

# Sarcopenia predicts readmission and mortality in elderly patients in acute care wards: a prospective study

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## Abstract

**Background** The aim of this study is to assess the prevalence of sarcopenia and investigate the associations between sarcopenia and long-term mortality and readmission in a population of elderly inpatients in acute care wards.

**Methods** We conducted a prospective observational study in the acute care wards of a teaching hospital in western China. The muscle mass was estimated according to a previously validated anthropometric equation. Handgrip strength was measured with a handheld dynamometer, and physical performance was measured via a 4 m walking test. Sarcopenia was defined according to the recommended diagnostic algorithm of the Asia Working Group for Sarcopenia. The survival status and readmission information were obtained via telephone interviews at 12, 24, and 36 months during the 3 year follow-up period following the baseline investigation.

**Results** Two hundred and eighty-eight participants (mean age: 81.1 ± 6.6 years) were included. Forty-nine participants (17.0%) were identified as having sarcopenia. This condition was similar in men and women (16.9% vs. 17.5%, respectively,  $P=0.915$ ). During the 3 year follow-up period, 49 men (22.7%) and 9 women (16.4%) died ( $P=0.307$ ). The mortality of sarcopenic participants was significantly increased compared with non-sarcopenic participants (40.8% vs. 17.1%, respectively,  $P<0.001$ ). After adjusting for age, sex and other confounders, sarcopenia was an independent predictor of 3 year mortality (adjusted hazard ratio: 2.49; 95% confidential interval: 1.25–4.95) and readmission (adjusted hazard ratio: 1.81; 95% confidential interval: 1.17–2.80).

**Conclusions** Sarcopenia, which is evaluated by a combination of anthropometric measures, gait speed, and handgrip strength, is valuable to predict hospital readmission and long-term mortality in elderly patients in acute care wards.

**Keywords** Sarcopenia; Survival; Mortality; Readmission; Acute care

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## Introduction

Sarcopenia is defined as an age-related loss of muscle mass, strength, and muscle function, and is currently considered a new geriatric syndrome.<sup>1</sup> According to a recent systematic review, the prevalence of sarcopenia was approximately 1–29% in community-dwelling populations, 14–33% in long-term care populations, and 10% in a hospitalized population, depending

on the characteristics of the study populations and the diagnostic methodology.<sup>2</sup>

Previous studies have indicated that sarcopenia was significantly associated with repeated falls, fractures, functional decline, disability, hospital and nursing home admissions, poor quality of life, and death. However, most previous studies that have focused on the effect of sarcopenia on mortality have been conducted in community-dwelling elderly adults<sup>3</sup> or nursing home residents.<sup>4</sup>

Evidence regarding the effect of sarcopenia on survival in hospitalized populations is relatively limited. Recently, Vetrano *et al.*<sup>5</sup> recruited 770 elderly patients in acute care wards, measured the muscle mass via bioelectrical impedance analysis (BIA), and defined sarcopenia according to the European Working Group on Sarcopenia in Older People (EWGSOP) criteria. The results indicated that sarcopenia was a significant predictor of 1 year mortality (hazard ratio [HR]: 1.59; 95% confidential interval [CI]: 1.10–2.41). Using similar methods, Cerri *et al.*<sup>6</sup> applied the data from 103 acutely ill elderly patients with malnutrition or at risk of malnutrition and demonstrated that sarcopenia was associated with 3 month mortality (HR was not reported). In addition, Gariballa *et al.*<sup>7</sup> estimated the muscle mass with the mid-arm muscle circumference (MAMC) and used the EWGSOP criteria to define sarcopenia; they demonstrated that non-sarcopenia was a protective factor for 6 month mortality in 432 hospitalized patients (HR: 0.45; 95% CI: 0.21–0.97). These evidences indicate that sarcopenia is an important prognostic factor to predict mortality in elderly patients in acute care hospitals, regardless of how it is measured.

However, it remains unclear whether sarcopenia is a predictor of long-term mortality and readmission in hospitalized elderly patients. In addition, there are limited data that address sarcopenia and its adverse effects on clinical outcomes in non-Caucasian elderly inpatients. We therefore conducted this study to (i) assess the prevalence of sarcopenia in a population of elderly inpatients in acute care wards and (ii) investigate the associations between sarcopenia and long-term (3 years) mortality and readmission.

## Methods

This study was conducted in the acute care wards of the Center of Gerontology and Geriatrics, West China Hospital of Sichuan University, which is located in Sichuan province, China. The study protocol was approved by the Research Ethics Committee of Sichuan University. All participants (or their legal proxies) signed a written informed consent.

### Study population

All subjects aged 60 years and older who were living in the acute care ward of the Center of Gerontology and Geriatrics of West China Hospital between February and August, 2012, were considered eligible for this study. Subjects, who could not communicate with the interviewers or perform the gait speed (GS) test as a result of severe diseases, were excluded from the study. Subjects with cachexia as defined by the Society on Sarcopenia, Cachexia, and Wasting Disorders<sup>8</sup> were also excluded. Three hundred and thirteen elderly subjects agreed to participate in this study.

### Data collection

The trained interviewers collected the main data from all study subjects using questionnaires via face-to-face interviews within 48 hours of admission. The anthropometric measurements were also performed by trained technicians. All interviewers and technicians were trained using investigation manuals, multimedia materials, and simulated patients and were required to pass a training test prior to the formal investigation.

### Assessment of sarcopenia

In this study, we adopted the recommended diagnostic algorithm of the Asia Working Group for Sarcopenia (AWGS).<sup>9</sup> According to the AWGS recommendation, individuals with a low muscle mass plus either or both a low handgrip strength (HS) and a low gait speed were considered to have sarcopenia; in contrast, the individuals without a low muscle mass, low HS, and low GS were classified as ‘no sarcopenia’.

### Muscle mass assessment

Body weight and height were measured using a wall-mounted stadiometer and a digital floor scale to the nearest 0.1 cm and 0.1 kg, respectively. The body mass index (BMI) was calculated using the weight in kilograms divided by the square of the height in metres (kg/m<sup>2</sup>). We also measured the calf circumference (CC) with the subject placed in the supine position, with the left knee raised and the calf placed at a right angle to the thigh, using a millimetre-graded tape to the nearest 0.1 cm.

The muscle mass was estimated by the appendicular skeletal muscle mass (ASM) using a previously validated equation in a Chinese population<sup>10</sup>:

$$\text{ASM} = 0.193 \times \text{body weight} + 0.107 \\ \times \text{height} - 4.157 \times \text{sex} - 0.037 \times \text{age} - 2.631.$$

The body weight, height, and age were measured in kilograms, centimetres, and years, respectively. For sex, the value 1 represented men, and the value 2 represented women.<sup>10</sup> Using dual-energy X-ray absorptiometry (DEXA) as the gold standard,<sup>10</sup> the adjusted R<sup>2</sup> of the equation model was 0.90, and the Standard Error of Estimate was 1.63 kg.

After estimating the ASM values, the muscle mass index (SMI) was calculated using the ASM divided by the square of the height in metres (SMI = ASM/height<sup>2</sup>). In accordance with previous studies,<sup>11–13</sup> the cut-off of the SMI used in this study was based on the 20% lowest percentile of the study population; therefore, a low muscle mass was classified as an SMI less than 6.70 kg/m<sup>2</sup> in men and less than 4.75 kg/m<sup>2</sup> in women.

### Handgrip strength measurement

The HS was measured using a handheld dynamometer based on strain gauge sensors (EH101, Xiangshan Inc., Guangdong, China) to the nearest 0.1 kg. Both hands were tested with the subject seated; the elbow was flexed at a 110° angle, the wrist was placed in a neutral position, and the interphalangeal joint of the index finger was positioned at a 90° angle. Three readings were obtained for each hand, and the highest value in either hand was used for the analyses. Using the cut-off points from the AWGS consensus, low HS referred to <26 kg for men and <18 kg for women.<sup>9</sup>

### Gait speed measurement

The GS was evaluated by measuring the participants' usual gait (in m/s) in a 4 m course. The participants were required to walk a 4 m course at their usual gait, with the use of walkers and canes if necessary.<sup>14</sup> Using the cut-off points from the AWGS consensus, a low GS was defined as less than 0.8 m/s.<sup>9</sup>

### Nutritional and cognitive status

We assessed the participants' nutritional status using the revised Mini Nutritional Assessment short-form.<sup>15</sup> A score between 8 and 11 indicates that the subjects are 'at risk of malnutrition', whereas a score of  $\leq 7$  indicates that the subjects suffer from malnutrition. In addition, prealbumin was measured as a nutrition marker.

We also assessed the cognitive status using the Chinese version of the Mini-Mental Status Examination.<sup>16</sup> Cognitive impairment was defined as a score of Mini-Mental Status Examination score  $\leq 17$  for illiterates,  $\leq 20$  for primary school graduates, and  $\leq 24$  for high school graduates or individuals with higher education.<sup>17</sup>

### Covariates

The following covariates were collected from the hospital information systems and the face-to-face interviews: age, sex, education level (illiterates, primary school graduates, and high school graduates or above), physical activity in the previous 6 months ( $\geq 30$  min/day or not), smoking status (current smoker or not), alcohol consumption status (current drinker or not), polypharmacy (defined as the concomitant use of five or more medications,<sup>18</sup> yes or no), and comorbidities (hypertension, diabetes, ischemic heart disease, respiratory disease, central nervous system disease, gastrointestinal disease, liver disease, chronic kidney disease, osteoarthritis, tumour, acute infection, and falls in the previous 12 months). Depression was evaluated using the Chinese version of the 30-item

Geriatric Depression Scale; a score of  $\geq 11$  suggests depression.<sup>19</sup> Haemoglobin was also tested for each participant.

### Survival status and readmission information

The survival status and readmission information for all participants were obtained via telephone interviews at 12, 24, and 36 months during the 3 year period following the baseline investigation. The survival status was also confirmed using the Sichuan Province Death Registry. For the participants who died during the follow-up, the period from the first investigation to the date of death was recorded; for the individuals who did not die during the study follow-up, the period from the first investigation to the end of the last follow-up was recorded. For the individuals who were readmitted to hospitals several times during the follow-up, the first readmission time was recorded.

### Statistical analyses

All statistical analyses were performed with SPSS version 11.5 (SPSS Inc., Chicago, IL, USA). The categorical data were presented as absolute numbers and percentages (%) of the total. The continuous data were presented as the mean  $\pm$  standard deviation (SD) if they were normally distributed; otherwise, they were presented as the median  $\pm$  interquartile range. To compare the differences between groups, we used the Pearson chi-squared test for categorical data, a one-way ANOVA for continuous data with a normal distribution; and the Mann-Whitney *U* test for continuous data with an abnormal distribution. A *P*-value less than 0.05 was considered statistically significant.

The time to death was calculated from the date of the baseline investigation to the date of death. Similarly, the time to readmission was calculated from the date of the baseline investigation to the date of the first readmission after discharge. The crude and adjusted HR and 95% CI for mortality and readmission by sarcopenia were estimated using Cox proportional-hazard models. We adjusted age and sex, as well as other confounders which were significantly different between the sarcopenic group and the non-sarcopenic group. As a result, Model 1 was adjusted for age and sex. Model 2 was adjusted for age, sex, and hypertension. Model 3 was adjusted for age, sex, hypertension, nutrition status, BMI, and CC. In these models, the age, BMI, and CC were treated as continuous data, whereas the other variables were treated as categorical data. In addition, Kaplan-Meier curves of survival and readmission were analysed following an adjustment for age and sex to determine the impact of sarcopenia on mortality and readmission, respectively. The differences between the curves were assessed using the log-rank test.

## Results

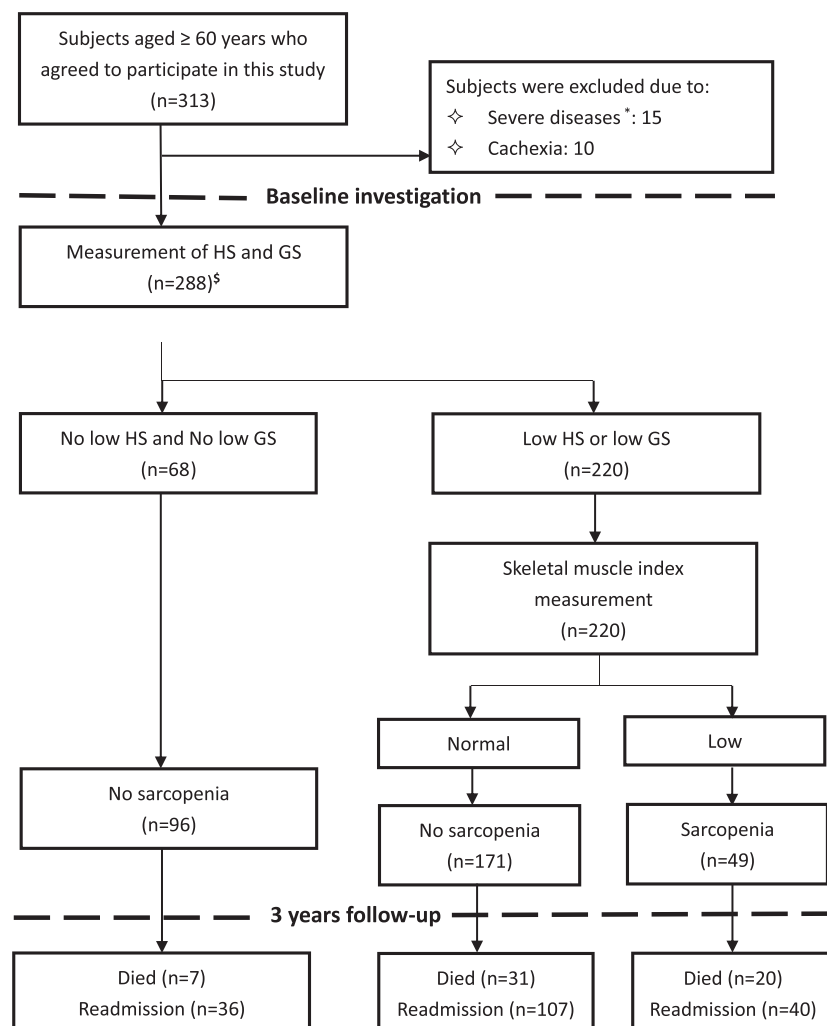
### Description of the study population

Of the 313 participants who agreed to participate in this study, 15 individuals were excluded because of severe disease and 10 individuals were excluded because of cachexia. The remaining 288 participants were included in the baseline analyses. Seventeen participants were lost during follow-up, which led to a final sample of 271 participants. The mean age of the study participants was  $81.1 \pm 6.6$  years, and 63 participants (21.9%) were women. According to the suggested algorithm of the AWGS, 49 subjects (17.0%) were identified as having sarcopenia (Figure 1). The prevalence of

sarcopenia was similar in men and women (16.9% vs. 17.5%, respectively,  $P=0.915$ ).

The baseline characteristics of the study population are presented in Table 1. The subjects with sarcopenia were older compared with the subjects without sarcopenia (mean age 83.7 vs. 80.5, respectively,  $P < 0.002$ ). Compared with the subjects without sarcopenia, the sarcopenic subjects were more likely to be 'at risk of malnutrition', have malnutrition, and exhibit a lower BMI and CC. The common comorbidities (with the exception of hypertension) were similar between the sarcopenic and non-sarcopenic subjects. In addition, the sarcopenic subjects appeared to have lower haemoglobin and prealbumin; however, the difference was not statistically significant.

**Figure 1** Study profile using the diagnostic algorithm recommended by the Asian Working Group for Sarcopenia (AWGS). GS: gait speed; HS: handgrip strength. \* Only those who could not communicate with the interviewers or perform the gait speed test due to severe diseases were excluded. Among the 15 excluded patients, 4 suffered from tumor of any type. <sup>5</sup> Among the 288 included patients, 45 suffered from tumor of any type. However, none of these patients with tumor received tumor-directed therapy (e.g. chemotherapy, immunotherapy, or radiation) during the duration of hospital stay at the baseline investigation.



**Table 1** Baseline characteristics of participants with or without sarcopenia

Characteristic	No sarcopenia (n = 239)	Sarcopenia (n = 49)	P
Age (years)	80.5 ± 6.6	83.7 ± 5.9	0.002
Men	187 (78.2)	38 (77.6)	0.915
Current smokers	21 (8.8)	7 (14.3)	0.484
Current alcohol drinkers	29 (12.1)	4 (8.2)	0.427
Physical activity ≥30 min/day	111 (46.0)	25 (51.0)	0.523
Comorbidities			
Hypertension	151 (63.2)	23 (46.9)	0.034
Ischemic heart disease	88 (36.8)	14 (28.6)	0.271
Respiratory disease	63 (26.4)	17 (34.7)	0.235
Acute infection	51 (21.3)	14 (28.6)	0.270
Liver disease	20 (8.4)	6 (12.2)	0.388
CKD	34 (14.2)	6 (12.2)	0.715
CNS disease	12 (5.0)	3 (6.1)	0.752
Diabetes	77 (32.2)	9 (18.4)	0.054
Osteoarthritis	64 (26.8)	11 (22.4)	0.529
Tumour of any type	38 (15.9)	7 (14.3)	0.777
Falls in the previous 12 months	33 (13.8)	7 (14.3)	0.930
GI disease	20 (8.4)	4 (8.2)	0.926
Depression	55 (23.0)	15 (30.6)	0.259
Cognitive impairment	79 (33.1)	21 (42.9)	0.189
Polypharmacy	113 (47.3)	17 (34.7)	0.107
Nutrition status			
At risk of malnutrition	96 (40.2)	30 (61.2)	<0.001
Malnutrition	19 (7.9)	10 (20.4)	
BMI (kg/m <sup>2</sup> )	23.3 ± 3.3	19.0 ± 2.5	<0.001
CC (cm)	33.0 ± 4.0	30.7 ± 4.2	<0.001
Gait speed (m/s)	0.8 ± 0.4	0.7 ± 0.3	0.212
Handgrip strength (kg)	21.5 ± 8.7	17.5 ± 8.0	0.004
SMI (kg/m <sup>2</sup> )	7.8 ± 1.0	6.7 ± 1.0	<0.001
Haematological parameters			
Haemoglobin, g/l	123.9 ± 24.5	117.3 ± 21.2	0.078
Prealbumin, mg/l	200.9 ± 55.1	189.8 ± 55.3	0.459

Data are presented as the number (per cent) for the following variables: women, current smokers, current alcohol drinkers, physical activity, specific comorbidities, polypharmacy, and nutrition status. For the other variables, the mean ± SD are used.

One-way ANOVA was used for the continuous variables, and the Pearson chi-squared test was used for the categorical variables. During testing,  $P < 0.05$  was considered statistically significant.

BMI, body mass index; CC, calf circumference; CKD, chronic kidney disease; CNS, central nervous system; GI, gastrointestinal; SMI, skeletal muscle index.

**Table 2** Association between sarcopenia and mortality (3 year follow-up) according to Cox regression models adjusted for potential confounders

	Unadjusted	Model 1	Model 2	Model 3
Sarcopenia	2.67 (1.55–4.60)	2.26 (1.29–3.95)	2.33 (1.32–4.12)	2.49 (1.25–4.95)
Age		1.63 (0.80–3.32)	1.66 (0.81–3.39)	1.42 (0.69–2.92)
Sex (men)		1.07 (1.02–1.12)	1.07 (1.02–1.11)	1.07 (1.02–1.12)
Hypertension			1.18 (0.69–2.02)	1.04 (0.59–1.86)
Malnutrition				2.09 (1.09–4.02)
At risk of malnutrition				1.90 (0.69–5.28)
BMI				1.09 (0.99–1.18)
CC				1.02 (0.94–1.09)

Data are presented as hazard ratios (95% confidential intervals). Model 1: adjusted for age and sex. Model 2: adjusted for age, sex and hypertension. Model 3: adjusted for age, sex, hypertension, nutrition status, BMI, and CC.

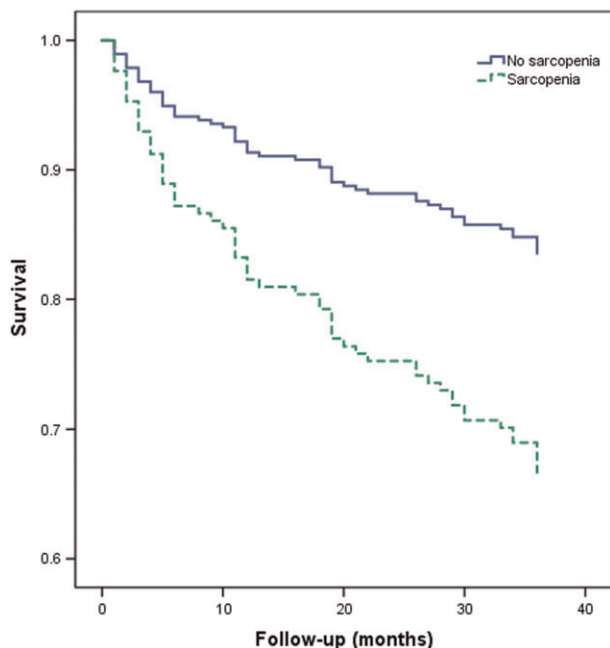
BMI, body mass index; CC, calf circumference.

### Association between sarcopenia and 3-year mortality

During the 3 year follow-up, 49 men (22.7%) and 9 women (16.4%) died ( $P=0.307$ ). The mortality of the sarcopenic subjects was significantly increased compared with the non-sarcopenic subjects (40.8% vs. 17.1%, respectively,  $P < 0.001$ ). As indicated in Table 2, sarcopenia was an

independent predictor of 3 year mortality (HR: 2.67, 95% CI: 1.55–4.60) in the unadjusted model. Following an adjustment for the potential confounders, the association between sarcopenia and 3 year mortality remained significant (Table 2). In the full adjusted model, the sarcopenic subjects exhibited an increased 3 year mortality compared with the non-sarcopenic subjects (HR: 2.49; 95% CI: 1.25–4.95).

**Figure 2** Survival curves of the study population according to sarcopenia at baseline. Survival curves significantly differed in the log-rank test ( $P < 0.001$ ).



The effect of sarcopenia on the 3 year mortality was tested by comparing the Kaplan–Meier survival curves for mortality. The survival curves of the subjects with or without sarcopenia are presented in Figure 2. The survival curves were significantly different in the log-rank test ( $P < 0.001$ ).

In addition, malnutrition was also independently associated with mortality (HR: 2.09; 95% CI: 1.09–4.02).

### Association between sarcopenia and readmission

During the 3 year follow-up, 150 men (69.4%) and 33 women (60.0%) were readmitted to the hospital at least one time ( $P = 0.182$ ). The subjects with sarcopenia were more likely to be readmitted to hospital compared with the subjects without sarcopenia (71.0% vs. 56.3%, respectively,

$P = 0.027$ ). As presented in Table 3, sarcopenia was an independent predictor for readmission (HR: 1.82; 95% CI 1.28–2.59) in the unadjusted model. Following an adjustment for age, sex, hypertension, nutrition status, BMI, and CC, the sarcopenic subjects remained at an increased risk of readmission compared with the subjects without sarcopenia (HR: 1.81; 95% CI: 1.17–2.80).

Kaplan–Meier curves for readmission were also applied to assess the effect of sarcopenia on readmission (Figure 3). The survival curves were significantly different in the log-rank test ( $P = 0.019$ ).

## Discussion

To the best of our knowledge, this study is the first investigation to address the associations between sarcopenia and long-term mortality and readmission in a longitudinal study of Chinese hospitalized elderly patients. This study indicates that sarcopenia is common (17.0%) in Chinese elderly patients in acute geriatric wards. Sarcopenia, which is defined by a low muscle mass estimated by anthropometric measurements, a low HS, and a low GS, is associated with long-term mortality and readmission, independent of age, sex, and other potential confounders.

Numerous studies have addressed the prevalence of sarcopenia in various populations; however, relatively limited evidence is available regarding the prevalence of sarcopenia in acute care geriatric settings. Rossi and colleagues<sup>20</sup> applied the diagnostic criteria of the EWGSOP and estimated the muscle mass via BIA. They reported that one of four elderly patients had sarcopenia in acute care departments. Vetrano *et al.*<sup>5</sup> applied similar diagnostic methods and determined that 28% of patients in acute care wards were sarcopenic. However, using the EWGSOP criteria and estimating the muscle mass via the MAMC, Gariballa *et al.*<sup>7</sup> identified only 10% of participants as having sarcopenia among geriatric inpatients. This study applied the AWGS criteria and measured the muscle mass with an anthropometric equation. We identified 17.0% of participants with sarcopenia. It is difficult to compare the results from these different studies because of the various measurement methods, diagnostic criteria, and study populations.

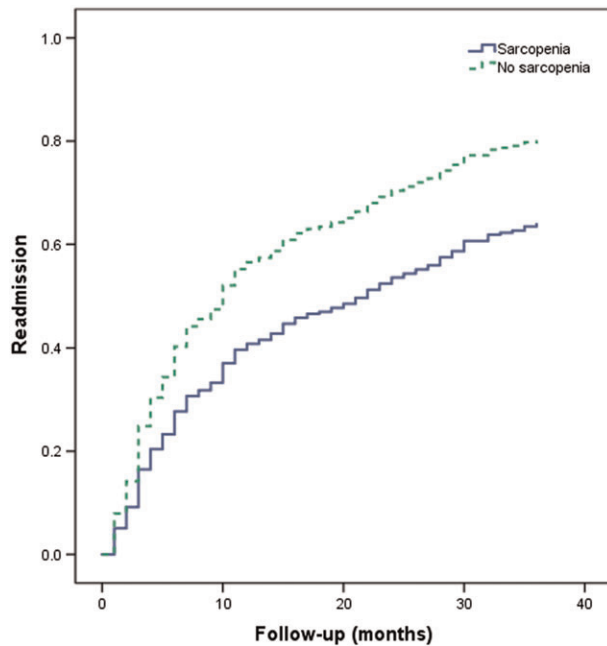
**Table 3** Association between sarcopenia and readmission (3 year follow-up) according to Cox regression models adjusted for potential confounders

	Unadjusted	Model 1	Model 2	Model 3
Sarcopenia	1.82 (1.28–2.59)	1.67 (1.16–2.39)	1.67 (1.16–2.41)	1.81 (1.17–2.80)
Age		1.37 (0.94–2.00)	1.37 (0.94–2.01)	1.45 (0.97–2.17)
Sex (men)		1.03 (1.01–1.06)	1.03 (1.01–1.06)	1.03 (1.01–1.05)
Hypertension			1.01 (0.74–1.36)	1.01 (0.73–1.38)
Malnutrition				1.02 (0.72–1.44)
At risk of malnutrition				1.00 (0.59–1.70)
BMI				1.03 (0.98–1.08)
CC				0.98 (0.94–1.02)

Data are presented as hazard ratios (95% confidential intervals). Model 1: adjusted for age and sex. Model 2: adjusted for age, sex and hypertension. Model 3: adjusted for age, sex, hypertension, nutrition status, BMI, and CC. BMI, body mass index; CC, calf circumference.



**Figure 3** Kaplan–Meier curves for readmission according to sarcopenia at baseline. These curves significantly differed in the log-rank test ( $P = 0.019$ ).



Furthermore, this study demonstrated that sarcopenia may also represent a prognostic factor for readmission during the 3 year follow-up. This finding was consistent with a previous study.<sup>7</sup> In their manuscript, Gariballa *et al.*<sup>7</sup> reported that the risk of readmission during the 6 month follow-up was significantly decreased in patients without sarcopenia compared with patients with sarcopenia. Additional prospective studies are necessary to confirm this finding in different study populations.

Both malnutrition and sarcopenia are common in elderly patients, especially in acute hospitalized elderly patients.<sup>21</sup> In this study, we demonstrated that malnutrition was independently associated with mortality. This finding was consistent with previous studies.<sup>22</sup> For example, Cederholm *et al.* reported that mortality after hospitalization was significantly increased in patients with malnutrition compared with well-nourished patients.<sup>23</sup> Previous studies have also indicated that malnutrition was associated with hospital readmission<sup>23,24</sup>; however, we failed to identify this association in our study population.

There are several limitations in this study. First, we estimated the muscle mass with an anthropometric equation, which has previously been validated in Chinese individuals, rather than BIA or DEXA as recommended by the EWGSOP<sup>25</sup> and AWGS.<sup>9</sup> Anthropometric measures are considered poor markers of muscle mass.<sup>25</sup> However, DEXA is expensive and has a risk of X-ray exposure. BIA is rarely available in hospitals in mainland China, and the cut-off points of BIA for defining low muscle mass in Chinese elderly individuals have not been established.<sup>26,27</sup> Furthermore, common conditions in hospitalized patients (e.g., fluid and electrolytes imbalance) may lead

to erroneous results for BIA.<sup>28</sup> Therefore, DEXA and BIA were not appropriate for our study population. More importantly, recent studies that assessed sarcopenia and mortality in elderly individuals used the same concepts of muscle strength and GS; however, the muscle mass was measured in difference ways (BIA,<sup>4</sup> CC,<sup>29</sup> and MAMC,<sup>30</sup> respectively). Regardless of these differences, similar HR values of sarcopenia for mortality were identified. This finding implies that the different measurement techniques for estimating the muscle mass (including anthropometric measures) are all valid for predicting mortality, regardless of the gold standard of DEXA. Furthermore, in a recent study, Alexandre *et al.*<sup>13</sup> demonstrated that the use of anthropometric equations to estimate the muscle mass combined with the handgrip and GS may comprise an important alternative to DEXA to improve the diagnosis of sarcopenia and reduce costs. This study confirmed the conclusion of Alexandre's study in a Chinese elderly inpatient population.

Second, although we adjusted for many regular confounders in this study, unmeasured factors (e.g. some geriatric syndromes, activity of daily living, and interventions) may bias the study results. Third, we did not measure the participants' functional independence, which may serve as an important confounder. Fourth, we excluded patients who could not perform the walking test as well as those with cachexia. This may result in an underestimation of sarcopenia. Fifth, we did not apply the Charlson Comorbidity Index<sup>31</sup> to assess chronic comorbidities in the study population. Using this standard index of comorbidity may benefit for comparisons between studies. Finally, similar to all cohort studies, selective survival prior to entry in the cohort should be considered.

## Conclusion

Sarcopenia, which is evaluated by a combination of anthropometric measures, GS, and HS, is valuable in the prediction of hospital readmission and long-term mortality in Chinese elderly patients in acute care wards. Additionally, prospective studies with large sample size are warranted to assess the value of different diagnostic methods (BIA, DEXA, and anthropometric measures) in the prediction of adverse outcomes in different clinical settings.

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manuscript. The authors certify that they comply with the ethical guidelines for publishing in the Journal of Cachexia, Sarcopenia and Muscle: update 2015.<sup>32</sup>

## Conflicts of interest

None declared.

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