Japanese Journal of Comprehensive Rehabilitation Science (2018)

Original Article

Relationship between weight gain, functional recovery and nutrition monitoring in underweight tube-fed stroke patients

Shinta Nishioka, RD,[1,2] Hidekazu Sugawara, MD, PhD,[1,3,4] Masako Takayama, RD, MS,[1,5] Maki Urushihara, RD,[1,6] Misuzu Watanabe, RD,[1,7] Yumiko Kiriya, RD,[1,8] Keiko Shintani, RD,[1,9] Hiromi Nakagomi, RD,[1,10] Noriko Kageyama, RD,[1,11] Takatsugu Okamoto, MD, PhD,[1,12] Satoshi Sumita, MD, PhD,[1,13] Masaaki Fujita, MD, PhD,[1,14] Shigeki Hashimoto, MD,[1,15] Makoto Ishikawa, MD, PhD,[1,3,16] Eiki Tsushima, RPT, PhD,[3,17] Akira Ogawa, MD. PhD[3,18]

[1]Kaifukuki Rehabilitation Ward Association
[2]Department of Clinical Nutrition and Food Services, Nagasaki Rehabilitation Hospital
[3]Algorithm for Post-stroke Patients to improve oral intake Level (APPLE) study group
[4]Department of Rehabilitation Medicine, Hatsudai Rehabilitation Hospital
[5]Department of Nutrition, Kumamoto Kinoh Hospital
[6]Department of Nutrition, Yawata Medical Center
[7]Department of Nutrition, Mihara Memorial Hospital
[8]Department of Nutrition, Funabashi Rehabilitation Hospital
[9]Department of Nutrition, Hatsudai Rehabilitation Hospital
[10]Department of Nutrition, Tokyo Bay Rehabilitation Hospital
[11]Department of Nutrition, Nishi-Hiroshima Rehabilitation Hospital
[12]Department of Rehabilitation Medicine, Nishi-Hiroshima Rehabilitation Hospital
[13]Department of Rehabilitation Medicine, Kinkai Rehabilitation Hospital
[14]Iyo Hospital
[15]Rehabilitation center of Sapporo Nishimaruyama hospital
[16]Hatsudai Rehabilitation Hospital
[17]Graduate School of Health Sciences, Hirosaki University
[18]Iwate Medical University

ABSTRACT

Nishioka S, Sugawara H, Takayama M, Urushihara M, Watanabe M, Kiriya Y, Shintani K, Nakagomi H, Kageyama N, Okamoto T, Sumita S, Fujita M, Hashimoto S, Ishikawa M, Tsushima E, Ogawa A. Relationship between weight gain, functional recovery and nutrition monitoring in underweight tube-fed stroke patients. Jpn J Compr Rehabil Sci 2018; 9: 3−10.

Objective: To investigate the relationship between the frequency of nutritional monitoring, and both weight gain and functional recovery in underweight, tube-fed stroke patients.

Methods: Data for tube-fed stroke patients aged ≥40 with an (age-dependent) body mass index (BMI) of either <18.5, <20.0, or <21.5 kg/m^2 were extracted from two studies included in the "Algorithm for Post-stroke Patients to improve oral intake Level (APPLE)" study, conducted at five Kaifukuki (convalescent) rehabilitation wards in Japan. The outcome measurements were compared between the wards participating in either weekly (WM), or monthly (MM) nutritional monitoring protocols by dietitians. Primary outcomes were a change in BMI, and functional independence measure (FIM) at discharge.

Results: There were 37 WM patients (18 women; mean age, 77 years) and 29 MM patients (19 women; mean age, 78 years) with no differences in stroke subtype, BMI, functional independence measure (FIM) and

Correspondence: Shinta Nishioka, RD
Department of Clinical Nutrition and Food Services, Nagasaki Rehabilitation Hospital, 4−11, Gin-ya machi, Nagasaki 850−0854, Japan.
E-mail: shintacks@yahoo.co.jp

Accepted: January 24, 2018.
Grant support: The current study analyzed data extracted from two studies of the multicenter investigation, "Algorithm for Post-stroke Patients to improve oral intake Level: APPLE". The Study 1 was funded by a Health and Labour Sciences Research Grant (Comprehensive Research on Aging and Health) from the Ministry of Health, Labour, and Welfare (No. 201417009A). The Study 2 was funded by EN Otsuka Pharmaceuticals Co. Ltd.

doi.org/10.11336/jjcrs.9.3

swallowing function. At discharge, WM patients showed a significantly higher BMI gain compared to MM patients (+0.2 kg/m^2 vs. −0.5 kg/m^2, p = 0.009). A greater proportion of WM patients than that of MM patients achieved full oral intake (81.1% vs. 44.8%, p = 0.002). WM was independently correlated with BMI change and discharge FIM on multivariable analyses.

Conclusions: Nutritional monitoring and planning recommendation at least once a week by dietitians may correlate with positive BMI change and better functions in tube-fed stroke patients.

Key words: convalescent rehabilitation wards, enteral nutrition, stroke patients, malnutrition, nutritional monitoring

Introduction

Malnutrition occurs in up to 62% of stroke patients [1], and is related to adverse outcomes such as mortality, complications, functional dependency, hospital cost, and swallowing dysfunction [2−5]. The causes of malnutrition in stroke patients are considered to be multifactorial [6, 7]; dysphagia is likely to be the predominant cause [7]. Notably, the correlation between dysphagia and malnutrition is stronger in a rehabilitation setting than in an acute care setting [7]. Therefore, nutritional support for stroke patients with dysphagia is a more critical issue in rehabilitation centers than in acute care hospitals. On the other hand, malnutrition can cause dysphagia through muscle weakness, muscle loss and fatigue [8]. More recently, the concept of sarcopenic dysphagia – difficulty swallowing due to sarcopenia of generalized skeletal muscles and swallowing muscles – has been proposed [9, 10]. In fact, severe malnutrition risk is a negative predictor of recovery of swallowing function in tube-fed stroke patients [4]. Thus, nutritional support with swallowing rehabilitation can possibly improve not only nutritional status but also swallowing function, physical functions and mortality.

Recommendation of nutritional plan for tube-fed patients by dietitians may improve clinical outcome. In a long-term acute care facility, higher energy and protein intake, shorter lengths of stay were achieved when physicians accepted dietitians' recommendations [11]. Similarly, documentation of nutritional requirements by dietitians is related to a higher daily energy intake and faster initiation of enteral nutrition in pediatric intensive care unit patients [12]. Thus, nutritional improvement may be achieved by recommending the appropriate amount and formulae based on individualized nutritional assessments. However, there is no study investigating the efficacy of nutritional care for improving nutritional status by dietitians in stroke patients. Moreover, since only 11% of dietitians use validated nutritional assessment tools [13], it is unclear if their nutritional recommendations are effective in improving nutritional and functional outcomes in stroke patients.

In rehabilitation hospitals, nutritional assessment, monitoring, and recommendations have a large impact on patients' nutritional status because of their longer hospital stays and the various physical activities. However, the optimal frequency of assessment and monitoring is unknown. Additionally, nutritional support may be inadequate in rehabilitation hospitals in Japan because it is not covered by the public health insurance system; only 20% of Kaifukuki (convalescent) rehabilitation wards (KRWs) were supported by a full-time dietitian [14]. Moreover, the number of patients who are underweight have increased among KRW residents from 22.8% (on admission) to 24.8% (at discharge) [14]. Therefore, establishing the appropriate nutritional support in convalescent rehabilitation wards is an issue of clinical importance. The aim of this pooled analysis was to evaluate the frequency of nutritional monitoring as related to nutritional and functional outcomes for tube-fed stroke patients in the KRWs.

Methods

1. Database

This study retrospectively analyzed a database that incorporated two observational studies (Study 1 and 2) from the "Algorithm for Post-stroke Patients to improve oral intake Level: APPLE" series study. Study 1 prospectively included stroke tube-fed patients who were admitted to the KRWs between January and October 2014, aged 65−80 years, with suspected malnutrition (body mass index [BMI] ≤18.5 kg/m^2 or Alb < 3.5 g/dL). This study was conducted in five KRWs in rehabilitation hospitals across Japan (Tokyo, Nagasaki, Ehime, Hokkaido, and Tottori). The five KRWs included in this study were categorized as grade 1 which is the best of the three grades. Exclusion criteria for Study 1 were injury to both the supra/infratentorial regions, strict medical nutritional therapy requirement (e.g., uncontrolled hyper/hypoglycemia or end-stage renal disease), gastrointestinal dysfunction (e.g., inflammatory bowel disease or short bowel syndrome), and dysphagia due to an organic problem, cognitive impairment and/or medication.

Study 2 was a retrospective cohort study conducted in 25 KRWs between March 2011 and March 2013 in Japan, and was reported elsewhere [4]. Study 2 included tube-fed stroke patients aged ≥40 years. The five KRWs in Study 1 were among those included in the 25 hospitals of Study 2. Study 1 was approved by the ethics committee at each hospital, whereas Study 2 was approved by the ethics committee at Hatsudai Rehabilitation Hospital. Because the present study was an observational study using existing and anonymized data of daily clinical practice, we provided information of the study to all patients concerned, and explained the opt-out option, which allowed patients to withdraw from the study at any time.

2. Data integration and eligibility criteria

We integrated the two databases and extracted data for the underweight study subjects who were ≥40 years old in the five KRWs involved in Study 1. Underweight was defined as a BMI <18.5 kg/m^2 (aged <50 years), <20.0 kg/m^2 (aged <70 years), and <21.5 kg/m^2 (aged ≥70 years) based on Dietary Reference Intakes for Japanese 2015 [15]. Exclusion criteria were ≥60 days between stroke onset and KRW admission or having spent <30 days in a KRW. Potential confounders such as patient characteristics (e.g., age, sex, type of stroke, stroke lesion, history of stroke, comorbidity, and onset-admission duration) were investigated in both studies. Because neither study reported the actual time of rehabilitation therapy for each subject, as confounders of functional outcome, the number of PT, OT and ST and the mean duration of rehabilitation therapy per day in each KRW were collected from annual KRWs survey between 2011 and 2014 [16]. We extrapolated mean time of rehabilitation therapy from the annual survey to each subject as estimated time of the therapy.

3. Monitoring frequency

The study compared nutritional outcomes in KRW patients with different nutritional monitoring protocols. Two of the five KRWs employed more than one clinical dietitian per ward, while for the three KRWs, one clinical dietitian was appointed between 2 (or more) wards. The former two KRWs that implemented a nutritional support protocol in which the patients' nutritional statuses were monitored at least once per week by dietitians (referred to as the weekly monitoring group [WM]), while the latter three KRWs underwent nutritional monitoring at least once per month (the monthly monitoring group [MM]). Nutritional monitoring included physical examination, nutritional intake, anthropometry, laboratory tests, and others examinations. The dietitians recommended nutritional plans (e.g., amount of nutrients, route of nutrition support, use of specific formulae, or administration of oral nutritional supplements) to physicians and nurses based on their evaluations. All the KRWs maintained same nutritional monitoring protocol for the durations of both studies. To confirm the effect of confounders on rehabilitation outcomes, we compared the motor and cognitive domain of the Functional Independence Measure (FIM) gain in non-underweight patients (BMI ≥ 18.5 kg/m^2), between the WM, and MM groups, using the annual survey data [16].

4. Nutrition-related parameters

Mean energy and protein intakes within five days (Study 1) or 7 days (Study 2) after admission were collected. BMI was calculated by (weight [kg]/height [m]^2) at admission and discharge. Alb was collected within 7 days before and after admission. To assess nutritional risk, we computed the Geriatric Nutritional Risk Index (GNRI) [17]. The GNRI equation is described below:

$$\text{GNRI} = (14.89 \times \text{Alb [g/dL]}) + 41.7 \times (\text{actual body weight [kg]/ideal body weight [kg]})$$

$$\text{ideal body weight} = \text{height (m)}^2 \times 22$$

If the actual weight exceeded the ideal body weight, the actual body weight/ideal body weight ratio was set to 1 in the above equation [17].

5. Functional indicators

The FIM is one of the most frequently used functional measurements and is composed of 13 motor-, and five cognitive-related items. Each item is graded on a scale between 1 (complete dependency) to 7 (independence) [18]. The total FIM scores ranged from 18 to 126 points. Fujishima's swallowing grade (FSG) was employed as an indicator of swallowing function. The FSG is a 10-grade scale (1: not eligible for swallowing rehabilitation, to 10: normal swallowing function) which was developed in Japan and is widely used [19]. In this study, we confirmed full oral intake using both an FSG ≥7 and reports regarding whether oral intake was actually achieved.

6. Minimal detectable difference

As this study was conducted as pooled analysis using a completed database, we included a limited number of participants. Therefore, we calculated the minimal detectable difference *post-hoc*, instead of performing a sample size calculation, using Power and Sample Size Calculation software (version 3.0, 2009; William D. Dupont and Walton D. Plummer). According to our previous study [4], the expected standard deviation of mean BMI change was 1.5 kg/m^2. If the study participants (n=66) were divided into two groups with a 1:1 ratio, the minimal detectable difference of BMI change was 1.1 kg/m^2, with a power (1-β) of 0.8, and an α of 0.05.

7. Statistical analysis

Normally distributed variables were expressed as mean values and standard deviations, while non-uniformly distributed or ordinal variables were presented as medians and interquartile ranges. Student's *t*-test, Mann-Whitney's *U* test, chi-squared test, and Fisher's exact test were performed for univariate analysis between different groups. To evaluate whether the frequency of monitoring was independently correlated with nutritional and functional outcomes, linear regression analysis for BMI change and FIM at discharge were performed. Additionally, binary logistic regression analysis for achievement of full oral intake was performed. Statistical significance was established at $p < 0.05$.

Results

Of 669 potential subjects, 508 Study 2 participants who were not included in Study 1, were excluded. After integrating the Study 1 participants into Study 2, seventy-three patients with BMIs ≥18.5, 20, or 21.5 kg/m^2 (depending on age) or missing BMI data, 10 with unavailable outcome data, and 14 with onset/admission durations >60 days were excluded. Ultimately, data for 66 subjects were analyzed (Figure 1). For one KRW, the annual survey data from 2011 were missing.

Table 1 shows the characteristics of the study subjects. Thirty-seven subjects were classified into the WM group (18 women), while 29 were included in the MM group (19 women). Data for location of stroke, history of stroke, and Alb level were missing for one subject. Of the 66 subjects, 36 had cerebral infarctions, 23 had intracerebral hemorrhages and five had subarachnoid hemorrhages. The WM group had a significantly higher proportion of atrial fibrillation (p = 0.049), lower protein intake (p = 0.013), higher time of occupational therapy (p = 0.044), and lower time of speech-language-hearing therapy (p < 0.001). The mean number of PT, OT, and ST who provided therapy were 11.6, 10.0, and 5.1 for the WM group and 9.8, 8.4, and 6.3 for the MM group. There were no differences in motor FIM gain (median [interquartile range], WM: 16.5 [7.8−28], MM: 16 [5.3−28], p = 0.549) and cognitive FIM gain (WM: 4.5 [0−8.3], MM: 3 [0−7], p = 0.195) for non-underweight patients (WM: n = 66, MM: n = 116), based on the annual survey data.

At discharge, the WM group showed a significantly higher BMI change (p = 0.009), proportion of full oral intake (p = 0.002), and motor FIM (p = 0.018) than the MM group (Table 2). There were no differences with respect to either the relative nutritional intake per body weight or the change in intake. Absolute change of energy and protein intake tended to be higher in the WM group (energy: 218 ± 362 kcal vs. 114 ± 313 kcal, respectively [p = 0.223]; protein: 9.1 ± 13.4 g vs. 4.1 ± 11.8 g, respectively [p = 0.114]).

Linear regression analysis showed that weekly monitoring independently correlated with change in BMI (β = 0.733, 95% confidence interval [CI]: 0.245−1.220) and FIM on discharge (β = 12.306, 95% CI: 1.448−22.180). Conversely, binomial logistic regression analysis revealed that weekly monitoring did not correlate with achievement of full oral intake (odds ratio: 5.417, 95% CI: 0.558−52.593) while FSG on admission was an independent predictor (odds ratio: 2.593, 95% CI: 1.226−5.482) (Table 3).

Discussion

This study produced two major findings. First, weekly monitoring and recommendation of a nutritional plan was positively correlated with higher BMI gain

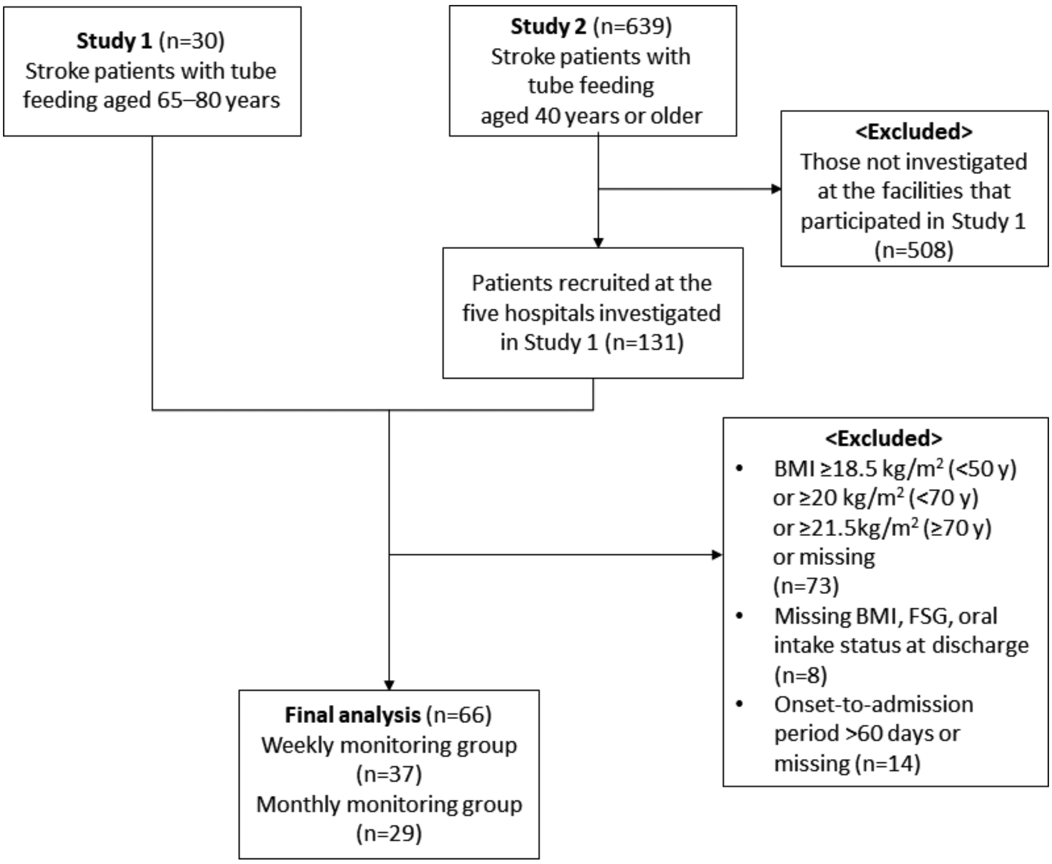

Figure 1. Flow diagram illustrating the selection process, and integration of the data of Studies 1 and 2.
BMI, body mass index; FSG, Fujishima's swallowing grade; WM, weekly monitoring protocol; MM, monthly monitoring protocol.

Table 1. Characteristics of 66 underweight tube-fed stroke patients.

	Overall	WM	MM	*p*-value
Number of participants	66	37	29	
Age, years mean (SD)	77.5 (8.4)	76.8 (9.2)	78.4 (7.4)	0.442††
Sex, *n* (%)				0.171‡‡
Male	29 (43.9)	19 (51.4)	10 (34.5)	
Female	37 (56.1)	18 (48.6)	19 (65.5)	
Diagnosis, *n* (%)				0.160§§
CI (lacunar)	4 (6.1)	3 (8.1)	1 (3.4)	
CI (atherothrombotic)	9 (13.6)	7 (18.9)	2 (6.9)	
CI (cardioembolic)	17 (25.8)	13 (35.1)	4 (13.8)	
CI (other etiology)	6 (9.1)	3 (8.1)	3 (10.3)	
ICH (hypertension)	12 (18.2)	5 (13.5)	7 (24.1)	
ICH (other etiology)	11 (16.7)	3 (8.1)	8 (27.6)	
SAH	5 (7.6)	2 (5.4)	3 (10.3)	
Uncertain	2 (3.0)	1 (2.7)	1 (3.4)	
Location of stroke, *n* (%)¶				0.136§§
Supratentorial	56 (86.2)	34 (91.9)	22 (75.9)	
Infratentorial	6 (9.2)	2 (5.4)	4 (13.8)	
Both regions	1 (1.5)	0	1 (3.4)	
Uncertain	2 (3.1)	0	2 (6.9)	
History of stroke, *n* (%)¶				0.377‡‡
Yes	24 (36.9)	15 (40.5)	9 (31.0)	
No	41 (63.1)	21 (56.8)	20 (69.0)	
Onset-to-admission period (days)				0.070††
Mean (SD)	38.1 (12.8)	35.6 (12.6)	41.3 (12.5)	
FIM, median (IQR)				
Motor domain	13 (13−15.3)	13 (13−17)	13 (13−14.5)	0.131¶¶
Cognitive domain	8 (5−11.3)	8 (5−12.5)	8 (5.5−10.5)	0.808¶¶
Comorbidity, *n* (%)				
Diabetes mellitus	14 (21.2)	7 (18.9)	7 (24.1)	0.607‡‡
Hypertension	32 (48.5)	16 (43.2)	16 (55.2)	0.336‡‡
Atrial fibrillation	17 (25.8)	13 (35.1)	4 (13.8)	0.049‡‡
Myocardial infarction	5 (7.6)	4 (10.8)	1 (3.4)	0.262§§
Dyslipidemia	4 (6.1)	2 (5.4)	2 (6.9)	0.801§§
Liver cirrhosis	1 (1.5)	0	1 (3.4)	0.255§§
Others	3 (4.5)	3 (8.1)	0	0.117§§
Serum albumin, g/dL¶				0.080††
Mean (SD)	3.3 (0.4)	3.4 (0.4)	3.2 (0.4)	
BMI, kg/m², mean (SD)	18.5 (2.1)	18.4 (2.0)	18.5 (2.2)	0.838††
Nutritional risk†, *n* (%)¶				0.141§§
Severe	21 (32.3)	10 (27.8)	11 (37.9)	
Moderate	38 (58.5)	20 (55.6)	18 (62.1)	
Mild	4 (6.2)	4 (11.1)	0	
No	2 (3.1)	2 (5.6)	0	
Nutritional intake, mean (SD)				
Energy (kcal/kgWt/day)	26.5 (6.0)	28.5 (8.4)	27.5 (5.1)	0.517††
Protein (g/kgWt/day)	1.1 (0.3)	1.1 (0.4)	1.2 (0.2)	0.013††
Swallowing disorder‡, *n* (%)				0.790§§
Severe	49 (74.2)	27 (73.0)	22 (75.9)	
Moderate	17 (25.8)	10 (27.0)	7 (24.1)	
Estimated time of therapy (minute/day), median (IQR)				
Physical therapy	74 (74−80)	74 (74−80)	66 (64−82)	0.806¶¶
Occupational therapy	66 (66−68)	66 (66−68)	64 (61−68)	0.044¶¶
Speech-language-hearing therapy	48 (42−62)	48 (42−48)	62 (56−66)	<0.001¶¶

CI, cerebral infarction; ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage; WM, weekly nutritional monitoring protocol; MM, monthly nutritional monitoring protocol; FIM, functional independence measure; BMI, body mass index; SD, standard deviation; IQR, interquartile range; SLT, speech-language-hearing therapists.

†Identified by the Geriatric Nutritional Risk Index (GNRI) score; severe: <82, moderate: 82 to <92, and mild: 92 to <98. There were no participants classified as no nutritional risk (GNRI>98).

‡Identified by the Fujishima's swallowing grade (FSG); severe: 1−3, moderate: 4−6.

§Extrapolated using the mean from three types of therapy in each KRW from the annual survey of the KRW Association.

¶One datawas missing, ††Student's *t*-test, ‡‡chi-squared test, §§Fisher's exact test, ¶¶Man-Whitney *U* test.

Table 2. Activities of daily living, swallowing function, nutritional intake and BMI on discharge of tube-fed stroke patients at the KRWs.

	Overall	WM	MM	*p*-value
Number of participants	66	37	29	
Length of KRW stay in days, mean (SD)	143.3 (36.8)	138.1 (40.6)	150.0 (30.8)	0.180††
FIM, median (IQR)				
Motor domain	27 (14−44.8)	34 (15−55.5)	18 (13.5−32)	0.018§
Cognitive domain	12.5 (8−20)	16 (8−21)	10 (7.5−15.5)	0.238§
Swallowing disorder†, *n* (%)				0.002§§
Severe	13 (19.7)	6 (16.2)	7 (24.1)	
Moderate	10 (15.2)	1 (2.7)*	9 (31.0)*	
Mild or No	43 (65.2)	30 (81.1)*	13 (44.8)*	
Full oral intake‡, *n* (%)	43 (65.2)	30 (81.1)	13 (44.8)	0.002§§
Pneumonia incidence, *n* (%)§	14 (21.2)	8 (21.6)	6 (20.7)	0.939§§
Nutritional intake, mean (SD)¶				
Energy (kcal/kgWt/day)	30.6 (8.6)	30.5 (6.7)	30.7 (10.5)	0.949††
Protein (g/kgWt/day)	1.2 (0.3)	1.2 (0.3)	1.3 (0.4)	0.220††
Change in nutritional intake, mean (SD)¶				
Energy (kcal/kgWt/day)	3.9 (8.2)	4.2 (7.6)	3.7 (9.0)	0.803††
Protein (g/kgWt/day)	0.2 (0.3)	0.2 (0.3)	0.1 (0.3)	0.554††
BMI, kg/m², mean (SD)	18.4 (2.1)	18.6 (2.0)	18.1 (2.2)	0.294††
Change in BMI, kg/m², mean (SD)	−0.1 (1.0)	0.2 (1.0)	−0.5 (1.0)	0.009††

KRWs, Kaifukuki rehabilitation wards; BMI, body mass index; WM, weekly monitoring protocol; MM, monthly monitoring protocol; IQR, interquartile range; SD, standard deviation.
†Identified by the Fujishima's swallowing grade (FSG); severe: 1−3, mild: 4−6, and mild or no: 7−10.
‡Identified by both FSG ≥7 and actual "full oral intake" status, §Two data were missing, ¶One data was missing, ††Student's *t*-test, ‡‡Man-Whitney's *U* test, §§chi-squared test. *$p < 0.05$ between the groups.

Table 3. Linear regression analysis and binominal logistic regression analyses of the effect of the frequency of nutritional monitoring on BMI change, FIM at discharge, and recovery of full oral intake among tube-fed stroke patients at the KRWs.

Outcomes	Monitoring frequency	β	Adjusted odds ratio	95% confidence interval		*p*-value
				Lower	Upper	
BMI change†	Weekly	0.733	—	0.245	1.220	0.004
($R^2 = 0.125$)	Monthly (reference)	—	—	—	—	—
FIM at discharge‡	Weekly	12.306	—	1.448	22.180	0.015
($R^2 = 0.613$)	Monthly (reference)	—	—	—	—	—
Full oral intake§	Weekly	—	5.417	0.558	52.593	0.145
($R^2 = 0.335$)	Monthly (reference)	—	—	—	—	—

KRWs, Kaifukuki rehabilitation wards; BMI, body mass index; FIM, functional independence measure.
†Linear regression analysis adjusted by age, sex and BMI on admission.
‡Linear regression analysis adjusted by age, sex, mean time of provided total rehabilitation therapies (physical, occupational and speech-language-swallowing therapy) and FIM on admission.
§Binominal logistic regression analysis adjusted by Fujishima's swallowing grade (FSG) on admission and mean time of speech-language-swallowing therapy. Full oral intake was defined by an FSG score ≥7 and actual "full oral intake" status.

among underweight tube-fed stroke patients. Second, this procedure was associated with recovery of physical and cognitive function.

Our study showed that tube-fed stroke patients exhibited a slight increase (mean increase 0.2 kg/m^2) in BMI if nutritional monitoring was performed and nutritional plans recommended by dietitians at least once a week were followed. These results are consistent with previous studies [11−13, 20], and are clinically relevant, because nutritional monitoring and evaluation by dietitians, which is one of the four steps of the nutrition care process, plays a key role in evaluating the efficacy of nutritional intervention, and may prevent weight loss [21]. Activity-related energy expenditure is the most variable form of energy expenditure [22]; moreover, ADLs are positively associated with resting energy expenditure [23]. Our results may suggest that more frequent recommendations of nutritional prescriptions based on the patients' physical activity levels and load of rehabilitation programs are effective for eliciting weight gain in these patients. However, the clinical significance of the between-group difference in BMI change (0.7 kg/m^2, which is comparable to 1.8 kg of a person with a height of 160 cm) remained unclear because there are no available data for a minimum clinically important difference (MCID) toward functional recovery in stroke patients. Further research investigating the MCID of BMI for stroke patients is required.

Change in nutritional intake did not differ between the two groups despite the BMI change being significant higher in the WM group. Conversely, a recent systematic review suggested that nutrition intervention as a part of rehabilitation may increase only nutritional intake, but not BMI or function [24]. Although the reason why our results are contrary to this is unclear, it is possible that a slight increase in energy intake was achieved during extended stays at the KRWs (in the range of 143 days) and led to increased BMI, as absolute energy intake tended to be high in the WM group. Additionally, stroke patients with dysphagia were usually prescribed a modified diet that is linked to decreased energy intake (926 kcal/d) during the transition period from tube-feeding to oral intake [25]. If a dietitian closely monitors patients' food intake and recommends an appropriate nutritional plan during the transition period, both weight gain and recovery of swallowing function can be achieved. However, further study will be required to determine the cumulative energy intake during KRW stays and the nature of BMI changes.

Weekly monitoring can correlate with better physical and cognitive function on multivariable analysis. In periods of starvation, physical and mental functions decline [26, 27]. Additionally, improved nutritional status, particularly when maintaining body weight, is related to the recovery of ADLs [28, 29]. Our results are consistent with such findings. We also found that weekly monitoring did not correlate with the recovery of swallowing capacity by multivariable analysis. This finding may partially be explained by the variety of nutritional risks existing among the subjects. Severe malnutrition risk may be an independent predictor of recovering swallowing ability as well as initial swallowing ability, pneumonia incidence, onset-admission duration and pre-stroke ADL [4]. Since our study included subjects with various risks of malnutrition, the effects of nutritional monitoring can vary widely. Another possibility is the existence of multicollinearity between monitoring frequency and estimated time of speech-language-hearing therapy, which were different between the groups. Further studies are needed to adjust for the actual duration and frequency of rehabilitation, nature of the rehabilitation program, and proficiency of therapists, nurses and physiatrists.

There are several limitations in our study. First, there remains the possibility that potential confounders which influence the quality of rehabilitation (e.g., proficiency of rehabilitation staff, actual time of rehabilitation) or quality of nutrition care (e.g., presence and activity of nutrition support team) may affects the outcome measures. Although we analyzed the FIM of non-underweight patients and estimated time of rehabilitation therapy, we could not adjust for all potential confounders which could potentially affect the outcomes. Future randomized controlled trials, or observational studies using propensity score should be conducted to overcome this limitation. Second, we did not observe a cause-and-effect relationship between the monitoring frequency and nutritional and functional outcomes due to the study design. Third, the small cohort size weakened the statistical power. Forth, BMI does not always represent nutritional status. While BMI is frequently used in validated screening tools [30], it is also affected by fluid status and inflammation. Body composition analysis would be useful to resolve such shortcoming.

In conclusion, nutritional monitoring and dietary recommendations at least once a week by dietitians seemed to be associated with an gain in body weight in underweight tube-fed stroke patients. Moreover, this procedure may also correlate with improved recovery of physical and cognitive function. These results may provide the basis for further research to determine whether the frequency of nutritional monitoring improves the outcome of stroke patients.

Acknowledgement

We are grateful to the directors of the KRW Association for their advice and expertise regarding this study, and to the staff at the Kinkai Rehabilitation Hospital, Iyo Hospital, Nagasaki Rehabilitation Hospital, Sapporo Nishi-Maruyama Hospital, and Hatsudai Rehabilitation Hospital for data collection. We also thank the Japanese Ministry of Health, Labour, and Welfare, and EN Otsuka Pharmaceuticals Co. Ltd. for their funding support.

References

1. Foley NC, Salter KL, Robertson J, Teasell, RW, Woodbury MG. Which reported estimate of the prevalence of malnutrition after stroke is valid? Stroke 2009; 40: e66−e74.
2. The FOOD Trial Collaboration. Poor nutritional status on admission predicts poor outcomes after stroke: observational data from the FOOD trial. Stroke 2003; 34(6): 1450−6.
3. Gomes F, Emery PW, Weekes CE. Risk of malnutrition is an independent predictor of mortality, length of hospital stay, and hospitalization costs in stroke patients. J Stroke Cerebrovasc Dis 2016; 25(4): 799−806.
4. Nishioka S, Okamoto T, Takayama M, Urushihara M, Watanabe M, Kiriya Y, et al. Malnutrition risk predicts recovery of full oral intake among older adult stroke patients undergoing enteral nutrition: secondary analysis of a multicentre survey (the APPLE study). Clin Nutr 2016; 36(4): 1089−96.
5. Zhang J, Zhao X, Wang A, Zhou Y, Yang B, Yu D, et al. Emerging malnutrition during hospitalisation independently predicts poor 3-month outcomes after acute stroke: Data from a Chinese cohort. Asia Pac J Clin Nutr 2015; 24(3): 379−86.
6. Paquereau J, Allart E, Romon M, Rousseaux M. The long-term nutritional status in stroke patients and its predictive factors. J Stroke Cerebrovasc Dis 2014; 23(6): 1628−33.
7. Foley NC, Martin RE, Salter KL, Teasell RW. A review of the relationship between dysphagia and malnutrition following stroke. J Rehabil Med 2009; 41(9): 707−13.
8. Veldee MS, Peth LD. Can protein-calorie malnutrition cause dysphagia? Dysphagia 1992; 101: 86−101.
9. Wakabayashi H. Presbyphagia and sarcopenic dysphagia: association between aging, sarcopenia, and deglutition disorders. J Frailty Aging 2014; 3(2): 97−103.
10. Maeda K, Akagi J. Sarcopenia is an independent risk factor of dysphagia in hospitalized older people. Geriatr Gerontol Int 2016; 16(4): 515−21.
11. Braga JM, Hunt A, Pope J, Molaison E. Implementation of dietitian recommendations for enteral nutrition results in improved outcomes. J Am Diet Assoc 2006; 106(2): 281−4.
12. Wakeham M, Christensen M, Manzi J, Kuhn EM, Scanlon M, Goday PS, et al. Registered dietitians making a difference: early medical record documentation of estimated energy requirement in critically ill children is associated with higher daily energy intake and with use of the enteral route. J Acad Nutr Diet 2013; 113(10): 1311−6.
13. Peters L, O’Connor C, Giroux I, Teasell R, Foley N. Screening and assessment of nutritional status following stroke: results from a national survey of registered dietitians in Canada. Disabil Rehabil 2015; 37(26): 2413−7.
14. Kaifukuki rehabilitation ward association. 2015 Annual Report from the Annual Survey Committee of Kaifukuki Rehabilitation Ward Association. February 2016. Japanese.
15. Ministry of Health, Labour and Welfare. Dietary Reference Intakes for Japanese 2015. Available from: http://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/Overview.pdf (cited 2017 Mar 16).
16. Miyai I, Sonoda S, Nagai S, Inoue Y, Kakehi A, Kurihara M, et al. Results of new policies for inpatient rehabilitation coverage in Japan. Neurorehabil Neural Repair 2011; 25(6): 540−7.
17. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent J-P, Nicolis I, et al. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. Am J Clin Nutr 2005; 82(4): 777−83.
18. Chumney D, Nollinger K, Shesko K, Skop K, Spencer M, Newton RA. Ability of Functional Independence Measure to accurately predict functional outcome of stroke-specific population: systematic review. J Rehabil Res Dev 2010; 47: 17−29.
19. Fujishima I. Textbook of rehabilitation for swallowing disorders associated with stroke, 1st ed. Tokyo: Ishiyaku Publishers; 1993. Japanese.
20. Imfeld K, Keith M, Stoyanoff L, Fletcher H, Miles S, McLaughlin J. Diet order entry by registered dietitians results in a reduction in error rates and time delays compared with other health professionals. J Acad Nutr Diet 2012; 112(10): 1656−61.
21. Brantley SL, Russell MK, Mogensen KM, Wooley JA, Bobo E, Chen Y, et al. American Society for Parenteral and Enteral Nutrition and Academy of Nutrition and Dietetics: revised 2014 standards of practice and standards of professional performance for registered dietitian nutritionists (competent, proficient, and expert) in nutritional support. Nutr Clin Pract 2014; 29(6): 792−828.
22. Westerterp KR, Schols AM, Singer P. Energy metabolism. In: Sobotka L, editor. Basics in Clinical Nutrition. 4th ed. Czech Republic: Galen; 2011: 96−103.
23. Sergi G, Coin A, Bussolotto M, Beninca P, Tomasi G, Pisent C, et al. Influence of fat-free mass and functional status on resting energy expenditure in underweight elders. J Gerontol A Biol Sci Med Sci 2002; 57(5): M302−M307.
24. Beck AM, Dent E, Baldwin C. Nutritional intervention as part of functional rehabilitation in older people with reduced functional ability: a systematic review and meta-analysis of randomised controlled studies. J Hum Nutr Diet 2016; 29 (6): 733−45.
25. Wright L, Cotter D, Hickson M, Frost G. Comparison of energy and protein intakes of older people consuming a texture modified diet with a normal hospital diet. J Hum Nutr Diet 2005; 18: 213−9.
26. Kalm LM, Semba RD. They starved so that others be better fed: remembering Ancel Keys and the Minnesota experiment. J Nutr 2005; 135(6): 1347−52.
27. Elia M. Hunger Disease. Clin Nutr 2000; 19(6): 379−86.
28. Nishioka S, Wakabayashi H, Nishioka E, Yoshida T, Mori N, Watanabe R. Nutritional improvement correlates with recovery of activities of daily living among malnourished elderly stroke patients in the convalescent stage: A cross-sectional study. J Acad Nutr Diet 2016; 116(5): 837−43.
29. Nii M, Maeda K, Wakabayashi H, Nishioka S, Tanaka A. Nutritional improvement and energy intake are associated with functional recovery in patients after cerebrovascular disorders. J Stroke Cerebrovasc Dis 2016; 25(1): 57−62.
30. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M. ESPEN Guidelines for Nutrition Screening 2002. Clin Nutr 2003; 22(4): 415−21.