ORIGINAL

The association between sarcopenia and functional outcomes in patients undergoing convalescent rehabilitation

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Abstract : Sarcopenia is widely believed to be linked to poorer outcomes in inpatient rehabilitation. This study aimed to assess the impact of sarcopenia on functional outcomes and dietary intake during hospitalization in adults undergoing convalescent rehabilitation. We conducted a retrospective cohort analysis at a single rehabilitation institution. The Asian Working Group Consensus Criteria for Sarcopenia was used to diagnose. The Functional Independence Measure (FIM) score was used at hospital discharge to measure the primary functional outcome. Energy and protein intakes during hospitalization were calculated as part of the nutritional assessment. There were 126 patients in the research (median age, 73 yr ; 54% women). Stroke (n = 73 ; 53.4% sarcopenia) and musculoskeletal disorders (n = 53 ; 56.6% sarcopenia) were among the admission diagnoses. Multiple linear regression analysis revealed that the FIM total score at discharge was modestly associated with sarcopenia only in stroke patients (β = –0.1872, P = 0.09), as well as significantly and independently associated with protein intake during admission only in stroke patients (β = 0.3217, P < 0.05). In hospitalized stroke patients undergoing convalescent therapy, sarcopenia is related to lower functional results. Early identification of sarcopenia and treatment with rehabilitation nutrition should be implemented in this population. J. Med. Invest. 70 : 457-463, August, 2023

Keywords **:** *Sarcopenia, Convalescent rehabilitation, Functional outcomes, Functional Independence Measure (FIM), Nutrition*

INTRODUCTION

Sarcopenia is defined as the loss of skeletal muscle mass and strength with aging (1). In frail older persons, maintaining or enhancing physical function and independent functioning is crucial (2), and sarcopenia adds to physical frailty (3). It causes more falls, functional dependency, and death (4). Sarcopenia has primarily been studied in community-dwelling adults and nursing home residents, and it is a major risk factor for mobility impairment, falls, disability, loss of independence, hospitalization, institutionalization, and death (5-8). The prevalence of sarcopenia in hospital-based rehabilitation settings is approximately 50% (9, 10). Although it is often assumed that sarcopenia is associated with poorer outcomes in hospital-based rehabilitation settings (11), few studies have established a connection between sarcopenia and functional outcomes in hospitalized older adults receiving rehabilitation.

Sarcopenia, a skeletal muscle ailment, is caused by aging, inadequate nutritional intake, disease, and inactivity, which results in a considerable loss of cell mass, particularly in skeletal muscle (12, 13). It is not enough to maintain these patients' nutritional condition ; a significant amount of energy is necessary to rebuild their lean mass and skeletal muscle mass. The clinical nutrition community has long acknowledged the importance of modifying energy requirements in these situations (14, 15). However, there is no clear idea of nutritional intervention to address these circumstances in sarcopenic patients. Furthermore, malnutrition is widely recognized in recovery and rehabilitation units (16), and because improved nutritional status and weight gain are associated with improved activities of daily living (ADLs) (17-19), developing a nutritional management strategy to improve nutritional status in clinical settings is important.

As a result, we conducted a retrospective cohort study of inpatient adults undergoing convalescent therapy to see how sarcopenia affected functional outcomes, such as ADLs, home discharge rates, and nutritional intake during hospitalization.

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MATERIALS AND METHODS

Participants and setting

From April 2019 to March 2022, we conducted a single-center, retrospective, cross-sectional study. We considered all consecutive patients hospitalized in Kawasaki Medical School Hospital's convalescent rehabilitation unit. The convalescent rehabilitation ward is unique in the Japanese healthcare system, serving patients who require rehabilitation after being discharged from an acute care unit. The study included patients newly admitted to the ward. Exclusion criteria included refusal to consent, missing data, altered consciousness, edema, and altered hydration status, pacemaker implantation, parenteral nutrition, or diseases other than the two main diseases (stroke and musculoskeletal diseases). The observation period lasted from the time of admission to the time of discharge from the hospital.

Data collection

At admission, basic information, such as age, gender,

admission diagnosis, body mass index (BMI), admission diagnosis, number of medications prescribed at admission (20), including antihypertensives and antipsychotics, time (days) since the onset of the primary illness, and some laboratory tests (serum albumin, hemoglobin, and C-reactive protein) were collected. BMI, bioelectrical impedance analysis (BIA) for skeletal muscle mass and fat mass, handgrip strength (HGS) and calf circumference (CC), and Functional Independence Measure (FIM) scores for physical and cognitive function were tested within 7 days of admission (21). HGS was measured using a Smedley hand dynamometer (TTM, Tokyo, Japan) with the patient standing or sitting, depending on ability, with arms straight at the side ; an average of two readings was taken. BIA was assessed under the following conditions : adequate hydration, 2 h after the last meal, bed rest for 20 min before the evaluation, and no current diagnosis of fever, tremor, or poor physical condition. The device used (InBody S10, InBody, Tokyo, Japan) was the latest version of a validated BIA device, and its measurement is considered minimally affected by fluid overload when estimating muscle mass (22).

Main outcomes

The primary outcome was the FIM score at the time of discharge from the convalescent rehabilitation center (21). The FIM is split into two domains : motor domain (FIM motor) with 13 sub-items and cognitive domain (FIM cognitive) with five sub-items. Tasks are graded on a 7-point ordinal scale ranging from complete help to complete independence. The FIM total score is between 18 and 126 points, the FIM motor score is between 13 and 91 points, and the FIM cognitive score is 5 to 35 points. Lower scores imply dependency.

BMI, skeletal muscle mass index (SMI), HGS, and CC at the time of discharge from the convalescent rehabilitation unit, length of stay (LOS), and discharge rate to home are secondary outcomes.

Diagnosis of sarcopenia

Sarcopenia was diagnosed based on the Asian Working Group for Sarcopenia 2019 consensus when both low muscle strength, as measured by grip strength, and low SMI, as measured by BIA, were present (23). Grip strength cutoff values were less than 28 kg for males and 18 kg for women, and SMI cutoff values were fewer than 7.0 kg/m^2 for men and 5.7 kg/m^2 for women.

Nutrition assessment

Energy and protein intake was assessed as the average during the entire hospitalization. Dietary intake at the time of admission was provide at 30 kcal per ideal body weight for energy and 1.2 g per ideal body weight for protein.

A nurse estimated the energy and protein intakes and visually checked the intake ratio to the amount given to the patient. Breakfast, lunch, and dinner intakes were recorded, and based on oral intake, average daily energy and protein intakes for the entire hospitalization period were calculated and divided by the desired weight at admission to estimate energy and protein intakes per ideal body weight. A BMI of 22.0 kg/m^2 was the ideal body weight (24).

Statistical analysis

For parametric data, values are provided as mean (*SD*) or as median (interquartile range [IQR]) and number (%) for nonparametric and categorical data, respectively. The *t* test, Mann–Whitney *U* test, and χ^2 test were used to compare those with and without sarcopenia according to disease. Multiple linear regression analyses were performed to assess if sarcopenia or energy and protein consumption at hospital admission were independently related to FIM total at hospital release. The variance inflation factor (VIF) was used to quantify multicollinearity : a VIF between 5 and 10 was deemed to reflect the absence of multicollinearity. $P<0.05$ was considered statistically significant. JMP software (SAS Institute Inc., Tokyo, Japan) was used for all statistical analyses.

Ethics

All participants or their legal guardians provided informed consent. The study was approved by the Institutional Review Board of Kawasaki Medical School Hospital (Okayama, Japan), where the study was conducted. This study was conducted in accordance with the tenets of the Declaration of Helsinki.

RESULTS

Patient characteristics and comparison based on the presence of sarcopenia

During the study period, 349 patients were newly admitted, met the inclusion criteria, and were further assessed for eligibility. Patients with missing data, altered consciousness, pacemaker implantation, and other than the two main diseases were excluded from the analysis. Finally, 126 participants were included in the study.

Table 1 shows the clinical and demographic data of the patients. The median age of the patients was 73 (IQR : 61–81) years, and 46.0% were male. The median FIM total, FIM motor, and FIM cognitive scores were 96 (IQR : 69–108), 66 (IQR : 44–75), and 34 (IQR : 27–35), indicating that a significant proportion of patients were physically at baseline. Stroke (n = 73 ; 57.9%) and musculoskeletal diseases (n = 53 ; 42.1%) were the most frequent medical problems. Sarcopenia was found in 53.4% (n = 39) of stroke patients and 56.6% (n = 30) of musculoskeletal patients. Patients with sarcopenia who had a stroke were substantially older ($P < 0.05$). They had lower BMI, SMI, and CC than people who did not have sarcopenia (all, $P < 0.01$). According to comorbidities, there were no variations in FIM score between individuals with and without sarcopenia. Patients with stroke who had sarcopenia had substantially longer days from onset than those who did not have sarcopenia ($P < 0.05$). According to significant comorbidities, indicators of nutritional status, such as albumin and hemoglobin, and markers of inflammation, such as C-reactive protein (CRP), showed no variations between patients with and without sarcopenia.

Clinical and functional outcomes at hospital discharge between patients with and without sarcopenia according to diseases

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. Patients with sarcopenia had substantially lower BMI, SMI, and CC than those without (all, $P < 0.01$). FIM total and FIM motor were significantly lower in patients with sarcopenia following stroke than in those without (all, $P < 0.01$ or $P < 0.05$). After the stroke, FIM cognitive function was slightly lower in patients with sarcopenia than those without ($P = 0.0699$). According to musculoskeletal illnesses, the FIM score revealed no differences between patients with and without sarcopenia. According to significant comorbidities, there were no differences in LOS between patients with and without sarcopenia. According to stroke, home discharge rate was marginally worse in patients with sarcopenia than those without ($P = 0.0571$). According to musculoskeletal illnesses, home discharge rate revealed no differences between patients with and without sarcopenia.

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

		Stroke (n = 73)			Musculoskeletal disease (n = 53)		
	Total (N = 126)	Sarcopenia (n = 39)	No sarcopenia (n = 34)	P value	Sarcopenia (n = 30)	No sarcopenia (n = 23)	P value
Demographic							
Age (yr), median (IQR)	73 (61–81)	76 (69–83)	65 (53–73)	0.0024	79 (70–82)	76 (58–80)	0.1406
Sex, n (%)				0.6356			0.0786
Male	58 (46.0)	21 (53.8)	21 (61.8)		6 (20.0)	10 (43.5)	
Female	68 (54.0)	18 (46.2)	13 (38.2)		24 (80.0)	13 (56.5)	
Reason for admission, n (%)							
Stroke							
Brain infarction	33 (26.2)	17 (43.6)	16 (47.1)				
Cervical spondylotic myelopathy	9 (7.1)	7 (17.9)	2 (5.9)				
Brain hemorrhage	8 (6.3)	2 (5.1)	6 (17.6)				
Subarachnoid hemorrhage	6 (4.8)	4 (10.3)	2 (5.9)				
Spinal cord injury	6 (4.8)	2 (5.1)	4 (11.8)				
Brain tumor	4 (3.2)	4 (10.3)					
Peripheral neuropathic	1 (0.8)	1 (2.6)					
Polyneuropathy	1 (0.8)	1 (2.6)					
Spinal cord tumor	1 (0.8)	1 (2.6)					
Multiple sclerosis	1 (0.8)		1 (2.9)				
Cerebral palsy	1 (0.8)		1 (2.9)				
Brain arteriovenous malformation	1 (0.8)		1 (2.9)				
Lateral medullar	1 (0.8)		1 (2.9)				
Musculoskeletal disease							
Fractures	33 (26.2)				18 (60.0)	15 (65.2)	
Degenerative joint disease	10 (7.9)				6 (20.0)	4 (17.4)	
Total knee arthroplasty	7 (5.6)				6 (20.0)	1 (4.3)	
Amputation	3 (2.4)					3 (13.0)	
Anthropometrics							
BMI (kg/m^2), median (IQR)	22.3 (24.7–20.2)	20.4 (18.7–22.4)	24.2 (22.0–26.9)	<0.0001	21.7 (19.3–22.6)	24.4 (22.7–25.4)	0.0004
SMI (kg/m^2), median (IQR)	6.2 (5.3–7.1)	5.5 (4.6–6.5)	7.2 (6.3–7.6)	<0.0001	5.4 (4.9–5.6)	7.4 (6.5–8.0)	<0.0001
CC (cm), mean (*SD*)	32.2 (3.6)	29.9 (2.9)	34.7 (2.8)	0.0001	30.7 (2.4)	34.4 (3.4)	<0.0001
Handgrip strength (kg), mean (*SD*)	20.1 (9.1)	18.4 (8.6)	23.2 (9.1)	0.0532	16.8 (6.5)	22.0 (10.8)	0.0666
FIM score, median (IQR)							
Total	96 (69–108)	86 (52–101)	95 (81–102)	0.2592	101 (89–109)	107 (87–112)	0.3643
Motor	66 (44–75)	63 (20–71)	62 (46–74)	0.4653	67 (54–74)	73 (52–77)	0.4562
Cognitive	34 (27–35)	30 (18–35)	33 (25–35)	0.1670	35 (32–35)	35 (33–35)	0.5228
Days from onset (days), median (IQR)	23 (17–34)	27 (19–40)	21 (14–32)	0.0240	23 (18–36)	20 (14–28)	0.1180
Drugs							
Total (n), median (IQR)	6 (3–7)	5 (3–7)	5 (4–7)	0.1441	5 (2–10)	4 (3–8)	0.4562
Antihypertensive drugs, n (%)	57 (45.2)	22 (56.4)	25 (73.5)	0.1483	4 (13.3)	6 (26.1)	0.2995
Antipsychotics, n (%)	30 (23.8)	9 (23.1)	8 (23.5)	0.9636	10 (33.3)	3 (13.0)	0.0666
Laboratory data							
Albumin (g/dL), mean (*SD*)	3.6 (0.5)	3.4 (0.4)	3.8 (0.5)	0.9745	3.5 (0.5)	3.5 (0.5)	0.9743
Hemoglobin (g/dL), mean (*SD*)	11.9 (1.9)	12.0 (1.8)	13.2 (1.9)	0.1639	10.8 (1.6)	11.4 (1.7)	0.1639
CRP (mg/dL), median (IQR)	0.24 (0.09–0.55)	0.14 (0.05–0.38)	0.23 (0.08–0.40)	0.6239	0.36 (0.14–0.64)	0.37 (0.14–1.01)	0.8393

Note. Data are presented as mean or median. Between-group comparisons were made using the t test and Mann–Whitney U test.
Abbreviations : BMI, body mass index ; CC, calf circumference ; CRP, C-reactive protein ; FIM, Functional Independence Measure ; IQR, interquartile rate ; SMI, skeletal muscle mass index.

Energy and protein intake and dietary assessment in admission between patients with and without sarcopenia by disease

Table 3 compares the dietary assessments of patients with and without sarcopenia admission based on the major disorders. According to the primary diseases, there were no changes in energy and protein intake and dietary intake rate between patients with and without sarcopenia.

Multiple linear regression analysis for FIM total at hospital discharge according to diseases

Table 4 shows the multivariate analyses for FIM total at hospital discharge after adjusting for sarcopenia or energy and

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

	Stroke (n = 73)			Musculoskeletal disease (n = 53)		
	Sarcopenia (n = 39)	No sarcopenia (n = 34)	P value	Sarcopenia (n = 30)	No sarcopenia (n = 23)	P value
Anthropometrics						
Body mass index (kg/m^2), median (IQR)	20.1 (18.8–20.5)	24.5 (21.9–26.0)	<0.0001	21.4 (18.9–22.7)	23.6 (22.0–25.5)	0.0006
SMI (kg/m^2), median (IQR)	5.7 (5.1–6.5)	7.1 (6.3–7.8)	0.0001	5.4 (5.1–6.0)	7.3 (6.4–7.8)	<0.0001
Calf circumference (cm), median (IQR)	31.0 (28.6–32.9)	35.4 (33.6–37.7)	<0.0001	31.6 (30.1–33.2)	33.8 (32.4–36.2)	0.0004
Handgrip strength (kg), mean (*SD*)	18.0 (9.3)	23.7 (8.7)	0.098	16.0 (5.9)	20.3 (10.7)	0.0980
FIM score, median (IQR)						
Total	102 (89–118)	118 (103–122)	0.0178	115 (108–118)	115 (113–120)	0.4275
Motor	80 (60–85)	86 (72–89)	0.0399	80 (74–83)	80 (79–85)	0.4060
Cognitive	31 (21–35)	34 (30–35)	0.0699	35 (33–35)	35 (35–35)	0.1221
LOS (days), median (IQR)	59 (32–113)	54 (42–86)	0.5802	57 (42–76)	58 (35–96)	0.3413
Home discharge, n (%)	33 (84.6)	33 (97.1)	0.0571	27 (90.0)	20 (87.0)	0.7299

Note. Data are presented as mean or median. Between-group comparisons were made using the t test and Mann–Whitney U test.
Abbreviations : FIM, Functional Independence Measure ; IQR, interquartile rate ; LOS, length of stay ; SMI, skeletal muscle mass index.

Table 3. Energy and protein intake and dietary intake rate in admission between patients with and without sarcopenia according to the diseases

	Stroke (n = 73)			Musculoskeletal disease (n = 53)		
	Sarcopenia (n = 39)	No sarcopenia (n = 34)	P value	Sarcopenia (n = 30)	No sarcopenia (n = 23)	P value
Dietary assessment						
Energy intake in admission (kcal/day/kg IBW), median (IQR)	26 (24–29)	27 (25–30)	0.6173	27 (24–32)	30 (26–34)	0.2391
Protein intake in admission (g/day/kg IBW), median (IQR)	1.1 (0.9–1.2)	1.0 (1.0–1.1)	0.3725	1.1 (0.9–1.2)	1.1 (1.0–1.3)	0.2541
Dietary intake rate in admission (%), median (IQR)	89 (83–93)	92 (86–96)	0.1378	90 (84–94)	93 (88–96)	0.0712

Note. Data are presented as mean or median. Between-group comparisons were made using the t test and Mann–Whitney U test.
Abbreviation : IQR, interquartile rate.

Table 4. Multiple linear regression analysis for FIM total at hospital discharge according to diseases

	Stroke (n = 73)		Musculoskeletal disease (n = 53)	
	β	P value	β	P value
Age	− 0.4941	<0.0001	− 0.1191	0.4263
Sex	− 0.1851	0.0896	− 0.1328	0.3943
Sarcopenia	− 0.1872	0.0856	− 0.0973	0.5285
Energy intake in admission	− 0.2363	0.1241	0.0022	0.9919
Protein intake in admission	0.3217	0.0365	− 0.0099	0.9648
R^2	0.3192		0.0575	
P value	<0.0001		0.7288	

Note. β, standardized partial regression coefficient. Adjusted for age and sex at admission.

protein consumption on admission by disease. After controlling for relevant confounders, such as age and gender, sarcopenia was modestly linked with FIM total at hospital release according to stroke (β = –0.1872, P = 0.0856). Furthermore, protein consumption at admission was linked with FIM total after hospital release on stroke (β = 0.3217, P < 0.05).

DISCUSSION

Sarcopenia, or the age-related loss of muscle mass and strength, dramatically hinders physical function and independent functioning in frail older persons, increasing the risk of falls, functional reliance, and death. In this cohort study, we investigated the impact of sarcopenia on functional outcomes, such as ADLs, and the rate of release to home among hospitalized people receiving convalescent therapy. There was no difference in admission FIM ratings between patients with and without sarcopenia for stroke. FIM ratings upon discharge were lower in patients with sarcopenia at the time of transfer than in patients without sarcopenia. Furthermore, sarcopenia was linked to ADL at discharge in people hospitalized for stroke. With a β of –0.1872 (stroke), the degree of association was mild to moderate. It is hypothesized that because stroke significantly impacts physical functioning, disability, and recovery, the impact of sarcopenia is reduced. This finding is consistent with the results of Yoshimura *et al*. survey (25). It has been observed that malnutrition and sarcopenia are related to poorer outcomes, such as ADL and home discharge rates in rehabilitation individuals (25, 26). Our discovery that poststroke sarcopenia is related to status after discharge emphasizes the necessity in hospitalized patients. We conducted further analyses to explore the relationship between the presence of sarcopenia and recovery of physical function. Specifically, we examined the difference in FIM scores from admission to discharge (FIM gain) in relation to sarcopenia. However, our results did not show a significant relationship (data not shown). It is worth noting that FIM gain is often difficult to improve in patients requiring total assistance, while a ceiling effect is observed in patients with light assistance, resulting in minimal gains. Conversely, patients with moderate assistance showed greater gains (27). In addition, the lack of improvement and ceiling effects observed in critically ill patients may influence FIM gains on admission (27). A plausible explanation for the lack of association between FIM gain and the presence of sarcopenia in our study could be due to the substantial interindividual variability in admission FIM scores, which consequently led to substantial interindividual variability in FIM gain. To obtain more precise results, future studies should consider increasing the sample size and performing a more comprehensive examination.

Based on the current findings, there is an urgent need to detect early (i.e., at hospital admission) to commence preventive and particular interventions to avoid worse functional outcomes among hospitalized individuals receiving rehabilitation. Resistance training and proper calorie and protein consumption should be the primary aims of sarcopenia treatment to preserve skeletal muscle mass and function and restore physical function (28). Protein consumption at admission was linked to FIM score at discharge in hospitalized stroke patients undertaking convalescent therapy in this research. In stroke patients, this risk was relatively low (β of 0.3217). In contrast, in hospitalized stroke patients receiving convalescent rehabilitation, energy intake at admission was not related to the FIM score at discharge. These findings imply that dietary protein intake regulation is more important than energy consumption functional outcomes in stroke patients. Protein intake of 1.0–1.5 g/kg of ideal body weight per day is indicated to improve sarcopenia (29). Protein consumption in stroke patients with sarcopenia was within the recommended range in this study. As a result of these findings, it is proposed that the target protein consumption be increased compared with the intake in this study to improve functional outcomes in stroke patients with sarcopenia. Nutritional therapy that accounts for daily energy consumption, protein requirements, and accumulation is required and will be a future challenge in this study (30).

Previous research has linked sarcopenia in patients with musculoskeletal disorders to poor functional outcomes due to impaired ADL (25, 31). Our study, however, found no link between sarcopenia at admission and functional outcomes, including ADLs, in patients with musculoskeletal disorders. This study's sub-analysis could not explain the reasons for the disparity with earlier investigations. Musculoskeletal disease is more likely to cause localized damage than cerebrovascular disease, and the disease's severity may be less severe. As a result, the recovery rate in functional prognosis with or without sarcopenia may differ. This study did not consider factors influencing sarcopenia on admissions and functional outcomes, such as rehabilitation duration, content, and physical activity levels, which may influence the association. Similarly, factors influencing these outcomes, such as family presence, long-term care insurance, living environment, disease severity, and treatment, were not investigated (32-34). Because the investigation was conducted retrospectively, certain unadjusted factors may have influenced the findings. High-quality prospective studies are needed to study the impact of sarcopenia and functional outcomes on hospital LOS and discharge rates to home, as well as social contexts, such as the presence of family members for support and social services.

This study has several limitations. First, the small sample size and single-study setting may reduce the precision of the statistical analysis and limit the generalizability of the results. Future research is needed to see if similar outcomes may be obtained in diverse therapeutic contexts. Second, the effects of various sarcopenia therapies, such as rehabilitation therapy and nutrition therapy, were not studied. Third, because the study was conducted retrospectively, the effect of confounding factors on the results could not be adequately corrected. Finally, there was no evidence of a causal association between diet and improved functional outcomes at hospital discharge in this trial. The clinical effects of a rehabilitation nutrition on sarcopenia and functional results in hospital-based rehabilitation settings should be investigated in future studies.

CONCLUSION

In conclusion, the results suggest that sarcopenia is associated with functional status at hospital discharge, emphasizing the importance of early detection and diagnosis of sarcopenia and dietary management (particularly protein intake) in patients undergoing convalescent rehabilitation, particularly those with stroke.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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