced muscle strength is called sarcopenia[3] and it may cause loss of functionality, increased risk of falls, fractures[4], and disability[5]. Consequently, there is impairment of quality of life and increased risk of mortality in older adults[6]. Recently, the evaluation of MM has been suggested by different groups[7,8] as a method to diagnose sarcopenia as well as variables of strength and functionality in older adults.

Total skeletal MM (TSMM) is measured in laboratories using magnetic resonance imaging (MRI) and computed tomography. Dual-energy X-ray absorptiometry (DEXA) can also be used to evaluate MM based on the analysis of lean soft tissue of upper and lower limbs. Considering that a large proportion of limbs lean soft tissue consists of muscle tissue, it is also called appendicular skeletal muscle mass (ASMM) and it can be included in studies investigating MM[1,5]. Nevertheless, despite of showing higher validity, these analyses are performed in laboratories and have higher operating costs. An alternative to these tests is the use of anthropometric methods.

In anthropometry, arm muscle area and calf circumference are often used as indicators of MM[9,10], but they are measured at the peripheral level. The use of TSMM and ASMM values, estimated based on predictive equations, has been suggested[11,12] to provide more valid estimates of MM. These equations use anthropometric measurements such as weight, height and hip circumference, as well as sociodemographic variables (sex, age, and ethnicity) and hand grip strength. Once the MM value is measured, it is possible to estimate the total muscle mass index (TMMI) or appendicular muscle mass index (AMMI), calculated as the ratio of TSMM or ASMM (in kg) to square height (in m). These values of body mass index (in $kg.m^{-2}$) are associated with greater functional disability and morbidity when compared with the MM values, and they are suitable for analysis in epidemiological studies[5].

Since the number of people aged 60 years or older increases in greater proportion than the other age groups[13], knowing the MM values (TSMM and/or ASMM) and their respective indexes, can be useful for two main reasons. First, to identify sarcopenia, considering that most sarcopenia classifications take into account the MM values[5,12] in isolation or in combination with measures of strength and functionality[7]. Second, to develop therapeutic and public health strategies with the purpose of preserving the MM of people in this age group, enhancing their functional capacity, reducing health risks, and improving their quality of life.

However, the use of normative data based on a large, representative, and heterogeneous sample is necessary to perform a qualitative analysis of MM and MMI values[14]. To our knowledge, studies demonstrating MM and MMI values of older adults have not been conducted in Brazil. Therefore, the objective of the present study was to present normative values of TSMM, ASMM, TMMI, and AMMI of older adults from the city of São Paulo, expressed as means and percentiles and arranged according to sex and age groups.

METHODS

The present study was based on the SABE Study (Health, Well-being, and Aging), conducted in 2000 in seven cities in Latin America and the Caribbean (Barbados, Buenos Aires, Mexico City, Havana, Montevideo, Santiago, and São Paulo) and in 2006 in the city of São Paulo. This study was initially coordinated by the Pan American Health Organization (PAHO). It consisted of a multicenter, epidemiological, international and home-based survey aimed at assessing the living conditions and health status of older adults.

In Brazil, the study was conducted in the city of São Paulo. It was coordinated by professors of the School of Public Health, Universidade de São Paulo (USP), supported by the Pan American Health Organization (PAHO/WHO), and funded by the Foundation for Research Support of the state of São Paulo (FAPESP) and the Ministry of Health (MH). The study was approved by the Research Ethics Committee at the School of Public Health of USP and the National Research Ethics Committee (Protocol no. 1930/2009).

The questionnaire used in the study was proposed by the PAHO and translated and adapted to be used in Brazil. Data collection was performed in two phases: 1) home visit conducted by a single interviewer, covering questions about life conditions and health status of the older adults; 2) home visit conducted by two interviewers in charge of performing the anthropometric measurements, tests of balance, flexibility, and strength.

The sampling procedures for the SABE Study have been described elsewhere[15]. The study phase conducted in the year 2000 was based on a population count provided by Fundação IBGE regarding 1996. A probability sample composed of two segments was used: the first segment comprised 1,568 individuals and the second one included 575 individuals, corresponding to the additions made to compensate for the higher rate of early mortality of males and the lower population density in the age group ≥ 75 years.

In 2000, the population of the SABE Study consisted of 2,143 male and female individuals (cohort A), aged 60 years or older, living in São Paulo, and who agreed to participate. In 2006, 649 deaths were detected and 1,304 older adults living in the city of São Paulo could be contacted. Of these, 177 refused to participate and 11 were living in long-term care facilities. Simultaneously, cohort B was initiated including 400 older adults aged between 60 and 65 years. In the present study, the sample was composed of the survivors of the cohort A and cohort B, which were added up, totaling 1,203 individuals (799 women and 503 men). Bedridden older adults and/or those with upper/lower limb amputations were excluded from the sample. We did not exclude/include any individuals based on different levels of physical activity, and all participants were classified into different categories of frailty (non-frail, pre-frail, and frail). For the statistical analysis, older adults were grouped according to sex and age group. The two age groups included individuals younger than 80 years and 80-year-old or older subjects.

Study variables

To identify the variables TSMM, ASMM, TMMI, and AMMI we used anthropometric measurements and hand grip strength measured by previously trained nutritionists, as well as sociodemographic variables.

MM values were measured using predictive equations of TSMM and ASMM as shown in Table 1.

Table 1. Predictive equations of total skeletal muscle mass (TSMM) and appendicular skeletal muscle mass (ASMM)

Variable	Reference	Equation	R^2	P
TSMM (kg)	Lee et al.[11]	TSMM = 0.244.BW + 7.80.H_1 - 0.098.A + 6.6.S + Et - 3.3	0.86	2.80
ASMM (kg)	Baumgartner et al.[12]	ASMM = 0.2487.BW + 0.0483.H_2 - 0.1584.HC + 0.0732.HGS + 2.5843.S + 5.8828	0.91	1.58

Note: BW = body weight in kg; H_1 = height in meters; H_2 = height in cm; A = age in years; Et = ethnicity (Caucasian = 0, African descent = 1.4, and Asian = -1.2); S = sex (female = 0 and male = 1); HC = hip circumference in cm; HGS = hand grip strength in kg.

Next, TMMI and AMMI values were estimated based on the ratio of TSMM or ASMM (in kg) to square height (in m), as described below:

$$\text{TMMI } (kg.m^{-2}) = \text{TSMMT}/H^2$$
$$\text{AMMI } (kg.m^{-2}) = \text{ASMM}/H^2$$

where H = height in meters.

BW was measured using a portable scale with a capacity of 150 kg and sensitivity of 1/2 kg, with the individual barefoot and wearing light clothes. Height (H) was measured using a 2-m stadiometer with sensitivity of 1 mm. HC measures were performed using an inelastic tape with sensitivity of 1 mm. Hand grip strength was measured using a dynamometry (in kg) in the dominant hand. The techniques used to obtain the anthropometric measurements were standardized according to Frisancho[16] and measurements were performed in triplicate, using the mean values for analysis, except for hand grip strength, for which we used the highest value.

Statistical Analysis

Descriptive statistics (means, standard deviations, and 10th, 25th, 50th, 75th and 90th percentile values) was used to characterize the sample according to sex and age group (<80 and ≥80 years) for the variables TSMM, ASMM, TMMI, and AMMI. Svy statistics was used for complex samples (weighted clustering), and the Wald test was used to compare the values of variables between sexes and age groups. Pearson's correlation coefficient was used to investigate the correlation between the variables. We used the statistical software Stata/SE 10.0 for Windows to perform the statistical analyses.

RESULTS

TSMM and ASMM were measured in 1,203 older adults (799 women and 503 men) aged between 60 and 99 years (73.9 ± 9.0 years). Mean body weight and height were, respectively, 62.9 ± 13.3 kg and 152.1 ± 6.8 cm for women and 69.0 ± 12.9 kg and 165.1 ± 7.2 cm for men.

The comparison between age groups, both for women (Table 2) and men (Table 3), showed greater relative difference between the age groups for the mean values of TSMM and TMMI in relation to the mean values of ASMM and AMMI, and the younger age group had higher MM values than the older age group. For all variables, the relative differences between the younger and older age groups were higher for women (19%, 17%, 10% and 7% for TSMM, TMMI, AMMI, and ASMM, respectively) compared with the differences found for men (10%, 9%, 8% and 5%, respectively). Likewise, the relative differences between P90 and P10 were higher for women (between 33% and 76%) than for men (between 27% and 43%) for all variables.

When comparing the means between sexes, older women had lower MM values, and in the younger age group, the differences were -34%, -22%, -31% and -20% for TSMM, TMMI, ASMM and AMMI, respectively. These differences increased when compared with the older age group (-40%, -29%, -33%, -21%, respectively).

For all the comparisons described above, we found a statistically significant difference for complex samples based on the Wald test.

Table 2. Mean values, standard deviations, confidence interval and percentiles for indicators of MM in older women according to age group. SABE Study - São Paulo - SP, Brazil, 2006 (<80 years = 571; ≥ 80 years = 228).

Variables				Percentile				
	X	SD	95%CI	10	25	50	75	90
TSMM (kg)								
60 to 79 years	17.7	3.6	17.3-18.0	13.3	15.1	17.5	20.1	22.4
80 years and over	14.4	3.2	13.9-14.8	10.6	12.3	14.1	16.3	18.6
ASMM (kg)								
60 to 79 years	14.4	2.1	14.2-14.6	11.7	12.9	14.3	15.7	17.3
80 years and over	13.0	2.0	12.8-13.2	10.7	11.7	12.8	14.2	16.0
TMMI (kg/m²)								
60 to 79 years	7.6	1.4.	7.4-7.7	5.9	6.6	7.4	8.4	9.5
80 years and over	6.3	1.2	6.1-6.5	4.8	5.5	6.2	7.1	7.8
AMMI (kg/m²)								
60 to 79 years	6.1	0.7	6.1-6.2	5.3%	5.7	6.2	6.6	7.1
80 years and over	5.7	0.7	5.6-5.8	4.9	5.3	5/6	6.1	6.5

Notes: X = mean; SD = standard deviation; 95%CI = 95% confidence interval; TSMM = total skeletal muscle mass; ASMM = appendicular skeletal muscle mass; TMMI = total muscle mass index; AMMI = appendicular muscle mass index.

In the present study, the variables used as anthropometric indicators of MM were highly correlated ($p < 0.05$), according to sex and age group, with r values ranging from 0.84 to 0.96, even when estimated using different predictive equations.

Table 3. Mean values, standard deviations, confidence interval and percentiles for indicators of MM in older men according to age group. SABE Study - São Paulo - SP, Brazil, 2006 (<80 years = 339; ≥ 80 years = 164).

Variables				Percentile				
	X	SD	95%CI	10	25	50	75	90
TSMM (kg)								
60 to 79 years	26.9	-3.8	26.4-27.3	22.3	24.4	26.6	29.4	31.8
80 years and over	24.1	2.9	23.5-24.7	20.1	22.2	24.0	26.0	27.9
ASMM (kg)								
60 to 79 years	21.0	2.8	20.6-21.3	17.6	18.9	20.7	23.0	24.9
80 years and over	19.4	2.3	18.9-20.0	16.4	-18.0	19.5	21.1	22.3
TMMI (kg/m²)								
60 to 79 years	9.8	1.1	9.6-9.9	8.5	9.0	9.7	10.4	11.1
80 years and over	8.9	0.9	8.8-9.1	7.8	8.4	8.9	9.5	10.3
AMMI (kg/m²)								
60 to 79 years	7.6	0.8	7.5-7.7	6.7	7.1	7.6	8.1.	8.5
80 years and over	7.2	0.7	7.1-7.3	6.3	6.8	7.3	7.6	8.2

Notes: X = mean; SD = standard deviation; 95%CI = confidence interval; TSMM = total skeletal muscle mass, ASMM = appendicular skeletal muscle mass; TMMI = total muscle mass index; AMMI = appendicular muscle mass index.

DISCUSSION

Much of lean body mass in humans is composed of MM. A significant portion of body MM is located in the upper and lower limbs[1], and it is called appendicular muscle mass (AMM). Different studies have discussed the reduction of MM considering different aspects[17]. However, in Brazil, there are few studies about the muscular component and its changes throughout aging. In this sense, using a representative sample of the SABE Study, which was conducted in the city of São Paulo, the objective of our study was to investigate the MM of male and female older adults using different anthropometric indicators.

TSMM and ASMM values were calculated based on specific equations[11,12], which were predicted in samples different from those used in our study. However, the characteristics of the samples are similar, especially in terms of the age groups included in these studies.

The mean values of TSMM of older adults in the present study are lower than those found by Janssen et al.[14], which were measured in individuals aged 60 to 69 years (18.4 kg and 30.2 kg for women and men, respectively), and 70 years or older (18.0 kg and 27.8 kg, respectively).The same study showed TMMI values of 7.0 $kg.m^{-2}$ and 7.3 $kg.m^{-2}$ for women, and 9.6 $kg.m^{-2}$ and 9.3 $kg.m^{-2}$ for men aged 70 years old or younger or older than 70, respectively. That is, when TSMM is adjusted for square height, the values of the U.S. and Brazilian samples are similar. Nevertheless, although Janssen et al.[14] consider the study as a reference, with a sample comprising 468 men and women from the United States and Canada, the age group of older adults included only 30 women and 25 men.

In a study involving a larger sample, Lannuzzi-Sucich[18] found mean ASMM values of 15.2 kg and 23.9 kg for women and men, respectively, among 337 U.S. older adults aged over 65 years old. Similarly to the previous study, the values are higher than those found in the city of São Paulo; however, when adjusted for square height (AMMI), the values showed smaller differences when compared with the present study (6.0 $kg.m^{-2}$ for women and 7.8 $kg.m^{-2}$ for men). Woo et al.[19] measured 3,153 Chinese men and women aged over 65 years old and found similar values, either for ASMM (13.9 kg and 19.3 kg for women and men, respectively) or for AMMI (7.3 $kg.m^{-2}$ and 6.1 $kg.m^{-2}$, respectively).

With regard to the comparison between sexes, all these studies are confirmed by the values found in the older adults living in the city of São Paulo, where men have, on average, between 30% and 40% higher MM values, either total or appendicular, compared with women, and the difference is higher at older ages. When these values are adjusted for square height, the difference is smaller, between 20% and 29% higher for men.

The comparison between age groups showed a reduction of the mean values of all anthropometric indicators in the older age group. Among women, the variables TSMM and TMMI showed a greater reduction from the younger to the older age group (19% and 17%, respectively), whereas the variables ASMM and AMMI showed a smaller reduction. In older men, the variables showed less variation, between 5% (AMMI) and 10% (TSMM).

In fact, several studies have demonstrated that the reduction of MM usually begins in the fifth decade of life, when there is decrease in muscle area[14], cell mass[20], and cell quality[21] along with lower isometric[22,23] and isokinetic[24,25] muscle strength. This decrease can be pathophysiologically explained by reduction of myofibrils, in particular, the type II fibers[26], decreased muscle protein synthesis, and changes in mitochondrial functions[27].

It is noteworthy that MM reduction promotes an overall decrease in muscle strength, which, together with the decrease in the resting metabolic rate and maximal oxygen uptake, is responsible for the lower total energy expenditure. These factors, coupled with chronic malnutrition, different morbidities, and the effect of aging, cause a higher reduction of total MM, starting a cycle of weakness[28], which lead to greater functional disability and, as a consequence, greater dependence on others to perform activities of daily living, lower quality of life, and increased risk of mortality.

We used the anthropometric method to identify the variables of MM, whereas the other studies mentioned above used laboratory methods for measuring the MM, either appendicular or total, such as magnetic resonance imaging (MRI)[14] or DEXA[18,19]. These methods have greater validity in comparison with anthropometry; however, other studies have used the anthropometric method to investigate the MM in older adults[12,29]. Therefore, it is also considered a valid method for this purpose and it has the advantage of being performed in a non-laboratory setting involving larger samples because of its greater simplicity and lower operating costs. It is also worth noting that our study has a cross-sectional design, which does not allow causal inference about the differences, especially between the age groups.

In the Pearson's correlation analysis, we found a high correlation between the anthropometric indicators, especially between TSMM, ASMM, TMMI, and AMMI ($R > 0.84$), with the values of TSMM and ASMM being calculated based on different equations, which is a sign of validity.

In short, MM values, regardless of the indicator used, are lower (between 5% and 19%) for older age groups (in the present study, the group older than 80 years). Older men have, on average, between 30% and 40% higher TSMM than women, whereas our sample had lower values compared with a U.S. sample[18] and similar values to a Chinese sample[19] including male and female older adults.

The proposal of reference data for the analysis of MM in older adults is very relevant to health professionals, especially to establish the diagnosis of sarcopenia, a disorder that requires intervention (drug treatment, specific diet, or physical activity) in order to reverse the process of frailty, providing greater independence and autonomy, and thus ensuring better quality of life for older adults.

Finally, considering that the values for the 10th and 25th percentiles suggested a higher risk of disability and frailty, we believe that further studies should be conducted to determine the prevalence of low MM and the association of these percentiles with sociodemographic variables, functional capacity, motor tests, and morbidity and mortality in Brazilian older adults, mainly involving laboratory methods for measuring TSMM and/or ASMM.

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