Spinal Cord (2019) 57:501–508
https://doi.org/10.1038/s41393-019-0245-9

ARTICLE

Relationship between nutritional status and improved ADL in individuals with cervical spinal cord injury in a convalescent rehabilitation ward

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Received: 11 August 2018 / Revised: 24 December 2018 / Accepted: 14 January 2019 / Published online: 30 January 2019

Abstract

Study design Retrospective cohort study.

Objectives To investigate the relationship of nutritional status with improvement of activities of daily living in individuals with cervical spinal cord injury.

Setting A convalescent rehabilitation ward at the Toyama Prefectural Rehabilitation Hospital and Support Center for Children with Disabilities in Japan.

Methods This retrospective analysis investigated adults (age ≥20 years) with cervical spinal cord injury who were consecutively admitted to a convalescent rehabilitation ward between 2006 and 2015. Data of 154 patients were analyzed. Nutritional status was evaluated using the Subjective Global Assessment (SGA; 3 groups: well-nourished, suspected of being malnourished or moderately malnourished, severely malnourished) and body mass index (BMI; 3 groups: underweight, standard, and overweight and obese). The main outcome was functional independence measure (FIM) efficiency. Multiple regression analysis was performed to investigate the relationship of SGA and BMI to FIM efficiency.

Results FIM efficiency was significantly higher in the well-nourished group based on the SGA than in the two groups with malnutrition ($P = .007$: 0.32 vs. 0.26 vs. 0.10). Multivariate regression analysis revealed that FIM efficiency was similar in the underweight and standard group, but was significantly higher in the overweight and obese group ($P = .006$: 0.20 vs. 0.21 vs. 0.31).

Conclusions SGA and BMI on admission may be independently associated with FIM efficiency in patients with cervical spinal cord injury.

Introduction

In recent years, many elderly people receiving rehabilitation have malnutrition and sarcopenia, and nutritional management is therefore an important consideration in rehabilitation [1]. The prevalence of malnutrition is reported to range from 20 to 69% in adults hospitalized for rehabilitation [2–4] and from 40 to 50% specifically in individuals with spinal cord injury (SCI) admitted to rehabilitation units [5]. Reports on muscle mass assessment and sarcopenic obesity in individuals with chronic SCI note the importance of nutritional management to prevent both malnutrition and obesity [6, 7]. In a study on nutritional status in SCI, body mass index (BMI) was found to be lower and nutritional status poorer in individuals with SCI than in a control group of patients without SCI [8]. A literature review on BMI and waist circumference in individuals with chronic SCI found no difference in their BMI,

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but significantly higher percent body fat compared with health-controlled people [9].

Although studies have indicated that nutritional status and nutritional improvement correlate with functional improvement in stroke patients [10, 11], no published studies to the authors' knowledge, have investigated this correlation in patients with SCI. The number of older patients with SCI is increasing with the progressive aging of the population [12]. Many of these SCIs in older patients are caused by trauma such as falls, reducing their activities of daily living (ADL) [12]. Also, in severe cases, especially patients with cervical SCI, long-term full-time care is required, and affected individuals can develop various complications, such as dysphagia, cardiovascular disease, and decubitus ulcers [13–15] that can contribute to malnutrition and sarcopenia. Therefore, the relationship between nutritional status and ADL improvement is important especially in older individuals with cervical SCI.

In this study, we focused on individuals with cervical SCI who were admitted to a convalescent rehabilitation ward in Japan. The convalescent rehabilitation ward is managed by a multidisciplinary team that provides intensive rehabilitation for 3 h per day during hospitalization [16], with the aim of a smooth transition for patients into social participation and eventual discharge home by improving their ADL. In Japan, indications for admission to this ward are target diseases, such as cerebrovascular disorders, and hip fracture, SCI, and hospital-associated deconditioning; admission is also limited to patients within 2 months of injury.

The purpose of this study was to investigate the relationship between nutritional status on admission to convalescent rehabilitation wards and ADL improvement in individuals with cervical SCI.

Methods

Participants

This retrospective cohort study analyzed data from the medical records of adult patients aged ≥20 years who were consecutively admitted for rehabilitation to the convalescent rehabilitation ward at Toyama Prefectural Rehabilitation Hospital and Support Center for Children with Disabilities between April 2006 and December 2015. Participants who died during hospitalization, were re-hospitalized, or were transferred to another acute care hospital were excluded.

Data collection

Main survey items were age, sex, length of hospital stay (LOS), days from SCI onset to admission, injury etiology, vertebral injury, spinal surgery, and American Spinal Injury Association (ASIA) impairment scale score from evaluation using the International SCI Core Data Set, mode of nutrition management (oral intake or tube feeding), nutritional indicator (Subjective Global Assessment [SGA], and BMI), and ADL index (Functional Independence Measure [FIM]).

The ASIA impairment scale score is an international standard for neurological classification of SCI [17] and classifies SCI into five groups: A (Complete: complete loss of motor and sensory function in the S4–5 area), B (Sensory incomplete: complete loss of motor function with sensory dysfunction including the S4–5 area), C (Motor incomplete: motor function is preserved below the neurological level and more than half of the key muscles below the neurological level have a muscle grade less than 3), D (Motor incomplete: motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more), and E (Normal: motor and sensory function are normal).

SGA is a method of nutritional assessment described in 1982 by Baker et al. with three classifications [18]: A (well-nourished), B (suspected of being malnourished or moderately malnourished), and C (severely malnourished). To evaluate the SGA, participants or family members answered questions relating to weight loss, eating habits, gastrointestinal symptoms, functional capacity, and disease, as well as physical examination. SGA is a widely used evaluation method and its reliability and validity have been verified [19]. In this study, participants were classified into three groups (A, well-nourished group; B, suspected of being malnourished or moderately malnourished group; C, severely malnourished group) and verified.

BMI was defined as weight in kilograms divided by the square of height in meters. Participants were also classified into 4 groups following the BMI categories for Asian populations as recommended by the World Health Organization [20]: underweight group, $<18.5\ kg/m^2$; standard group, 18.5 to $<23\ kg/m^2$; overweight group, 23 to $<27.5\ kg/m^2$; and obese group, $>27.5\ kg/m^2$. They were classified into three groups (low body weight group, standard group, overweight and obese group) and verified.

ASIA impairment scale score, SGA, and BMI had been systematically measured by a registered nurse and dietitian, respectively, on the day of admission.

Main outcome measurement

This study used FIM efficiency as the main outcome measurement. The FIM measure has been verified for reliability and validity, and consists of 13 items on motor function and 5 on cognitive function [21]. For each item, the independence level is evaluated in 7 stages from total assistance (1 point) to complete independence (7 points), and the total score ranges from 18 to 126 points. FIM efficiency is the improvement score in FIM per day and can be calculated as change in FIM score between admission and discharge to a convalescent rehabilitation ward divided by LOS.

Sample size calculation

The sample size was calculated using G*Power 3 [22]. Post hoc power analysis was performed using G*Power from the average value of each SGA group and the number of participants. In this study, we calculated the sample size using the ANOVA model instead of the regression model.

Statistical analysis

All statistical analysis was performed using SPSS version 21.0 (IBM Corporation; Armonk, NY). Parametric data are expressed as mean ± standard deviation and non-parametric data as median and interquartile range. One-way analysis of variance, the chi-square test, *t*-test, and Kruskal–Wallis test were used to analyze differences between groups as appropriate. Multiple regression analysis was used to investigate whether SGA and BMI independently affected FIM efficiency and FIM score at discharge. Other candidate factors for explanatory parameters were age, sex, ASIA impairment scale score, SGA, BMI category and FIM score at admission. In multiple regression analysis, SGA on admission and ASIA impairment scale score on admission were categorized and analyzed. A *P*-value less than .05 was considered statistically significant.

In the multiple regression analysis, the variance inflation factor (VIF) value was evaluated in order to investigate whether each variable had multicollinearity. If the VIF value is equal to 1, no multicollinearity exists in regression analysis. If the VIF value is >1, the regression analysis may be correlated. If the VIF value is 10 or less, it is considered that there is no multicollinearity. If the VIF value is 10 or more, it can be considered that the regression coefficient is not sufficiently estimated due to multicollinearity [23, 24].

Results

During the study period, 176 patients with cervical SCI requiring rehabilitation were admitted to the convalescent rehabilitation ward. Patients who transferred to other hospitals for acute care (4 cases) or were readmitted (19 cases) were excluded. The remaining 154 participants (132 men and 22 women; mean age 67.1 ± 12.7 years) were included in the study. None of the enrolled participants died during hospitalization. From post hoc power analysis using the ANOVA model, the sample size was effect size = 0.26, power = 0.82; power was ≥0.8, which was not optimal for the number of cases. Thus, this study included ~10 years of data to ensure a sufficient number of patients to achieve sufficient statistical power. The breakdown of patients by year of hospitalization was 10 in 2006, 20 in 2007, 17 in 2008, 21 in 2009, 12 in 2010, 15 in 2011, 13 in 2012, 11 in 2013, 19 in 2014, and 16 in 2015, and there was no statistically significant difference ($P = .736$).

Median LOS was 109 days. Median days from SCI onset to admission was 39 days. Total and motor FIM scores on admission were, respectively, 58.0 (38.0–73.8) points and 31.5 (13.0–46.5) points. AIS on admission was A (Complete) in 18 patients (11.7%), B (Sensory incomplete) in 10 (6.5%), C (Motor incomplete) in 79 (51.3%), and D (Motor incomplete) in 47 (30.5%). There were two participants with full FIM at the time of discharge.

Table 1 shows the characteristics of participants classified by SGA on admission: 44 (28.6%) were classified as A (well-nourished), 78 (50.6%) as B (suspected of being malnourished or moderately malnourished), and 32 (20.8%) as C (severely malnourished). Therefore, 110 participants (71.4%) were considered to have some level of malnutrition (SGA categories: B and C). Twenty-five participants (89.3%) who were judged as having low ASIA impairment scale score, AIS A and B were considered malnourished. Results below are presented as A vs. B vs. C. LOS was significantly shorter in the well-nourished group than in the other two groups ($P < .001$: 86.5 days vs. 125.2 days vs. 152.2 days). Total FIM score and motor FIM score on admission were significantly higher in the well-nourished group than in the other two groups (total FIM score: $P < .001$; 77.4 points vs. 53.6 points vs. 41.9 points, motor FIM score: $P < .001$; 47.3 points vs. 27.7 points vs. 18.7 points). FIM gain and motor FIM gain were higher in the groups with SGA of A or B than in the group with an SGA of C (FIM gain: $P = .006$; 24.0 points vs. 26.2 points vs. 13.7 points, motor FIM gain: $P < .001$; 21.9 points vs. 23.6 points vs. 10.6 points). Total FIM efficiency and motor FIM efficiency were significantly higher in the well-nourished group than in the other two SGA groups (total FIM efficiency: $P < .001$; 0.32 points vs. 0.26 points vs. 0.10 points, motor FIM efficiency: $P < .001$; 0.29 points vs. 0.23 points vs. 0.08 points).

Table 2 shows the characteristics of participants classified by BMI. Based on BMI at admission, 27 participants (17.5%) were classified as underweight, 79 (51.3%) as standard, 48 (31.2%) as overweight and obese (overweight group, 40 participants; obese group, 8 participants). There was no significant difference in LOS or AIS among these BMI groups ($P = .384$, $P = .56$, respectively). Also, the groups with higher BMI tended to have greater total FIM gain and motor FIM gain, but the univariate analysis revealed no significant difference (total FIM gain: $P = .555$; 19.3 points vs. 22.9 points vs. 25.2 points, motor FIM gain:

Table 1 Characteristics of patients classified by SGA

Characteristics	All ($n = 154$)	SGA: A ($n = 44$; 28.6%)	SGA: B ($n = 78$; 50.6%)	SGA: C ($n = 32$; 20.8%)	*P*-value
Mean age (SD), years	67.1 (12.7)	64.3 (11.6)	68.5 (13.2)	67.7 (12.6)	0.200[a]
Sex, n (%)					0.41[b]
Male	132 (85.7)	39 (88.6)	64 (82.0)	29 (90.6)	
Female	22 (14.3)	5 (11.4)	14 (18.0)	3 (9.4)	
Length of hospital stay (IQR), days	119.7 (71.3–146.5)	86.5 (56.3–109.3)	125.2 (74.3–156.8)	152.2 (116.5–154.75)	<0.001[c]
Days from SCI onset to admission (IQR), days	49.1 (34.0–60.0)	45.0 (30.8–58.3)	48.7 (36.0–59.8)	55.3 (38.0–64.8)	0.151[c]
Injury etiology, n (%)					0.075[b]
Sports	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Assault	1 (0.6)	1 (2.2)	0 (0.0)	0 (0.0)	
Transport	29 (18.8)	12 (27.3)	12 (15.4)	5 (15.6)	
Fall	121 (78.6)	29 (66.0)	66 (84.6)	26 (81.3)	
Other	3 (2.0)	2 (4.5)	0 (0.0)	1 (3.1)	
Vertebral injury, n (%)					0.528[b]
No	117 (76.0)	35 (79.5)	60 (76.9)	22 (68.8)	
Yes	37 (24.0)	9 (20.5)	18 (23.1)	10 (31.2)	
Unknown	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Spinal surgery, n (%)					0.34[b]
No	74 (48.0)	25 (56.8)	36 (46.2)	13 (40.6)	
Yes	80 (52.0)	19 (43.2)	42 (53.8)	19 (59.4)	
Unknown	0 (0.0)	0(0.0)	0(0.0)	0(0.0)	
ASIA Impairment scale score on admission, n (%)					<0.001[b]
A	18 (11.7)	2 (4.6)	10 (12.8)	6 (18.7)	
B	10 (6.5)	1 (2.3)	4 (5.2)	5 (15.6)	
C	79 (51.3)	17 (38.6)	43 (55.1)	19 (59.4)	
D	47 (30.5)	24 (54.5)	21 (26.9)	2 (6.3)	
Nutrition, n (%)					0.338[b]
Oral intake	152 (98.7)	43 (97.7)	78 (100.0)	31 (96.9)	
Tube feeding	2 (1.3)	1 (2.3)	0 (0)	1 (3.1)	
BMI					0.018[b]
Underweight (<18.5 kg/m^2)	27 (17.5)	2 (4.5)	14 (17.9)	11 (34.4)	
Standard (18.5 to <23 kg/m^2)	79 (51.3)	26 (59.1)	41 (52.6)	12 (37.5)	
Overweight and Obese (>23 kg/m^2)	48 (31.2)	16 (36.4)	23 (29.5)	9 (28.1)	
FIM on admission (IQR)	58.0 (38.0–73.8)	77.4 (55.5–95.3)	53.6 (37.0–67.8)	41.9 (34.0–46.3)	<0.001[c]
Motor FIM on admission (IQR)	31.5 (13.0–46.5)	47.3 (29.3–64.3)	27.7 (13.0–38.5)	18.7 (13.0–17.0)	<0.001[c]
Total FIM gain (IQR)	23.0 (6.5–34.0)	24.0 (11.8–33.3)	26.2 (8.0–40.8)	13.7 (4.8–15.5)	0.006[c]
Motor FIM gain (IQR)	20.4 (5.0–32.0)	21.9 (11.0–31.3)	23.6 (6.0–36.0)	10.6 (0–13.5)	<0.001[c]
Total FIM efficiency (IQR)	0.24 (0.07–0.36)	0.32 (0.15–0.40)	0.26 (0.08–0.36)	0.10 (0.03–0.12)	<0.001[c]
Motor FIM efficiency (IQR)	0.22 (0.05–0.32)	0.29 (0.14–0.37)	0.23 (0.06–0.33)	0.08 (0–0.1)	<0.001[c]

FIM functional independence measure, *SGA* subjective global assessment (A: well-nourished, B: suspected of being malnourished or moderately malnourished, C: severely malnourished)

[a] *t*-test

[b] The chi-square test

[c] Kruskal–Wallis test

Table 2 Characteristics of patients classified by BMI

Characteristics	All ($n = 154$)	Underweight <18.5 kg/m^2 ($n = 27$; 17.5%)	Standard 18.5 to <23 kg/m^2 ($n = 79$; 51.3%)	Overweight and obese >23 kg/m^2 ($n = 48$; 31.2%)	*P*-value
Mean age (SD), years	67.1 (12.7)	68.3 (12.3)	67.7 (13.3)	65.5 (11.9)	0.401[a]
Sex, n (%)					0.583[b]
Male	132 (85.7)	23 (85.2)	66 (83.5)	43 (89.6)	
Female	22 (14.3)	4 (14.8)	13 (16.5)	5 (10.4)	
Length of hospital stay (IQR), days	119.7 (109.2–130.3)	113.1 (70.0–140.0)	120.3 (80.5–144.0)	122.5 (61.5–157.5)	0.384[c]
Days from SCI onset to admission (IQR), days	49.1 (34.0–60.0)	59.3 (43.0–69.5)	49.9 (36.5–60.0)	41.9 (27.8–48.5)	0.637[c]
Injury etiology, n (%)					0.153[b]
Sports	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Assault	1 (0.6)	1 (3.7)	0 (0.0)	0 (0.0)	
Transport	29 (18.8)	3 (11.1)	20 (25.3)	6 (12.5)	
Fall	121 (78.6)	23 (85.2)	57 (72.2)	41 (85.4)	
Other	3 (2.0)	0 (0.0)	2 (2.5)	1 (2.1)	
Vertebral injury, n (%)					0.252[b]
No	117 (76.0)	18 (66.7)	59 (74.7)	40 (83.3)	
Yes	37 (24.0)	9 (33.3)	20 (25.3)	8 (16.7)	
Unknown	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Spinal surgery, n (%)					0.728[b]
No	74 (48.0)	11 (40.7)	39 (49.4)	24 (50.0)	
Yes	80 (52.0)	16 (59.3)	40 (50.6)	24 (50.0)	
Unknown	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
ASIA impairment scale score on admission, n (%)					0.56[b]
A	18 (11.7)	2 (7.4)	7 (8.9)	9 (18.8)	
B	10 (6.5)	3 (11.1)	5 (6.3)	2 (4.1)	
C	79 (51.3)	14 (51.9)	40 (50.6)	25 (52.1)	
D	47 (30.5)	8 (29.6)	27 (34.2)	12 (25.0)	
Nutrition, n (%)					0.26[b]
Oral intake	152 (98.7)	26 (96.3)	79 (100.0)	47 (97.9)	
Tube feeding	2 (1.3)	1 (3.7)	0 (0.0)	1 (2.1)	
SGA					0.018[b]
A	44 (28.6)	2 (7.4)	26 (32.9)	16 (33.3)	
B	78 (50.6)	14 (51.9)	41 (51.9)	23 (47.9)	
C	32 (20.8)	11 (40.7)	12 (15.2)	9 (18.8)	
FIM on admission (IQR)	58.0 (38.0–73.8)	54.9 (39.0–70.5)	59.6 (40.5–74.5)	57.0 (36.0–74.5)	0.505[c]
Motor FIM on admission (IQR)	31.5 (13.0–46.5)	29.7 (13.0–44.5)	32.4 (13.0–48.5)	30.8 (13.0–44.0)	0.812[c]
Total FIM gain (IQR)	23.0 (6.5–34.0)	19.3 (4.0–32.0)	22.9 (8.5–33.0)	25.2 (5.0–42.3)	0.555[c]
Motor FIM gain (IQR)	20.4 (5.0–32.0)	17.4 (1.0–30.0)	20.6 (6.5–30.5)	21.8 (3.0–38.0)	0.66[c]
Total FIM efficiency (IQR)	0.24 (0.07–0.36)	0.20 (0.06–0.36)	0.21 (0.07–0.34)	0.31 (0.07–0.36)	0.812[c]
Motor FIM efficiency (IQR)	0.22 (0.05–0.32)	0.18 (0.03–0.33)	0.20 (0.05–0.32)	0.27 (0.04–0.33)	0.853[c]

BMI body mass index, *FIM* functional independence measure, *SGA* subjective global assessment (A: well-nourished, B: suspected of being malnourished or moderately malnourished, C: severely malnourished)

[a] *t*-test

[b] The chi-square test

[c] Kruskal–Wallis test

Table 3 Multiple regression analysis of FIM efficiency in SGA

	Unadjusted coefficient	Standard error	Adjusted coefficient	VIF	95% CI	*P*-value
Age	−0.001	0.001	0.001	1.056	−0.004–0.002	0.428
Sex (female)	−0.029	0.052	0.052	1.035	−0.132–0.075	0.584
ASIA impairment scale score on admission	0.122	0.025	0.025	1.566	0.073–0.170	0.000
FIM score on admission	−0.002	0.001	0.001	1.82	−0.004–0.000	0.053
SGA	−0.083	0.030	0.030	1.385	−0.143 to −0.023	0.007

CI confidence interval, *FIM* functional independence measure, *SGA* subjective global assessment (A: well-nourished, B: suspected of being malnourished or moderately malnourished, C: severely malnourished), *VIF* variance inflation factor

Table 4 Multiple regression analysis of FIM efficiency in BMI

	Unadjusted coefficient	Standard error	Adjusted coefficient	VIF	95% CI	*P*-value
Age	−0.001	0.001	−0.071	1.045	−0.004–0.001	0.339
Sex (female)	−0.027	0.052	−0.037	1.035	−0.130–0.077	0.613
ASIA impairment scale score on admission	0.135	0.025	0.500	1.575	0.087–0.184	0.000
FIM score on admission	−0.001	0.001	−0.103	1.537	−0.003–0.001	0.253
BMI	0.073	0.027	0.203	1.022	0.021–0.126	0.006

CI confidence interval, *FIM* functional independence measure, *BMI* body mass index, *VIF* variance inflation factor

$P = .66$; 17.4 points vs. 20.6 points vs. 21.8 points). FIM efficiency and motor FIM efficiency tended to be higher in the overweight and obese group than in the other two BMI groups but there was no significant difference in the univariate analysis (total FIM efficiency: $P = .812$; 0.20 points vs. 0.21 points vs. 0.31 points, motor FIM efficiency: $P = .853$; 0.18 points vs. 0.20 points vs. 0.27 points).

Multivariate regression analysis that included age, sex (female), ASIA impairment scale score on admission, FIM score on admission, and SGA was performed to investigate the possibility of any of these factors being independently associated with FIM efficiency. No multicollinearity was observed between the variables. Better nutritional status (according to SGA) independently correlated with higher FIM efficiency ($R^2 = .220$, $P = .007$; Table 3). Multivariate regression analysis that included age, sex (female), ASIA impairment scale score on admission, FIM score on admission, and BMI was performed to investigate the possibility of any of these factors being independently associated with FIM efficiency. No multicollinearity was observed between the variables. In the multiple regression analysis of this study, multicollinearity was not observed between the variables. Higher BMI category also independently correlated with higher FIM efficiency ($R^2 = .221$, $P = .006$; Table 4).

Discussion

This study examined whether nutritional status on admission to a convalescent rehabilitation ward affects the improvement of ADL in adult patients with cervical SCIs. Two clinical observations were made. First, nutritional status on admission may have been associated with the degree of improvement in ADL. Second, ADL improvement was lower in patients who had low body weight on admission.

Patients with cervical SCI who were admitted to the rehabilitation ward of the hospital were found to have poor improvements in FIM if their BMI was lower. FIM gain and motor FIM gain tend to be higher with obesity. Also, FIM efficiency (for both total and motor FIM) tended to be higher among overweight and obese patients than among patients with lower BMI. This accords with previous studies in patients with stroke [25, 26] and hospital-associated deconditioning [27] showing that improvement in FIM was greater in obese patients than in those with low body weight. Also, in patients with congestive heart failure, high BMI may have been associated with better clinical outcomes [28]. In addition, the proportion of well-nourished patients (as opposed to malnourished patients) was higher in the overweight group than in the groups with lower BMIs. Therefore, obesity may be an important prognostic predictor. However, attention should be paid to the occurrence of various complications associated with obesity in patients with SCI, such as cardiovascular disease, endocrine disorders, dyslipidemia, hypertension, insulin resistance, and deep tissue injury [14, 15]. Also, it should be noted that it is difficult to investigate the proportion of body composition using BMI.

Many patients with cervical SCI are malnourished. In the present study, 71.4% of patients were considered to be malnourished or possibly malnourished, and this percentage was higher than in previous studies [5]. The reason for this higher percentage was likely advanced age. It has been reported that malnutrition may be associated with poor outcomes in ADL in other diseases, such as cerebrovascular disorders [10, 11, 25, 26], hip fracture [29, 30], hospital-associated deconditioning [31], and heart failure [32]. In those reports and the present study, ADL was found to improve if nutritional status improved. Therefore, even in patients with cervical SCI, the extent of malnutrition should be evaluated, and nutritional care as part of the rehabilitation program should be considered, especially in cases of low body weight. Such an approach may improve ADL and shorten the LOS.

Therefore, when a patient with cervical SCI is admitted to a convalescent rehabilitation ward, malnutrition should be diagnosed and addressed and the cause investigated (e.g., surgical invasiveness, inactivity, or dysphagia) [13–15]. Care must be taken because malnutrition can lead to severe complications, such as respiratory disorders, urological diseases, pressure ulcers, and deep venous thrombosis, all of which may delay or compromise rehabilitation and recovery [13–15].

This study had several limitations. First, we did not evaluate the method of nutritional management and the details of the rehabilitation program. Therefore, the possible influence of these factors on ADL outcomes could not be investigated. Second, during the 10-year period examined in this study, nutritional management methods and rehabilitation progressed, and this could have influenced the outcome of ADL. Third, the presence of complications was not assessed, and so we could not prove the relationship between complications and nutritional status. Fourth, we excluded participants who died during hospitalization, were readmitted or were transferred to another acute care hospital and this may have influenced the results. Fifth, few participants were designated overweight and obese based on BMI, and we could not prove the relationship between nutritional status and BMI. Sixth, the validity of sample size was verified by a post hoc power analysis, which is not optimal.

In conclusion, SGA and BMI on admission may be independently associated with FIM efficiency and utility in predicting improvements in FIM in patients with cervical SCIs. Patients with malnutrition on admission may benefit from early nutritional support. Future studies will be required to evaluate whether improvement in nutritional status during admission in rehabilitation wards affects functional outcome in patients with cervical SCIs.

Data archiving

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request

Author contributions MT: conception and design of the study, analyzing and interpreting data, drafting and revising the manuscript, and approval of the final version of the manuscript. RM, HW, TK, KM: conception and design of the study, analyzing and interpreting data, revising the manuscript, and approval of the final version of the manuscript. All authors of this manuscript meet the requirements of the guidelines for ethical authorship and publishing as stated in Spinal Cord.

Funding This work was supported by the Japan Society for the Promotion of Science (Grant Number: 15K01395). Funding from the Japan Society for the Promotion of Science foundation is gratefully acknowledged.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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