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Sarcopenia is associated with worse recovery of physical function and dysphagia and a lower rate of home discharge in Japanese hospitalized adults undergoing convalescent rehabilitation

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of sarcopenia on functional outcomes, including activities of daily living (ADLs); dysphagia status; and the rate of home discharge, among hospitalized adults receiving convalescent rehabilitation.

Methods: A retrospective cohort study was conducted with 898 patients newly admitted to in-hospital convalescent rehabilitation wards at a single rehabilitation hospital in Japan. Baseline sarcopenia was diagnosed using muscle mass index and handgrip strength according to the criteria of the European Working Group on Sarcopenia in Older People, with the cutoff values of the Asian Working Group for Sarcopenia. The primary outcome was ADLs, assessed by Functional Independence Measure motor (FIM-motor) score at hospital discharge. The secondary outcomes included dysphagia, assessed by the Food Intake Level Scale (FILS), at discharge, and the rate of home discharge. Three multivariate analyses revealed an association between sarcopenia and the clinical outcomes. Each analysis adjusted for the following confounders: age, sex, time from onset, premorbid ADLs, comorbidities, cognitive level, nutritional status, major drugs, and admission diagnoses.

Results: After enrollment, 795 patients (mean age 74.9 ± 13.2 y; 59% women) were included in the final analysis. Admission diagnoses included stroke (n = 276; 34.7%), musculoskeletal disorders (n = 382; 48.1%), and hospital-associated deconditioning (n = 137; 17.2%). Of the 795 patients examined, 402 (50.6%) had sarcopenia. The multiple linear regression analysis showed that sarcopenia was independently associated with FIM motor score at discharge in patients with all disease types (β = −0.189 [stroke], −0.240 [musculoskeletal disorders], −0.230 [hospital-associated deconditioning]; all $P < 0.05$), with FILS score at discharge only in patients with musculoskeletal disorders (β = −0.271, $P < 0.001$), but not in patients with stroke (β = −0.061, $P = 0.375$) or those with hospital-associated deconditioning (β = −0.131, $P = 0.070$). The multiple logistic regression analysis showed that sarcopenia was associated with rate of home discharge in all disease types (odds ratio [OR], 0.201; 95% confidence interval [CI], 0.067–0.597 for stroke; OR, 0.242; 95% CI, 0.076–0.772 for musculoskeletal disorders; OR, 0.121; 95% CI, 0.110–0.347 for hospital-associated deconditioning; all $P < 0.05$).

Conclusions: Sarcopenia is associated with worse recovery of ADLs and dysphagia and a lower rate of home discharge in hospitalized adults undergoing convalescent rehabilitation. Early detection of sarcopenia and treatment by rehabilitation nutrition should be implemented in this population.

AS and YY had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis, including and especially any adverse effects. HW contributed to the concept and design, data analysis, data interpretation, and drafting of the manuscript. YT, SS, and SJ contributed to the concept, data acquisition, and data analysis. All authors revised the manuscript critically for important intellectual content and approved the final version of the manuscript. The authors have no conflicts of interest to declare.

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Introduction

Sarcopenia has gained increasing interest both in research and in clinical practice and is now recognized as an independent medical condition by the International Classification of Diseases, Tenth Edition (M62.84) defined in 2016 [1]. The preservation or improvement of physical functioning and independent living are vital in frail older adults [2], and sarcopenia is a major contributor to physical frailty [3]. The prevalence of sarcopenia among older adults ranges from 5% to 50% across different settings [4–7]. Sarcopenia has been studied mainly in community-dwelling older adults and nursing home residents and is one of the most important risk factors for mobility impairment, falls, disability, loss of independence, hospitalization, institutionalization, and death [4,5,8,9]; however, to our knowledge, few studies have demonstrated the clinical effects of sarcopenia on hospitalized patients undergoing rehabilitation.

Sarcopenia among older adults receiving in-hospital rehabilitation is an emerging concept [6,10]. Compared with community or nursing home settings, the prevalence of sarcopenia in hospital-based rehabilitation settings is reported to be relatively higher, at ~50% [6,11]. It is widely assumed that sarcopenia is associated with worse outcomes in hospital-based rehabilitation settings [10]; however, to our knowledge, only a few studies have reported the association between sarcopenia and functional outcomes in hospitalized older adults receiving rehabilitation. Sánchez-Rodríguez et al. [12] and Landi et al. [13] showed that sarcopenia was associated with worse functional outcomes after several weeks of in-hospital rehabilitation. They used a small sample size of ~100 older patients. Morandi et al. [14] presented similar results with an adequate sample size of 280 patients, but the sarcopenia definition adopted in the study was based on anthropometric parameters (handgrip strength [HGS] and calf circumference). In addition, the early recognition, diagnosis, and management of sarcopenia in rehabilitation settings is becoming crucial in the era of rapid population aging. Therefore, further studies are needed to elucidate the clinical effects of sarcopenia in hospital-based rehabilitation settings (Fig. 1).

Sarcopenic dysphagia is characterized by a loss of swallowing muscle mass and function associated with a generalized loss of muscle mass and function [10,15]. Sarcopenic dysphagia is common in older adults with sarcopenia and dysphagia and can be both a result and cause of aspiration pneumonia [15]. Moreover, age-related loss of muscle mass also occurs in swallowing muscles [16–18]. Furthermore, loss of skeletal muscle mass [19–23], HGS [24,25], and generalized sarcopenia [26–28] are associated with dysphagia among older adults in various settings; however, the association has not been verified in rehabilitation settings, and further advances in this area are needed [29].

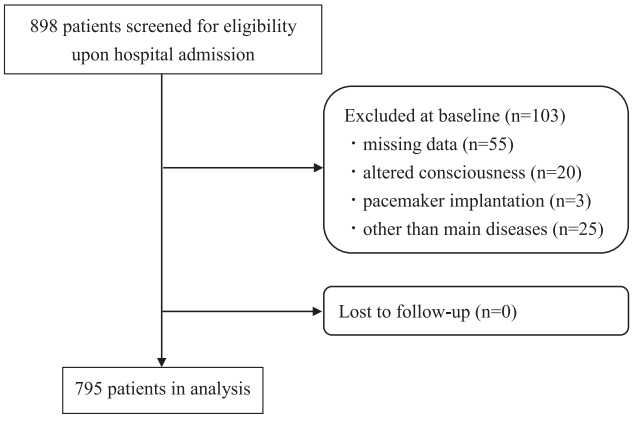

Fig. 1. Flowchart showing the screening, inclusion, and follow-up of participants.

Therefore, we conducted a retrospective cohort study to evaluate the effects of sarcopenia on functional outcomes, including activities of daily living (ADLs), dysphagia status, and the rate of home discharge, among hospitalized adults receiving convalescent rehabilitation.

Methods

Participants and setting

We conducted a single-center, observational cohort study at a 225-bed rehabilitation hospital, which includes a convalescent rehabilitation ward with 135 beds in Kumamoto, Japan [30]. A local core rehabilitation hospital was included, which had three convalescent rehabilitation wards, each containing 45 beds, and was located in a city with a population of ~750 000, where about 31% of the population is >65 y of age. The convalescent rehabilitation ward inpatients were mainly divided into three categories: stroke, musculoskeletal disorders, and hospital-associated deconditioning [31]. All patients with stroke were transferred from the Stroke Care Unit of another acute-care hospital, and >90% of patients with musculoskeletal disease and hospital-associated deconditioning also were transferred from another hospital once they were medically stable.

The rehabilitation program (≤3 h/d) was tailored to fit the functional abilities and disabilities of the patient; for example, physical therapy included paralyzed limb facilitation (for leg paralysis), range of motion exercises, basic movement training (mainly for the legs), walking training, and ADL training.

The nutritional management during hospitalization also was tailored to fit the patients' nutritional and functional status, for example, aggressive nutritional support for malnourished patients, including provision of high energy and high protein, under the guidance of registered dietitians and a nutrition support team.

The study commenced in June 2014, with enrollment and follow-up ending in January 2016 and June 2016, respectively. All newly admitted patients to the wards were eligible to enroll in the study. The exclusion criteria included refusal of consent to participate, missing data, altered consciousness, edema and altered hydration states, pacemaker implantation, or diseases other than the three main diseases (stroke, musculoskeletal disorders, and hospital-associated deconditioning). The observation period was during hospitalization (i.e., from the date of admission to the date of discharge).

Data collection

Basic information was recorded at admission, including age, sex, body mass index (BMI), nutritional status using the Mini Nutritional Assessment-Short Form (MNA-SF) [32], dysphagia status using the Food Intake Level Scale (FILS) [33], comorbidities using the Charlson Comorbidity Index (CCI) [34], premorbid ADLs using the modified Rankin Scale (mRS) [35], admission diagnosis, some laboratory tests (serum albumin, hemoglobin, and C-reactive protein), the number of drugs being prescribed at admission [36] including antihypertensives and antipsychotics (phenothiazine, butyrophenone, benzamide, and atypical antipsychotics) [37], and time (days) from onset of main disease. Hospital-associated deconditioning is unrelated to orthopedic or neurologic diseases [38] and was characterized by the functional decline that occurs during acute hospitalization due to injury, illness, or both.

Within 72 h of admission, BMI, bioelectrical impedance analysis (BIA) for skeletal muscle mass and fat mass, HGS, and the Functional Independence Measure (FIM) scores [39] for physical and cognitive function were measured. HGS was measured using the Smedley hand-dynamometer (TTM, Tokyo, Japan) in the non-dominant hand (or in case of hemiparesis, in the non-paralyzed hand), with the patient in a standing or seated position, depending on ability and with arms straight at the side; the higher value from three measurements was recorded. BIA was measured with adequate hydration and the following conditions: 8 h after the last meal, patient had rested in bed for 1 h before assessment, and no current diagnosis of fever, tremor, or poor physical condition. The instrument used (InBody S10; InBody, Tokyo, Japan) was the latest version of a validated BIA instrument, and its measurement is considered to be minimally affected by fluid overload when estimating muscle mass [40].

Main outcomes

The primary outcome was the motor domain score of the FIM [39] at the time of discharge from the convalescent rehabilitation ward. The FIM is divided into a motor domain (FIM-motor) with 13 sub-items and a cognitive domain (FIM-cognitive) with five sub-items. Tasks are rated on a 7-point ordinal scale that ranges from total assistance to complete independence. The total FIM score ranges from

18 to 126 points; the FIM-motor score ranges from 13 to 91 points, and the FIM-cognitive from 5 to 35 points. Lower scores indicate dependency.

The secondary outcomes include dysphagia status at discharge and the rate of home discharge. The FILS [33], a 10-point observer-rating scale for assessment of dysphagia, was used to classify the severity of dysphagia as follows: "no oral intake" (score: 1–3), "oral intake and alternative nutrition" (score: 4–6), and "oral intake alone" (score: 7–10).

To reduce bias, the physical, occupational, and swallowing rehabilitation therapists and the nurses who assessed FIM and FILS, as well as the medical social workers who were responsible for the patients' residential destinations were independent from those involved in clinical decision making for the treatment and care of the patients.

Sarcopenia definition

In the present study, sarcopenia was diagnosed when both low skeletal muscle mass index (SMI) measured by BIA and low muscle strength measured by HGS were present according to the European Working Group on Sarcopenia in Older People (EWGSOP) criteria [9], with cutoff values specific to Asian older adults [41]. A multifrequency validated BIA instrument was used to measure skeletal muscle mass and fat mass. SMI was calculated from the measured skeletal muscle mass divided by the squared body height in meters. Fat mass index was calculated in the same way. The cutoff values for SMI to define sarcopenia for men and women were <7 and < 5.7 kg/m^2, respectively. The cutoff values for HGS to define sarcopenia for men and women were <26 and <18 kg, respectively [41].

Sample size calculation

The sample size was calculated using data from a previous study [42], the results of which showed that the FIM-motor score of patients admitted to the hospital was normally distributed with a SD of 26. If the true difference in means between those with and without sarcopenia is 10, a sample size of ≥107 participants would be needed in each group to reject the null hypothesis with a power of 0.8 and α-error of 0.05. In the present study, therefore, data were collected for more than 1 y to obtain ≥107 participants in each group.

Statistical analysis

All analyses were performed using SPSS version 21 (IBM, Armonk, NY, USA). The results are reported as means (SD) for parametric data, as medians and 25th to 75th percentiles (interquartile range; IQR) for nonparametric data, and as number (%) for categorical data. Between-group comparisons were made using the *t* test, Mann–Whitney U test, and χ^2 test for those with and without sarcopenia according to the diseases. Multiple linear regression analyses were used to determine whether the presence of sarcopenia on hospital admission was independently associated with FIM-motor and FILS at hospital discharge. Multiple logistic regression analysis was used to determine whether the presence of sarcopenia on hospital admission was independently associated with home discharge from the hospital. Covariates selected to adjust bias were age; sex; days from onset; premorbid mRS; hospital length of stay (LOS); baseline values of CCI, FILS, FIM-motor, FIM-cognitive, and MNA-SF score; the number of total, antihypertensive, and antipsychotic drugs; and admission diagnosis, all of which were reported to be clinically relevant for rehabilitation outcomes [10,43]. The multicollinearity was assessed using the Variance Inflation Factor (VIF): A VIF value between 1 and 10 was considered as the absence of multicollinearity. $P < 0.05$ was considered statistically significant.

Ethics

Informed consent was obtained from all participants or their legal guardians. The study was approved by the Institutional Review Board of Kumamoto Rehabilitation Hospital (Kumamoto, Japan), where the study was conducted. This research was conducted in accordance with the Declaration of Helsinki.

The present study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (Supplementary file).

Results

During the study period, 898 patients were newly admitted, met the inclusion criteria, and were further examined for eligibility. Of these, patients with missing data (n = 55), altered consciousness (n = 20), pacemaker implantation (n = 3), and other than the three main diseases (n = 25) were excluded from the analysis. Finally, 795 participants were enrolled in the study.

The baseline characteristics of the enrolled participants are summarized in Table 1. The mean age was 74.9 y (13.2 y). Of the patients, 59% were women. The main diseases included stroke (n = 276; 34.7%), musculoskeletal disorders (n = 382; 48.1%), and hospital-associated deconditioning (n = 137; 17.2%). Of the 795 patients examined, 402 (50.6%) had sarcopenia, including 155 of the 324 men (47.8%) and 247 of the 471 women (52.4%). Of the patients, 320 (40.3%) were malnourished and 373 (46.9%) at risk for malnutrition. The median initial (IQR) FIM-motor and FIM-cognitive scores were 54 (29–73) and 30 (21–35), respectively, suggesting that a large number of patients were physically dependent at baseline. Patients with sarcopenia were significantly older and had lower MNA-SF scores, BMI, fat mass, HGS, FIM score, FILS score, and serum albumin levels than those without sarcopenia (all; $P < 0.001$). Comorbidity assessed by CCI was significantly worse in patients with sarcopenia ($P < 0.001$). Before hospital admission, patients with sarcopenia were more physically dependent, with higher scores on the premorbid mRS than patients without sarcopenia: 0 (0–1) versus 1 (0–2; $P < 0.001$).

The results of the univariate analysis for clinical and functional outcomes at hospital discharge between patients with and without sarcopenia according to the main diseases are shown in Table 2. All parameters, including FIM-motor, FIM-cognitive, hospital LOS, and the rate of home discharge, were significantly worse in patients with sarcopenia than in those without sarcopenia (all; $P < 0.05$).

The multivariate analyses for FIM-motor and FILS at hospital discharge, and the rate of home discharge after adjusting for potential confounders including the diseases are shown in Tables 3 to 5. All these multivariate analyses included the same covariates for adjusting, and there was no multicollinearity between the variables. The multiple linear regression analysis showed that the presence of sarcopenia at hospital admission was independently and negatively associated with the FIM-motor score at discharge in patients with stroke ($\beta = -0.189$, $P = 0.011$), with musculoskeletal diseases ($\beta = -0.240$, $P = 0.002$), and with hospital-associated deconditioning ($\beta = -0.230$, $P < 0.001$; Table 3), and that the presence of sarcopenia at hospital admission was independently and negatively associated with FILS score at discharge in patients with musculoskeletal diseases ($\beta = -0.271$, $P < 0.001$), but not in those with stroke ($\beta = -0.061$, $P = 0.375$), or with hospital-associated deconditioning ($\beta = -0.131$, $P = 0.070$; Table 4). In addition, the multiple logistic regression analysis showed that the presence of sarcopenia at hospital admission was independently and negatively associated with the rate of home discharge in patients with stroke (odds ratio [OR], 0.201; 95% confidence interval [CI], 67–0.597; $P = 0.004$), with musculoskeletal diseases (OR, 0.242; 95% CI, 0.076–0.772, $P = 0.013$), and with hospital-associated deconditioning (OR, 0.121; 95% CI, 0.110–0.347; $P = 0.009$; Table 5).

Discussion

In this cohort study, we examined the effect of sarcopenia on functional and clinical outcomes in hospitalized adults undergoing convalescent rehabilitation and highlighted the following important findings:

1. Sarcopenia is associated with less ability to perform ADLs at hospital discharge.
2. Sarcopenia is associated with poor dysphagia status at hospital discharge.
3. Sarcopenia is associated with lower rates of home discharge.

Sarcopenia was associated with ADL at discharge in hospitalized adults undergoing convalescent rehabilitation. The degree of

Table 1
Baseline characteristics of participants and between-group comparison according to the presence of sarcopenia

	Total (N = 795)	Sarcopenia (n = 402)	No sarcopenia (n = 393)	*P*-value
Age, y, mean (SD)	74.9 (13.2)	80.5 (9.7)	69.3 (14)	<0.001*
Sex, n (%)				0.220†
Male	324 (40.8)	155 (38.6)	169 (43)	
Female	471 (59.2)	247 (61.4)	224 (57)	
Reason for admission, n (%)				<0.001†
Stroke				
Brain infarction	154 (19.4)	90 (22.4)	64 (16.3)	
Brain hemorrhage	95 (11.9)	46 (11.4)	49 (12.5)	
Subarachnoid hemorrhage	27 (3.4)	8 (2)	19 (4.8)	
Musculoskeletal disease				
Hip fracture	164 (20.6)	90 (22.4)	74 (18.8)	
Vertebral compression fracture	101 (12.7)	52 (12.9)	49 (12.5)	
Total knee arthroplasty	117 (14.7)	38 (9.5)	79 (20.1)	
Hospital-associated deconditioning	54 (6.8)	50 (12.4)	4 (1)	
Due to Pneumonia	83 (10.4)	28 (7)	55 (14)	
Due to others				
MNA-SF score, median [IQR]	8 [6–11]	6 [5–8]	10 [8–11]	<0.001‡
Nutritional status, n (%)				
Normal	102 (12.8)	8 (2.3)	74 (25.2)	<0.001†
At risk	373 (46.9)	106 (30.9)	187 (63.6)	
Malnutrition	320 (40.3)	229 (66.8)	33 (11.2)	
Body mass index, kg/m^2, mean (SD)	21.6 (3.6)	20.1 (2.9)	23.2 (3.5)	<0.001*
SMI, kg/m^2, mean (SD)	5.9 (1.4)	5.1 (0.9)	6.7 (1.2)	<0.001*
FMI, kg/m^2, mean (SD)	6.7 (2.9)	6.3 (2.6)	6.9 (2.8)	0.081*
Handgrip strength, kg, mean (SD)	17.3 (9.7)	11.3 (6.5)	23.4 (9.4)	<0.001*
FIM, score, median [IQR]				
Total	82 [56–107]	64 [43–88]	100 [73–112]	<0.001‡
Motor	54 [29–73]	38 [23–61]	68 [44–79]	<0.001‡
Cognitive	30 [21–35]	28 [18–33]	32 [22–35]	0.231‡
Premorbid mRS, score, median [IQR]	0 [0–1]	1 [0–2]	0 [0–1]	<0.001‡
CCI, median [IQR]	2 [1–3]	3 [2–3]	1 [1–2]	<0.001‡
FILS, score, median [IQR]	8 [6–9]	7 [3–8]	9 [7–10]	<0.001‡
Days from onset, d, mean (SD)	15 (5)	15 (5)	14 (5)	0.110*
Drugs, n, median [IQR]				
Total	4 [2–6]	5 [3–7]	2 [1–4]	<0.001‡
Antihypertensive drugs	1 [1–2]	1 [1–2]	1 [1–1]	0.111‡
Antipsychotics	0 [0–1]	1 [0–1]	0 [0–1]	0.021‡
Laboratory data				
Albumin, g/dL, mean (SD)	3.5 (0.4)	3.4 (0.4)	3.7 (0.4)	<0.001*
Hemoglobin, g/dL, mean (SD)	11.9 (1.7)	11.4 (1.5)	12.3 (1.7)	0.110*
C-reactive protein, mg/dL, mean (SD)	0.4 (0.8)	0.5 (0.8)	0.4 (0.8)	0.621*

CCI, Charlson's Comorbidity Index; FILS, Food Intake Level Scale; FIM, Functional Independence Measure; FMI, fat mass index; MNA-SF, Mini Nutritional Assessment-Short Form; mRS, modified Rankin scale; SMI, skeletal muscle mass index.
*t test.
†χ^2 test.
‡Mann-Whitney U test.

association was weak to mild, with a β of −0.184 (stroke), −0.240 (musculoskeletal disease), and −0.230 (hospital-associated deconditioning). It is assumed that stroke has a major influence on physical functioning, disability, and recovery, and therefore the influence of sarcopenia is alleviated. In addition, sarcopenia had relatively mild effects on the recovery of physical functioning in patients with musculoskeletal disease and hospital-associated deconditioning. Despite the growing interest in sarcopenia, information regarding the condition in hospital-based rehabilitation and its possible association with functional recovery after intensive convalescent rehabilitation programs is limited. To our knowledge, only three studies have demonstrated the association between sarcopenia and functional outcomes in those patients [12–14]. The relatively high prevalence of sarcopenia and its association with worse functional outcomes in the present study, regardless of age, sex, nutritional status, and other possible confounders, is consistent with previous findings in hospital-based rehabilitation settings. Furthermore, a novel aspect of the present study is that we demonstrated the association between sarcopenia and functional outcome in this population, using the largest sample size in relevant study fields, and a reliable sarcopenia definition based on the EWGSOP criteria with Asia Working Group for Sarcopenia cut-off values. Our finding that sarcopenia is associated with functional status at discharge emphasizes the importance of sarcopenia management among hospitalized adults.

Sarcopenia was associated with dysphagia status at discharge. To the best of our knowledge, this cohort study is the first to evaluate the association between sarcopenia and the recovery of dysphagia in a hospital-based rehabilitation setting. Interestingly, this finding was observed only in patients with musculoskeletal diseases (β = −0.271), but not in patients with stroke and hospital-associated deconditioning, indicating that the association between sarcopenia and the recovery of dysphagia largely depends on disease condition. Dysphagia is common in patients after stroke and is one of the most life-threatening post-stroke complications, which can lead to adverse events such as pneumonia, malnutrition, dehydration, and mortality [44,45]. Furthermore, post-stroke dysphagia occurs in as high as 64% to 78% of patients [43]. Therefore, it is assumed that stroke has a major influence on dysphagia and its recovery and that the influence of sarcopenia is alleviated. The

Table 2
Univariate analysis for clinical and functional outcomes at hospital discharge between patients with and without sarcopenia according to the diseases

Outcomes	Stroke (n = 276)			Musculoskeletal disease (n = 382)			Hospital-associated deconditioning (n = 137)		
	Sarcopenia (n = 144)	No sarcopenia (n = 129)	*P*-value	Sarcopenia (n = 180)	No sarcopenia (n = 202)	*P*-value	Sarcopenia (n = 78)	No sarcopenia (n = 59)	*P*-value
FIM-motor, score, median [IQR]	57 [31–79]	90 [75–91]	<0.001*	55 [34–76]	88 [73–91]	<0.001*	45 [28–66]	82 [72–91]	<0.001*
FIM-cognitive, score, median [IQR]	25 [16–31]	33 [30–35]	<0.001*	32 [23–35]	35 [31–35]	<0.001*	24 [17–34]	35 [31–35]	<0.001*
FILS, score, median [IQR]	8 [7–9]	9 [9–10]	<0.001*	7 [7–8]	9 [8–10]	<0.001*	7 [6–8]	9 [8–10]	<0.001*
LOS, d, mean (SD)	107.0 (33.2)	94.3 (31.4)	0.002†	56.5 (5.4)	46.3 (5.9)	<0.001†	76.2 (11.0)	66.2 (10.4)	0.005†
Home discharge, n (%)	77 (54.2)	119 (90.2)	<0.001‡	102 (56.7)	189 (93.6)	<0.001‡	35 (45.5)	52 (89.7)	<0.001‡

FILS, Food Intake Level Scale; FIM, Functional Independence Measure; LOS, length of stay.
*Mann–Whitney U test.
†*t* test.
‡χ^2 test.

same may be true for hospital-associated deconditioning. In the present study, most of the cases of hospital-associated deconditioning were due to pneumonia, and 93% (50 of 54) of these patients were diagnosed with sarcopenia. Although we did not analyze the causes of pneumonia, it is assumed that most of the pneumonia cases were caused by dysphagia-related aspiration in this high-age population. The presence of both dysphagia and sarcopenia at baseline, therefore, might explain the lack of association between sarcopenia and the recovery of dysphagia in patients with (aspiration) pneumonia in this study.

Sarcopenia was an independent risk factor for dysphagia recovery in patients with musculoskeletal diseases in particular. We speculate that the reason for this involves the fact that a generalized loss of muscle mass and function is associated with a loss of swallowing muscle mass [10–15], and consequently, worsening or inadequate improvement of sarcopenia directly leads to a poor recovery of dysphagia. Because hospitalized older patients are likely to experience a further decline in muscle mass [46], older adults with low muscle mass but without dysphagia before the onset of acute diseases might develop a further decline in muscle mass upon hospitalization and may consequently develop, or hinder the improvement of, dysphagia. This hypothesis indicates that sarcopenia management during hospitalization is crucial not only for the recovery of physical function, but also for the recovery of dysphagia.

Sarcopenia was associated with the rate of home discharge in hospitalized adults undergoing convalescent rehabilitation. This risk was relatively mild in patients with stroke (OR, 0.200) and musculoskeletal disease (OR, 0.242), but weak in those with hospital-associated deconditioning (OR, 0.121). There is some evidence showing that physical disability, inactivity, dysphagia, and cognitive impairment are risk factors for not returning home from post-acute settings [47–49]. It is possible that the negative association between sarcopenia and home discharge is directly related to our finding that sarcopenia is associated with functional and swallowing recovery. Furthermore, it is also possible that the relationship between sarcopenia and home discharge is independent of its relationship with functional and swallowing recovery.

Based on the present findings, there is an urgent need to identify sarcopenia at an early stage (i.e., at hospital admission) to initiate prevention and specific intervention to avoid worse functional outcomes among hospitalized adults undergoing rehabilitation. The main goals of sarcopenia treatment should include resistance training and sufficient protein intake, to maintain skeletal muscle mass and function and to recover physical and swallowing function [50]. A recent meta-analysis showed that low-intensity resistance training sufficiently enhances the synthesis of muscle proteins and is therefore recommended for maintaining skeletal muscle mass in frail older people [51]. Furthermore, early nutritional assessment and timely nutritional support is needed to make these exercises multimodal, especially in patients with sarcopenia. It is well accepted that individuals performing resistance training require adequate protein intake, and older adults may benefit from increasing their consumption of branched-chain amino acids, especially leucine [50,52–54]. Rehabilitation nutrition, a concept combining both rehabilitation and nutrition care management, presented by Wakabayashi et al. [10], therefore can further improve functional outcomes among hospitalized patients with sarcopenia undergoing rehabilitation. The concept of rehabilitation nutrition and the International Classification of Functioning, Disability and Health guidelines should be used to evaluate the nutritional status and to maximize functionality in frail older adults and other people with functional disability. Additional studies on rehabilitation nutrition are required to elucidate the

Table 3
Multiple linear regression analysis for FIM-motor at hospital discharge according to the diseases

Variables on hospital admission	Stroke (n = 276)		Musculoskeletal disease (n = 382)		Hospital-associated deconditioning (n = 137)	
	β	*P*-value	β	*P*-value	β	*P*-value
Age	0.131	0.122	0.038	0.459	0.192	0.589
Sex	−0.043	0.239	0.046	0.182	0.022	0.655
Days from onset	−0.012	0.733	0.015	0.670	−0.060	0.190
Premorbid mRS	−0.122	0.013	−0.019	0.664	0.085	0.178
Length of stay	0.077	0.076	−0.026	0.546	−0.136	0.023
CCI	−0.054	0.097	0.002	0.868	0.155	0.009
FILS	0.122	0.045	0.169	0.001	0.104	0.279
FIM-motor	0.561	<0.001	0.519	<0.001	0.590	<0.001
FIM-cognitive	0.114	0.016	0.119	0.005	0.223	0.002
MNA-SF	0.221	0.068	0.025	0.067	0.067	0.395
Total drugs (N)	0.024	0.065	−0.015	0.100	0.024	0.725
Antihypertensive drugs (n)	0.112	0.135	0.014	0.241	0.103	0.448
Antipsychotic drugs (n)	−0.292	0.031	−0.102	0.130	−0.093	0.321
Sarcopenia	−0.189	0.011	−0.240	0.002	−0.230	<0.001
Stroke						
Brain infarction	(Ref)	–	–		–	
Brain hemorrhage	−0.035	0.385	–		–	
Subarachnoid hemorrhage	−0.030	0.404	–		–	
Musculoskeletal disease						
Hip fracture	–		(Ref)	–	–	
Vertebral compression fracture	–		0.071	0.073	–	
Total knee arthroplasty	–		−0.011	0.779	–	
Hospital-associated deconditioning	–		–		(Ref)	–
Due to pneumonia	–		–		−0.100	0.304
Due to others						
*R*2	0.719		0.651		0.790	

CCI, Charlson's Comorbidity Index; FILS, Food Intake Level Scale; FIM, Functional Independence Measure; MNA-SF, Mini Nutritional Assessment-Short Form; mRS, modified Rankin scale.

multimodal treatment responses, considering that the number of older people with disabilities is expected to increase.

Although we have reported novel findings, the present study had some limitations. First, this study was carried out at a single rehabilitation hospital in Japan, possibly limiting the generalization of the results. Future studies are required to determine if similar results can be obtained in different clinical settings. Second, the effect of various interventions, such as rehabilitation treatment

Table 4
Multiple linear regression analysis for FILS at hospital discharge according to the diseases

Variables on hospital admission	Stroke (n = 276)		Musculoskeletal disease (n = 382)		Hospital-associated deconditioning (n = 137)	
	β	*P*-value	β	*P*-value	β	*P*-value
Age	−0.108	0.301	−0.125	0.313	−0.260	0.297
Sex	−0.101	0.088	0.008	0.636	0.067	0.254
Days from onset	−0.030	0.566	−0.038	0.322	−0.117	0.038
Premorbid mRS	−0.076	0.272	−0.027	0.580	−0.139	0.072
Length of stay	0.013	0.282	−0.074	0.118	−0.045	0.534
CCI	−0.010	0.771	−0.008	0.350	−0.064	0.373
FILS	0.223	0.007	0.205	0.059	0.130	0.257
FIM-motor	0.293	<0.001	0.422	<0.001	0.632	<0.001
FIM-cognitive	0.124	0.053	0.187	<0.001	0.154	0.075
MNA-SF	0.093	0.233	0.076	0.153	0.038	0.312
Total drugs (N)	−0.021	0.474	−0.101	0.012	−0.030	0.716
Antihypertensive drugs (n)	0.032	0.110	0.034	0.151	0.053	0.198
Antipsychotic drugs (n)	−0.225	0.042	−0.113	0.070	−0.293	0.061
Sarcopenia	−0.061	0.375	−0.271	<0.001	−0.131	0.070
Stroke						
Brain infarction	(Ref)	–	–		–	
Brain hemorrhage	−0.023	0.674	–		–	
Subarachnoid hemorrhage	0.001	0.899	–		–	
Musculoskeletal disease						
Hip fracture	–		(Ref)	–	–	
Vertebral compression fracture	–		0.044	0.320	–	
Total knee arthroplasty	–		−0.002	0.870	–	
Hospital-associated deconditioning	–		–		(Ref)	–
Due to pneumonia	–		–		0.155	0.141
Due to others						
R^2	0.583		0.576		0.687	

CCI, Charlson's Comorbidity Index; FILS, Food Intake Level Scale; FIM, Functional Independence Measure; MNA-SF, Mini Nutritional Assessment-Short Form; mRS, modified Rankin scale.

Table 5
Multiple logistic regression analysis for home discharge according to the diseases

Variables on hospital admission	Stroke (n = 276)		Musculoskeletal disease (n = 382)		Hospital-associated deconditioning (n = 137)	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P* value
Age	0.890 (0.822–1.049)	0.381	0.910 (0.925–1.073)	0.375	0.893 (0.822–1.095)	0.116
Sex	0.764 (0.307–1.901)	0.562	1.460 (0.501–4.268)	0.487	0.548 (0.046–2.534)	0.232
Days from onset	0.956 (0.896–1.019)	0.169	1.051 (0.923–1.211)	0.422	0.775 (0.606–0.990)	0.042
Premorbid mRS	0.777 (0.508–1.187)	0.243	0.617 (0.284–1.333)	0.224	0.364 (0.030–4.379)	0.426
Length of stay	1.010 (0.993–1.027)	0.261	0.992 (0.923–1.067)	0.738	0.876 (0.774–0.990)	0.034
CCI	1.068 (0.710–1.608)	0.331	0.736 (0.463–1.170)	0.195	2.406 (0.984–5.894)	0.060
FILS	1.044 (0.782–1.397)	0.167	1.650 (1.076–2.529)	0.022	1.041 (0.624–1.998)	0.444
FIM-motor	1.098 (1.061–1.139)	<0.001	1.463 (1.075–1.952)	<0.001	1.451 (1.102–1.911)	0.008
FIM-cognitive	1.028 (0.975–1.083)	0.102	1.096 (0.962–1.195)	0.094	1.160 (0.969–1.389)	0.147
MNA-SF	1.049 (0.818–1.344)	0.307	1.050 (0.765–1.182)	0.126	1.072 (0.449–1.810)	0.328
Total drugs (N)	0.823 (0.794–1.211)	0.862	0.893 (0.707–1.129)	0.345	0.871 (0.112–1.122)	0.142
Antihypertensive drugs (n)	1.021 (0.891–1.144)	0.635	1.141 (0.898–1.301)	0.281	1.150 (0.710–2.103)	0.341
Antipsychotic drugs (n)	0.892 (0.790–0.987)	0.030	0.910 (0.878–1.011)	0.100	0.823 (0.512–1.593)	0.321
Sarcopenia	0.201 (0.067–0.597)	0.004	0.242 (0.076–0.772)	0.016	0.121 (0.110–0.347)	0.009
Stroke						
Brain infarction	(Ref)	–	–		–	
Brain hemorrhage	0.579 (0.191–1.754)	0.334	–		–	
Subarachnoid hemorrhage	0.325 (0.062–1.715)	0.185	–		–	
Musculoskeletal disease						
Hip fracture	–		(Ref)	–	–	
Vertebral compression fracture	–		1.177 (0.585–4.091)	0.246	–	
Total knee arthroplasty	–		0.529 (0.157–1.785)	0.305	–	
Hospital-associated deconditioning						
Due to pneumonia	–		–		(Ref)	–
Due to others	–		–		0.063 (0.001–3.047)	0.125

CCI, Charlson's Comorbidity Index; FILS, Food Intake Level Scale; FIM, Functional Independence Measure; MNA-SF, Mini Nutritional Assessment-Short Form; mRS, modified Rankin scale.

and nutrition therapy, was not investigated. Future studies should investigate the clinical effects of rehabilitation nutrition on sarcopenia and functional outcomes in hospital-based rehabilitation settings.

Conclusions

Sarcopenia is associated with worse recovery of ADLs and dysphagia and a lower rate of home discharge in hospitalized adults undergoing convalescent rehabilitation. Early detection of sarcopenia and treatment by rehabilitation nutrition should be implemented in this population.

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