European Journal of Clinical Nutrition (2016) 70, 1046–1051

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ORIGINAL ARTICLE

Financial impact of sarcopenia on hospitalization costs

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BACKGROUND/OBJECTIVES: This study aims to increase knowledge regarding the association of sarcopenia with hospitalization costs among a wide-ranging sample of adult hospitalized patients.
SUBJECTS/METHODS: A prospective study was conducted among hospitalized adult patients. Sarcopenia was identified according to the European Working Group on Sarcopenia in Older People, as low muscle mass, assessed by bioelectrical impedance analysis and low muscle function evaluated by handgrip strength. Hospitalization cost was calculated for each patient based on discharge diagnosis-related group codes and determined on the basis of a relative weight value. Costs were defined as the percentage of deviation from the cost of a patient with a relative weight equal to one. Multivariable linear regression models were performed to identify the factors independently associated with hospitalization costs.
RESULTS: A total of 656 hospitalized patients aged ⩾18 years (24.2% sarcopenic) composed the study sample. Sarcopenia increased hospitalization costs by €1240 (95% confidence interval (CI): €596–1887) for patients aged <65 years and €721 (95% CI: €13–1429) for patients aged ⩾65 years. Sarcopenic overweight was related to an increase in hospitalization costs of €884 (95% CI: €295–1476).
CONCLUSIONS: Sarcopenia is independently related to hospitalization costs. This condition is estimated to increase hospitalization costs by 58.5% for patients aged <65 years and 34% for patients aged ⩾65 years.

European Journal of Clinical Nutrition (2016) 70, 1046–1051; doi:10.1038/ejcn.2016.73; published online 11 May 2016

INTRODUCTION

Sarcopenia is currently defined as a combination of both low muscle mass and low muscle function, according to the European Working Group on Sarcopenia in Older People (EWGSOP).[1]

It is estimated that sarcopenia occurs between 5 and 45% of community-dwelling older adults.[2–4] Although this condition has been mainly described in older adults, it can also be present in younger individuals. Cherin *et al.*[5] in a study conducted among community-dwelling adults showed that 9% of the individuals aged between 45 and 54 years and 13.5% of those aged from 55 to 64 years were sarcopenic. Previous studies have shown that this condition is highly frequent among hospitalized older patients,[6–10] ranging from 10 to 37.3%, and was identified in circa one-fifth of patients aged under 65 years.[9]

This condition has been associated with physical disability, low quality of life and higher mortality in community-dwelling older adults.[1,11] Among hospitalized patients, sarcopenia has been related with poor clinical outcome, namely worse postoperative outcomes,[12–15] higher risk of non-elective readmission[6] and higher mortality.[6,8,16]

Although sarcopenia differs from undernutrition, both of these conditions can cause muscle mass and/or strength loss.[1] The main difference between these two conditions is that undernutrition, especially because of starvation, generally reacts to nutrition support, whereas sarcopenia can be refractory to nutritional intervention.[17]

Considering the impact of sarcopenia on both community-dwelling and hospitalized individuals, health-care costs of this condition are expected to be high.[18] However, according to our knowledge, data on the economic burden of sarcopenia are limited. One study from 2004,[19] conducted among representative samples of American adults aged ⩾60 years, reported that the estimated health-care cost attributable to sarcopenia defined as the loss of muscle mass was $18.5 billion ($10.8 billion in men, $7.7 billion in women). Recent studies from 2013[20] and 2015[21,22] reported that sarcopenia determined by computed tomography scans was associated with increased costs in major surgery. Nevertheless, the impact of sarcopenia on hospitalization costs among a wider variety of patients, from surgical and medical wards, remains to be documented.

Considering the adverse consequences sarcopenia entails among hospitalized patients and the financial constraints that health-care systems often face, it is important to recognize and explore the association of sarcopenia with hospitalization costs, to maximize resources and provide a more effective health-care plan.

Therefore, the present study aims to increase the knowledge on the association of sarcopenia with costs among a wide-ranging sample of adult hospitalized patients.

MATERIALS AND METHODS

Study sample and design

A prospective study was conducted between July 2011 and December 2014 in Hospital de Santo António, Centro Hospitalar do Porto, Porto, which is a general and university hospital. A consecutive sampling method was applied in medical and surgical wards. Patients were eligible to participate in the study if they were aged 18 years and older, Caucasian, with an expected hospital stay longer than 24 h, conscious, cooperative and capable of providing written informed consent.

Patients unable to perform the handgrip strength (HGS) technique were excluded from the study. This impossibility in carrying out HGS

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Received 6 October 2015; revised 14 March 2016; accepted 10 April 2016; published online 11 May 2016

measurement was defined as an inability to understand verbal instructions or having a condition limiting HGS measurement (namely pain). Critically ill patients, that is, with a life-threatening medical or surgical condition requiring intensive care unit-level care, presenting severe organ system dysfunction and needing for active therapeutic support were excluded.[23] Pregnancy and patient ward isolation were also defined as exclusion criteria.

According to these criteria, patients admitted to neurology, clinical hematology and intensive care unit wards were not recruited, whereas participants from the following departments were selected: angiology and vascular surgery, cardiology, digestive surgery, endocrinology, gastroenterology, hepatobiliary surgery, internal medicine, nephrology, non-digestive surgery, orthopedics, otorhinolaryngology and urology. Therefore, from the daily list of inpatients admitted to each of these wards, those who fulfilled inclusion criteria were invited to participate in the study, until the number of patients had attained the total number of beds of the ward.

From 992 patients who fulfilled the inclusion criteria and were invited to participate, 336 (33.9%) were not included. The reasons were refusals ($n = 198$), cognitive impairment ($n = 13$) and missing data ($n = 125$).

Ethics

This research was conducted according to the recommendations established by the Declaration of Helsinki and approved by the Institutional ethics and review boards of Centro Hospitalar do Porto. All study participants provided written informed consent.

Data collection

Demographical and clinical data, medical diagnoses, and data of hospital admission were retrieved from patient's clinical file at the time of evaluation. Date of hospital discharge and discharge diagnosis were retrieved from hospital records after the patient had left the hospital. All other information was obtained by two trained registered nutritionists through a structured questionnaire within 72 h of admission to the hospital.

Education was evaluated by the number of completed school years and the following categories were created: 0–4, 5–12 and more than 12 years. Marital status was categorized as single and not single (married or in a civil partnership, divorced and widowed). Cognitive impairment was evaluated with the Abbreviated Mental Test.[24] Independence in activities of daily living was assessed with the Katz index,[25] and two categories were defined according to the score obtained: ⩽5–moderate/severe dependence and 6–independent. The Charlson Disease Severity Index[26] was recorded by two previously trained interviewers using medical discharge diagnoses in the patient's clinical record.

Patient nutritional status was evaluated with Patient-Generated Subjective Global Assessment (PG-SGA).[27] Standing height (cm) was measured with a metal tape (Rosscraft, Innovations Incorporated, Surrey, BC, Canada), with a 0.1 cm resolution and a headboard. Body weight (kg) was assessed with a calibrated portable beam scale with a 0.5 kg resolution. All anthropometric measurements were performed by two previously trained registered nutritionists using standard methods.[28]

Sarcopenia was defined according to the EWGSOP as the presence of both low muscle mass and low muscle function.[1]

Whole-body resistance (ohms) and reactance (ohms) were assessed through tetrapolar bioelectrical impedance analysis using a Biodynamics Model 450 (Seattle, WA, USA) with 0.1 ohm resolution, operating at a single frequency of 50 KHz.

Muscle mass was evaluated using the equation of Janssen *et al.*:[29] $((\text{height}^2/\text{resistance} \times 0.401)+(\text{gender} \times 3.825)+(\text{age} \times -0.071))+5.102$, with height measured in cm; resistance measured in ohms; for gender, men = 1 and women = 0; and age measured in years. Muscle mass was adjusted for height. Gender-specific cutoff points indicated in the EWGSOP consensus were used: less than 10.75 kg/m^2 for men and 6.75 kg/m^2 for women.[1]

Muscle function was evaluated by HGS, using a calibrated Jamar Hydraulic Hand dynamometer (Sammons Preston, Bolingbrook, IL, USA), with 0.1 kgf resolution. The Jamar dynamometer is proposed by the American Society of Hand Therapists as the gold standard for measurements of HGS.[30] Each subject undertook three measurements using the non-dominant hand with a 1-min interval between measurements and the maximum value was selected.[31] Low HGS was classified using the cutoffs proposed in the EWGSOP Consensus:[1] less than 30 kgf for men and 20 kgf for women.

Body mass index was determined through the standard formula (weight (kg)/height^2 (m)), and body mass index categories were created according to the World Health Organization cutoffs.[32]

Statistics

According to the normality of variable distribution, evaluated through the Kolmogorov–Smirnov test, results were described as mean and s.d. or as median and interquartile range (IQR) in case of non-normal distribution. Categorical variables were reported as frequencies.

Hospitalization cost was calculated for each patient based on discharge diagnosis-related group (DRG) codes. The DRG system is used to calculate hospital reimbursements, with the amounts determined on the basis of a relative weight value. This weight value reflects the main diagnosis, surgical interventions, pathologies, complications, clinical procedures, medium length of hospital stay (LOS), age, gender and discharge destination.

The information about DRG codes and its amounts was obtained from Portuguese Ministerial Directive number 839-A, 31 July 2009,[33] for data obtained between 2011 and 2012; number 163, 24 April 2013,[34] was used for data obtained in 2013 and number 20 from 29 January 2014[35] was used for data obtained in 2014. The percentage of cost deviation was calculated from the difference between the cost of each patient and the cost of a patient with a relative weight equal to one (€2396 for data obtained between 2011 and 2012; €2142 for data obtained in 2013; €2120 for data obtained in 2014). Percentage of cost deviation was summarized into quartiles using the cutoffs of the sample distribution: ⩽−35.3 (24.1%); − 35.2, − 1.10 (25.8%); − 1.09, 88.4 (24.5%); ⩾88.5 (25.6%).

LOS was determined from the date of hospital admission and discharge. LOS was also dichotomized according to a cutoff of 7 days based on the median LOS of the entire sample, and in agreement with the median LOS in Portuguese hospitals.[36]

To select variables associated with sarcopenia and with percentage of cost deviation, patients were compared for several demographic and clinical characteristics. All the comparisons were computed using the Mann–Whitney test, or Student's *t* test for independent samples, or the Kruskal–Wallis test for continuous variables and Pearson χ^2 for categorical variables.

Multivariable linear regression models using a forward stepwise method were performed to identify the independent variables associated with the percentage of cost deviation. The following variables were included in the model: sarcopenia status (categorical), age (continuous), gender (categorical), marital status (categorical), the Katz index (categorical), education (categorical), nutrition status (categorical), hospital ward (categorical), LOS (categorical), the Abbreviated Mental Test score (continuous) and the Charlson comorbidity index score (continuous). These variables were included, as they were considered potential confounders.

Statistical significance was set at $P < 0.05$. All analyses were conducted with the Software Package for Social Sciences (SPSS) for Windows (version 20.0; SPSS, Inc., Chicago, IL, USA).

RESULTS

Baseline characteristics of the 656 hospitalized patients enrolled in this study, according to sarcopenia status, are shown in Table 1. Approximately half of the patients were women (46.1%), age ranged between 18 and 90 years, median (IQR) = 56 (22) years. Sarcopenia was highly frequent affecting 24.2% of the participants.

Sarcopenic patients were older and presented longer LOS than non-sarcopenic patients (Table 1). Also, sarcopenic patients were more likely to be male, to be undernourished and to present a higher Charlson index score than non-sarcopenic patients (Table 1). There was a higher proportion of sarcopenic patients in medical wards than in surgical wards (Table 1). The highest proportion of sarcopenic patients (34.3%) was observed in internal medicine wards.

Hospitalization costs within the present sample ranged from €387 to €30 880, median (IQR) of €2369 (€3094). These values are the minimum and the maximum cost per patient observed in this sample, respectively.

Sarcopenic patients presented higher hospitalization costs, median (IQR) = €3151 (€4175), than non-sarcopenic patients,

Table 1. Participants' baseline characteristics according to sarcopenia status

	Non-sarcopenic (n = 497)	*Sarcopenic* (n = 159)	P
Age (years), median (IQR)	54 (24.0)	64 (19.0)	< 0.001[a]
Age categories, n *(%)*			
< 65	368 (74.0)	85 (53.5)	
⩾ 65	129 (26.0)	74 (46.5)	< 0.001[b]
Gender, n *(%)*			
Women	244 (49.1)	58 (36.5)	
Men	253 (50.9)	101 (63.5)	0.006[b]
Education (years), n *(%)*			
0–4	184 (37.0)	81 (50.9)	
5–12	270 (54.3)	64 (40.3)	0.005[b]
> 12	43 (8.7)	14 (8.8)	
Marital status, n *(%)*			
Single	91 (18.3)	25 (15.7)	
Not single	406 (81.7)	134 (84.3)	0.550[b]
AMT, median (IQR)	10.0 (1.0)	10.0 (1.0)	0.455[a]
Charlson Index, median (IQR)	1.0 (2.0)	2.0 (3.0)	0.002[a]
PG-SGA, n *(%)*			
Non-undernourished	299 (60.2)	63 (39.6)	< 0.001[b]
Undernourished	198 (39.8)	96 (60.4)	
Katz index, n *(%)*			
Independent	482 (97.0)	143 (89.9)	0.001[b]
Moderate/severe dependence	15 (3.0)	16 (10.1)	
BMI categories, n *(%)*			
Underweight	11 (2.2)	8 (5.0)	
Normal weight	207 (41.6)	62 (39.0)	0.173[b]
Overweight /obesity	279 (56.1)	89 (56.0)	
Hospital ward, n *(%)*			
Medical	223 (44.9)	96 (60.4)	
Surgical	274 (55.1)	63 (39.6)	0.001[b]
LOS, days, median (IQR)	6.0 (6.0)	9.0 (10.0)	< 0.001[a]
LOS, days, n *(%)*			
< 7	252 (50.7)	55 (34.6)	
⩾7	245 (49.3)	104 (65.4)	< 0.001[b]
HGS (kgf), median (IQR)			
Women	18.0 (9.4)	13.0 (6.5)	< 0.001[a]
Men	35.5 (8.0)	23.4 (7.2)	< 0.001[a]
SMI (kg/m^2), mean (s.d.)			
Women	8.6 (1.4)	6.6 (1.0)	0.003[c]
Men	11.1 (1.5)	9.4 (0.8)	< 0.001[c]
Percentage of cost deviation (€), median (IQR)	− 5.1 (103.1)	44.3 (178.5)	< 0.001[a]

Abbreviations: AMT, Abbreviated Mental Test; BMI, body mass index; HGS, handgrip strength; IQR, interquartile range; LOS, length of hospital stay; PG-SGA, Patient-Generated Subjective Global Assessment; SMI, skeletal muscle mass index (muscle mass/height^2). [a]Mann–Whitney test. [b]Chi-square test. [c]Independent samples *t*-test.

median (IQR) = €2170 (€2515), $P < 0.001$. Patients' characteristics were stratified according to the percentage of cost deviation quartiles, as shown in Table 2. Sarcopenic patients presented a positive percentage of cost deviation, that is, these patients present a mean cost higher than the cost of a patient with relative weight equal to one. Otherwise, median percentage of cost deviation was negative for non-sarcopenic patients. Thus, non-sarcopenic patients present a mean cost lower than the cost of a patient with relative weight equal to one.

Compared with patients in the upper quartiles of percentage of cost deviation, patients in the lower quartiles had a higher education level, were more likely to be single, were less likely to be dependent and presented better nutrition status and shorter LOS (Table 2). The highest proportion of sarcopenic patients was found in the highest quartile of percentage of cost deviation distribution. There was a higher proportion of patients admitted to surgical wards in the two upper quartiles of percentage of cost deviation (Table 2).

Multivariable linear regression models calculated to predict the percentage of cost deviation are presented in Table 3. The analysis was displayed for the entire sample (model 1) and according to age groups, < 65 years and ⩾65 years (models 2 and 3). In addition, model 4 considered sarcopenic overweight (sarcopenia associated with body mass index ⩾ 25 kg/m^2) as an independent variable.

In model 1, being not single, undernourished, admitted to a surgical ward, having ⩾7 days of hospitalization and being sarcopenic were associated with higher hospitalization costs. For patients who were aged < 65 years (model 2), age, admission to a surgical ward, undernutrition, ⩾7 days of hospitalization and sarcopenia were associated with higher percentage of cost deviation. In model 3, for patients aged ⩾65 years, admission to a surgical ward, ⩾7 days of hospitalization and sarcopenia were also associated with higher hospitalization costs. Sarcopenic overweight or sarcopenic obesity (body mass index ⩾ 25 kg/m^2) was also able to predict a higher percentage of cost deviation, together with age, undernutrition, admission to surgical ward and LOS (model 4).

After adjustment for potential confounders, the economic impact of sarcopenia in hospitalization cost, reflected in the incremental cost per patient, in the entire sample is estimated to be €1117 (95% confidence interval (CI): €644–1588) and €1240 (95% CI: €596–1887) for patients aged < 65 years and €721 (95% CI: €13–1429) for patients aged ⩾ 65 years. Sarcopenic overweight is estimated to be associated with an increase of €884 (95% CI: €295–1476) in hospitalization costs.

The multivariable model was also stratified according to two categories of the Charlson Index score: no comorbidities–0 or presence of comorbidities– > 0. For patients with no comorbidities ($n = 225$), sarcopenia was estimated to increase hospitalization costs by 39.2% (95% CI: 4.0–74.4%), $P = 0.029$; for patients with comorbidities ($n = 431$), sarcopenia was estimated to increase hospitalization costs by 54.3% (95% CI: 24.5–82.1%), $P < 0.001$.

A multivariable linear regression model using the same variables as in the original analysis, but excluding patients with edema ($n = 204$), was conducted. In this new model, sarcopenia was still independently associated with hospitalization costs (regression coefficient (95% CI) = 39.2 (13.2–65.1), $P = 0.003$). A multivariable linear regression model considering only the patients with edema was further performed and a significant association of sarcopenia with hospitalization costs was also observed (regression coefficient (95% CI) = 68.9 (23.2–114.7), $P = 0.003$).

DISCUSSION

The present study results show that sarcopenia is associated with a major increase in hospitalization costs, considering the effect of potential confounders. After stratifying the model according to the age group, this effect was still visible for both younger and older adults, in spite of being stronger for younger patients.

It is worth highlighting that, with the exception of sarcopenia, factors associated with hospitalization costs changed across the two different age groups. Although age, undernutrition, being on

Table 2. Participants' characteristics according to percentage of cost deviation quartiles

	Percentage of cost deviation quartiles				
	1st ⩽ − 35.3 (n = 158)	*2nd − 35.2, − 1.10 (n = 169)*	*3rd − 1.09, 88.4 (n = 161)*	*4th ⩾ 88.5 (n = 168)*	P
Gender, n *(%)*					
Women	77 (48.7)	78 (46.2)	69 (42.9)	78 (46.4)	
Men	81 (51.3)	91 (53.8)	92 (57.1)	90 (53.6)	0.770[a]
Age, median (IQR)	53.0 (30.3)	52.0 (23.0)	58.0 (21.0)	61.0 (18.5)	< 0.001[b]
Education (years), n *(%)*					
0–4	46 (29.1)	68 (40.2)	65 (40.4)	86 (51.2)	
5–12	90 (57.0)	89 (52.7)	80 (49.7)	75 (44.6)	0.001[a]
> 12	22 (13.9)	12 (7.1)	16 (9.9)	7 (4.2)	
Marital status, n *(%)*					
Single	35 (22.2)	34 (20.1)	31 (19.3)	16 (9.5)	
Not single	123 (77.8)	135 (79.9)	130 (80.7)	152 (90.5)	0.013[a]
AMT, median (IQR)	10.0 (1.0)	10.0 (1.0)	10.0 (1.0)	9.0 (2.0)	0.081[b]
Katz index, n *(%)*					
Independent	154 (97.5)	163 (96.4)	156 (96.9)	152 (90.5)	
Moderate/severe dependence	4 (2.5)	6 (3.6)	5 (3.1)	16 (9.5)	0.008[a]
PG-SGA, n *(%)*					
Non-undernourished	103 (65.2)	100 (59.2)	85 (52.8)	74 (44.0)	
Undernourished	55 (34.8)	69 (40.8)	76 (47.2)	94 (56.0)	0.001[a]
Sarcopenia, n *(%)*					
Non-sarcopenic	128 (81.0)	138 (81.7)	128 (79.5)	103 (61.3)	
Sarcopenic	30 (19.0)	31 (18.3)	33 (20.5)	65 (38.7)	< 0.001[a]
BMI categories, n *(%)*					
Underweight	2 (1.3)	5 (3.0)	8 (5.0)	4 (2.4)	
Normal weight	69 (43.7)	74 (43.8)	54 (33.5)	72 (42.9)	0.232[a]
Overweight/obesity	87 (55.1)	90 (53.3)	99 (61.5)	92 (54.8)	
Charlson Index, median (IQR)	2.0 (2.0)	1.0 (2.0)	2.0 (3.0)	2.0 (3.0)	0.264[b]
Hospital ward, n *(%)*					
Medical	94 (59.5)	91 (53.8)	81 (50.3)	53 (31.5)	
Surgical	64 (40.5)	78 (46.2)	80 (49.7)	115 (68.5)	< 0.001[a]
LOS, days, median (IQR)	5 (5)	5 (5)	8 (7)	9 (9)	< 0.001[b]
LOS, days, n *(%)*					
< 7	103 (65.2)	97 (57.4)	64 (39.8)	43 (25.6)	
⩾7	55 (34.8)	72 (42.6)	97 (60.2)	125 (74.4)	< 0.001[a]

Abbreviations: AMT, Abbreviated Mental Test; BMI, body mass index; IQR, interquartile range; LOS, length of hospital stay; PG-SGA, Patient-Generated Subjective Global Assessment. [a]Chi-square test. [b]Kruskal-Wallis test.

a surgical hospital ward and length of stay were related to higher hospitalization costs for younger patients, in the model carried out for patients aged ⩾ 65 years, only length of stay and the ward of hospitalization were associated with the percentage of cost deviation. Moreover, sarcopenic overweight (or obesity) was also a predictor of higher hospitalization costs, even though the association was weaker than the one described for sarcopenic patients.

In addition, it is worth mentioning that the multivariable linear regression model was adjusted for LOS using a dichotomised variable (< 7 days, ⩾ 7 days), although medium LOS is included in the weighing value used for calculating hospitalization cost. The inclusion of this variable in the multivariable analyses is justified by the existence of an interval of days of hospitalization for each DRG code. These defined intervals can be wide ranging. Depending on the interval indicated to each DRG code, the same DRG code can be attributable to a patient with a short LOS (< 7 days) and a patient with a longer LOS (⩾7 days). The potential confounding effect of different LOS was, therefore, controlled.

The present study results increase the knowledge about sarcopenia and hospitalization costs by providing an estimation on this association. Sarcopenia defined by computed tomography scans was related with higher costs among patients who underwent surgery.[20–22] The ability of HGS, as a single parameter in predicting higher hospitalization costs, has also been recently described.[37] However, as far as we are concerned, there were no previous reports where sarcopenia was defined as low muscle mass and low muscle function and among hospitalized patients with a wide range of diagnoses and age. Therefore, because of differences in methodology, these results are not comparable with previous reports. The impact of sarcopenia in health-care costs has been described in the United States.[19] However, in this report, sarcopenia was defined merely by the loss of muscle mass, and the observation was not focused on hospitalized patients.

The current definition of sarcopenia includes muscle function in the diagnostic criteria of sarcopenia, namely through the assessment of muscle strength by HGS. This definition limits the application of these criteria for the identification of sarcopenia among patients who are unable to perform functional tests.

Table 3. Multivariable linear regression models for prediction of hospitalization cost

	Regression coefficient (95% CI)	P	*Cost (€) (95% CI)*
Model 1 (entire sample)			
Sarcopenia (reference: non-sarcopenic)	52.7 (30.4–74.9)	< 0.001	1117 (644–1588)
Marital status (reference: single)	29.8 (5.27–54.2)	0.017	
PG-SGA (reference: non-undernourished)	27.7 (8.08–47.4)	0.006	
Hospital ward (surgical *vs* medical)	66.8 (47.9–85.6)	< 0.001	
LOS, days (reference: LOS < 7 days)	62.4 (42.8–81.9)	< 0.001	
Model 2 (age < 65 years)			
Sarcopenia (reference: non-sarcopenic)	58.5 (28.1–89.0)	< 0.001	1240 (596–1887)
Age, years	1.31 (0.37–2.25)	0.007	
PG-SGA (reference: non-undernourished)	28.5 (3.87–53.2)	0.023	
Hospital ward (surgical *vs* medical)	51.8 (28.6–75.0)	< 0.001	
LOS, days (reference: LOS < 7 days)	59.0 (35.0–83.0)	< 0.001	
Model 3 (age ⩾ 65 years)			
Sarcopenia (reference: non-sarcopenic)	34.0 (0.60–67.4)	0.046	721 (13–1429)
Hospital ward (surgical *vs* medical)	101.7 (69.5–134.0)	< 0.001	
LOS, days (reference: LOS < 7 days)	64.6 (31.2–98.0)	< 0.001	
Model 4 (entire sample)			
Sarcopenic overweight (reference: non-sarcopenic overweight)	41.7 (13.9–69.6)	0.003	884 (295–1476)
Age, years	0.80 (0.19–1.41)	0.010	
PG-SGA (reference: non-undernourished)	29.3 (9.4–49.1)	0.004	
Hospital ward (surgical *vs* medical)	63.8 (45.0–82.7)	< 0.001	
LOS, days (reference: LOS < 7 days)	63.8 (44.0–83.5)	< 0.001	

Abbreviations: CI, confidence interval; LOS, length of hospital stay; PG-SGA, Patient-Generated Subjective Global Assessment. Variables included sarcopenia or sarcopenic overweight status (non-sarcopenic used as reference), age, gender (women used as reference), marital status (single used as reference), the Katz index (independent used as reference), education (dichotomized as 0–4 years and ⩾ 5 years; ⩾ 5 years was used as reference), undernutrition status according to PG-SGA (non-undernourished used as reference), hospital ward (surgical used as reference), length of hospital stay (< 7 days used as reference), the Abbreviated Mental Test score and the Charlson comorbidity index score. Dependent variable: percentage of cost deviation.

This situation may constitute a study limitation because these patients, owing to their clinical condition, would be likely to present muscle mass depletion and reduced function and, therefore, to be sarcopenic. Moreover, physical performance was not assessed because of the characteristics of our sample, as this test is not applicable to all hospitalized patients. Consequently, some sarcopenia diagnoses, in patients with low muscle mass and low physical performance but with normal HGS, could have been missed.

In the present study, muscle mass was assessed with bioelectrical impedance analysis, instead of using computed tomography or magnetic resonance imaging, which are the golden standards for quantifying muscle mass, or dual energy X-ray absorptiometry, the selected alternative for estimating muscle mass in research and clinical use.[1] This could be a study limitation. However, bioelectrical impedance analysis is an economical, practical and a reproducible method, which, used under standard conditions, has been described as a suitable alternative to dual energy X-ray absorptiometry.[1] Although bioelectrical impedance analysis may not be reliable in conditions such as heart failure, kidney failure and dehydration,[29] not all patients with these conditions were excluded. This may have caused a misclassification of muscle mass and consequently a misclassification of sarcopenia. Nevertheless, after stratifying the multivariable linear regression model for the presence of edema, we can conclude that the inclusion of patients with edema in the original model of the manuscript did not lead to a significant distortion of the results.

Moreover, it could be hypothesized that sarcopenia is associated with higher costs because patients with sarcopenia have higher level of comorbidity. However, after stratifying the multivariable model according to the Charlson index score categories, sarcopenia independently increased hospitalization costs even in those patients with no comorbidities.

According to hospital discharge records, the proportion of discharged older patients (aged ⩾ 65 years) was 38.3% in 2012 and 40% in 2013. The proportion of patients aged over 65 years in our sample is lower (31%). This situation may have led to a lower representation of an important group of high-risk patients, underestimating sarcopenia burden. Nevertheless, the diagnostic criteria of sarcopenia recommended by the European Consensus require the application of functional tests, thus excluding patients who are unable to carry out these tests.[8] The lower representation of older patients in this sample may be explained by the need to comply with this.

The DRG system has been shown to underestimate the real hospitalization costs as it reflects only direct hospitalization costs. Indirect costs, such as societal costs, are not taken into account.[38] Therefore, because of DRG system limitations, the real financial impact of sarcopenia in this hospital setting could be even higher than the present estimates. Nonetheless, this methodology was used in the present study, as it allows for an assortment of patients with a diversity of diagnoses and procedures.

Several strengths of this study could be emphasized. This sample is composed of a large number of hospitalized patients, with a wide age range, from 18 to 90 years. The patients enrolled in the present study were from a multiplicity of hospital surgical and medical wards, which ensured a variety of diagnoses and diseases. These characteristics strengthen the generalizability of our results for other hospitalized patients.

Further investigation is needed to explore the extent of the influence of the early identification of sarcopenia in the reduction in adverse outcomes and, therefore, the reduction in inherent hospitalization costs.

In conclusion, present research shows that sarcopenia is independently related to hospitalization costs. This condition is estimated to increase hospitalization costs by 52.7% (58.5% for patients aged < 65 years and 34% for patients aged ⩾ 65 years).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

We thank Centro Hospitalar do Porto and all ward directors for facilitating the data collection. RSG received a scholarship from Fundação para a Ciência e a Tecnologia, financing program POPH/FSE, under the project SFRH/BD/61656/2009.

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