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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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 = $-1.287 \times$ EAT-10 (score 3-40: 1, score 0-2: 0) $- 1.576 \times$ (acute hospital setting: 1, other settings: 0) $+ 1.438 \times$ (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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