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DYSPHAGIA ASSESSED BY THE 10-ITEM EATING ASSESSMENT TOOL IS ASSOCIATED WITH NUTRITIONAL STATUS AND ACTIVITIES OF DAILY LIVING IN ELDERLY INDIVIDUALS REQUIRING LONG-TERM CARE

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Abstract: *Objectives:* The 10-item Eating Assessment Tool (EAT-10) is a self-administered questionnaire for dysphagia screening, with each item scored from 0 to 4. We assessed the associations among the EAT-10 score, nutritional status and activities of daily living (ADL) in elderly individuals requiring long-term care. *Design:* Cross-sectional study. *Setting:* Geriatric health services facilities, acute hospitals, and the community. *Participants:* Elderly individuals ≥65 years of age with dysphagia or possible dysphagia (N=237). *Measurements:* The EAT-10, the Mini Nutritional Assessment Short Form (MNA-SF) and the Barthel Index. *Results:* There were 90 males and 147 females. Mean age was 82 ± 8 years. Eighty-nine were in geriatric health services facilities, 28 were in acute hospitals, and 120 were community-dwelling. The median Barthel Index score was 55 (interquartile range: 25, 80). The median EAT-10 score was 1 (interquartile range: 0, 9), and 101 respondents a score > 3, indicating the presence of dysphagia. The MNA-SF revealed that 81 were malnourished, 117 were at risk of malnutrition, and 39 had a normal nutritional status. The Barthel Index score and MNA-SF score were significantly lower in those with an EAT-10 score between 3 and 40, compared to those with an EAT-10 score between 0 and 2. The EAT-10 has an independent effect on the Barthel Index and the MNA-SF by adjusting for covariates such as age, gender, and setting in multiple regression analysis. *Conclusions:* Dysphagia assessed by the EAT-10 is associated with nutritional status and ADL in elderly individuals requiring long-term care.

Key words: Deglutition disorders, malnutrition, sarcopenia, frailty, sarcopenic dysphagia.

Introduction

The associations among dysphagia, nutritional status and activities of daily living (ADL) have been explored. In a systematic review of nursing home patients, the factors most consistently associated with poor nutrition included impaired function and swallowing/chewing difficulties (1). The overall odds of being malnourished were higher among subjects who were dysphagic compared with subjects with intact swallowing ability following stroke (2), but not during the first 7 days of hospital admission (2, 3). Dysphagia was associated with malnutrition in community-dwelling frail older adults (4, 5), hospitalized older adults (6-9), nursing home residents (10) and residents of assisted-living facilities (11). Mid-upper arm circumference and calf circumference were correlated with dysphagia (12, 13). Dysphagia was associated with impaired ADL in community-dwelling frail older adults (5), hospitalized older adults (6, 9, 14) and stroke patients (15, 16). However, methods of assessing dysphagia varied considerably among studies.

Belafsky et al. (17) developed the 10-item Eating Assessment Tool (EAT-10, Table 1), a questionnaire for dysphagia screening, with each item scored from 0 to 4, with a score of 0 indicating no problem and a score of 4 indicating a severe problem. The EAT-10 was designed specifically to address the clinical need for a rapid, self-administered and easily scored questionnaire to assess the severity of dysphagia symptoms. An EAT-10 score ≥ 3 is abnormal and indicates the presence of swallowing difficulties. The EAT-10 has been confirmed to have excellent internal consistency, test-retest reproducibility, and criterion-based validity (17). In a previous study, we translated the EAT-10 into Japanese, and determined the reliability and validity of the Japanese version of the questionnaire (18). The EAT-10 was also translated into Spanish (19), Italian (20) and Portuguese (21).

One Spanish publication has reported an evaluation of the relationships among dysphagia assessed by the questionnaire, nutritional status and ADL. Galán Sánchez-Heredero MJ et al. (22) assessed the relationships among oropharyngeal dysphagia assessed by the EAT-10 and the volume-viscosity evaluation method, nutritional risk factors and functional impairment in the elderly admitted to a medical-surgical hospital unit. The logistic regression analysis showed that a low score on the Barthel index (23) and dysphagia were associated with a greater likelihood of suffering from malnutrition. However, no English articles have reported an investigation of these associations. Furthermore, associations among dysphagia assessed by the questionnaire, nutritional status and ADL were not evaluated in elderly individuals requiring long-term care in geriatric health services facilities and in community-dwelling individuals. Therefore, the aim of the current study was to investigate the associations among dysphagia assessed by the EAT-10, nutritional status and ADL in elderly individuals requiring long-term care in acute hospitals, geriatric health services

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facilities and the community.

Materials and Methods

A cross-sectional study was performed in 237 Japanese elderly individuals aged 65 years or older who required long-term care and who were recruited from 3 geriatric health services facilities in the Tohoku region, 2 acute hospitals (1 community-based hospital in the Tohoku region and 1 university hospital in Yokohama) between August and December 2012. Long-term care services have been provided In Japan through the social insurance system enacted in the Long-term Care Insurance Act. All participants from geriatric health services facilities and acute hospitals were inpatients. Community-dwelling elderly individuals requiring long-term care and receiving home medical care, such as nursing, nutrition, and rehabilitation in Japan were also recruited. Recruitment of research participants was performed through research collaborators involved in dysphagia rehabilitation in the Japanese Association of Rehabilitation Nutrition. The inclusion criteria required that individuals were at least 65 years of age, eligible for a long-term care insurance program, and diagnosed with dysphagia or possible dysphagia. Exclusion criteria were terminal-stage malignancy and inability to respond to the EAT-10. The ethics committee of the Yokohama City University Medical Center approved the study. All participants provided informed consent prior to enrollment. We obtained permission to use all of the surveys in the study.

The data were collected by 24 research collaborators (doctors, dentists, nurses, speech therapists, physical therapists, occupational therapists, dental hygienists, or registered dietitians) at geriatric health services facilities, acute hospitals, or participants' homes. To obtain the greatest possible uniformity of data collection in different settings, research collaborators involved only in dysphagia rehabilitation in daily clinical practice were included. We formed a study group to discuss data collection and the collection of data with standardized questionnaires and implementation manuals. Nutritional status and ADL were assessed by research collaborators.

The EAT-10 was self-administered by participants. Participants were stratified into two groups: an EAT-10 score between 0 and 2 and an EAT-10 score between 3 and 40, because an EAT-10 score ≥ 3 is abnormal and indicates the presence of swallowing difficulties (17, 18). The sensitivity and specificity of an EAT-10 score of 3 or above for oropharyngeal dysphagia assessed by videofluoroscopy were 0.85 and 0.82, respectively (24). Nutritional status was assessed by the Mini Nutritional Assessment Short Form (MNA-SF) (25-27, Table 2). The MNA-SF is comprised of 6 questions addressing decline in food intake and weight loss over the past 3 months, mobility, psychological stress or acute disease in the past 3 months, neuropsychological problems, and body mass index. ADL were evaluated by the Barthel Index (23, Table 3). The Barthel Index consists of 10 items which are, feeding, moving from a wheelchair to bed and return, grooming, transferring to and from a toilet, bathing, walking on a level surface, going up and down stairs, dressing, continence of bowels and bladder.

Statistical analyses were performed with IBM SPSS Statistics 21 software. Parametric data were reported as the mean ± SD, whereas nonparametric data were expressed as the median and interquartile range. The Chi-square test, t-test and the Mann-Whitney U test were used to analyze the differences between the two groups stratified by the EAT-10 score (0-2 and 3-40). Multiple regression analysis was used to examine whether the EAT-10 has an independent effect on the Barthel Index and the MNA-SF by adjusting for covariates such as age, gender, and setting. A P-value < 0.05 was considered statistically significant.

Results

A total of 237 elderly individuals with a mean age of 82 ± 8 years participated in the study. Common diseases included cerebrovascular disorders (49%), chronic heart failure (11%), respiratory diseases (9%), Parkinson's disease (8%), and cancer (8%). Table 4 summarizes the measurements for the EAT-10, nutritional status, and ADL. The median EAT-10 score was 1 (interquartile range: 0-9), and a total of 101 (43%) elderly individuals had EAT-10 scores between 3 and 40, indicating the presence of dysphagia. Based on the MNA-SF, 81 (34%) were malnourished, 117 were at risk of malnutrition, and 39 were of normal nutritional status. The median Barthel Index score was 55. The EAT-10, the MNA-SF, and the Barthel Index were different between settings. The frequency of dysphagia was lower in geriatric health service facilities than in the other settings. The frequency of malnutrition was lower in the community than in the other settings. The Barthel index score was lower in geriatric health service facilities than in the other settings.

Age, gender, presence of Parkinson's disease, setting, Barthel Index score, and MNA-SF score differed significantly between the two groups classified by the EAT-10 score (0-2 and 3-40) (Table 5). The Barthel Index score and the MNA-SF score were significantly lower in the group with an EAT-10 score between 3 and 40, compared to the group with an EAT-10 score between 0 and 2.

Age, gender, setting and the EAT-10 score were included in a multiple regression analysis of the MNA-SF score. There was no multicollinearity between variables. The EAT-10 score, an acute hospital setting and community dwelling were independently associated with MNA-SF score (MNA-SF score = – 1.287 × EAT-10 (score 3-40: 1, score 0-2: 0) – 1.576 × (acute hospital setting: 1, other settings: 0) + 1.438 × (community-dwelling: 1, other settings: 0) + 8.183, $R^2 = 0.174$, $P < 0.001$, Table 6). The EAT-10 score was independently associated with nutritional status.

Table 1
10-item Eating Assessment Tool (EAT-10)

To what extent are the following scenarios problematic for you?
Each item is scored from 0 to 4 according to the severity of the problem.
0 = No problem, 4 = Severe problem
1. My swallowing problem has caused me to lose weight.
2. My swallowing problem interferes with my ability to go out for meals.
3. Swallowing liquids takes extra effort.
4. Swallowing solids takes extra effort.
5. Swallowing pills takes extra effort.
6. Swallowing is painful.
7. The pleasure of eating is affected by my swallowing.
8. When I swallow food, it sticks in my throat.
9. I cough when I eat.
10. Swallowing is stressful.
If the EAT-10 score is 3 or higher, you may have problems swallowing efficiently and safely.

Table 2
Mini Nutritional Assessment Short Form

Complete the screen by filling in the boxes with the appropriate numbers. Total the numbers for the final screening score.
A. Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake
B. Weight loss during the last 3 months
0 = weight loss greater than 3 kg (6.6 lbs)
1 = does not know
2 = weight loss between 1 and 3 kg (2.2 and 6.6 lbs)
3 = no weight loss
C. Mobility
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out
D. Has suffered psychological stress or acute disease in the past 3 months?
0 = yes
2 = no
E. Neuropsychological problems
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems
F1. Body Mass Index (BMI) (weight in kg) / (height in m^2)
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater
If BMI is not available, replace question F1 with question F2. Do not answer question F2 if question F1 is already completed.
F2. Calf circumference (CC) in cm
0 = CC less than 31
3 = CC 31 or greater
Screening score (max. 14 points)
12-14 points: Normal nutritional status
8-11 points: At risk of malnutrition
0-7 points: Malnourished

Table 3
Barthel index

Feeding
0 = unable
5 = needs help cutting, spreading butter, etc., or requires modified diet
10 = independent
Bathing
0 = dependent
5 = independent (or in shower)
Grooming
0 = needs to help with personal care
5 = independent face/hair/teeth/shaving (implements provided)
Dressing
0 = dependent
5 = needs help but can do about half unaided
10 = independent (including buttons, zips, laces, etc.)
Bowels
0 = incontinent (or needs to be given enemas)
5 = occasional accident
10 = continent
Bladder
0 = incontinent, or catheterized and unable to manage alone
5 = occasional accident
10 = continent
Toilet use
0 = dependent
5 = needs some help, but can do something alone
10 = independent (on and off, dressing, wiping)
Transfers (bed to chair and back)
0 = unable, no sitting balance
5 = major help (one or two people, physical), can sit
10 = minor help (verbal or physical)
15 = independent
Mobility (on level surfaces)
0 = immobile or < 50 yards
5 = wheelchair independent, including corners, > 50 yards
10 = walks with help of one person (verbal or physical) > 50 yards
15 = independent (but may use any aid; for example, stick) > 50 yards
Stairs
0 = unable
5 = needs help (verbal, physical, carrying aid)
10 = independent

Age, gender, setting and the EAT-10 score were included in a multiple regression analysis of the Barthel Index score. There was no multicollinearity between variables. The EAT-10 score, an acute hospital setting and community dwelling were independently associated with the Barthel Index score (Barthel Index score = – 21.210 × EAT-10 (score 3-40: 1, score 0-2: 0) + 24.306 × (acute hospital setting: 1, other settings: 0) + 28.936 × (community-dwelling: 1, other settings: 0) + 32.387, $R^2 = 0.241$, $P < 0.001$, Table 6). The EAT-10 score was independently associated with ADL.

Table 4
The EAT-10 score, nutritional status, and ADL

	Total	GHSF	AH	CD
Age, y				
mean ± SD	82 ± 8	84 ± 7	80 ± 8	81 ± 8
Gender, n (%)				
male	90 (38%)	20 (22%)	12 (43%)	58 (48%)
female	147 (62%)	69 (78%)	16 (57%)	62 (52%)
EAT-10 score, n (%)				
3 and above	101 (43%)	26 (29%)	20 (71%)	55 (46%)
less than 3	136 (57%)	63 (71%)	8 (29%)	65 (54%)
MNA-SF score, n (%)				
malnourished	81 (34%)	32 (36%)	20 (71%)	29 (24%)
at risk of malnutrition	117 (49%)	47 (53%)	7 (25%)	63 (53%)
normal nutritional status	39 (16%)	10 (11%)	1 (4%)	28 (23%)
Barthel index				
median (25-75 percentile)	55 (25-80)	40 (15-61)	53 (30-78)	75 (35-86)

GHSF: geriatric health services facilities; AH: acute hospitals; CD: community-dwelling

Table 5
t-test, chi-square test, and Mann-Whitney U test of differences between individuals with an EAT-10 score of 0-2 and an EAT-10 score of 3-40

	EAT-10 score		
	0 to 2 n = 136 (57%)	3 to 40 n = 101 (43%)	P-value
Age, y , mean ± SD	83 ± 8	80 ± 8	0.004[1)] t-value: -2.89
Gender, n (%)			0.009[2)]
male	42 (47%)	48 (53%)	
female	94 (64%)	53 (36%)	
Diagnosis of diseases, n (%)			
cerebrovascular disorders	68 (59%)	48 (41%)	0.706[2)]
chronic heart failure	17 (65%)	9 (35%)	0.382[2)]
respiratory diseases	15 (68%)	7 (32%)	0.282[2)]
Parkinson's disease	5 (28%)	13 (72%)	0.008[2)]
cancer	7 (39%)	11 (61%)	0.099[2)]
Setting, n (%)			<0.001[2)]
geriatric health services facilities	63 (71%)	26 (29%)	
acute hospitals	8 (29%)	20 (71%)	
community	65 (54%)	55 (46%)	
MNA-SF score, n (%)			0.001[2)]
malnourished	33 (41%)	48 (59%)	
at risk of malnutrition	76 (65%)	41 (35%)	
normal nutritional status	27 (69%)	12 (31%)	
Barthel Index, median (25-75 percentile)	65 (36-85)	40 (15-72)	<0.001[3)]

1) t-test, 2) chi-square test, 3) Mann-Whitney U test

Table 6
Multiple regression analysis

	unstandardized coefficient					
	B	standard error	95% Confidence interval of B		standardized coefficient	P-value
MNA-SF						
EAT-10	-1.287	0.378	-2.033	-0.542	-0.214	0.001
AH	-1.576	0.619	-2.796	-0.357	-0.171	0.012
CD	1.438	0.399	0.651	2.224	0.242	<0.001
Age	0.001	0.025	-0.048	0.051	0.003	0.965
Gender	-0.234	0.404	-1.030	0.563	-0.038	0.564
Constant	8.183	2.021	4.202	12.165		<0.001
Barthel Index						
EAT-10	-21.210	3.871	-28.840	-13.581	-0.338	<0.001
AH	24.306	6.251	11.988	36.625	0.256	<0.001
CD	28.936	4.118	20.820	37.051	0.465	<0.001
Age	0.052	0.257	-0.453	0.558	0.013	0.838
Gender	-4.661	4.138	-12.816	3.494	-0.073	0.261
Constant	32.387	20.733	-8.471	73.245		0.120

MNA-SF: Mini Nutritional Assessment Short Form; AH: acute hospitals; CD: community-dwelling; Dummy variables AH: AH setting: 1, other settings: 0; Dummy variables CD: CD: 1, other settings: 0

Discussion

This study addressed two questions concerning the associations among the EAT-10 score, nutritional status and ADL in elderly individuals requiring long-term care in acute hospitals, geriatric health services facilities and the community. First, the EAT-10 score was independently associated with nutritional status after adjusting for age, gender and setting. Second, the EAT-10 score was independently associated with ADL after adjusting for age, gender and setting.

The EAT-10 was associated with nutritional status in the elderly requiring long-term care after adjusting for age, gender, and setting. Causes of adult malnutrition are related to acute illness or injury, chronic illness, or social and environmental circumstances (28). These factors may also play a role in the etiology of nutrition- and disease-related sarcopenia (29), and contribute to sarcopenic dysphagia (30, 31) in elderly individuals requiring long-term care. Malnutrition can cause dysphagia (32, 33). Therefore, nutritional assessment is important for elderly individuals requiring long-term care with an EAT-10 score ≥ 3, regardless of the setting.

The EAT-10 was associated with ADL in elderly individuals requiring long-term care after adjusting for age, gender, and setting. Cerebrovascular disorders and Parkinson's disease cause both dysphagia and paralysis of the extremities that impair ADL. Dysphagia can cause nutrition-related sarcopenia. Sarcopenia is a syndrome characterised by progressive and generalised loss of skeletal muscle mass and strength with a risk of adverse outcomes such as physical disability, poor quality of life and death (29). Therefore, neurological diseases and sarcopenia can be involved in the association between dysphagia and ADL.

The frequency of dysphagia was lower in geriatric health service facilities than in the other settings. One reason for this is that there were few males in geriatric health service facilities. Being male is a risk factor for dysphagia in the elderly (34). In contrast, the frequency of malnutrition was lower in the community than in the other settings. One reason for this is that the median Barthel index was lower in geriatric health service facilities, and the MNA-SF includes an item of mobility. The difference in setting is important, because settings were independently associated with the MNA-SF score and the Barthel Index score.

The strength of the EAT-10 is that it is a rapid, self-administered and easily scored questionnaire. There are several methods to screen and assess swallowing function, such as water or food swallowing tests, pulse oximetry, cervical auscultation, videofluoroscopy or videoendoscopic evaluation. However, these swallowing tests cannot be administered by the subject. Furthermore, these swallowing tests are not easy to perform, compared to the EAT-10. The EAT-10 should be performed first. Then, if the EAT-10 score is ≥ 3, further assessment of swallowing function, nutrition status and ADL is required.

This study had a few limitations. First, information bias might have occurred when the MNA-SF and the Barthel index were obtained, because both were assessed by the same research collaborator. Second, formal inter-rater reliability testing of data collection was not performed between research collaborators. Third, sarcopenia assessment was not performed. Further studies investigating dysphagia, nutrition status and ADL should evaluate generalized and swallowing skeletal muscle mass and strength.

In conclusion, dysphagia assessed by the EAT-10 is associated with nutritional status and ADL in elderly individuals requiring long-term care. We should assess swallowing function, nutritional status and ADL in elderly individuals requiring long-term care whose EAT-10 score is ≥ 3.

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Ethical standards: This study complies with the Japanese ethical guidelines for epidemiological research.

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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Head lifting strength is associated with dysphagia and malnutrition in frail older adults

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Aim: The purpose of the present study was to assess the association between head lifting strength, dysphagia and malnutrition in frail older adults.

Methods: A cross-sectional study was carried out in 386 frail older adults aged 65 years and older with dysphagia or suspected dysphagia. Head lifting strength was assessed by the Medical Research Council score. The severity of swallowing and nutritional status was evaluated using the Dysphagia Severity Scale and the Mini-Nutritional Assessment Short Form, respectively. Univariate and logistic regression analyses were applied to examine the associations between head lifting strength, dysphagia and malnutrition.

Results: There were 129 men and 257 women. The mean age was 83 years. The median Barthel Index score was 30 (interquartile range 5–65). A total of 189 (49%) older adults could independently lift their head. Based on the Dysphagia Severity Scale, 79 participants had no dysphagia, 138 had dysphagia without aspiration and 169 had dysphagia with aspiration. The Mini-Nutritional Assessment Short Form showed that 175 older adults were malnourished, 171 were at risk for malnutrition and 40 had a normal nutritional status. The Medical Research Council score in men was higher compared with women. Head lifting strength was significantly correlated with age ($r = -0.256$), the Barthel Index ($r = 0.540$), the Dysphagia Severity Scale ($r = 0.458$) and the Mini-Nutritional Assessment Short Form ($r = 0.331$). In logistic regression analysis, the Medical Research Council score was independently associated with both dysphagia with aspiration and malnutrition.

Conclusions: Head lifting strength is associated with dysphagia with aspiration and malnutrition in frail older adults. **Geriatr Gerontol Int 2015; 15: 410–416.**

Keywords: deglutition disorders, frailty, malnutrition, presbyphagia, sarcopenia.

Introduction

Dysphagia is common in older adults. The prevalence of dysphagia has been reported to range between 11.4–38% in community-dwelling elderly individuals,[1–5] and 40–68% in nursing home residents.[6–8] Dysphagia management is regarded as an important current and future public health issue in geriatric rehabilitation medicine as a result of the increased risk of complications, such as aspiration pneumonia, choking, dehydration, malnutrition and reduction in quality of life accompanying the loss of enjoyment during eating. Although dysphagia is primarily caused by stroke, presbyphagia and sarcopenic dysphagia can occur commonly in frail and sarcopenic older adults.[9]

Presbyphagia refers to age-related changes in the swallowing mechanism in older adults associated with a frailty in swallowing.[9] Presbyphagia differs from dysphagia, and can present with several findings, such as a lack of muscle strength complicating bolus propulsion, diminished lingual pressure, obstructing bolus driving or halting of the bolus while swallowing, which leads to more difficult cleansing of residues. Other manifestations include a decline in taste and smell that makes it more difficult to initiate swallowing, difficulty in controlling the bolus from the anticipatory phase, and entry of the bolus into the lower airway. Finally, lack of teeth and wearing or not wearing complete dentures can also influence chewing.[8]

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Sarcopenic dysphagia is characterized by difficulty in swallowing as a result of sarcopenia of the general skeletal muscles and swallowing muscles.[9–11] Sarcopenia has been described as a syndrome marked by progressive and generalized loss of skeletal muscle mass and strength. According to the European Working Group on Sarcopenia in Older People,[12] this syndrome has been associated with a risk of adverse outcomes, such as physical disability, poor quality of life and death. Similar to the European Working Group on Sarcopenia in Older People recommendation for evaluating sarcopenia, which includes the assessment of muscle mass, muscle strength and physical performance,[12] the examination for sarcopenic dysphagia entails an evaluation of the swallowing muscle mass, swallowing muscle strength and swallowing function.

Age-related loss of swallowing muscle mass in the tongue and geniohyoid muscle has been previously studied.[13,14] Methods for assessing swallowing function include the use of a dysphagia screening questionnaire, such as the 10-item Eating Assessment Tool[15,16] bedside dysphagia screening tests, such as a water test combined with pulse oximetry,[17] observation of the individual during eating, videofluoroscopy and videoendoscopic evaluation of swallowing. Quantitatively, swallowing function can be evaluated using the Functional Oral Intake Scale,[18] the Food Intake Level Scale[19] and the Dysphagia Severity Scale (DSS).[20] In contrast, few methods for measuring swallowing muscle strength exist. Tongue pressure has been primarily studied as an assessment tool for swallowing muscle strength. Tongue pressure, reduced by aging, has been associated with symptoms of dysphagia.[21,22] The jaw-opening force test might be a useful screening tool for predicting pharyngeal residue.[23] However, evaluating tongue pressure and jaw-opening force quantitatively requires a tongue pressure measurement device and a sthenometer, which might not be readily utilized in daily clinical practice. It is therefore important to develop a simple tool for assessing swallowing muscle strength in frail older adults with presbyphagia and sarcopenic dysphagia.

Head lifting strength can reflect the strength of the suprahyoid muscles, a group of four swallowing-related muscles. A systematic review of the effects of head lift exercise on swallowing function reported beneficial effects, including an increase in the anterior excursion of the larynx and anteroposterior diameter of the upper esophageal sphincter opening, which was associated with elimination of dysphagic symptoms.[24] Although head lifting strength appeared to be associated with dysphagia, this systematic review included only patients who could independently lift their head. Measuring the genio-sternum distance grade (GS grade) is a method for assessing suprahyoid muscle strength.[25] The patient is placed in the supine position with the neck passively and fully flexed, and is directed to maintain this position with the chin down. Support is then withdrawn and the level to which the head drops is evaluated in four steps.[25] GS grade can be readily used in daily clinical practice, but is only suitable for patients who can independently lift their head. Some frail older adults cannot lift their head by themselves, and there were no studies investigating the association between the ability of head lifting strength and dysphagia. Therefore, whether head lifting strength is associated with the severity of dysphagia is yet to be determined. Whereas older adults with dysphagia are often malnourished, and dysphagia has been associated with malnutrition in nursing home and stroke patients in systematic reviews,[26,27] the relationship between head lifting strength and malnutrition is unknown. The current study aimed to investigate the association between head lifting strength, dysphagia and malnutrition in frail older adults.

Methods

A cross-sectional study was carried out in 386 frail older adults, aged 65 years and older, residing in three geriatric health services facilities, two acute hospitals, and community-dwellings between August and December 2012. Study participants were recruited by research collaborators involved in dysphagia rehabilitation at the Japanese Association of Rehabilitation Nutrition. The inclusion criteria selected individuals aged at least 65 years who were eligible for the long-term care insurance program as a result of frailty or disability, and carried a diagnosis of dysphagia or suspected dysphagia. Individuals with terminal-stage malignancy were excluded. The ethics committee of the Yokohama City University Medical Center approved the study. All participants or their legal representatives provided informed consent before enrolment.

Data were collected at geriatric health service facilities, acute hospitals or the participants' homes by 24 research collaborators, including doctors, dentists, nurses, speech therapists, physical therapists, occupational therapists, dental hygienists and registered dietitians. To maximize consistency in data collection across different settings, only researchers involved in dysphagia rehabilitation in daily clinical practice were designated as study collaborators. A study group was assembled to discuss data collection methods, which entailed the use of standardized questionnaires and a manual for implementing the questionnaires.

The research collaborators assessed variables, such as head lifting strength, the severity of dysphagia, activities of daily living and nutritional status. Head lifting strength was manually tested by placing the chin downwards toward the sternum, and scored using the Medical Research Council (MRC) scale.[28] Applying a six-point ordinal scale, MRC scores ranging from 0 to 5 were assigned, with 0 indicating no contraction; 1 denoting flicker or trace contraction; 2, active movement with gravity eliminated; 3, active movement against gravity; 4, active movement against gravity and resistance; and 5, normal power.[28] The reliability and validity of the MRC score have been evaluated in patients with radial palsy,[29] and in patients with sporadic amyotrophic lateral sclerosis in studies of neck flexor strength.[30] In the current study, neck flexion range of motion was examined before assessing the MRC scores for head lifting strength. A MRC score of 3 or greater indicated that the older adults were able to lift their head by themselves while showing a range of motion exceeding 50% of neck flexion in the supine position. For older adults who were unable to lift their head in the supine position, head lifting strength was assessed in the lateral position.

Using the DSS,[20] the severity of dysphagia was assessed on a seven-point ordinal scale, where a score of 1 indicated saliva aspiration, characterized as an unstable medical condition as a result of severe saliva aspiration; 2, food aspiration with no effect of compensatory techniques or food consistency changes; 3, water aspiration, defined as the aspiration of thin liquids; 4, occasional aspiration, meaning possible aspiration or aspiration while chewing or swallowing; 5, oral problems, defined as significant symptoms during the oral preparatory or oral phase without aspiration; 6, minimal problems, characterized by some symptoms of dysphagia without aspiration; and 7, within normal limits, meaning no dysphagia. Scores less than 7 signified the presence of dysphagia, with scores of 1 to 4 being indicative of dysphagia with aspiration. The interclass reliability and validity of the DSS have been previously established.[16,31] A single research collaborator assessed the DDS by observing the participant during eating and by administering various tests for dysphagia, such as water or food swallowing tests, pulse oximetry, or cervical auscultation, at the bedside. Activities of daily living were evaluated by the Barthel Index.[32] Nutritional status was assessed by the Mini-Nutritional Assessment Short Form (MNA-SF).[33–35] The MNA-SF was comprised of six questions addressing decline in food intake and weight loss over the past 3 months, mobility, psychological stress or acute disease in the past 3 months, neuropsychological problems, and body mass index. A total of 386 frail older adults, 129 men and 257 women, with a mean age of 83 years (Table 1) participated in the study. Common diseases included cerebrovascular disorders, chronic heart failure, respiratory diseases, Parkinson's disease and cancer.

Statistical analyses were carried out using IBM SPSS Statistics 21 software (IBM Corporation, Armonk, NY, USA). Parametric data were reported as the mean ± SD, whereas non-parametric data were expressed as the median and interquartile range. A χ^2-test was used to analyze the differences between places of residence. Associations between the MRC score for head lifting strength, the DSS, MNA-SF score, Barthel Index score and age were examined using the Spearman rank correlation coefficient. The χ^2-test, *t*-test and the Mann–Whitney *U*-test were used to analyze the differences between two groups stratified by the MRC score (0–2 and 3–5). Logistic regression analysis was used to examine the associations between potential independent predictors, including age, sex, the MNA-SF score, the MRC score, places of residence and the Barthel Index, and presence and absence of each of the following variables: dysphagia, dysphagia with aspiration and malnutrition. The DSS was divided into dichotomous categories to show the presence or absence of dysphagia (1–6 and 7, respectively) and the presence or absence of dysphagia with aspiration (1–4 and 5–7, respectively). Similarly, MNA-SF scores were dichotomously classified to show the presence or absence of malnutrition (0–7 and 8–14, respectively). The strength of association between predictor and dependent variables was reported as the odds ratio (OR) and 95% confidence interval (CI). A *P*-value <0.05 was considered statistically significant.

Table 1 Demographics of participants

	Value
Age, years (mean ± SD)	83 ± 8
Male/female, *n* (%)	129 (33%)/ 257 (67%)
Diagnosis of diseases, *n* (%)	
Cerebrovascular disorders	214 (55%)
Chronic heart failure	67 (17%)
Respiratory diseases	44 (11%)
Parkinson's disease	38 (10%)
Cancer	23 (6%)
Place of residence, *n* (%)	
Geriatric health services facilities	197 (51%)
Acute hospitals	67 (17%)
Community dwellings	122 (32%)
Barthel Index, median (interquartile range)	30 (5–65)

SD, standard deviation.

Results

Table 2 summarizes the measurements for head lifting strength, the severity of dysphagia and nutritional status. A total of 189 (49%) older adults had MRC scores between 3 and 5, indicating the ability to lift their head by themselves. Based on the DSS, 79 had no dysphagia, 138 had dysphagia without aspiration and 169 had dysphagia with aspiration. The MRC score, the DSS and the MNA-SF score differed significantly between places of residence.

Table 2 Head lifting strength, severity of dysphagia and nutritional status

	n (%) Total	GHSF	AH	CD	*P*-value
MRC					<0.001
5	25 (7%)	12 (6%)	2 (3%)	11 (9%)	
4	81 (21%)	32 (16%)	18 (27%)	31 (25%)	
3	83 (22%)	44 (22%)	14 (21%)	25 (20%)	
2	110 (29%)	46 (23%)	20 (30%)	44 (36%)	
1	47 (12%)	29 (15%)	11 (16%)	7 (6%)	
0	40 (10%)	34 (17%)	2 (3%)	4 (3%)	
DSS					<0.001
7	79 (21%)	15 (8%)	1 (1%)	63 (52%)	
6	86 (22%)	49 (25%)	22 (33%)	15 (12%)	
5	52 (14%)	39 (19%)	4 (6%)	9 (7%)	
4	58 (15%)	32 (16%)	13 (19%)	13 (11%)	
3	50 (13%)	28 (14%)	8 (12%)	14 (11%)	
2	38 (10%)	21 (11%)	14 (21%)	3 (2%)	
1	23 (6%)	13 (7%)	5 (7%)	5 (4%)	
MNA-SF					<0.001
Malnourished	175 (45%)	94 (48%)	48 (72%)	33 (27%)	
At risk of malnutrition	171 (44%)	92 (47%)	18 (27%)	61 (50%)	
Normal nutritional status	40 (10%)	11 (6%)	1 (1%)	28 (23%)	

P-value refers to the difference between places of residence. AH, acute hospitals; CD, community dwelling; DSS, Dysphagia Severity Scale; GHSF, geriatric health services facilities; MNA-SF, Mini-Nutritional Assessment Short Form; MRC, Medical Research Council score

Table 3 Head lifting strength, age, severity of dysphagia, nutritional status and activities of daily living: Spearman rank correlations

	Age	DSS	MNA-SF	ADL
MRC	−0.256*	0.458*	0.331*	0.540*
Age		−0.064	−0.074	−0.208*
DSS			0.536*	0.757*
MNA-SF				0.510*

*$P < 0.05$. ADL, activities of daily living, Barthel Index score; DSS, Dysphagia Severity Scale, MNA-SF, Mini-Nutritional Assessment Short Form; MRC, Medical Research Council.

The MRC score, age, the DSS, the MNA-SF score and the Barthel Index score showed significant correlations (Table 3); among these, the DSS and the Barthel Index score ($r = 0.757$) were most highly correlated. Age, sex, the Barthel Index score, the MNA-SF, presence of dysphagia and dysphagia with aspiration differed significantly between two groups classified by the MRC scores (0–2 and 3–5; Table 4). In contrast, places of residence did not significantly differ between the two groups. The sensitivity and specificity of the 0–2 MRC score for dysphagia with aspiration were 0.680 and 0.622, respectively.

Age, sex, the MNA-SF score, the MRC score, places of residence and the Barthel Index were included in logistic regression analysis of the DSS. In the logistic regression analysis of the DSS categories for dysphagia, the MNA-SF score, places of residence and the Barthel Index score were independently associated with the presence of dysphagia (Table 5). In contrast, the MRC score was not independently associated with dysphagia. In the logistic regression analysis of the DSS categories for dysphagia with aspiration, sex, the MNA-SF score, the MRC score and the Barthel Index score were independently associated with dysphagia with aspiration.

Age, sex, the DSS, the MRC score and places of residence were included in logistic regression analysis of the two MNA-SF categories (0–7 and 8–14, indicating the presence and absence of malnutrition, respectively). The Barthel Index score was excluded from the multiple regression analysis because of multicollinearity between the DSS and the Barthel Index score. The MRC score (OR 1.352, 95% CI 1.108–1.651; $P = 0.003$), the DSS (OR 1.501, 95% CI 1.285–1.754; $P \leq 0.001$) and places of residence were independently associated with presence of malnutrition.

Discussion

The present study addressed two questions regarding the association between head lifting strength, dysphagia and malnutrition in frail older adults. First, head lifting

Table 4 Differences between study participants categorized by Medical Research Council score

	MRC score category 3–5 n = 189	0–2 n = 197	P-value
Age. years (mean ± SD)	81 ± 7	85 ± 8	<0.001†
Sex, n (%)			<0.001‡
Male	78 (40%)	51 (26%)	
Female	111 (60%)	146 (74%)	
Places of residence, n (%)			0.195‡
Geriatric health services facilities	88 (47%)	109 (55%)	
Acute hospitals	34 (18%)	33 (17%)	
Community dwelling	67 (35%)	55 (28%)	
Barthel Index (median)	45	5	<0.001§
DSS category, n (%)			
1–6 (Presence of dysphagia)	142 (75%)	165 (84%)	0.036‡
7 (No dysphagia)	47 (25%)	32 (16%)	
1–4 (Dysphagia with aspiration)	54 (29%)	115 (58%)	<0.001‡
5–7 (Without aspiration)	135 (71%)	82 (42%)	
MNA-SF, n (%)			<0.001‡
Malnourished	63 (33%)	112 (57%)	
At risk of malnutrition	102 (54%)	69 (35%)	
Normal nutritional status	24 (13%)	16 (8%)	

†Student's t-test; ‡χ^2-test; §Mann–Whitney U-test. DSS, Dysphagia Severity Scale; MNA-SF, Mini-Nutritional Assessment Short Form; MRC, Medical Research Council; SD, standard deviation.

Table 5 Logistic regression analysis of the Dysphagia Severity Scale

	±Dysphagia with aspiration OR	95% CI		P-value	±Dysphagia OR	95% CI		P-value
Age	1.022	0.984	1.062	0.257	1.038	0.982	1.097	0.193
Sex	0.238	0.120	0.471	<0.001	1.049	0.436	2.524	0.915
MNA-SF	1.139	1.015	1.278	0.027	1.342	1.119	1.609	0.002
MRC	1.504	1.181	1.914	0.001	1.353	0.902	2.030	0.143
PD								
CD				0.347				0.001
GHSF	1.598	0.719	3.554	0.250	0.286	0.119	0.688	0.005
AH	0.998	0.396	2.512	0.996	0.035	0.004	0.344	0.004
ADL	1.045	1.032	1.058	<0.001	1.054	1.035	1.074	<0.001
Constant	0.009			0.010	<0.001			<0.001

ADL, activities of daily living, Barthel Index score, AH, acute hospitals; CD, community dwelling; CI, confidence interval; DSS, Dysphagia Severity Scale; GHSF, geriatric health services facilities; MNA-SF, Mini-Nutritional Assessment Short Form; MRC, Medical Research Council; OR, odds ratio; PD, places of residence.

strength was independently associated with dysphagia with aspiration after adjusting for age, sex, places of residence, ADL and nutritional status. Therefore, head lifting strength is a useful tool for assessing the severity of dysphagia. Second, head lifting strength was independently associated with malnutrition after adjusting for age, sex, places of residence and the severity of dysphagia.

Head lifting strength was independently associated with dysphagia with aspiration, but not the presence of dysphagia. In the DSS, dysphagia without aspiration includes oral problems and minimal problems. The present findings show that sarcopenia of the suprahyoid muscles might be responsible for the association between head lifting strength and aspiration, because oral problems and minimal problems can develop in the absence of suprahyoid muscle weakness. However, the sensitivity and specificity of head lifting ability for dysphagia with aspiration were unremarkable.

Head lifting strength was independently associated with malnutrition. Causes of adult malnutrition could be related to either acute illness or injury, chronic illness or social and environmental circumstances.[36] These factors might also play a role in the etiology of nutrition- and disease-related sarcopenia,[9] and contribute to weakness in head lifting in frail older adults. Furthermore, 90% of research participants were malnourished or at risk for malnutrition. Therefore, nutritional assessment is a key component of dysphagia assessment.

Head lifting strength might be a useful tool for assessing suprahyoid muscle strength. Evaluating swallowing muscle strength is important in older adults with dysphagia, because presbyphagia and sarcopenic dysphagia can be common and associated with swallowing muscle weakness. The MRC scale offers a simple method for evaluating muscle strength in daily clinical practice, and does not necessitate the use of special devices. Although swallowing muscle strength was not included in the consensus diagnostic criteria for sarcopenic dysphagia[9] proposed at the 19th Annual Meeting of the Japanese Society of Dysphagia Rehabilitation, this measure should be included in future revisions of the consensus diagnostic criteria for sarcopenic dysphagia.

The present study had a few limitations. First, the DSS was assessed by observing eating and by carrying out tests for dysphagia at the bedside. Carrying out videofluoroscopy or videoendoscopic evaluation of swallowing could reduce bias in assessing dysphagia. Second, information bias might have occurred when obtaining the MRC score and the DSS, because both were assessed by the same research collaborator. Third, we did not carry out any physiological or kinesiological tests for assessing swallowing muscle strength. Further studies investigating the association between sarcopenia of the swallowing muscles, presbyphagia and sarcopenic dysphagia should evaluate not only head lifting strength and dysphagia, but also generalized skeletal muscle mass and the swallowing muscle.

In conclusion, head lifting strength was independently associated with dysphagia with aspiration and malnutrition. Head lifting strength is a useful tool for assessing the severity of dysphagia in frail older adults.

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Disclosure statement

The authors declare no conflict of interest.

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REVIEW

Rehabilitation nutrition for sarcopenia with disability: a combination of both rehabilitation and nutrition care management

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Abstract Malnutrition and sarcopenia often occur in rehabilitation settings. The prevalence of malnutrition and sarcopenia in older patients undergoing rehabilitation is 49–67 % and 40–46.5 %, respectively. Malnutrition and sarcopenia are associated with poorer rehabilitation outcome and physical function. Therefore, a combination of both rehabilitation and nutrition care management may improve outcome in disabled elderly with malnutrition and sarcopenia. The concept of rehabilitation nutrition as a combination of both rehabilitation and nutrition care management and the International Classification of Functioning, Disability and Health guidelines are used to evaluate nutrition status and to maximize functionality in the elderly and other people with disability. Assessment of the multifactorial causes of primary and secondary sarcopenia is important because rehabilitation nutrition for sarcopenia differs depending on its etiology. Treatment of age-related sarcopenia should include resistance training and dietary supplements of amino acids. Therapy for activity-related sarcopenia includes reduced bed rest time and early mobilization and physical activity. Treatment for disease-related sarcopenia requires therapies for advanced organ failure, inflammatory disease, malignancy, or endocrine disease, while therapy for nutrition-related sarcopenia involves appropriate nutrition management to increase muscle mass. Because primary and secondary sarcopenia often coexist in people with disability, the concept of rehabilitation nutrition is useful for their treatment. Stroke, hip fracture, and hospital-associated deconditioning are major causes of disability, and inpatients of rehabilitation facilities often have malnutrition and sarcopenia. We review the concept of rehabilitation nutrition, the rehabilitation nutrition options for stroke, hip fracture, hospital-associated deconditioning, sarcopenic dysphagia, and then evaluate the amount of research interest in rehabilitation nutrition.

Keywords Rehabilitation nutrition · Stroke · Hip fracture · Hospital-associated deconditioning · Sarcopenic dysphagia

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1 Introduction

Rehabilitation nutrition is a combination of both rehabilitation and nutrition care management, and this concept is used with International Classification of Functioning, Disability and Health guidelines to evaluate nutrition status and to maximize functionality in the elderly and other people with disability. Rehabilitation nutrition may further improve physical and mental function, activities of daily living, and quality of life. The term "rehabilitation nutrition" is quite different from that of "nutritional rehabilitation." Nutritional rehabilitation usually refers to nutritional improvement of malnourished children in developing countries. In contrast, rehabilitation nutrition not only refers to nutritional improvement but also to rehabilitation in people with disability [1, 2]. Rehabilitation nutrition is similar to sports nutrition. The key aims of rehabilitation nutrition assessment [2] are to assess the following: (1) the presence and cause of malnutrition; (2) the presence and cause of sarcopenia; (3) the presence and cause of dysphagia; (4) the adequacy of nutrition care management with prediction of future nutritional status; and (5) whether rehabilitation for functional improvement, such as resistance training and endurance training, can be conducted.

The prevalence of malnutrition in rehabilitation settings is high. In elderly patients hospitalized for rehabilitation, the prevalence of compromised nutrition status was estimated to be 49–67 % [3]. In Australia, 33 and 51.5 % of patients admitted to rehabilitation hospitals were classified as malnourished and at nutritional risk using the Mini Nutritional Assessment (MNA) and the MNA short-form (MNA-SF) [4]. One study using pooled MNA data found that the prevalence of malnutrition in elderly people was highest in rehabilitation settings (rehabilitation, 50.5 %; hospital, 38.7 %) [5]. Another study using the MNA-SF revealed a 40.8 % prevalence of malnutrition in rehabilitation settings [6]. A systematic review found that malnutrition in older adults admitted for rehabilitation has a negative effect on functional recovery and quality of life following discharge to the community [7]. Furthermore, rehabilitation outcome has been shown to be poor in malnourished patients with stroke [8], hip fracture [9], hospital-associated deconditioning [10, 11], and a variety of other diseases.

The prevalence of sarcopenia in rehabilitation settings is also high: 10–30 % in community-dwelling elderly [12] and 40 % in ambulatory rehabilitation facility-dwelling elderly 60 years and older [13]. Another study revealed that 46.5 % patients admitted to a subacute geriatric care unit who underwent a rehabilitation intervention met the diagnostic criteria for sarcopenia [14].

The European Working Group on Sarcopenia in Older People categorized sarcopenia into primary sarcopenia (age-related sarcopenia) and secondary sarcopenia (i.e., activity-, disease-, or nutrition-related sarcopenia) [15]. Assessment of the multifactorial causes of primary and secondary sarcopenia is indispensable because rehabilitation nutrition for sarcopenia differs depending on its etiology. Treatment of age-related sarcopenia includes resistance training, protein and amino acid supplementation, smoking cessation, and pharmaceutical therapies [16, 17]. Pharmaceutical therapy of sarcopenia is likely to advance in the near future because our understanding of the role of regulators in sarcopenia has increased [18, 19]. Early ambulation, exercise, and avoiding bed rest are important for preventing and treating activity-related sarcopenia. Treatment of disease-related sarcopenia includes therapies for advanced organ failure, inflammatory disease, malignancy, and endocrine disease, while treatment of nutrition-related sarcopenia includes appropriate nutrition management to increase muscle mass [16, 17]. In cases of age-, activity-, disease-, and nutrition-related sarcopenia, rehabilitation nutrition can be used to maximize functionality.

Stroke, hip fracture, and hospital-associated deconditioning are major causes of disability in inpatient rehabilitation facilities. In the USA, the six largest diagnostic impairment categories receiving inpatient rehabilitation include stroke, lower extremity fracture, lower extremity joint replacement, debility, neurologic disorders, and brain dysfunction [20]. Hip fracture is a leading cause of disability in lower extremity fracture patients, and debility is synonymous with hospital-associated deconditioning. In Japan, common causes of inpatient rehabilitation in convalescent rehabilitation wards are stroke (47.9 %); orthopedic diseases, including hip fracture (35.2 %); disuse syndrome (10.5 %); and traumatic brain and spinal cord injury (5.4 %) [21]. Disuse syndrome is synonymous with hospital-associated deconditioning. These data indicate that management of patients with stroke, hip fracture, and hospital-associated deconditioning is an important part of inpatient rehabilitation. The term "sarcopenic dysphagia" refers to difficulty swallowing due to sarcopenia of generalized skeletal muscles and swallowing muscles [22, 23]. Age-related loss of the tongue and geniohyoid muscle mass has been studied in the elderly [24, 25]. Sarcopenic dysphagia is an important current and future public health issue, because it is common in the elderly and can lead to aspiration pneumonia, the prevalence of which is increasing with the aging of society [23]. Therefore, we review rehabilitation nutrition for stroke, hip fracture, hospital-associated deconditioning, and sarcopenic dysphagia, and then assess the level of research interest in rehabilitation nutrition.

2 Stroke

Stroke is the leading cause of disability in Western and East Asian countries. More than 60 % of patients remain disabled, 50 % of patients suffer from hemiparesis, and 30 % remain unable to walk without assistance [26]. As the benefits of rehabilitation are beyond doubt, rehabilitation strategies play center stage in optimizing functional recovery after stroke [27, 28].

Both malnutrition and obesity are nutritional problems in stroke. According to a recent systematic review, malnutrition and dysphagia respectively occur in 8.2–49.0 % and 24.3–52.6 % of subjects following stroke [29]. In subgroup analysis, the odds of malnutrition were significantly increased during the rehabilitation stage (odds ratio (OR), 2.445; 95 % confidence interval (CI), 1.009–5.925) [29]. Tissue wasting, sarcopenia, and cachexia may impair and delay poststroke rehabilitation and worsen the prognosis, and increasing evidence suggests that patients who are overweight and mildly obese may actually have a better outcome [30]. Analysis of data from the China National Stroke Registry on patients grouped according to their body mass index (BMI) into underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23–27.4 kg/m^2), obese (27.5–32.4 kg/m^2), or severely obese (≥32.5 kg/m^2) [31] found that overweight was independently associated with favorable 3-month functional recovery (OR, 1.24; 95 % CI, 1.12–1.38), but severe obesity was independently associated with higher 3-month mortality (OR, 2.01; 95 % CI, 1.10–3.69) [31]. In stroke patients admitted to a rehabilitation hospital, the underweight group had the lowest functional independence measure (FIM) efficiency, followed by the obese and normal-weight subgroups [32]. The overweight group had the highest FIM efficiency (p=0.05) when compared with the obese subgroup [32]. These results indicate that outcome is better in overweight stroke patients than in underweight stroke patients. However, the obesity paradox seems not to be applicable to poststroke rehabilitation.

Skeletal muscles are the main effector organs impacted by disability in stroke, but little attention is paid to structural, metabolic, and functional alterations of muscle tissue after stroke [27, 28]. Stroke-induced sarcopenia is difficult to differentiate from hemiparesis in terms of evaluating muscle strength and physical performance. Therefore, diagnosis of stroke-induced sarcopenia is a challenging task. In a systematic review of loss of skeletal muscle mass after stroke [33], lean tissue mass was significantly less in the paretic than the nonparetic lower limb (median, 342.3 g; 95 % CI, 247.0–437.6 g) and upper limb (median, 239.9 g; 95 % CI, 181.7–298.2 g), and midthigh muscle cross-sectional area (median, 15.4 cm^2; 95 % CI, 13.8–16.9 cm^2) was significantly less in individuals at least 6 months poststroke. Mechanisms of muscle wasting in stroke-related sarcopenia include disuse atrophy, spasticity, inflammation, denervation, reinnervation, impaired feeding, and intestinal absorption [28]. Further research will be required to diagnose and treat stroke-induced sarcopenia.

Nutritional supplements can improve outcomes in poststroke rehabilitation [34]. A randomized study comparing intensive nutritional supplementation to routine nutritional supplementation was performed in 116 undernourished stroke inpatients [34]. Compared with those on standard nutritional supplements, patients receiving intensive nutritional supplementation improved more on measures of motor function (total FIM, FIM motor subscore, 2 and 6-min timed walk tests, p<0.002) [34]. In a randomized, controlled trial comparing routine care with individualized, nutritional care aiming to prevent weight loss in acute stroke patients at nutritional risk [35], 20.7 % of the intervention group lost ≥5 % weight compared with 36.4 % of the control group (p=0.055) at follow-up. The intervention group had a significantly higher increase in QoL score (p=0.009) and in handgrip strength (p=0.002) [35]. In a Cochrane Database of Systematic Review [36], nutritional supplementation in acute and subacute stroke was associated with reduced frequency of pressure sores (OR: 0.56; 95 % CI: 0.32–0.96), and increased energy intake (mean differences (MD), 430.18 kcal/day; 95 % CI, 141.61–718.75) and protein intake (MD, 17.28 g/day; 95 % CI, 1.99–32.56). These results indicate that nutrition support for stroke rehabilitation patients at malnutrition or nutritional risk seems to improve nutrition intake and rehabilitation outcome.

3 Hip fracture

Hip fractures are associated with more disability, health care costs, and mortality than all other osteoporotic fractures combined [37]. In 2005, hip fractures in the USA were estimated to account for 14 % of total fractures but 72 % of total fracture-related health care costs [37]. Compared with its pre-fracture level, post-fracture function is deteriorated in 60 % of patients with hip fracture [38]. The demographic trend worldwide is that more and more people are suffering from hip fracture. The number of hip fractures is expected to rise from 1.6 million in 2000 up to 6.3 million in 2050 [37]. Hip fracture is the most common condition requiring geriatric musculoskeletal rehabilitation.

The prevalence of malnutrition in hip fracture depends on the method of nutrition assessment. Malnutrition prevalence was lowest when assessed by BMI (13 %), followed by MNA-SF (27 %), International Classification of Disease, 10th Revision, Australian Modification (ICD10-AM) (48 %), albumin (53 %), and geriatrician individualized assessment (55 %) [39]. Malnutrition prevalence in hip fracture was 37.5 % using ICD10-AM criteria in another study [40]. Nutrition status assessed by MNA in one hip fracture study revealed that 8.8 % of elderly patients were undernourished, 43.7 % at risk of malnutrition, and 47.5 % well-nourished [41]. Nutrition status in another hip fracture study revealed that 11.6 % were malnourished, 44.2 % at risk of malnutrition, and 44.2 % were well-nourished [42]. MNA predicted gait status and mortality 6 months after hip fracture [43]. Serum albumin level (p=0.0004; OR, 5.8541) and BMI (p=0.0192; OR, 1.1693) significantly influenced mortality after hip fracture [44]. Malnutrition and being at risk for malnutrition are common in patients with hip fracture and seem to affect rehabilitation outcome.

The prevalence of sarcopenia in patients with hip fracture is high. In the Sarcopenia and Hip Fracture study [45], 71 % of participants were sarcopenic. Another study in women with hip fracture revealed that 58 % were sarcopenic [46]. Using normative data from the New Mexico Elder Health Study [47], 64.0 % of female hip fracture inpatients and 95.0 % of male hip fracture inpatients admitted to rehabilitation wards had sarcopenia. Analysis of other data revealed that 21.8 % of female hip fracture patients and 86.7 % of male hip fracture patients had sarcopenia [47]. In 357 Japanese patients immediately after hip fracture, 44.7 % of women and 81.1 % of men had sarcopenia, and the presence of sarcopenia was independently associated with the occurrence of hip fracture [48]. On the other hand, only 4 of the 71 hip fracture patients (5.6 %) were identified as cachectic [49]. Sarcopenia not cachexia seems to be common in elderly patients with hip fracture.

A Cochrane Database Systematic Review of nutritional supplementation in elderly patients with hip fracture found weak evidence for the effectiveness of protein and energy supplements [50]. One trial of multinutrient intravenous feeding followed by oral supplements found a reduction in the number of participants with complications (RR, 0.21; 95 % CI, 0.10–0.46), but not in mortality rate (RR, 0.11; 95 % CI, 0.01–2.00) [50]. A controlled prospective cohort study in patients with hip fracture found a significant association of multidisciplinary postoperative nutritional care with a decline in the number of malnourished patients and a decline in the EuroQol ($p=0.004$) after 3 months of the intervention [51]. In a randomized, controlled study [52], nutritional support actively supervised by a dietician and guided by repeated measurements of resting energy requirements was achievable and improved outcomes in geriatric patients following surgery for hip fractures. Multidisciplinary nutritional care reduced nutritional deterioration during admission (5.4 vs. 20.5 %; $p=0.049$), and increased the rate of discharge directly back to the community (48.0 vs. 17.6 %; $p=0.012$) in a pragmatic intervention study [53]. A high-protein nutritional intervention-based study on β-hydroxy-β-methylbutyrate, vitamin D3, and calcium in obese and lean aged patients with hip fractures and sarcopenia will be implemented [54]. These results indicate that nutrition support for hip fracture patients may improve nutrition status and rehabilitation outcome.

4 Hospital-associated deconditioning

Hospital-associated deconditioning is characterized by the functional decline that occurs during acute hospitalization due to illness or injury, or both, and is unrelated to a specific neurological or orthopedic insult, or both [55]. Several concepts have been proposed to explain the consequences of inactivity and disuse in the hospital, and include debility [20], disuse syndrome [10, 21], hospital-associated deconditioning [11, 55], hospitalization-associated disability [56], and post-hospital syndrome [57]. During hospitalization, patients are commonly deprived of sleep, experience disruption of normal circadian rhythms, are nourished poorly, have pain and other discomfort, confront a baffling array of mentally challenging situations, receive medications that can alter cognition and physical function, and become deconditioned by bed rest or inactivity [57]. Hospitalization-associated disability occurs in approximately one-third of patients older than 70 years of age and may be triggered even when the illness that necessitated the hospitalization is successfully treated [56]. Therefore, hospital-associated deconditioning represents an important condition in geriatric rehabilitation medicine [11].

Malnutrition is associated with poor rehabilitation outcome in hospital-associated deconditioning. In an acute rehabilitation setting, obese patients with deconditioning show greater improvement in FIM scores, compared with patients whose BMI is in the normal range or lower (BMI 18.5) [58]. This lower BMI group shows the smallest increase in FIM motor scores with rehabilitation [58]. In elderly patients with deconditioning, admission Norton scale scores were correlated with discharge walking FIM scores ($r=0.32$; $p=0.003$), discharge transfer FIM scores ($r=0.30$; $p=0.005$), and length of rehabilitation ($r=-0.37$; $p<0.0001$) [59]. In our previous prospective cohort study [11], 87.6 % of patients were malnourished, 12.4 % were at risk for malnutrition, and there were none with normal nutritional status. In multiple regression analysis, the MNA-SF score, albumin level, and cachexia status were significantly associated with the Barthel Index score at discharge [11]. These results indicated that patients with hospital-associated deconditioning may experience not only activity-related sarcopenia but also nutrition-related and disease-related sarcopenia [11]. Nutrition management and sarcopenia treatment in patients with hospital-associated deconditioning may lead to improvement of disability, although further studies are required.

5 Sarcopenic dysphagia

Sarcopenic dysphagia is characterized by the loss of swallowing muscle mass and function associated with generalized loss of skeletal muscle mass and function. The prevalence of dysphagia has been reported to be 11.4–38 % in community-dwelling elderly individuals [60–64] and 40–68 % in nursing home residents [65–67]. Dysphagia management is important because dysphagia is common in the elderly and increases the risk of related complications such as aspiration pneumonia, choking, dehydration, malnutrition, and a lower quality of life following the loss of the joy of eating. Furthermore, sarcopenic dysphagia is not only the result of aspiration pneumonia, but also an important cause of recurrent aspiration pneumonia [23]. Sarcopenic dysphagia may be common in elderly subjects with sarcopenia and dysphagia [23].

Age-related loss of swallowing muscles has been studied [24, 25]. Swallowing muscles include the intrinsic muscle of the tongue and the mimic, masticatory, suprahyoid, infrahyoid, palatal, pharyngeal, and esophageal muscles. Tamura et al. [24] evaluated thickness of the central part of the tongue in the elderly using ultrasonography and showed mid-arm muscle area and age were associated independently with tongue thickness. These results indicate that tongue muscle mass is associated with generalized skeletal muscle mass and aging. Feng et al. [25] assessed the geniohyoid muscle in healthy older adults using computed tomography. A decrease in the cross-sectional area of the geniohyoid muscle has been shown to occur with increasing age, with this area being significantly smaller in aspirators compared with non-aspirators, but only in older men [25]. These findings suggest that geniohyoid muscle atrophy may be a component of

Table 1 Number of PubMed entries retrieved in a search of seven rehabilitation journals for the terms "nutrition" and "sarcopenia." Accessed on 25 April 2014 from www.pubmed.gov

Journal name	Total no. of entries	Nutrition	Sarcopenia
Archives of Physical Medicine and Rehabilitation	11,856	96	2
Clinical Rehabilitation	1,768	10	1
Journal of Rehabilitation Medicine	1,499	6	0
European Journal of Physical and Rehabilitation Medicine	523	5	5
American Journal of Physical Medicine and Rehabilitation	3,123	30	0
Disability and Rehabilitation	3,638	27	0
International Journal of Rehabilitation Research	1,807	11	0
Total	24,214	185 (0.8 %)	8 (0.03 %)

decreased swallowing safety and aspiration in older adults with presbyphagia or frailty of swallowing.

Mid-upper arm circumference and calf circumference were correlated with dysphagia [22, 68]. The circumference of the mid-upper arm in older Japanese adults with suspected swallowing disorders was correlated significantly with swallowing function [22]. This finding suggested that swallowing impairment was related to thinness. It is likely that the general reduction in lean body mass, including the swallowing muscle mass, is responsible for the association between mid-upper arm circumference and swallowing function, and indicates the presence of sarcopenic dysphagia [22]. Another study revealed that swallowing measures had significant correlations with the functional and nutritional measures including serum albumin levels, mid-upper arm circumference, and calf circumference but not with age [68]. Given that sarcopenia is exacerbated by disease, inactivity, and malnutrition, sarcopenia involving the swallowing muscle mass and its function may account for this result [68].

Malnutrition can cause dysphagia [69, 70]. Malnutrition results in both increased adductor pollicis muscle fatigability and an altered pattern of muscle contraction and relaxation which are reversible by nutritional supplementation [71]. No experimental evidence shows that malnutrition would affect the loss of swallowing muscle fibers. However, deglutition muscles that have a moderate to high percentage of type II fibers may be among the first to atrophy at malnutrition because malnutrition affects type II muscle fibers to a much greater extent than it does type I fibers [69, 70]. Furthermore, malnutrition was associated with dysphagia and head lifting strength which reflects the strength of the suprahyoid muscles in frail older adults [72].

Therapy for sarcopenic dysphagia includes dysphagia rehabilitation, treatment of sarcopenia, and nutrition improvement. The core components of dysphagia rehabilitation are oral health care, rehabilitative techniques, and food modification. Malnutrition contributes to the etiology of secondary sarcopenia and sarcopenic dysphagia. Therefore, nutrition management to increase muscle mass is indispensable for sarcopenic dysphagia rehabilitation, and the concept of rehabilitation nutrition is useful. Further research on sarcopenic dysphagia is required, although consensus diagnostic criteria for sarcopenic dysphagia have been proposed [23].

6 Research interest in rehabilitation nutrition

The rehabilitation medicine literature lacks research focused on nutrition and sarcopenia. We searched seven major rehabilitation journals cited in the article "Publishing in physical and rehabilitation medicine" [73] and indexed by PubMed. These rehabilitation journals were the Archives of Physical Medicine and Rehabilitation, Clinical Rehabilitation, Journal of Rehabilitation Medicine, the European Journal of Physical and Rehabilitation Medicine, the American Journal of Physical Medicine and Rehabilitation, Disability and Rehabilitation, and International Journal of Rehabilitation Research. Of 24,214 PubMed entries for these seven journals, 185 (0.8 %)

Table 2 Number of Japan Medical Abstracts Society Database entries retrieved in a search of four Japanese rehabilitation journals for the words "nutrition" and "sarcopenia." Accessed on 25 April 2014 from http://www.jamas.or.jp/about/english.html

	Entire period			From 2010		
Journal name	Total	Nutrition	Sarcopenia	Total	Nutrition	Sarcopenia
The Japanese Journal of Rehabilitation Medicine	24,457	545	17	4,419	136	15
Sogo Rihabiriteshon	7,759	136	8	1,100	31	5
Journal of Clinical Rehabilitation	4,602	180	9	839	53	8
Medical Rehabilitation	2,080	231	21	778	97	20
Total	38,898	1,092 (2.8 %)	55 (0.1 %)	7,136	317 (4.4 %)	48 (0.7 %)

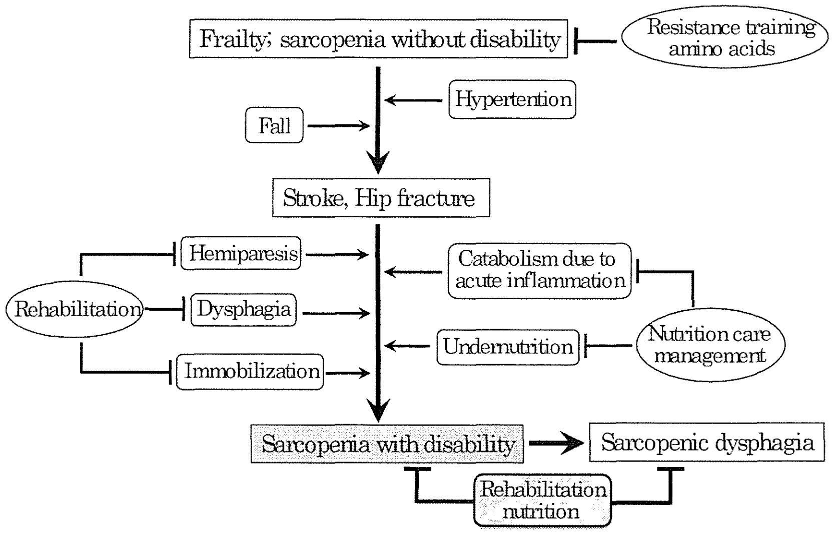

Fig. 1 Mechanism of sarcopenia with disability in frail elderly with stroke and hip fracture. Frail elderly with stroke or hip fracture becomes sarcopenia with disability because of hemiparesis, dysphagia, immobilization, catabolism due to acute inflammation, and undernutrition. Rehabilitation for hemiparesis, dysphagia, immobilization, and nutrition care management for catabolism due to acute inflammation and undernutrition are usually provided separately. Sarcopenia with disability induces sarcopenic dysphagia which is characterized by the loss of swallowing muscle mass and function associated with generalized loss of skeletal muscle mass and function. Rehabilitation nutrition can be used to improve functionality in people with sarcopenic dysphagia and sarcopenia with disability

and 8 (0.03 %), respectively, contained the words "nutrition" and "sarcopenia" on 25 April 2014 (Table 1). Four articles (one editorial and three reviews) published in the European Journal of Physical and Rehabilitation Medicine contained the word "sarcopenia" and were about sarcopenia and muscular modifications in disabling pathologies [74–77]. Though the importance of nutrition in rehabilitation was already recognized in the 1940s [78], interest in nutrition and sarcopenia in rehabilitation medicine has remained very low.

In Japan, interest in rehabilitation nutrition has increased in recent years. Using the Japan Medical Abstracts Society Database, we searched for articles in four major Japanese rehabilitation journals including the Japanese Journal of Rehabilitation Medicine, Sogo Rihabiriteshon, Journal of Clinical Rehabilitation, and Medical Rehabilitation. Of the 38,898 entries of these four journals, 1092 (2.8 %) and 55 (0.1 %), respectively, contained the words "nutrition" and "sarcopenia" on 25 April 2014 (Table 2). When the search was limited to entries after 2010, 4.4 and 0.7 %, respectively, contained the words "nutrition" and "sarcopenia".

We established the Japanese Association of Rehabilitation Nutrition in 2011; its membership in April 2014 had increased to more than 3300 people and included physical therapists, registered dietitians, speech-language-hearing therapists, etc. Moreover, 629 people attended the 3rd Congress of the Japanese Association of Rehabilitation Nutrition held in 2013.

Interest in rehabilitation nutrition is increasing in Japan because of the emergence of a rapidly aging society, high number of convalescent rehabilitation beds, and high number of nutrition support teams in hospitals. The aging rate in Japan is the highest in the world (i.e., 25.1 % in October 2013). The number of convalescent rehabilitation beds available under the Japanese Medical Insurance System has increased since 2000 to 68,316 in March 2014. The mean age of the patients in convalescent rehabilitation wards is 73.0 years [21]. These data suggest that the number of disabled elderly with malnutrition and sarcopenia is increasing at an accelerated pace. The number of hospitals that have nutrition support teams certified by the Japan Council for Nutritional Therapy was 1001 in 2013. Many physical therapists, occupational therapists, and speech-language-hearing therapists are actively involved in nutrition support teams and interested in nutrition care management. Collaborative studies of rehabilitation nutrition have been undertaken by the Japanese Association of Rehabilitation Nutrition [72]. Furthermore, the Japanese Society for Sarcopenia, Cachexia and Wasting Disorders was established in 2014. Further, more focused, research on rehabilitation nutrition will be needed because the number of elderly with disability is expected to increase in developed countries as the population ages [79, 80].

7 Conclusion

The prevalence of malnutrition and sarcopenia in physically disabled elderly patients who undergo rehabilitation is high. In contrast, the amount of research focused on nutrition and sarcopenia in rehabilitation medicine is very low. The major causes of disability in inpatients of rehabilitation facilities, including stroke, hip fracture, and hospital-associated deconditioning, are often complicated by malnutrition and sarcopenia. Sarcopenic dysphagia is common in the elderly