The Journal of Nutrition, Health & Aging©
Volume 18, Number 3, 2014

PREVALENCE AND ASSOCIATED FACTORS OF SARCOPENIA AMONG ELDERLY IN BRAZIL: FINDINGS FROM THE SABE STUDY

T. DA SILVA ALEXANDRE[1], Y.A. DE OLIVEIRA DUARTE[2], J.L. FERREIRA SANTOS[3], R. WONG[4], M.L. LEBRÃO[1]

1. Department of Epidemiology, School of Public Health, University of São Paulo, Brazil, Department of Physical Therapy, University of Pindamonhangaba; 2. Department of Medical-Surgical Nursing, Nursing School, University of São Paulo, Brazil; 3. Department of Social Medicine, University of São Paulo, Brazil; 4. Department of Preventive Medicine and Community Health, University of Texas Medical Branch, USA. Corresponding author: Tiago da Silva Alexandre, University of São Paulo, Epidemiology Department, Brazil, tsfisioalex@gmail.com

Abstract: *Objectives:* The aim of the present study was to examine the prevalence and factors associated with sarcopenia in older residents in São Paulo, Brazil. *Design:* Cross-sectional study. *Setting:* São Paulo, Brazil. *Participants:* 1,149 older individuals from the second wave of the Saúde, Bem-Estar e Envelhecimento (SABE) study from 2006. *Measurements:* The definition of sarcopenia was based on the consensus of the European Working Group on Sarcopenia in Older People (EWGSOP), which include three components: low muscle mass, assessed by a skeletal muscle mass index of ≤8.90kg/m^2 for men and ≤6.37kg/m^2 for women; low muscle strength, assessed by handgrip strength <30kg for men and <20kg for women; and low physical performance, assessed by gait speed <0.8m/s. Diagnosis of sarcopenia required presence of low muscle mass plus low muscle strength or low physical performance. Socio-demographic and behavioral characteristics, medical conditions and nutritional status were considered as independent variables to determine the associated factors using a logistic regression model. *Results:* The prevalence of sarcopenia was 16.1% in women and 14.4% in men. Advanced age with a dose response effect, cognitive impairment, lower income, smoking, undernutrition and risk for undernutrition (p<0.05) were factors associated with sarcopenia. *Conclusions:* The EWGSOP algorithm is useful to define sarcopenia. The prevalence of sarcopenia in the Brazilian elderly population is high and several associated factors show that this syndrome is affected by multiple domains. No differences were observed by gender in any age groups.

Key words: Sarcopenia, elderly, prevalence, SABE study.

Introduction

Sarcopenia has been defined as a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength with a high risk of adverse outcomes such as decreased function of the lower extremity, physical disability, poor quality of life and death (1-4). The European Working Group on Sarcopenia in Older People (EWGSOP) recommends the diagnosis of sarcopenia using the presence of low muscle mass (LMM) plus low muscle strength (LMS) (measured by handgrip) or low physical performance (LPP) (measured by gait speed). Using such a system in clinical practice, which is easy to apply and requires no expensive equipment, should improve both the identification and treatment of the syndrome (5).

The prevalence of sarcopenia varies depending on the definition used. According to EWGSOP, this prevalence ranges 5-13% in those 60 to 70 years old, reaching 11-50% in those more than 80 years old (6). Based on skeletal mass index, the prevalence of sarcopenia has been reported between 22.6% and 51.9% in women and 26.8% and 50.4% in men (2, 7). Using data from China, Lau et al. (8) found a 12.3% prevalence of sarcopenia in men and 7.6% in women, while Tichet et al. (9) used data from a French population and Masanes et al. (10) used data from a Spanish population to find rates of 23.6% and 33% in women and 12.5% and 10% in men, respectively.

Several factors are associated with sarcopenia. For example, Baumgartner et al. (11) showed that older age, low income, smoking and chronic lung disease were associated with sarcopenia. Furthermore, certain risk factors such as atherosclerosis, underweight and physical inactivity has also been associated with sarcopenia (12).

Few studies or none have estimated the prevalence of sarcopenia in Latin America using the EWGSOP definition. Arango-Lopera et al. (13), using data from a population in Mexico, found a prevalence of sarcopenia of 27.4% in men and 48.5% in women. The aim of the present study is to estimate the prevalence and associated factors of sarcopenia in a community dwelling elderly population in São Paulo, Brazil using the EWGSOP definition.

Methods

Study population

Data are from the SABE Study (Saúde, Bem-Estar e Envelhecimento/Health, Wellbeing and Ageing), a study of three cohorts that began in 2000 with a probabilistic sample of 2,143 individuals representative of the urban population aged 60 years and older living in São Paulo, Brazil.

In 2006, 1,115 individuals from the first cohort were interviewed in person; 11 were institutionalized, 51 moved to another city, 178 refused to participate, 139 were lost to follow-up and 649 deaths were confirmed through the state and municipal mortality system in Brazil. A new cohort

Received May 29, 2013
Accepted for publication July 24, 2013

representative of the urban population aged 60-64 years in the same city composed of 298 individuals was added to the original cohort in 2006 for a total sample of 1,413.

The present study used all data from the cohort interviewed in 2006. Of 1,413 participants interviewed in 2006, we excluded 264 due to missing data on handgrip strength, gait speed, weight and height, all variables needed to define sarcopenia, for a final sample of 1,149. These measurements were not taken in elderly unable to perform the handgrip strength test or the walking portion of the Short Physical Performance Battery Assessing Lower Extremity Function, or in those confined to bed or unable to stand for measurement of weight and height. The excluded subjects were older, had less education, drank less, reported more difficulties in activities of daily living and instrumental activities of daily living, more hypertension, diabetes, lung disease, heart disease, stroke, falls, instances of hospitalization, a more sedentary lifestyle, more cognitive impairment, undernutrition and risk for undernutrition according to the Mini-Nutritional Assessment (MNA®). All participants signed a statement of informed consent and the SABE study received approval from the Human Research Ethics Committee of the institution. Figure 1 shows the sample distribution according to the EWGSOP algorithm for the definition of sarcopenia.

Measures

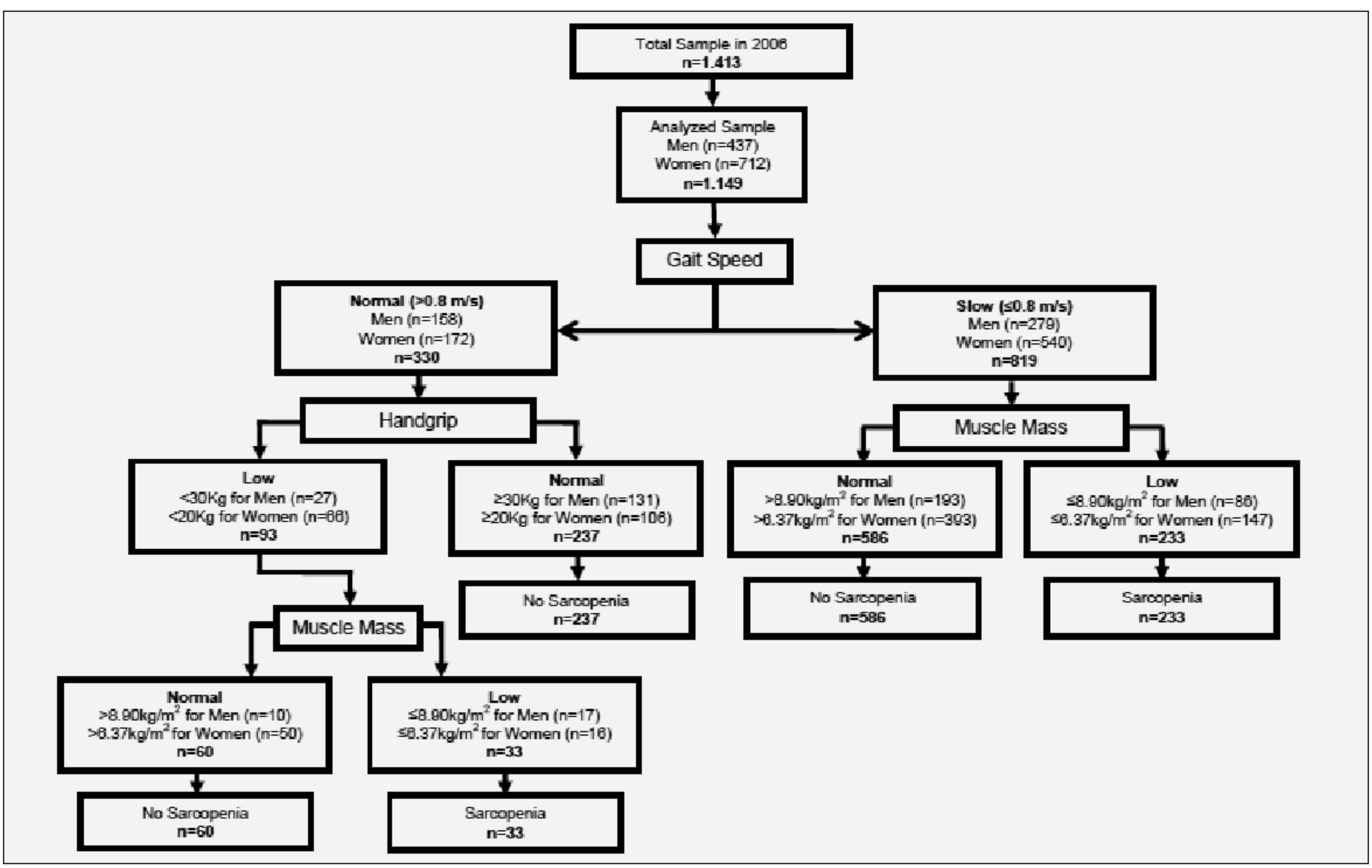
Sarcopenia was defined using the EWGSOP criteria. Participants with LMM plus LMS or LPP were considered positive for a diagnosis of sarcopenia (Figure 1) (5). Muscle mass was estimated by appendicular skeletal muscle mass (ASM) using the Lee equation as follows (14):

$$ASM = (0.244 * \text{body weight}) + (7.8 * \text{height}) + (6.6 * \text{gender}) - (0.098 * \text{age}) + (\text{race} - 3.3)$$

with body weight in kilograms and height in meters. The value 0 must be used for women, 1 for men, then 0 for whites, 1.4 for blacks and –1.2 for Asians (14). This equation has been validated in the Brazilian population using dual-energy X-ray absorptiometry (DEXA) as a gold standard, with high correlation between methods (r=0.86 for men and r=0.90 for women, respectively, p<0.05). The agreement between DEXA and the predictive equation to determine sarcopenia prevalence is strong (k=0.74; p<0.001), with high specificity (89%) and sensitivity (86%) (15).

After estimating the values, we adjusted the ASM by height squared to create the skeletal muscle mass index (SMI). Following the studies of Delmonico et al. (3) and Newman et al. (2), the cutoff of SMI used in the present study was based on

Figure 1
European Working Group on Sarcopenia in Older People Algorithm



the 20% lowest percentile of the population distribution, representing 6.37 kg/m^2 for women and 8.90 kg/m^2 for men.

Muscle strength was assessed with handgrip strength in kg using a hand-held dynamometer (Takei Kiki Kogyo TK 1201, Tokyo, Japan). During the test, the participant was in a sitting position, with elbow and forearm resting in the table and with palms facing up. The participant was prompted to grip the device using as much strength as possible. The grip size was adjustable so that each participant, regardless of size, could feel comfortable while squeezing the grip. The test was performed twice in the dominant limb, with a 1-min rest between tests and the higher value of the two trials was used for scoring. The cut-off points of < 30 kg for men and < 20 kg for women were considered to represent LMS (16).

Physical performance was assessed with gait speed (in meter/seconds), determined by the walk test of the Short Physical Performance Battery Assessing Lower Extremity Function. The test was assessed in an 8-foot walking course, with no obstructions for an additional 2 feet at either end and was denoted by placing a rigid 8-foot carpenter´s rule to the side of the course. Participants were instructed to "walk at your usual speed, just as if you were walking down the street to go to the store". Participants could use an assistive device, if needed, and each was timed for two walks. The faster of the two was used for the analyses (17). The cut-off speed of ≤ 0.8m/s was considered to represent LPP (5, 16).

Socio-demographic characteristics included age, gender, marital status, income and schooling. Age was grouped in three 10-year categories, with all those aged 80 years or older combined into one group. Marital status was classified as married (married or in a stable relationship) or not married/single (divorced, separated or widowed). Income, in Brazilian monthly minimum salary (R$ 350.00 = US$ 161.74), was classified in three categories: up to two (US$ ≤323.50), two to five (>US$ 323.50 and ≤US$ 808.70) and more than five times the minimum salary (>US$ 808.70). Schooling (in years) was analyzed as a continuous variable.

Smoking status was assessed by asking participants if they were non-smokers, former smokers or current smokers. Current smokers were asked how many cigarettes they smoke per day and how long they had smoked, in order to calculate smoking pack-years (18).

Alcohol intake was assessed by asking participants whether they were non-drinkers, drank once a week, drank two to six days a week or drank every day. The amount of alcohol consumed per week, in grams, in each group, was figured based on the number of glasses of beer, glasses of wine or shot of spirits per week and their respective alcohol content, following the recommendations of the World Health Organization (19).

Physical activity was assessed using the Brazilian version of the International Physical Activity Questionnaire (IPAQ) (20). The calculation of caloric expenditure involved the metabolic equivalent (MET – metabolic cost of the physical activity in question), the activities performed by the participant, the number of days per week each activity was performed, time spent performing the activity and individual body weight (21). Men and women with a caloric expenditure of less than 390.5 kcal and 478.15 kcal, respectively (smallest quintile), were classified as having a sedentary lifestyle.

Health status was assessed through self-report of arterial hypertension, diabetes, lung disease, heart disease, stroke, osteoarthritis, falls and hospitalizations in the previous 12 months. Cognitive status was assessed using the modified version of the Mini Mental State Exam (MMSE) due to the low level of schooling of the Brazilian elderly population. This measure has 13 items that do not depend upon schooling with a total possible score of 19 points (22). Participants with a cutoff point of ≤ 12 were considered to have cognitive impairment (23). Depressive symptoms were assessed using the Geriatric Depression Scale (24, 25). Participants with a score of ≥ 6 were considered to have depressive symptoms (25).

Body mass index (BMI) was computed by dividing weight in kilograms by height in meters squared (kg/m2) (26). Body weight was measured by a trained interviewer using a calibrated scale, with the individual barefoot and wearing light clothing. Height was measured using a stadiometer fixed to a plain wall.

Mini-Nutritional Assessment (MNA®) is a multidimensional and validated method composed of 18 questions grouped into 4 parts: anthropometry (BMI, weight loss, mid upper arm and calf circumference), clinical state (medications, mobility, pressure sores and skin ulcers, lifestyle, psychological stress or neuropsychological problems), dietary assessment (autonomy in feeding, quality and number of meals, fluid intake) and self perception about health and nutrition. The total score ranges from 0 to 30 points. Participants with a score from 17 through 23.5 were considered at risk for undernutrition and those with a score <17 were considered undernourished; good nutritional status was defined as an MNA score > 23.5 (27, 28).

Statistical Analyses

The prevalence of sarcopenia was estimated using a 95% confidence interval (CI). Differences in the characteristics according to sarcopenia status and gender were analyzed using the Rao and Scott Wald test and chi-square test with Rao and Scott correction. Logistic regression analysis was used to analyze the factors associated with sarcopenia. Associations with a p-value of 0.2 or less in the univariate analysis were selected for the multiple regression analysis, in which forward stepwise selection was used.

The area under the receiver operating characteristic (ROC) curve was used to assess the predictive value for the model. In this analysis, the power of the model's predicted values to discriminate between positive and negative cases is quantified by the Area under the ROC curve (AUC). The AUC, referred to as the c-statistic (or concordance index), is a value that varies from 0.5 (discriminating power not better than chance) to 1.0

Table 1
Descriptive characteristics of participants by gender and sarcopenia status in São Paulo, Brazil, 2006 (N=1,149)

	Men			Women		
	Total	No Sarcopenia	Sarcopenia	Total	No Sarcopenia	Sarcopenia
Total	437	334	103	712	549	163
Socio-demographic variables						
Age	n=437	68.1±0.6*§	74.8±1.0*	n=712	68.9±0.6*§	75.8±1.0*
60 – 69 Y.O.	n=169	65.2%*	32.0%*	n=263	60.7%*	26.6%*
70 – 79 Y.O.	n=133	29.4%*	42.2%*	n=252	32.0%*	40.1%*
80 or more Y.O.	n=135	5.4%*	25.8%*	n=197	7.3%*	33.3%*
Schooling (years)	n=434	5.2±0.4§	4.2±0.6	n=711	4.4±0.2§	3.9±0.4
Marital Status						
Married/partner	n=323	82.6%*§	67.3%*§	n=254	47.0%*§	27.9%*§
Single (single, divorced, widowed)	n=113	17.4%*§	32.7%*§	n=458	53.0%*§	72.1%*§
Income						
US$ ≤323.50	n=135	21.0%*§	51.9%*	n=340	39.0%*§	56.3%*
>US$ 323.50 and ≤US$ 808.70	n=113	23.4%*§	25.9%*	n=147	16.4%*§	23.3%*
>US$ 808.7	n=66	15.4%*§	9.2%*	n=43	6.5%*§	4.3%*
Missing	n=123	40.2%*§	13.0%*	n=182	38.1%*§	16.2%*
Behavioral variables						
Smoking						
Non-smoker	n=122	31.0%§	18.5%§	n=512	69.7%§	67.7%§
Former smoker	n=256	52.5%§	58.1%§	n=131	19.4%§	15.7%§
Current smoker	n=59	16.5%§	23.4%§	n=69	10.9%§	16.6%§
Pack year		34.4±3.2	36.8±5.4		38.4±5.3	28.7±5.4
Weekly alcohol intake						
None	n=247	48.2%§	63.3%§	n=573	78.3%§	80.6%§
Once a week	n=83	22.7%§	10.6%§	n=104	16.7%§	13.7%§
Grams of alcohol		20.1±1.8*	12.5±2.1*		19.6±2.5	15.1±1.7
2 to 6 days a week	n=62	17.6%§	13.0%§	n=23	3.8%§	3.9%§
Grams of alcohol		74.8±8.2*§	32.8±6.5*		43.7±6.6§	58.7±24.5
Every day	n=44	11.5%§	13.1%§	n=10	1.2%§	1.8%§
Grams of alcohol		163.5±18.0*	435.0±78.5*§		159.7±41.0	98.0±1.0§
Sedentary Lifestyle	n=93	18.8%	15.7%	n=156	14.9%*	25.5%*
Health Status						
Arterial hypertension (yes)	n=245	56.7%§	45.0%§	n=478	65.8%§	61.2%§
Diabetes (yes)	n=77	19.1%	13.9%	n=139	20.7%*	15.6%*
Lung disease (yes)	n=53	12.5%	13.2%§	n=70	10.4%	6.4%§
Heart disease (yes)	n=113	23.4%	20.0%	n=150	18.7%	22.7%
Stroke (yes)	n=41	9.0%§	14.4%	n=44	5.1%§	7.7%
Osteoarthritis (yes)	n=91	21.2%*§	8.5%*§	n=300	42.5%§	33.6%§
Falls in previous 12 months (yes)	n=102	19.5%§	22.1%	n=251	31.9%§	34.2%
Hospitalization in previous 12 months (yes)	n=43	7.3%	12.4%	n=61	7.4%	8.0%
Mini Mental State Exam (≤12 points)	n=60	9.3%*	25.3%*	n=97	7.0%*	18.9%*
Geriatric Depression Scale (≥6 points)	n=41	10.0%§	10.1%	n=113	17.2%§	15.6%
Anthropometric and performance variables						
Weight (kg)	n=437	73.6±0.8*§	56.8±0.9*§	n=712	67.3±0.6*§	48.4±0.5*§
Height (m)	n=437	1.66±0.01§	1.66±0.01§	n=712	1.53±0.01*§	1.51±0.01*§
Body Mass Index (kg/m2)	n=437	26.7±0.2*§	20.6±0.2*§	n=712	28.7±0.2*§	21.3±0.2*§
Handgrip (kg)	n=437	34.5±0.6*§	26.7±1.0*§	n=712	20.1±0.2*§	15.9±0.4*§
Gait speed (m/s)	n=437	0.86±0.01*§	0.75±0.03*§	n=712	0.77±0.01*§	0.66±0.02*§
Skeletal muscle mass index (kg/m2)	n=437	10.1±0.07*§	8.3±0.06*§	n=712	7.99±0.07*§	5.67±0.06*§
Not undernourished (MNA > 23.5)	n=317	78.9%*	52.1%*	n=490	75.7%*	47.1%*
At risk for undernutrition (17 ≥ MNA ≤ 23.5)	n=112	20.2%*	39.8%*	n=212	23.8%*	49.7%*
Undernourished (MNA < 17)	n=8	0.9%*	8.1%*	n=10	0.5%*	3.2%*

* The difference by sarcopenia status within the same gender is significant at α≤0.05; § The difference between genders within the same sarcopenia status is significant at α≤0.05; Proportions were calculated considering the weight of the sample.

(perfect discriminating power) (29).

Because our data came from a multistage cluster sampling, sample weights were employed in all analyses. The Stata 10® program (StataCorp, College Station, TX) was used for all data analysis.

Results

The mean age ± standard deviation of the participants was 69.6 ± 0.6 years; of these, 59.5% were female, 58.7% were married and the mean years of education was 4.6 ± 0.2 years. The most prevalent medical conditions were arterial hypertension (61%), osteoarthritis (32.4%) and heart disease (20.8%). Using MNA® criteria, 26% of the cohort was at risk for undernutrition and 1.3% was undernourished. Table 1 presents the descriptive characteristics of participants by gender and sarcopenia status. Participants with sarcopenia were significantly more likely to be older, unmarried, to have the lowest income, low physical activity (women only), lower cognitive status, lower handgrip strength and gait speed, lower BMI, lower SME, be at increased risk of undernutrition and were more likely to be undernourished, with lower prevalence of diabetes (women only) and osteoarthritis (men only). The prevalence of sarcopenia was 16.1% in women and 14.4% in men, increasing with age and not significantly different by gender in all age categories (Table 2).

Table 2
Prevalence (%) and Confidence Interval (95%) of sarcopenia by gender and age group in São Paulo, Brazil, 2006 (N=1,149)

	Total	60–69 Y.O.	70–79 Y.O.	80 or more Y.O.
Men	14.4 (11.3–18.3) (n=103)	7.6 (4.5–12.8) (n=12)	19.5 (13.7–27.0) (n=27)	44.7 (35.3–54.4) (n=64)
Women	16.1 (13.5–19.0) (n=163)	7.7 (4.9–11.9) (n=19)	19.4 (15.5–24.0) (n=54)	46.6 (37.6–55.9) (n=90)

Prevalence was calculated considering the weight of the sample.

Table 3
Weighed logistic regression analysis for sarcopenia in São Paulo, Brazil, 2006 (N=1,120*)

	OR	95% CI	p
Age (60 – 69 Y.O.)	1.00		
Age (70 – 79 Y.O.)	2.00	1.01–3.95	0.046
Age (80 or more Y.O.)	7.53	3.79–14.97	< 0.001
Male	1.00		
Female	0.85	0.55–1.32	0.471
Income (> US$ 808.70)	1.00		
Income (323.50 > US$ ≤ 808.70)	2.16	0.83–5.65	0.113
Income (US$ ≤ 323.50)	2.57	1.06–6.20	0.036
Income (missing)	1.08	0.38–3.06	0.889
Married/partner	1.00		
Not Married (single, divorced, widowed)	1.43	0.90–2.28	0.126
Schooling (years)	1.05	0.98–1.12	0.125
Non-smoker	1.00		
Former smoker	1.16	0.76–1.78	0.491
Current smoker	2.00	1.11–3.63	0.022
Active Lifestyle	1.00		
Sedentary Lifestyle	0.66	0.42–1.06	0.086
Mini Mental State Exam (≥13 points)	1.00		
Mini Mental State Exam (≤12 points)	2.68	1.23–5.84	0.014
Not undernourished (MNA > 23.5)	1.00		
At risk for undernutrition (17 ≥ MNA ≤ 23.5)	3.15	2.03–4.89	p < 0.001
Undernourished (MNA < 17)	11.54	3.45–38.59	p < 0.001
Number of diseases	0.86	0.62–1.19	0.359

Area under ROC curve=80%; * The sample size decreased due to missing data on covariates.

Table 3 presents the weighted logistic regression analysis for sarcopenia. The odds ratio (OR) and 95% CI in the final model for the factors statistically significantly associated with sarcopenia were 2.00 (95% CI=1.01-3.95) for those aged 70–79 years, 7.53 (95% CI=3.79-14.97) for those aged 80 years or more, 2.68 (95% CI=1.23-5.84) for cognitive impairment (MMSE ≤ 12), 2.57 (95% CI=1.06-6.20) for lower income (US$ ≤ 323.5), 2.00 (95% CI=1.11-3.63) for current smokers, 3.15 (95% CI=2.03-4.89) for risk for undernutrition (17 ≥ MNA ≤ 23.5) and 11.54 (95% CI=3.45-38.59) for undernourished (MNA < 17).

Discussion

The objective of the present study was to estimate the prevalence of and factors associated with sarcopenia in a community dwelling elderly population in São Paulo, Brazil. The overall prevalence of sarcopenia using the EWGSOP definition was 15.4%, with 16.1% in women and 14.4% in men.

The prevalence of sarcopenia we found is different from that of previous reports. For example, Baumgartner et al. (11), using DEXA and regression equations to measure and estimate ASM (7.26 kg/m^2 for men and 5.45 kg/m^2 for women), found that the prevalence of sarcopenia varied from 13% to 24% in persons under 70 years of age, increasing to more than 50% in persons aged 80 years or older. In another study, Newman et al. (2) found a prevalence of sarcopenia of 51.9% in women and 50.4% in men, using DEXA to estimate SMI and appendicular lean mass (7.23 kg/m^2 for men and 5.67 kg/m^2 for women). These results are higher than our estimates, which rely only on muscle mass to determine sarcopenia.

Recently, Patel et al. (30), using the EWGSOP recommendation in an UK population, showed a prevalence of sarcopenia of 4.6% in men and 7.9% in women, lower rates than in our findings. However, despite the similar mean ages, other factors likely explain the higher prevalence in the Brazilian population: anthropometric and socioeconomic differences between the two populations, the distinct techniques used to measure muscle mass and the cut-off adopted to determine LMM in this group. While muscle mass from the UK population was assessed primarily using the skin-fold thickness test, our study estimated muscle mass based on a validated equation (15).

The results of this study are consistent with earlier findings of factors associated with sarcopenia. For example, several studies have found increasing age associated with sarcopenia (1, 7, 8, 11, 12). Baumgartner et al. (11) found, in a population in New Mexico, that low income is associated with sarcopenia in American men who received less than US$ 15,000 annually. The present study shows that lower income (less than US$ 323.50 monthly) was associated with sarcopenia in both men and women, reinforcing the role of socioeconomic factors in this syndrome.

Smoking has been found in other studies to be associated with sarcopenia (2,12). Smoking can compromise the ability of the already suffering system to obtain muscular energy due several factors: a) reduction in blood flow to the muscles while at rest and during certain types of contraction; b) inability of the circulatory and muscular systems to remove metabolic products; and c) insufficient supply of energy and oxygen to the metabolic pathways (31, 32). All these changes related to aging -- added to smoking status -- increase muscle fatigue and consequently the protein catabolism that can reduce both muscles mass and function.

Cognitive impairment reinforces and emphasizes the neuronal changes in the central nervous system leading to changes in the levels and activity of neurotransmitters, which, together with the inadequate distribution of oxygen to the brain, lead to a reduction in motor units and in the ability to maintain muscle activation (33). Besides these central alterations, peripheral alterations due to changes in the neuromuscular junction and muscle tissue can alter the functioning of the neuromuscular system. This process further compromises the ability of muscles to generate strength and endurance, which leads to gait and balance disorders, reduction in psychomotor activity, slowness in activities that involve dual tasks (cognitive and physical) and impaired motor control (33-36).

We found low prevalence of undernutrition but high prevalence of risk for undernutrition in community-dwelling elderly in São Paulo. Malnutrition is highly prevalent in the frailest groups, especially in low-income people. Beyond low-income, socioeconomic factors such as loneliness and low levels of education may affect food availability and, subsequently, nutritional status (37).

Malnutrition is the consequence of energy and protein deficiencies that cause adverse effects on body composition (37). The absence of adequate nutritional intake activates the immune system and increases synthesis of inflammatory cytokines amplifying the chronic catabolic conditions reducing muscle mass and, consequently, affecting body function (38).

This study has some limitations. First, the analysis was cross-sectional, and therefore cannot be used to establish cause and effect. Second, the use of the regression equation to estimate muscle mass may under- or over-estimate the prevalence of sarcopenia in our study. However, few studies have used DEXA in community-dwelling populations. Furthermore, the public health system should have options by which to estimate muscle mass without relying on expensive equipment to screen populations at risk. Third, since the estimation used includes weight and height, BMI was not included in the logistic regression analysis. Meanwhile, other studies have shown that BMI explains almost 50% of the variance in muscle mass (7, 12, 39), preventing the identification of other factors associated with muscle mass. Fourth, we used the lowest quintile of the percentile distribution to define low ASM, due to the lack of standard criteria in the Brazilian population. Fifth, the SABE study was focused on the community-dwelling elderly population and did not include residents of nursing homes. Thus, the estimates may have some degree of bias, as institutionalized elderly individuals may have a greater prevalence of sarcopenia (40). However, the institutionalized population in Brazil is relatively small, which minimizes such bias (41). Sixth, the population excluded from the analyses was older and had worse health and functional conditions, which could underestimate the prevalence of sarcopenia in the population as a whole.

This study also has strengths. First, the study was conducted on a large sample of community-dwelling adults that represents the elderly population in the city of São Paulo. Second, as far as we are aware, this study is the first to analyze the prevalence of sarcopenia in Latino America using the EWGSOP criteria.

Conclusions

The EWGSOP algorithm is useful to define sarcopenia in the Brazilian population. The prevalence of sarcopenia is high, increases with age, low income, smoking, cognitive impairment, undernutrition and risk for undernutrition, showing that this syndrome is affected by multiple domains and that elderly with these characteristics should be the target of prevention strategies.

Acknowledgements: This study is supported by the Foundation of Research Support of São Paulo (FAPESP) which financed the SABE Study. Tiago da Silva Alexandre was a visiting scholar (CAPES 12629-12-0) at the WHO/PAHO Collaborating Center on Aging and Health at UTMB during this study. The authors acknowledge valuable contributions and comments from Dr. Soham Al Snih on an earlier version of this paper, as well as editorial assistance from Dr. Sarah Toombs Smith.

References

1. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. J Am Geriatr Soc 2002;50:889-896.
2. Newman AB, Kupelian V, Visser M, et al. Sarcopenia: Alternative definitions and associations with lower extremity function. J Am Geriatr Soc 2003;51:1602-1609.
3. Delmonico MJ, Harris TB, Lee JS, et al. Alternative definitions of sarcopenia, lower extremity performance, and functional impairment with aging in older men and women. J Am Geriatr Soc 2007;55:769-774.
4. Landi F, Cruz-Jentoft AJ, Liperoti R, et al. Sarcopenia and mortality risk in frail older persons aged 80 years and older: results from ilSIRENTE Study. Age Ageing 2013;42(2):203-209.
5. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosis. Age Ageing 2010;39:412-413.
6. Morley JE. Sarcopenia: diagnosis and treatment. J Nutr Health Aging 2008;12:452-456.
7. Iannuzzi-Sucich M, Prestwood KM, Kenny AM. Prevalence of Sarcopenia and Predictors of skeletal muscle mass in healthy, older men and women. J Geront A Biol Sci Med Sci 2002;57A(12):M772-M77.
8. Lau EMC, Lynn HSH, Woo JW, Kwok TCY, Melton LJ. Prevalence of and risk factors for sarcopenia in elderly Chinese men and women. J Geront A Biol Sci Med Sci 2005;60A(2):213-216.
9. Tichet J, Vol S, Goxe D, Salle A, Berrut G, Ritz P. Prevalence of sarcopenia in the French senior population. J Nutr Health Aging 2008;12(3):202-206.
10. Masanes F, Culia A, Navarro-Gonzalez M et al. Prevalence of sarcopenia in health community-dwelling elderly in a urban area of Barcelona (Spain). J Nutr Health Aging 2012;16(2):184-187.
11. Baumgartner RN, Kathleen MK, Gallagher D, et al. Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 1998;147:755-763.
12. Lee JSW, Auyeung TW, Timothy K, Lau EMC, Leung PC, Woo J. Associated factors and health impact of sarcopenia in older Chinese men and women: a cross-sectional study. Gerontology 2007;53:404-410.
13. Arango-Lopera VE, Arroyo P, Gutiérrez-Robledo LM, Pérez-Zepeda UM. Prevalence of sarcopenia in Mexico city. Europ Geriatr Med 2012;3(3):157-160.
14. Lee RC, Wang Z, Heo M, Ross R, Janssen I, Heymsfield SB. Total-body skeletal

muscle mass: development and cross-validation of anthropometric prediction models. Am J Clin Nutr 2000;72:796-803.
15. Rech CR, Dellagrana RA, Marucci MFN, Petroski EL. Validity of anthropometric equations for the estimation of muscle mass in elderly. Braz J Kineant 2012;14(1):23-31.
16. Laurentani F, Russo C, Bandinelli S, et al. Age-associated changes in skeletal muscles and their effect on mobility: an operational diagnosis of sarcopenia. J Appl Physiol 2003;95:1851-1860.
17. Guralnik JM, Simonsick EM, Ferruci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. Journal Gerontology 1994; 49(2): M85-M94.
18. Peto R (1986) Influence of dose and duration of smoking on lung cancer rates. In: Zaridze D & Peto R (eds) Tobbaco: A Growing International Health Hazard (IARC Scientific Publications No.74), Lyon, IARC Press, pp 23-33.
19. Lexicon of alcohol and drug terms. 1994. World Health Organization.
20. Guedes DP, Lopes CC, Guedes JERP. Reprodutibilidade e validade do Questionário Internacional de Atividade Física em adolescentes. Rev Bras Med Esp 2005;11(2):151-157.
21. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Spor Exer 2003;35:1381-1395.
22. Folstein MF, Folstein SE, Mchugh PR. A practical method for grading the cognitive state of patient for the clinician. J Psych Res 1975;12:189-198.
23. Icaza MC, Albala C. PROJETO SABE. Minimental State Examination (MMSE) del Studio de dementia en Chile: Análisis estadístico. 1999. OPAS, 1–18.
24. Sheikh JI, Yesavage JA. Geriatric Depression Scale (GDS): recent evidence and development of a short version. Clinical Gerontology 1986;5:165-173.
25. Almeida OP, Almeida SA (1999). Short versions of the Geriatric Depression Scale: A Study of their validity for the diagnosis of a major depressive episode according to ICD-10 e DSM-IV. Inter J Ger Psych 1999;14:858-865.
26. Keys A, Fidanza F, Karvonen MJ, Kimura N, Taylor HL. Indices of relative weight and adiposity. J Chronic Dis 1972;25:329-343.
27. Guigoz Y, Vellas B. Test d´evaluation de létat nutritionnel de la personne âgee: le Mini Nutritional Assessment (MNA®) [Test to assess the nutritional status of the elderly: The Mini Nutritional Assessment - MNA]. Med Hyg 1995;53:1965-1969.
28. Guigoz Y. The Mini Nutritional Assessment (MNA®) review of the literature – what does it tell us? J Nutr Health Aging 2006;10:466-487.
29. Angelos Tosteson AN, Begg CB. A general regression methodology for ROC curve estimation. Med Decis Making 1988;8:2014-2015.
30. Patel HP, Syddall HE, Jameson K, et al. Prevalence of sarcopenia in community-dwelling older people on the UK using the European Working Group on Sarcopenia in Older People (EWGSOP) definition: findings from the Hertfordshire Cohort Study (HCS). Age Ageing 2013;42(3):378-384.
31. Abbiss CR, Laursen PB. Models to explain fatigue during prolonged endurance cycling. Sports Med 2005;35:865-898.
32. Meeusen R, Watson P, Hasegawa H et al. Central fatigue. The serotonin hypothesis and beyond. Sports Med 2006;36:881-909.
33. Walston J, Hadley EC, Ferrucci L, et al. Research agenda for frailty in older adults: Toward a better understanding of physiology and etiology: Summary from the American Geriatrics Society/National Institute on Aging Research Conference on frailty in older adults. J Am Geriatr Soc 2006;54:991-1001.
34. Schwendner KI, Mikesky, AE, Holt HSJ, Peacock M, Burr DB. Differences in muscle endurance and recovery between fallers and non fallers, and between Young and older women. J Geront A Biol Sci Med Sci 1997;52:M155-M160.
35. Nybo L, Rasmussen P. Inadequate cerebral oxygen delivery and central fatigue during strenuous exercise. Exer Sport Sci Rev 2007;35:110-118.
36. Tanko LB, Movsesyan L, Mouritzen U, Christiansen C, Svendsen OL. Appendicular lean tissue mass and the prevalence of sarcopenia among healthy women. Metabolism 2002;51:69-74.
37. Donini LM, Scardella P, Piombo L, et al. Malnutrition in elderly: social and economic determinants. J Nutr Health Aging 2013;17(1):9-15.
38. Donini JE, Savina C, Piredda M, et al. Senile anorexia in acute-ward and rehabilitation settings. J Nutr Health Aging 2008;12:511-517.
39. Janssen I, Heymsfield SB, Wang Z, Ross R. Skeletal muscle mass and distribution in 468 men and women aged 18-99 yr. J Appl Physiol 2000;89:81-88.
40. Andrade FCD, Guevara PE, Lebrão ML, Duarte YAO, Santos JLF. (2011). Gender differences in life expectancy and disability-free life expectancy among older adults in São Paulo, Brazil. Women's Health Issues. 2011;21:64–70.
41. Camarano AA, Watanabe HAW, Andrade A, Carvalho DF, Diniz H, Mello JL et al. Relatório do projeto instituições de longa permanência para idosos - ILPI no Brasil: Tipologia e proposta de modelo básico de assistência multidimensional 2009. Processo 555079/2006-6. Edital MCT-CNPq/MS-SCTIE-DECIT, n 17/2006. Rio de Janeiro, Brasil: IPEA.