Aging Medicine and Healthcare 2022;13(2):51-59. doi:10.33879/AMH.132.2021.03012

Aging Medicine and Healthcare
https://www.agingmedhealthc.com

Original Article

Prevalence and Factors Associated with Sarcopenia in Hospitalized Elderly Patients

*Rodrigo Cerqueira Borges[1], Daniel Imay Correa[1], Lourdes Jaqueline Sampaio Correa[1], Alexandra Siqueira Colombo[1], Celso Ricardo Fernandes Carvalho[2]

[1]University Hospital, University of São Paulo, São Paulo, Brazil
[2]Physical Therapy Department, School of Medicine, University of São Paulo, São Paulo, Brazil

***Correspondence**
Dr. Rodrigo Cerqueira Borges
University Hospital, University of São Paulo, São Paulo, Brazil
E-mail: rodrigounopar@yahoo.com.br

Received 21 April 2021
Accepted 15 May 2021

Keywords
Sarcopenia, prevalence, hospitalization, elderly, general ward, cognitive aspects.

ABSTRACT

Background/Purpose: Sarcopenia is a public health problem; however, it remains poorly evaluated during hospitalization. The aim of this study was to evaluate the prevalence of sarcopenia and the factors associated with this condition in hospitalized elderly patients

Methods: A total of 122 elderly individuals were evaluated in this case-control study (61=hospitalized and 61=non-hospitalized). Sarcopenia was defined and evaluated according to the criteria of the European Working Group on Sarcopenia in Older People (EWGSOP2). The Charlson comorbidity index, geriatric depression scale, body mass index (BMI), Barthel Index, Mini-Mental State Examination (MMSE), Lawton-Brody index, and Mini Nutritional Assessment Instrument-Short Form (MNA-SF) were also used for the evaluations.

Results: The prevalence of sarcopenia was 38% in hospitalized patients compared to 11% in controls. Hospitalized elderly patients showed a significant reduction in functionality, muscle strength, and mental and nutritional status compared to the controls. Sarcopenic patients were older, had a lower BMI, and obtained worse MMSE results than non-sarcopenic individuals. There was an association between the MMSE results and the BMI in patients with sarcopenia that was independent of the group.

Conclusion: Sarcopenia is highly prevalent in hospitalized elderly individuals, and it is associated with cognitive state and BMI.

1. INTRODUCTION

Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength, with a risk of adverse outcomes, such as physical disability, poor quality of life, and death.[1] Several mechanisms seem to be involved in the onset and progression of sarcopenia, including reductions in protein synthesis, proteolysis, neuromuscular integrity, and muscle fat content. In addition, other factors, such as immobility, inflammation, an inactive lifestyle, and malnutrition, may also influence the development of sarcopenia.[1]

Previous studies have reported that the worldwide prevalence of sarcopenia ranges from 1% to 29% among community-dwelling older people.[2] The wide differences seen between studies occur due to the different diagnostic criteria and methods used to assess muscle mass and physical performance.

Sarcopenia has been mainly studied in community-dwelling older adults and nursing home residents. However, the prevalence of sarcopenia and associated outcomes in hospitalized patients remains poorly understood.[2,3] Hospitalization might induce negative effects because it represents an additional stressor that reduces caloric intake, physical activity, and prolonged bed rest.[4] There is also evidence that hospitalization leads to cognitive impairment, physical incapacity, social isolation, and decreased quality of life.[5]

Some studies in developed countries sought to address this issue of sarcopenia in hospitalized patients,[3,4,6-8] however, in countries underdeveloped with limited health resources are still lacking information. A Brazilian study found a prevalence of 21.8% in patients.[9] Despite that, due to the territorial dimensions, there is extreme variation in public access to health and socio-economic conditions in different regions of the country; therefore, this prevalence, and the associated outcomes, may be very different from those been observed so far. In addition, the methods used to define sarcopenia might have influenced the results presented in that study,[9] because the authors did not use the recommendations for assessing muscle mass according to the guidelines of the European Working Group on Sarcopenia in Older People (EWGSOP). Therefore, our study aimed to evaluate the prevalence of sarcopenia in hospitalized elderly individuals using the criteria of the EWGSOP and to evaluate the factors associated with sarcopenia. The functionality, muscle strength, and mental and nutritional status of the hospitalized elderly patients were compared of non-hospitalized elderly individuals.

2. METHODS

This case-control study evaluated hospitalized patients in a medical clinic ward with a total of 28 beds in a Brazilian university hospital from January to December 2018. This ward is divided into patients with high or low functional dependence according to a classification by the hospital's nursing team. All hospitalized patients in the ward aged ≥65 years were included. Patients were excluded if they met the following criteria: patients transferred from the intensive care unit (ICU), with current or previous illnesses that impeded the performance of the evaluations proposed in the study, insufficient cognitive level to perform the tests, and patients in the terminal phase of the disease. The Hospital Ethics Committee approved the study (1.785.788), and all participants provided written informed consent before participating.

Hospitalized elderly were recruited daily. Clinical and laboratory data at the time of evaluation were collected from the patients' physical and electronic records. All patients included in the study were examined on the penultimate or on the last day of hospitalization. Assessments in the first days of admission were avoided because acute illness impacts muscle strength and functional performance, which cannot be considered representative of the patient. Bioelectrical impedance analysis could also be highly influenced by changes in body water distribution due to acute disease.

A control group composed of community-dwelling non-hospitalized elderly individuals, who were matched by age, sex, and body mass index, was also evaluated. For each case, we chose a control that was in the same age group of five years (for example, if the case was 77 years old, the control chosen was between 75-79 years old) and for the body mass index the variation was 5 kg/m^2 (for example, if the case was 22 kg/m^2, the control chosen was between 20-24 kg/m^2).

The control group was recruited from among healthy individuals during regular medical visits in the hospital or those accompanying the hospitalized patients. Only those elderly individuals who had not participated in recreational or competitive physical activities in the last six months and who were not hospitalized in the previous year were included. The clinical history of the control group was collected to evaluate current or prior health problems. Medical visit records were also used to search for other health problems. All evaluations were performed on a single day. The control group was formed in a 1:1 proportion to the hospitalized elderly individuals.

2.1. Sarcopenia

Sarcopenia was defined according to the EWGSOP criteria based on the presence of low muscle strength and low muscle mass. Severe sarcopenia was established in the concomitant presence low physical performance.[10] Muscle mass was measured using bioelectrical impedance analysis (BIA) (Biodynamics, Model 450, United States). This is a tetrapolar equipment with a 50 kHz sine wave and wave 800 mA current. Whole-body BIA measurements were taken between the right wrist and ankle with the patient in a supine position.[11] Muscle mass was estimated using the equation developed by Janssen and colleagues: 12 skeletal muscle mass (kg)=((height^2/BIA resistance × 0.401) + (sex × 3.825) + (age × –0.071)) + 5.102; height was measured in cm; BIA resistance was measured in Ω; for sex, men=1 and women =0; and age was measured in years. The skeletal muscle index (SMI) was obtained by dividing the absolute muscle mass by the squared height (kg/m^2). Low muscle mass was classified as an SMI <7.0 and 5.5 kg/m^2 in men and women, respectively.[10]

2.2. Assessments

Handgrip strength of the dominant upper limb was assessed using a dynamometer (T18; Takei, Tokyo, Japan). The measurement was standardized by asking the patient to sustain the maximum strength for 5 s. Three attempts were made, and patients received verbal encouragement during the tests. The tests were performed with a dominant upper limb elbow flexion of 90°, adduction of the shoulder, and with the wrist maintained in a neutral position with patients in a seated position. Before the test, patients underwent two attempts in order to reduce learning effects. Low muscle strength was classified as a muscle-strength handgrip of less than 27 kg and 16 kg in men and women, respectively.[10]

Physical performance was evaluated by measuring the participants' usual gait speed (in m/s) over a 4-m course. A cut-off point of <0.8 m/s identified patients with poor physical performance.[10]

The severity of the hospitalized elderly was classified using the Charlson comorbidity index (CCI). The CCI classifies disease severity based on secondary morbidities and generates the patient's death risk.[13] The CCI score is the sum of the weights assigned to the 17 predetermined clinical conditions. The score can be combined with age to form a single index, where every decade of life adds one point to the initial score.[14]

The Barthel Index was applied to evaluate the independence capacity of the elderly in different basic activities of daily living. Higher scores indicate better independence.[15] This instrument was validated for the Portuguese language.[16]

The Mini-Mental State Examination (MMSE) was specifically used to screen for cognitive impairments and dementia. The exam has two parts: one evaluates memory and attention, with a maximum score of 21 points. The other part addresses specific skills, such as naming and comprehension, with a maximum of nine points. The total score is 30 points, and higher scores indicate greater cognitive performance.[17]

The Geriatric Depression Scale (GDS) was used to evaluate depression in the elderly. The scale is a valid and reliable scale with 15 objective questions, and every question scores one point.[18] Patient scores ranging from 1 to 6 are classified as normal, from 6 to 10 as having mild to moderate depression, and >10 points as presenting with severe depression.

The Lawton–Brody index was used to assess the level of independence of the elderly patients in performing instrumental activities, such as using the telephone, shopping, preparing food, cleaning the house, washing clothes, using transportation, preparing medications, and managing money. For women, a final score of 8 points is considered independent, and those presenting smaller scores suggested a dependency that can be classified as mild, moderate, or severe. The score ranges from 0 to 5 points for men, with a higher score representing total independence. The score is differentiated for men because they usually do not perform domestic activities.[19]

The nutritional status of the elderly was assessed using the Mini Nutritional Assessment Instrument Short-Form (MNA-SF), a reliable tool for assessing malnutrition in all geriatric settings. The score is based on objective parameters, such as body mass index and calf circumference, as well as subjective parameters that include appetite, mobility, and psychological status. The final score ranges from 0 to 14 points, with a score ≤7 indicating overt malnutrition, between 8 and 11 indicating a high risk of malnutrition, and a score between 12 and 14 suggesting good nutritional status.[20]

2.3. Statistical Analysis

The parametric distribution of the data was evaluated using the Shapiro-Wilk test. Quantitative variables were expressed as medians and interquartile ranges (25–75%). Categorical variables are presented as the total number of patients and percentages. The sample size was calculated based on previous data from hospitalized elderly patients[9] and in community-dwelling older people.[21] This calculation was done in order to detect a difference of 7% in the prevalence of sarcopenia between the groups, in order to yield an 80% power and an alpha ≤5%. A sample size of 156 patients (78 per group) was determined. The comparison between hospitalized and healthy elderly individuals and between sarcopenic and non-sarcopenic groups was performed using the Mann–Whitney U test. The chi-square test was used for categorical variables. Following the initial comparisons, three logistic regression models were performed with sarcopenia-dependent variables as the input method. In the first model, only the variables with p <0.05 in the comparison between hospitalized and control elderly were inserted. A second model was utilized for only the hospitalized elderly, in which only the variables with p <0.05 in the comparisons between sarcopenic and non-sarcopenic patients were inserted. The third model was used for all the elderly, along with all of the independent variables from the comparison between sarcopenic and non-sarcopenic individuals. The variables that were entered could be removed or inserted to better fit in the model. The significance level was set at 5% (p <0.05), and statistical analyses were performed using the statistical program SPSS 17.0 (SPSS Inc., Chicago, IL, USA).

3. RESULTS

A total of 78 hospitalized elderly patients underwent evaluation close to hospital discharge. Five patients were transferred to the ICU after evaluation, three died, and nine patients were transferred to other hospitals for specialized medical care. A total of 61 hospitalized elderly patients and 61 controls were included. Hospitalized elderly patients remained, on average, in-hospital stay for 10 days (from 5 to 16 days), and no difference was observed between sarcopenic and non-sarcopenic individuals (11 days (from 5 to 18 days) and 10 days (from 5 to 13 days), respectively). The main causes of hospitalization were cardiac (34%), respiratory (23%), and renal diseases (18%).

The general characteristics of the hospitalized and control elderly patients are described in Table 1. There was no difference in age, sex, and BMI between the control and hospitalized elderly patients. A higher prevalence of sarcopenia was observed in the hospitalized elderly (38%) than in the control group (11%) (p <0.05). There was a difference in age

Table 1. General characteristics of hospitalized and controls elderly

Outcome	Hospitalized elderly			Controls elderly		
	Total (n=61)	Non-sarcopenic (n=38)	Sarcopenic (n=23)	Total (n=61)	Non–sarcopenic (n=54)	Sarcopenic (n=7)
Age, yr	74.0 (68.0-78.0)	72.0 (67.0-77.0)	77.0 (70.0-82.0)#	71.0 (67.0-76.0)	70.5 (67.0-74.0)	78.0 (71.0-88.0)#
Sex, male, n (%)	25.0 (41.0)	16.0 (42.1)	9.0 (39.1)	19.0 (31.1)	17.0 (31.5)	2.0 (28.6)
Body mass index, kg/m^2	25.9 (23.0-29.0)	27.1 (24.2-29.5)	24.2 (22.1-26.8)#	27.5 (24.2-30.8)	28.1 (24.7-31.1)	25.1 (21.6-26.4)#
Individual income, thousand annual dollars	2.1 (1.9–2.9)*	2.2 (1.9-3.2)	1.9 (1.9–2.2)	3.3 (2.1-5.4)	3.6 (2.1-6.2)	2.2 (1.9-3.3)
Family income, annual dollars	3.6 (1.9-6.0)*	3.9 (2.0-6.1)	3.0 (1.9-5.7)	5.6 (4.0-9.0)	5.6 (4.2-9.6)	4.5 (4.2-6.3)
Civil status, n (%)						
Single	7.0 (11.4)	5.0 (13.2)	2.0 (8.7)	7.0 (11.4)	6.0 (11.1)	1.0 (14.3)
Married	23.0 (37.7)*	13.0 (34.2)	10.0 (43.5)	42.0 (68.8)	37.0 (68.5)	5.0 (71.4)
Widower	21.0 (34.4)*	12.0 (31.6)	9.0 (39.1)	8.0 (13.1)	8.0 (14.8)	0.0 (0.00)
Divorced	10.0 (16.3)	8.0 (21.1)	2.0 (8.7)	4.0 (6.5)	3.0 (5.6)	1.0 (14.3)
Years of study, n (%)						
0-4 years	44.0 (72.1)*	24.0 (63.2)	20.0 (86.9)*	20.0 (32.8)	16.0 (29.6)	4.0 (57.2)
5-8 years	9.0 (14.8)	7.0 (18.4)	2.0 (8.7)	8.0 (13.1)	7.0 (13.0)	1.0 (14.3)
≥9 years	8.0 (13.1)*	7.0 (18.4)	1.0 (4.3)	33.0 (54.1)	31.0 (57.4)	2.0 (28.6)
Charlson comorbidity index	5.0 (4.0-6.0)	5.0 (4.0-6.0)	5.0 (4.0-6.0)	3.0 (3.0-5.0)	3.0 (3.0-5.0)	4.0 (3.0-5.0)
Comorbidities						
SAH	44.0 (72.1)	27.0 (71.1)	17.0 (73.9)	36.0 (59.0)	33.0 (61.1)	3.0 (42.9)
Diabetes mellitus	30.0 (49.2)*	17.0 (44.7)	13.0 (56.5)	15.0 (24.6)	14.0 (25.9)	1.0 (14.3)
COPD	8.0 (13.1)	4.0 (10.5)	4.0 (17.4)	4.0 (6.6)	4.0 (7.4)	0.0 (0.0)
Chronic heart failure	14.0 (22.9)	8.0 (21.0)	6.0 (26.0)	9.0 (14.7)	8.0 (14.8)	1.0 (14.3)
Dyslipidemia	12.0 (19.1)	8.0 (21.1)	4.0 (17.4)	8.0 (13.1)	6.0 (11.1)	2.0 (28.6)
Drug	3.0 (2.0-6.0)	4.0 (1.0-6.0)	3.0 (2.0-5.0)	2.0 (1.0-4.5)	2.0 (1.0-5.0)	2.0 (0.0-3.0)
Hospitalization (last year), n (%)	13.0 (21.3)	8.0 (21.1)	5.0 (21.7)	9.0 (14.7)	9.0 (16.7)	0.0 (0.0)
Falls (last year), n (%)	21.0 (34.4)	13.0 (34.2)	8.0 (34.8)	15.0 (24.6)	13.0 (24.1)	2.0 (28.6)
Smoking, n (%)						
No	38.0 (62.2)	22.0 (57.9)	16.0 (69.6)	44.0 (72.1)	38.0 (70.0)	6.0 (85.7)
Yes	6.0 (9.8)	5.0 (13.2)	1.0 (4.3)	4.0 (6.5)	4.0 (7.4)	0.0 (0)
Ex-smokers	17.0 (27.8)	11.0 (28.9)	6.0 (26.1)	13.0 (21.3)	12.0 (22.2)	1.0 (14.3)
Alcohol consumption, weekly n (%)						
No	51 (83.6)	31.0 (81.6)	20.0 (87.7)	52.0 (85.2)	45.0 (83.3)	7.0 (100.0)
One day	8.0 (13.1)	6.0 (15.8)	2.0 (8.7)	8.0 (13.1)	8.0 (14.8)	0.0 (0.0)
Two to six times	1 (1.6)	0 (0.0)	1.0 (4.3)	0 (0.0)	0 (0.0)	0 (0.0)
Every day	1 (1.6)	1.0 (2.6)	0 (0.0)	1 (1.6)	1.0 (1.9)	0 (0.0)

Quantitative data are presented as median (25-75th percentile) and qualitative data such as number subjects (percentage). SAH, systemic artery hypertension; COPD, chronic obstructive pulmonary disease. Drug=quantity of drugs prescribed by physicians and used continuously at home. Charlson comorbidity índex=Age adjusted Charlson Co-morbidity Index. *p <0.05 compared between the total of each group. *p <0.05 compared between sarcopenic and non-sarcopenic in each group.

Table 2. Functionality, cognitive, nutritional status and muscular strength of the hospitalized and controls elderly

Outcome	Hospitalized elderly			Controls elderly		
	Total (n=61)	Non-sarcopenic (n=38)	Sarcopenic (n=23)	Total (n=61)	Non–sarcopenic (n=54)	Sarcopenic (n=7)
Barthel Index	100.0 (95.0-100.0)*	100.0 (98.0-100.0)	98.0 (86.0-100.0)#	100.0 (100.0-100.0)	100.0 (100.0-100.0)	100.0 (100.0-100.0)
Lawton–Brody index	5.0 (3.0-7.0)*	5.0 (4.0-7.0)	4.0 (2.0-7.0)	8.0 (5.0-8.0)	8.0 (5.0-8.0)	7.0 (5.0-8.0)
Geriatric Depression Scale	2.0 (1.0–4.0)	2.0 (1.0-4.2)	3.0 (1.0-4.0)	1.0 (0.0–3.0)	1.0 (0.0-3.2)	2.0 (1.0-3.0)
Mini mental state examination	22.0 (17.5-26.0)*	24.0 (20.0-28.0)	18.0 (16.0-22.0)#	27.0 (25.0–29.0)	27.0 (25.0-29.0)	25.0 (17.0-26.0)#
MNA-SF	9.0 (8.0 -11.0)*	10.0 (8.0-11.2)	9.0 (6.0-11.0)	13.0 (11.5-14.0)	13.0 (12.0-14.0)	12.0 (10.0-14.0)
Handgrip strength, Kgf	21.0 (16.5-25.5)*	23.5 (18.0-28.0)	18.0 (13.0-23.0)#	23.5 (20.0-31.0)	23.5 (20.3-32.0)	24.0 (14.0-29.0)
Men	26.0 (21.0-32.0)*	29.0 (22.0-34.2)	23.0 (20.5-27.5)#	35.0 (31.0-40.0)	35.0 (31.0-40.5)	27.0 (25.0-27.0)#
Women	19.0 (13.5-23.75)*	20.7 (17.5-24.2)	14.5 (12.0-19.0)#	21.7 (19.7-30.8)	22.0 (20.0-25.0)	18.0 (14.0-26.5)#
4-Meter Gait Speed Test, m/s	0.6 (0.4-0.8)*	0.7 (0.5-0.8)	0.5 (0.3-0.6)#	1.0 (0.8-1.2)	1.0 (0.9-1.2)	0.6 (0.6-1.0)#
Skeletal Muscle Index, Kg/m^2	7.5 (6.2-9.1)*	8.2 (7.0-10.1)	6.2 (5.7-7.9)#	8.3 (7.5-9.4)	8.3 (7.8-9.5)	6.0 (5.9-7.8)#
Men	8.7 (8.1-10.1)*	9.7 (8.5-10.7)	7.9 (7.5-8.3)#	10.1 (8.2-10.7)	10.2 (9.1-10.8)	7.9 (7.8-7.9)#
Women	6.7 (5.8-7.4)*	7.0 (6.8-7.9)	5.8 (5.3-6.1)#	7.9 (6.56-8.4)	8.1 (7.3-8.5)	6.0 (5.8-6.0)#

Quantitative data are presented as median (25-75th percentile). MNA-SF=Mini Nutritional Assessment Instrument-Short Form. *p <0.05 compared between the total of each group. #p <0.05 compared between sarcopenic and non-sarcopenic in each group.

between hospitalized sarcopenic and non-sarcopenic patients (77 (70–82) years versus 72 (67–77) years, respectively) and between the sarcopenic and non-sarcopenic controls (78 (71–88) years and 70 (67–74) years, respectively) (p <0.05). BMIs were lower in sarcopenic controls and hospitalized patients when compared to non-sarcopenic controls in each group (p <0.05). The Charlson comorbidity index scores were not different between the hospitalized and control groups, but only the prevalence of diabetes mellitus was higher in the hospitalized elderly patients (p <0.05). The hospitalized elderly patients had fewer years of schooling and included a higher prevalence of widowers compared to controls (p <0.05).

The functionality, cognitive and nutritional status, and muscular strength of the hospitalized and control individuals are described in Table 2. The total Barthel Index, Lawton–Brody index, MMSE, and MNA-SF scores were lower for hospitalized patients than for controls (p <0.05). In addition, the scores obtained in the MMSE were lower in both hospitalized and control sarcopenic patients compared to non-sarcopenic individuals (p <0.05).

In all three logistic regression models, the independent risk factor for sarcopenia was lower scores in the MMSE (Table 3). BMIs were also associated with sarcopenia in the third model (p <0.05).

4. DISCUSSION

The present study showed that the prevalence of sarcopenia was three times higher in hospitalized elderly patients than in healthy controls. In addition, hospitalized elderly individuals had a significant reduction in functionality, muscle strength, and mental and nutritional status compared to the elderly controls. MMSE scores and BMIs were associated with the presence of sarcopenia in hospitalized and healthy elderly individuals. To the best of our knowledge, this is the first study to compare hospitalized and community-dwelling non-hospitalized sarcopenia elderly simultaneously.

Despite the recent increase in the interest in sarcopenia, information about its prevalence in hospitalized elderly patients remains poorly understood.[3,4,6-8,22] A study evaluating 103 older adults admitted to geriatric medicine wards presenting with a higher risk of malnutrition demonstrated a prevalence of sarcopenia of approximately 21.4%.[6] Gariballa and Alessa observed sarcopenia in 10% of elderly individuals aged >65 years.[7] In another study with hospitalized elderly individuals, the prevalence was close to 22%.[9] In our study, the prevalence was almost twice (38%) that observed by Martinez et al.[9] and other authors,[6] and this can have occurred for several reasons. First, the assessments of sarcopenia in these studies were exclusively based on handgrip strength and mid-arm muscle circumference[7] or predictive equations.[9] Second, 22.3% of the recruited patients were unable to perform both the gait speed test and handgrip measurements.[6] Third, in the period of hospitalization in which the evaluations took place (72 hours post-admission), it was often not

Table 3. Logistic regression analysis of factors associated with sarcopenia

	Exp (B)	Wald	*p*	95% CI for EXP (B)	
Model 1					
Individual income	1.000	0.025	0.873	1.000	1.000
Barthel index	0.817	2.340	0.126	0.630	1.059
Lawton–Brody index	1.237	1.736	0.188	0.902	1.697
Mini mental state examination	0.767	13.932	0.001*	0.667	0.882
MNA-SF	0.858	1.776	0.183	0.684	1.075
Diabetes mellitus	1.176	0.082	0.775	0.388	3.564
0-4 years of study	2.054	1.189	0.276	0.563	7.489
Married	1.695	0.821	0.365	0.541	5.309
Constant	1608336.1	4.741	0.029		
Model 2					
Age	1.018	0.111	0.739	0.918	1.128
Barthel Index	0.872	1.746	0.186	0.711	1.069
Mini mental state examination	0.809	6.525	0.011*	0.687	0.952
0-4 years of study	2.574	1.158	0.282	0.460	14.411
Body mass index	0.855	3.342	0.068	0.723	1.011
Constant	272079.6	2.695	0.101		
Model 3					
Age	1.049	1.020	0.313	0.956	1.151
Body mass index	0.830	6.835	0.009*	0.721	0.954
Individual income	1.000	0.160	0.690	0.999	1.000
Charlson comorbidity index	0.785	3.488	0.062	0.609	1.012
Barthel Index	0.955	0.037	0.847	0.595	1.531
Lawton–Brody index	1.253	1.724	0.189	0.895	1.756
Mini mental state examination	0.792	8.504	0.004*	0.677	0.926
0-4 years of study	1.540	0.407	0.523	0.409	5.800
Constant	9372504.975	4.175	0.041		

MNA-SF=Mini Nutritional Assessment Instrument-Short Form. First model: only the variables with p <0.05 of the comparison between hospitalized and controls elderly were inserted. Second regression model: only the variables with p <0.05 in the comparisons between hospitalized sarcopenic and non-sarcopenic. A third model: was performed with all the elderly with p <0.05 in the comparisons between sarcopenic and non-sarcopenic.

possible to perform the gait speed test due to the patient's clinical conditions.[6,9] Our results are similar to those obtained in a large multicenter Italian study in 12 inpatient units (n=770 patients) that used the same criteria for assessing sarcopenia, which found a prevalence close to 35% in the patients evaluated.[3] These different methodologies could have led to an underestimation of the condition.

Another factor that can change the prevalence of sarcopenia is the characteristics of the studied population. In this study, the control group had a lower prevalence of sarcopenia (11%) than those hospitalized. It is plausible to state that the small number of elderly people in the study would not be representative of the Brazilian population. However, even with a smaller number of elderly individuals evaluated in comparison to other studies, our values are close to those obtained (15%) in another large Brazilian study of community-dwelling older adults.[21] A study by Patel et al.[23] that applied the EWGSOP criteria found a prevalence of sarcopenia of 7.8% in a sample of 1787 community-dwelling older persons. In another large European study, the InCHIANTI study,[24] the prevalence was 10.2% in the evaluated population. In addition, we initially calculated the sample size needed to detect differences between the elderly, and a much smaller number of evaluations compared to other studies were found to be necessary. This reinforces the importance of the findings that are in agreement with the results obtained by other authors.[21,23,24]

These differences in the prevalence of sarcopenia between hospitalized and control elderly individuals may have occurred due to several factors. First, although the control group had the same anthropometric and gender characteristics as those hospitalized, other characteristics not evaluated in the study such as malnutrition, bed rest or sedentary lifestyles, inflammation, endocrine disorders, and certain drug treatments can contribute to sarcopenia.[25] Second, it is possible that elderly sarcopenic individuals are more susceptible to hospitalization than non-sarcopenic individuals. Results from the Health ABC Study showed that low muscle mass, low muscle density, muscle weakness, and impaired physical function increased the risk of requiring hospital admission.[26] Legrand et al.[27] recently argued that, in people aged 80 years and older, physical performance and muscle strength are strong predictors of hospitalization, independently of comorbidity. Third, our evaluations were carried out close to hospital discharge. Hospitalizations frequently result in the appearance of a new disability, failure to recover from the prehospitalization functional loss, or even a continued functional decline. Furthermore, hospital-related functional decline is associated with a wide range of negative outcomes such as institutionalization and severe limitations to functional independence.[5] Finally, several initial characteristics such as income, years of schooling, diabetes, and marital status, as well as other functional

characteristics such as basic and instrumental activities of daily living and nutritional and cognitive status, presented different values between hospitalized elderly and controls. However, only MMSE and BMIs were associated with sarcopenia in elderly people.

Sarcopenia was found to be associated with cognitive impairment in both cross-sectional[28] and longitudinal studies.[29] Skeletal muscle is known to secrete neurotrophic factors that affect brain function and motor units in skeletal muscle.[30] The central nervous system plays a crucial role in maintaining muscle integrity in older people.[31] Several age-related changes in the nervous system, including downregulated dopaminergic neurotransmission and inherent decline of the supraspinal drive, inflammation, and remodeling of the neuromuscular junction, may affect musculoskeletal activity.[32] These processes further compromise the ability of muscles to generate strength and endurance, which leads to gait and balance disorders, reductions in psychomotor activity, slowness in activities that involve dual tasks (cognitive and physical), and impaired motor control.[33,34] The results of our study are consistent with previous findings of factors associated with sarcopenia. Hsu et al.[35] and Alexandre et al.[21] showed that cognitive impairment was an independent risk factor in multivariate analyses adjusted for potential confounders, including age, sex, nutritional status, and physical function. Despite these results, the transversal nature of the current study does not allow for inference of the cause-and-effect relationship between cognitive decline and sarcopenia. Therefore, treatment and prophylaxis for cognitive decline should be designed to prevent the development of sarcopenia or vice versa.

In the regression analysis, BMI was an independent factor that was associated with sarcopenia; on the other hand, age and Barthel index and Charlson comorbidity index scores, among others, were not in agreement with previous studies.[8,36] One possible explanation for BMI being associated with sarcopenia could be an insufficient provision of protein and energy, leading to a loss of fat-free mass or muscle. Undernutrition is a powerful risk factor for sarcopenia[37] and might explain the increased prevalence of sarcopenia in patients with lower BMIs. Although sarcopenia often coexists with an elevated BMI, a condition referred to as sarcopenic obesity, it has been demonstrated that compared to normal-weight individuals, obese individuals have greater thigh muscle volume, an increased cross-sectional area of type I skeletal muscle fibers, and increased muscle lipid content.[38]

This study has some limitations to be considered. First, the cross-sectional design of the study did not allow us to clarify any temporal or causal relationships between sarcopenia and its associated factors. On the other hand, the inclusion of the control group allowed for the assessment of a higher prevalence of sarcopenia in elderly hospitalized patients, since the control group came from the same population as the cases and had the same anthropometric characteristics such as age and BMI. Second, the participants' acute conditions, often related to momentary functional impairments, could have contributed to an overestimation of the diagnosis of sarcopenia in our sample. In order to minimize these effects, all evaluations were performed at the end of hospitalization. Third, the use of BIA with a frequency of 50Hz for muscle mass assessment presents some drawbacks, mainly due to the hydration problems usually observed in older and hospitalized people, possibly resulting in underestimations of body fat and overestimations of fat-free mass. For this reason, we did not carry out evaluations with bioimpedance at the beginning of hospitalization, due to the fact that at hospital discharge, peripheral edema was almost completely resolved. On the other hand, BIA is inexpensive and is considered valid, reliable, and feasible for community-dwelling older people.[39] and also used in other large study of sarcopenia in hospitalized elderly.[8] BIA appears potentially capable to estimate muscle mass in different clinical disorders.[40] As in most hospitals, more elaborate body composition measurements were not available; BIA can be considered a good alternative if its limitations are kept in mind. Finally, it is possible that the small number of elderly in our sample may increase the chance of error type II. However, other studies have found a prevalence of sarcopenia close to that obtained by us in hospitalized[3] and community elderly.[24] In addition, we calculated the sample size to reduce this bias. Another aspect that the small sample size may influence is the instability of the logistic regression model when the number of events per variable is less than 10. Despite this, we use more than one regression model to confirm our findings.[40]

5. CONCLUSION

Sarcopenia had a high prevalence in elderly patients that are hospitalized. Considering the growing population of older adults with multiple comorbidities, more research is needed to identify sarcopenia and develop interventions that are directed at attenuating or reversing muscle loss at this stage. In addition, cognitive impairments and BMIs can be independent explanatory variables associated with sarcopenia.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.
This study was not supported by grants.

REFERENCES

1. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. European Working Group on Sarcopenia in Older People Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. *Age Ageing.* 2010;**39**(4):412-23.
2. Cruz-Jentoft AJ, Landi F, Schneider SM, Zúñiga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). *Age Ageing.* 2014;**43**(6):748-59.
3. Bianchi L, Abete P, Bellelli G, Bo M, Cherubini A, Corica F, et al. GLISTEN Group Investigators. Prevalence and Clinical Correlates of Sarcopenia, Identified According to the EWGSOP Definition and Diagnostic Algorithm, in Hospitalized Older People: The GLISTEN Study. *J Gerontol A Biol Sci Med Sci.* 2017;**72**(11):1575-81.
4. Martone AM, Bianchi L, Abete P, Bellelli G, Bo M, Cherubini A, et al. The incidence of sarcopenia among hospitalized older patients: results from the Glisten study. *J Cachexia Sarcopenia Muscle.* 2017;**8**:907–914.
5. Zisberg A, Shadmi E, Gur-Yaish N, Tonkikh O, Sinoff G. Hospital-associated functional decline: the role of hospitalization processes beyond individual risk factors. *J Am Geriatr Soc.* 2015;**63**(1):55-62.
6. Cerri AP, Bellelli G, Mazzone A, Pittella F, Landi F, Zambon A, et al. Sarcopenia and malnutrition in acutely ill hospitalized elderly: Prevalence and outcomes. *Clin Nutr.* 2015;**34**(4):745-51.
7. Gariballa S, Alessa A. Sarcopenia: prevalence and prognostic significance in hospitalized patients. *Clin Nutr.* 2013;**32**(5):772-6.
8. Vetrano DL, Landi F, Volpato S, Corsonello A, Meloni E, Bernabei R, et al. Association of sarcopenia with short- and long-term mortality in older adults admitted to acute care wards: results from the CRIME study. *J Gerontol A Biol Sci Med Sci.* 2014;**69**(9):1154-61.
9. Martinez BP, Batista AK, Gomes IB, Olivieri FM, Camelier FW, Camelier AA. Frequency of sarcopenia and associated factors among hospitalized elderly patients. *BMC Musculoskelet Disord.* 2015;**16**:108.
10. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Writing Group for the European Working Group on Sarcopenia in Older People 2 (EWGSOP2), and the Extended Group for EWGSOP2. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing.* 2019;**48**(1):16-31.
11. Lukaski HC, Johnson PE, Bolonchuk WW, Lykken GI. Assessment of fat-free mass using bioelectrical impedance measurements of the human body. *Am J Clin Nutr.* 1985;**41**(4):810-7.
12. Janssen I, Baumgartner RN, Ross R, Rosenberg IH, Roubenoff R. Skeletal muscle cutpoints associated with elevated physical disability risk in older men and women. *Am J Epidemiol.* 2004;**159**(4):413-21.
13. Charlson ME, Pompei P, Ales KL, MacKenzie R. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;**40**:373-83.
14. Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. *J Clin Epidemiol.* 1994;**47**(11):1245-51.
15. Mahoney FI, Barthel DW: Functional Evaluation: The Barhel Index. *Md State Med J.* 1965;**14**:61–5.
16. Minosso JSM , Amendola F, Alvarenga MRM , Oliveira MAC. Validation of the Barthel Index in elderly patients attended in outpatient clinics, in Brazil. *Acta Paul Enferm.* 2010;**23**(2):218-23.
17. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res.* 1975;**12**(3):189-98.
18. Almeida OP, Almeida SA. Short versions of the geriatric depression scale: a study of their validity for the diagnosis of a major depressive episode according to ICD-10 and DSM-IV. *Int J Geriatr Psychiatry.* 1999;**14**(10):858-65.
19. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. *Gerontologist.* 1969;**9**(3):179-86.
20. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. *J Nutr Health Aging.* 2009;**13**(9):782-8.
21. Alexandre T da S, Duarte YA, Santos JL, Wong R, Lebrão ML.Prevalence and associated factors of sarcopenia among elderly in Brazil: findings from the SABE study. *J Nutr Health Aging.* 2014;**18**(3):284-90.
22 Bertschi D, Kiss CM, Beerli N, Kressig RW. Sarcopenia in hospitalized geriatric patients: insights into prevalence and associated parameters using new EWGSOP2 guidelines. *Eur J Clin Nutr.* 2021;**75**(4):653-60.
23. Patel HP, Syddall HE, Jameson K, Robinson S, Denison H, Roberts HC,et al. Prevalence of sarcopenia in community-dwelling older people in 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):378-84.
24. Bianchi L, Ferrucci L, Cherubini A, Maggio M, Bandinelli S, Savino E, et al. The predictive value of the EWGSOP definition of sarcopenia: results from the InCHIANTI study. *J Gerontol A Biol Sci Med Sci.* 2016;**71**:259–64.
25. Muscaritoli M, Anker SD, Argilés J, Aversa Z, Bauer JM, Biolo G, et al. Consensus definition of sarcopenia, cachexia and pre-cachexia: joint document elaborated by Special Interest Groups (SIG) "cachexia-anorexia in chronic wasting diseases" and "nutrition in geriatrics". *Clin Nutr.* 2010;**29**:154–9.
26. Cawthon PM, Fox KM, Gandra SR, Delmonico MJ, Chiou CF, Anthony MS, et al. Health, Aging and Body Composition Study. Do muscle mass, muscle density, strength and physical function similarly influence risk of hospitalization in older adults? *J Am Geriatr Soc.* 2009;**57**:1411–9.
27. Legrand D, Vaes B, Mathei C. Muscle strength and physical performance as predictors of mortality, hospitalization, and disability in the oldest old. *J Am Geriatr Soc.* 2014;**62**:1030–8.
28. Chang KV, Hsu TH, Wu WT, Huang KC, Han DS. Association Between Sarcopenia and Cognitive Impairment: A Systematic Review and Meta-Analysis. *J Am Med Dir Assoc.* 2016;**17**(12):1164.e7-15.
29. Nishiguchi S, Yamada M, Shirooka H, Nozaki Y, Fukutani N, et al. Sarcopenia as a Risk Factor for Cognitive Deterioration in Community-Dwelling Older Adults: A 1-Year Prospective Study. *J Am Med Dir Assoc.* 2016;**17**(4):372.e5-8.
30. Pasco JA, Williams LJ, Jacka FN, Stupka N, Brennan-Olsen SL, et al. Sarcopenia and the Common Mental Disorders: A Potential Regulatory Role of Skeletal Muscle on Brain Function? *Curr Osteoporos Rep.* 2015;**13**(5):351-7.
31. Lauretani F, Meschi T, Ticinesi A, Maggio M. "Brain-muscle loop" in the fragility of older persons: From pathophysiology to new organizing models. *Aging Clin Exp Res.* 2017;**29**:1305–11.
32. Kwon YN, Yoon SS. Sarcopenia: Neurological Point of View. *J Bone Metab.* 2017;**24**(2):83-9.
33. Nybo L, Rasmussen P. Inadequate cerebral oxygen delivery and central fatigue during strenuous exercise. *Exerc Sport Sci Ver.* 2007;**35**(3):110-8.

34. Schwendner KI, Mikesky AE, Holt WS Jr, Peacock M, Burr DB. Differences in muscle endurance and recovery between fallers and nonfallers, and between young and older women. *J Gerontol A Biol Sci Med Sci*. 1997;**52**(3):M155-60.

35. Hsu YH, Liang CK, Chou MY, Liao MC, Lin YT, Chen LK, et al. Association of cognitive impairment, depressive symptoms and sarcopenia among healthy older men in the veterans retirement community in southern Taiwan: a cross-sectional study. *Geriatr Gerontol Int*. 2014;**14**(Suppl 1):102–8.

36. Volpato S, Bianchi L, Cherubini A, Landi F, Maggio M, Savino E, et al. Prevalence and clinical correlates of sarcopenia in community-dwelling older people: application of the EWGSOP definition and diagnostic algorithm. *J Gerontol A Biol Sci Med Sci*. 2014;**69**:438–46.

37. Mithal A, Bonjour JP, Boonen S, Burckhardt P, Degens H, El Hajj Fuleihan G, et al. Impact of nutrition on muscle mass, strength, and performance in older adults. *Osteoporos Int*. 2013;**24**(5):1555-66.

38. Choi SJ, Files DC, Zhang T, Wang ZM, Messi ML, Gregory H, et al. Intramyocellular lipid and impaired myofiber contraction in normal weight and obese older adults. *J Gerontol A Biol Sci Med Sci*. 2016;**71**(4):557–64.

39. Mijnarends DM, Meijers JM, Halfens RJ, ter Borg S, Luiking YC, Verlaan S, et al. Validity and reliability of tools to measure muscle mass, strength, and physical performance in community-dwelling older people: A systematic review. *J Am Med Dir Assoc*. 2013;**14**(3):170-8.

40. Bosaeus I, Wilcox G, Rothenberg E, Strauss BJ. Skeletal muscle mass in hospitalized elderly patients: comparison of measurements by single-frequency BIA and DXA. *Clin Nutr*. 2014;**33**(3):426-31.

41. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. *J Clin Epidemiol*. 1996;**49**(12):1373-9.