Relationship between swallowing function and the skeletal muscle mass of elderly persons requiring long-term care

Kohji Murakami[1], Hirohiko Hirano[2], Yutaka Watanabe[3], Ayako Edahiro[2], Yuki Ohara[4], Hideyo Yoshida[2], Hunkyoung Kim[2], Daisuke Takagi[1], Shouji Hironaka[1]

1. Department of Special Needs Dentistry, Division of Hygiene and Oral Health, Showa University School of Dentistry, Tokyo, Japan
2. Research Team for Promoting Independence of the Elderly, Tokyo Metropolitan Institute of Gerontology, Tokyo, Japan
3. Oral Diseases Research, Department of Advanced Medicine, Division of Oral and Dental Surgery, National Center for Geriatrics and Gerontology, Aichi, Japan
4. Section of Oral Health Education, Graduate School of Medical and Dental Science, Tokyo Medical and Dental University, Tokyo, Japan

Corresponding Author:

Hirohiko Hirano, DDS, PhD

Research Team for Promoting Independence of the Elderly

Tokyo Metropolitan Institute of Gerontology

32-2 Sakae-cho, Itabashi-ku, Tokyo 173-0015, Japan

E-mail: hhirano@tmig.or.jp

Tel: +81 3 3964 3241

Fax: +81 3 3964 2316

Running Title: Swallowing function and muscle mass

Abstract

Aim: This study investigated the risk factors for dysphagia among elderly persons who require long-term care, and also examined the systemic sarcopenia-related decrease in skeletal muscle mass.

Methods: We evaluated 399 people who required long-term care and who were residing in Omori town, Yokote city, Akita prefecture. After excluding 144 subjects due to missing data or inability to complete our tests, we analyzed data from 255 people for whom complete information regarding sex, age, case history (cerebrovascular disease, Parkinson's disease, and dementia), Barthel Index, skeletal muscle mass index, oral function test, and modified water swallowing test results were available. Subjects were classified as having good or poor swallowing functions based on their modified water swallowing test results, and a univariate analysis was performed for each study parameter. Parameters with a P-value <0.25 in the univariate analysis were subsequently included in a multiple logistic regression analysis as explanatory variables, and good or poor swallowing function were defined as the dependent variables.

Results: After adjusting for age and sex, our analysis revealed that tongue motility, rinsing ability, and skeletal muscle mass index significantly correlated with swallowing function.

Conclusions: Decreased swallowing function was closely correlated with poor tongue motility and poor rinsing ability, and these findings are similar to those of previous studies. However, our results also indicate that decreased skeletal muscle mass index is a novel risk factor for dysphagia among elderly persons who require long-term care.

Keywords: dysphagia, modified water swallowing test, long-term care, Sarcopenia, skeletal muscle mass index

Introduction

A wide range of studies have determined that stroke is a major cause of dysphagia among elderly people, and various assessment and treatment methods are becoming standardized. In addition, interest has recently increased regarding whether dysphagia is caused by a reduction in muscle mass due to aging (sarcopenia) and the accompanying decrease in muscle strength and motor function,[1-4] although few studies have addressed this topic.[5] If the systemic decrease in muscle mass decreases a person's swallowing function, their nutritional status may also worsen, resulting in a vicious cycle. However, as muscle mass can be recovered through improvements in nutritional status and physical activity,[6,7] it may be an important measure for swallowing rehabilitation in cases of dysphagia caused by sarcopenia.

Various risk factors for dysphagia among elderly patients who require nursing care have previously been reported. However, this study used skeletal muscle mass (as evaluated using the Skeletal Muscle Index [SMI]) as the main indicator for sarcopenia, and aimed to elucidate the relationship between SMI and dysphagia.

Methods

Participants

This study evaluated 399 subjects who were certified as requiring nursing care and were living in Omori town, Yokote city, Akita prefecture. The study tests were conducted in Omori hospital's disability or nursing care wards (Yokote city), healthcare facilities for the elderly in Omori town, special nursing homes for the aged, 3 group homes for elderly patients with dementia, day service institutions, and the subjects' homes. After excluding 144 subjects with incomplete data or who could not complete our tests, we included 255 subjects with complete data regarding sex, age, case history (cerebrovascular disease, Parkinson disease, and dementia), Barthel Index, SMI, oral function test results, and modified water swallowing test (MWST) results.

Ethical considerations

Informed consent was obtained from each subject or their agent before their participation in this study. All subjects were fully informed regarding the purpose, nature, and potential risks of the experiments; that participation was voluntary; and that they would not be placed at any disadvantage if they refused to participate in the study or withdrew from it before its completion. Subjects' names and dates were recorded as numbers to prevent the identification of any individual. The study design was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology (Issue #38 in 2009) and the Ethics Committee of the Showa University School of Dentistry (Issue #2014-010 in 2014). All tests were performed in accordance with the tenets of the Declaration of Helsinki, as revised in 2008.

Study design

This study was carried out in February 2014. All swallowing and oral function tests were performed by dental specialists who had 10 h of training in the study's tests and experience in more than 10 cases; the evaluation criteria were calibrated to account for inter-investigator differences. Basic subject information, assessments of activities of daily living, and nutritional assessments were obtained from the nursing staff who provided daily support to the subjects. To evaluate rinsing ability in daily life, we referred to assessments that were made by the nursing staff for each subject. Cognitive functional assessments were performed by specialized investigators, and were based on information that was provided by the nursing staff.

1. Basic information

Data regarding the subject's age, sex, and medical history (cerebrovascular disease, Parkinson disease, and dementia) were obtained from the nursing staff.

2. Barthel Index

The subjects' ability to perform their activities of daily living was measured using the Barthel Index,[8] with scores ranging from 0 to 100 points.

3. Skeletal muscle index

The subjects' body composition was measured using the InBodyS10® system (Bio Space, South Korea), via the bioelectrical impedance analysis (BIA) method, over a 5-min period, in one of the following positions: sitting upright, sitting at a 45° angle, or lying supine. Patients with a cardiac pacemaker were excluded from the study. For the multivariate analysis, the 25th percentile was used as the cut-off, and the subjects were categorized into either the reduced muscle mass group or the normal muscle mass group.

4. Oral function

1) Occlusal contacts

We evaluated the state of molar occlusion using the methods described by Kikutani *et al*.[9] The occlusal support region from the first premolar tooth to the second molar tooth was defined as the posterior molar occlusion, and a 3-level assessment was made. Subjects whose molar occlusion was only established with the remaining teeth were designated as Group A, subjects who required dentures to maintain occlusion were designated as Group B, and subjects without dentures and who did not have molar occlusion were designated as Group C. For analysis, Groups A and B were defined as the molar occlusion group, and Group C was defined as the no occlusion group.

2) Tongue motility

To evaluate tongue motility, subjects were asked to stick out their tongues. Subjects who could not obey instructions were examined by an investigator who stuck out his/her own tongue and asked the subject to imitate this action. If a subject's proglossis could pass beyond the dental arch, their tongue motility was defined as good; all other subjects were defined as having poor tongue motility.

3) Rinsing ability

Subjects who could rinse rhythmically and sequentially without leaking water were defined as have a good rinsing ability, and subjects who could not successfully complete this test were defined as having poor rinsing ability.

4) Mouth dryness

Mouth dryness was categorized as absent or present, based on a visual examination by a dentist.

5. Swallowing function

We evaluated swallowing function using a modified water swallowing test (MWST), as previously described.[10] In short, 3 mL of cold water was poured into the floor of the subject's mouth with a 5 mL syringe, after which the participant was instructed to swallow, and their swallowing was scored (Table 1). If their score was ≥4, the test was repeated twice, and the lowest score was used as the test result. A score of 4 or 5 was defined as good swallowing function, and a score of ≤3 was defined as poor swallowing function. The swallowing function of subjects who were at risk of severe dementia or whose general status was unknown was not tested.

Statistical analysis

Continuous variables were analyzed using the unpaired *t*-test and Mann-Whitney *U*-test, and categorical variables were analyzed using the chi-square test. To identify the factors that were related to good or poor swallowing function, factors that were significant in the univariate analysis ($P < 0.25$) were selected as explanatory variables for the multiple logistic-regression analyses, which were performed with "good" or "poor" swallowing function as the dependent variables. SPSS® Statistics (version 22, IBM Japan, Tokyo) was used for all analyses, and the significance level was set at <0.05.

Results

The subjects' clinical characteristics are shown in Table 2. This study included 58 men (mean age: 83.6 ± 7.7 years) and 197 women (mean age: 85.7 ± 5.9 years). Among the 255 subjects, 91 (35.7%) had a history of cerebrovascular disease, 7 (2.7%) had Parkinson's disease, and 221 (86.7%) had dementia.

The mean value and frequency for each surveyed item was calculated and compared according to swallowing function (Table 3). In the univariate analysis, significant differences were observed for the Barthel Index ($P < 0.001$), SMI ($P < 0.001$), presence of cerebrovascular disease ($P = 0.016$), presence of dementia ($P = 0.028$), absence of molar occlusion ($P < 0.001$), poor tongue motility ($P < 0.001$), poor rinsing ability ($P < 0.001$), and an SMI of less than the 25th percentile ($P < 0.001$). Next, a multiple logistic regression analysis was performed using the factors that were associated with “good” or “poor” swallowing function as the explanatory variables ($P <$ 0.25 in the univariate analysis; cerebrovascular disease, dementia, Barthel Index, the 2 molar occlusion groups, the 2 tongue motility values, the 2 rinsing values, and the 2 SMI values). “Good” or “poor” swallowing function was set as the dependent variables, and analysis of the sex- and age-adjusted odds ratios (OR) revealed that tongue motility (OR: 2.79, 95% confidence interval [CI]: 1.01–7.70, $P = 0.047$), rinsing ability (OR: 2.77, 95% CI: 1.02–7.50, $P = 0.045$), and SMI (OR: 3.53, 95% CI: 1.42–8.77, $P = 0.007$) were significantly associated with swallowing function (Table 4).

Discussion

Japan has an aging rate of 25% and a population that is characterized by abnormal longevity (vs. other nation),[11] therefore a significant amount of age-related research has been conducted in the Japanese population. Among this body of research, sarcopenia (muscle mass reduction due to aging)[1-4] has been a topic of interest, as well as the accompanying decrease in muscle strength and motor function, as these factors can cause weakness and necessitate nursing care among the elderly population. Sarcopenia can also lead to a low nutritional status, due to the reduction in muscle mass. In addition to the establishment of diagnostic criteria, the association between sarcopenia and systemic disease, oral function, and nutritional status has also been reported.[12] Furthermore, the relationship between swallowing function and systemic disease, oral function, and nutritional status among elderly people who require nursing care has also been reported,[13,14] although few studies have evaluated the relationship between swallowing function and sarcopenia. Therefore, this study was designed to investigate the relationship between the known risk factors for dysphagia among elderly people who require nursing care, which include age, oral function (occlusion state, rinsing ability, lingual function), stroke, Parkinson’s disease, dementia, and SMI (which is the main indicator for sarcopenia). Our results indicate that poor rinsing ability, reduced tongue motility, and reduced SMI are risk factors for dysphagia.

Regarding methods that are used to assess swallowing function, videofluoroscopic swallowing tests (VF) or videoendoscopic swallowing tests (VE) have frequently been used. However, these testing methods require special facilities, are performed in an unnatural environment, and are not suitable for general use, as they impose a significant burden on the subject. In contrast, the MWST can be performed at the bedside, and Tohara *et al.*[10] have reported that its sensitivity is 70% and its specificity is 88% for detecting aspiration. Therefore, it is believed that the MWST is a useful screening test for detecting aspiration among home-dwelling and institutionalized elderly people who require nursing care. Therefore, we used the MWST as a method for assessing swallowing function, and were able to detect the presence or absence of dysphagia to a certain level of accuracy.

Previous studies have reported that the loss of occlusion support leads to a decline in nutritional status,[9] and may trigger dysphagia. In addition, reduced physical function, degenerative disease, and dietary intake have also been suggested as causes of poor nutrition.[15] Furthermore, mastication function, which encompasses the number of remaining teeth, number of functional teeth, and general oral health is also considered a major factor.[16,17] However, we did not find a significant relationship between swallowing function and the presence or absence of molar occlusion. Interestingly, the presence or absence of molar occlusion has a major impact on mastication function, and is thus thought to play a major role in swallowing function.[18] However, we believe that this association was absent because most of our subjects were currently residing in nursing care institutions and were receiving food that was appropriate to their level of mastication function. Furthermore, the MWST cannot assess mastication function, which may have masked any association between swallowing function and mastication function.

Many methods exist for assessing oral dryness,[19] although our assessments were made via visual examination of the oral cavity by a dentist. An association between oral dryness and dysphagia has been reported using the Repetitive Saliva Swallowing Test (RSST).[20] However, no such association was observed in our study. We believe that this is due to the fact that the MWST was performed by pouring 3 mL of cold water onto the floor of the oral cavity and asking the subject to swallow, which would have minimized the effect of oral dryness, compared to that experienced during the RSST, where the subject swallows his or her own saliva.

Sato *et al*. evaluated Alzheimer patients with dementia in elder-care facilities, and reported that poor rinsing was a risk factor for dysphagia.[21] In that study, an MWST score of <3 was defined as dysphagia (we also used the same criterion), and the fact that we also identified poor rinsing as a risk factor for reduced swallowing function demonstrates the validity of assessing swallowing function by assessing rinsing and via the MWST. Furthermore, good or poor rinsing can easily be assessed by nursing or care staff during their observation of the subject's daily activities. We believe that the validation of good or poor rinsing as a screening method for dysphagia is a key finding of the present study.

Tongue motility is very important for the formation of a food bolus and transfer during the oral phase,[22] and is also a key factor in swallowing. As tongue motility is strongly related to tongue pressure and muscle mass, Yoshida *et al.*[24] have reported that tongue pressure is significantly reduced in patients with dysphagia. In addition, Okayama *et al.* evaluated tongue pressure and thickness among elderly persons who required nursing care,[25] and they reported that subjects with dysphagia had low values for tongue pressure and thickness, and that there was an association between tongue motility and dysphagia. Our findings support the conclusion that poor tongue motility is a risk factor for reduced swallowing function. Therefore, together with rinsing, sticking out the tongue can be used as a simple screening method for dysphagia, which is another key finding of our study. Moreover, reduced tongue thickness and pressure is significantly associated with the period of nursing care and BMI,[25] which indicates that sarcopenia may occur systemically and specifically in the tongue. In addition, reduced swallowing function occurs when sarcopenia is present in the muscles that are involved in swallowing food. Therefore, in cases of frail elderly patients with dysphagia, difficulties in closing the pharyngeal vestibule, failure to transfer food via the tongue, and delays in hyoid bone movement should be considered.[26] Finally, Tamura *et al.* measured tongue muscle thickness in elderly patients used an ultrasound diagnostic device,[27] and they reported that nutritional status also influenced tongue muscle thickness.

In our study, a reduced SMI was a significant risk factor for reduced swallowing function. However, our most notable finding was that a reduced SMI was more strongly associated with a reduced swallowing function than any of the previously described risk factors, including age, oral function (occlusion state, rinsing ability, and tongue motility), stroke, Parkinson disease, and dementia. Interestingly, much research and debate exists regarding the precise definition and diagnostic criteria for sarcopenia, which have yet to be standardized.[1-4] However, several published articles[3] have stated that the broad diagnostic criteria for sarcopenia include both a reduction in muscle mass and a reduction in muscle strength and physical function. Nevertheless, the measurement of muscle mass is indispensable in all of the criteria. Various methods have been used to evaluate muscle mass, including computed tomography, magnetic resonance imaging, dual x-ray absorptiometry, and the BIA method. However, after considering the effects of x-ray exposure on our subjects and the available facilities, we selected the BIA method, which can be performed in the seated upright position, while seated at a 45° angle, or while in the supine position.

Muscles undergo repetitive cycles of protein synthesis and breakdown, and muscle mass is known to decrease during aging as the rate of breakdown exceeds the rate of synthesis; the state of sarcopenia occurs when this imbalance becomes severe. Nutritional habits, such as the consumption amino acids and vitamin D, are crucial to maintaining protein synthesis, and the worsened nutritional status during aging affects the muscle mass of the whole body, including the muscles that are involved in swallowing, and thus leads to a reduction in swallowing function. Kuroda *et al.* used the graded water-swallowing test for assessing swallowing function,[5] and reported that dysphagia among elderly patients was correlated with upper arm circumference, which also suggests the presence of sarcopenia in dysphagia. In contrast, we used the BIA method, which is more accurate than upper arm circumference for assessing muscle mass (as it measures lean body mass), and were able to more clearly highlight the relationship between sarcopenia and dysphagia.

Our results indicate that a cycle exists where a reduction in nutritional status occurs due to a reduction in swallowing function, which in turn leads to a reduction in SMI and tongue muscle mass, and these reductions result in a further reduction in swallowing function. In the future, given the increasing average lifespan and the development of disease prevention methods, an increase can be predicted in elderly patients who experience a decline in swallowing function that does not have a clear cause (e.g., stroke) and proceeds sub-clinically. Furthermore, our results indicate that oral function assessment methods (e.g., tongue motility and rinsing ability) and systemic muscle mass assessment (e.g., via SMI) can be used to effectively screen for declining swallowing function due to aging and poor nutrition. Using these screening methods, patients can be identified and provided with appropriate nutritional therapy and rehabilitation. Moreover, these methods may be relevant and easy to use for elderly subjects and those involved in their care, and we hope that these findings can be used to prevent the decline in swallowing function among elderly persons.

In conclusion, based on our analysis of the risk factors for dysphagia among elderly subjects who required nursing care, a reduced SMI was found to be a statistically significant risk factor for dysphagia, even after adjusting for age, oral function (occlusion state, rinsing ability, and tongue motility), stroke, Parkinson disease, and dementia.

Limitations

This study used a cross-sectional design, therefore we are unable to comment on the causality of the relationship between SMI and swallowing function. However, as we performed our analysis with “good” or “poor” swallowing function as the dependent variables, we were able to indicate that a reduction in SMI was a significant risk factor for reduced swallowing function. Nevertheless, a longitudinal study is needed to determine whether reduced SMI can cause a decline in swallowing function.

In addition, although we evaluated the swallowing function, oral function, and SMI of elderly subjects who required nursing care, we did not study the relationship between SMI and the mass of the muscles that are involved in mastication and swallowing, such as the tongue, masseter, or suprahyoid muscles. Furthermore, we did not investigate the relationship with the quality of these muscles. In the future, the relationship between oral function (swallowing and mastication functions) and the systemic muscle state should be investigated in new subjects, using BIA and an ultrasonographic diagnostic device, to evaluate the association between the systemic muscle mass and that of the muscles that are involved in mastication.

Disclosure statement

No conflicts of interest exist regarding this study.

References

1 Rosenberg IH. Sarcopenia: origins and clinical relevance. *J Nutr* 1997; 127 (5 Suppl): 990S–991S.

2 Baumgartner RN, Koehler KM, Gallagher D, *et al*. Epidemiology of sarcopenia among the elderly in New Mexico. *Am J Epidemiol* 1998; 147: 755–763.

3 Cruz-Jentoft AJ, Baeyens JP, Bauer JM, *et al*. European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age Ageing* 2010; 39: 412–423.

4 Fried LP, Tangen CM, Walston J, *et al*. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; 56: M146–M156.

5 Kuroda Y, Kuroda R. Relationship between thinness and swallowing function in Japanese older adults: implications for sarcopenic dysphagia. *J Am Geriatr Soc* 2012; 60: 1785–1786.

6 Rabadi MH, Coar PL, Lukin M, Lesser M, Blass JP. Intensive nutritional supplements can improve outcomes in stroke. *Neurology* 2008; 71: 1856–1861.

7 Ha L, Hauge T, Spenning AB, Iversen PO. Individual, nutritional support prevents undernutrition, increases muscle strength and improves QoL among elderly at

nutritional risk hospitalized for acute stroke: a randomized, controlled trial. *Clin Nutr* 2010; 29: 567–573.

8 Mahoney FI, Barthel DW. FUNCTIONAL EVALUATION: THE BARTHEL INDEX. *Md State Med J* 1965; 14: 61–65.

9 Kikutani T, Yoshida M, Enoki H, *et al*. Relationship between nutrition status and dental occlusion in community-dwelling frail elderly people. *Geriatr Gerontol Int* 2013; 13: 50–54.

10 Tohara H, Saitoh E, Mays K, Kuhlemeier K, Palmer JB. Three tests for predicting aspiration without videofluorography. *Dysphagia* 2003; 18: 126–134.

11 Statistics Bureau, Japan. Statistical Handbook of Japan 2014. [Cited 30 August 2014] Available from: http://www.stat.go.jp/english/data/handbook/index.htm.

12 Doherty TJ. Invited review: Aging and sarcopenia. *J Appl Physiol* 2003; 95: 1717–1727.

13 Miller N, Noble E, Jones D, Burn D. Hard to swallow: dysphasia in Parkinson's disease. *Age Ageing* 2006; 35: 614–618.

14 Sumi Y, Miura H, Nagaya M, Nagaosa S, Umemura O. Relationship between oral function and general condition among Japanese nursing home residents. *Arch Gerontol Geriatr* 2009; 48: 100–105.

15 Donini LM, Savina C, Cannella C. Eating habits and appetite control in the elderly: the anorexia of aging. *Int Psychogeriatr* 2003; 15: 73–87.

16 Sheiham A, Steele JG, Marcenes W, *et al*. The relationship among dental status, nutrient intake, and nutritional status in older people. *J Dent Res* 2001; 80: 408–413.

17 Nowjack-Raymer RE, Sheiham A. Association of edentulism and diet and nutrition in US adults. *J Dent Res* 2003; 82: 123–126.

18 Tamura F, Mizukami M, Ayano R, Mukai Y. Analysis of feeding function and jaw stability in bedridden elderly. *Dysphagia* 2002; 17: 235–241.

19 Sreebny LM, Valdini A. Xerostomia. A neglected symptom. *Arch Intern Med* 1987; 147: 1333–1337.

20 Mizuhashi F, Koide K, Toya S, Kitagawa T, Morita O. Examination of Oral Dryness Patients; Comparison of Four Tests: Flow Rate of Rest Saliva, Saxon Test, Oral Moisture, and RSST. *Japanese Journal of Gerodontology* 2010; 24: 374–380. [Japanese]

21 Sato E, Hirano H, Watanabe Y, *et al*. Detecting signs of dysphagia in patients with Alzheimer's disease with oral feeding in daily life. *Geriatr Gerontol Int* 2013; 14: 549–555.

22 Leopold NA, Kagel MC. Swallowing, ingestion and dysphagia: a reappraisal.

Arch Phys Med Rehabil 1983; 64: 371–373.

23 Hiiemae KM, Palmer JB. Tongue movements in feeding and speech. *Crit Rev Oral Biol Med* 2003; 14: 413–429.

24 Yoshida M, Kikutani T, Tsuga K, Utanohara Y, Hayashi R, Akagawa Y. Decreased tongue pressure reflects symptom of dysphasia. *Dysphagia* 2006; 21: 61–65.

25 Okayama H, Tamura F, Tohara T, Kikutani T. A Study on the Tongue Thickness of the Elderly with Care Needs. *JJSDH* 2010; 31: 723－729. [Japanese]

26 Rofes L, Arreola V, Romea M, *et al*. Pathophysiology of oropharyngeal dysphasia in the frail elderly. *Neurogastroenterol Motil* 2010; 22: 851–585.

27 Tamura F, Kikutani T, Tohara T, Yoshida M, Yaegaki K. Tongue thickness relates to nutritional status in the elderly. *Dysphagia* 2012; 27: 556–561.

Table 1. Modified water swallowing test score

Score 1	Inability to swallowing with choking and / or breathing changes
Score 2	Swallowing occurred, but with breathing changes
Score 3	Swallowing occurred with no breathing changes, but with choking and / or wet hoarseness
Score 4	Swallowed successfully with no choking or wet hoarseness
Score 5	Furthermore to Score 4, additional deglutition (dry swallowing) occurred more than twice within 30s

Table 2. Participants' characteristics and sex differences

		Male (n = 58)		Female (n = 197)		Total (n = 255)		U-test
		mean	SD	mean	SD	mean	SD	P-value
Age		83.6	7.7	85.7	5.9	85.2	6.4	0.052
Barthel Index		47.7	31.1	42.8	34.1	43.9	33.5	0.250
†SMI (kg/m^2)		6.0	1.2	4.3	1.2	4.7	1.4	$P < 0.001$
		Applicable patients (%)	Overall (n)	Applicable patients (%)	Overall (n)	Applicable patients (%)	Overall (n)	χ^2-test P-value
Stroke	onset	53.4%	31	30.5%	60	35.7%	91	0.001
Parkinson's disease	onset	1.7%	1	3.0%	6	2.7%	7	0.588
Dementia	onset	81.0%	47	88.3%	174	86.7%	221	0.151
Mouth dryness	onset	86.2%	50	91.4%	180	90.2%	230	0.245
Occlusal contacts	absence	25.9%	15	38.1%	75	35.3%	90	0.087
Tongue motility	Poor	15.5%	9	19.3%	38	18.4%	47	0.515
Rinsing ability	Poor	25.9%	15	27.4%	54	27.1%	69	0.815
†SMI cut off	Poor	24.1%	14	25.4%	50	25.1%	64	0.848

†SMI: skeletal muscle index

Table 3. A comparison of the survey items according to swallowing function

		Good (n = 215)		Poor (n = 40)		U-test
		mean	SD	mean	SD	P-value
Age		85.2	6.4	85.3	6.3	0.877
Barthel Index		48.1	32.3	21.5	30.9	P < 0.001
†SMI (kg/m²)		4.9	1.3	4.1	1.9	P < 0.001
		Applicable patients (%)	Overall (n)	Applicable patients (%)	Overall (n)	χ^2-test P-value
Stroke	onset	32.6%	70	52.5%	21	0.016
Parkinson's disease	onset	2.3%	5	5.0%	2	0.342
Dementia	onset	84.7%	182	97.5%	39	0.028
Mouth dryness	onset	90.7%	195	87.5%	35	0.532
Occlusal contacts	absence	30.2%	65	62.5%	25	P < 0.001
Tongue motility	Poor	12.1%	26	52.5%	21	P < 0.001
Rinsing ability	Poor	20.0%	43	65.0%	26	P < 0.001
†SMI cut off	Poor	19.1%	41	57.5%	23	P < 0.001

†SMI: skeletal muscle index

Table 4. Logistic regression analysis of risk factors for swallowing function

		‡OR	§95% CI	P-value
Sex	0: male 1: female	0.62	0.24—1.62	0.329
Age		0.97	0.91—1.03	0.279
Stroke	0: absence 1: onset	1.40	0.62—3.19	0.421
Dementia	0: absence 1: onset	4.25	0.50—36.22	0.185
Barthel Index		1.00	0.98—1.02	0.933
Occlusal contacts	0: onset 1: absence	1.49	0.60—3.72	0.391
Tongue motility	0: good 1: poor	2.79	1.01—7.70	0.047
Rinsing ability	0: good 1: poor	2.77	1.02—7.50	0.045
†SMI cut off	0: good 1: poor	3.53	1.42—8.77	0.007

†SMI: skeletal muscle index, ‡OR: oddes ratio, §CI: confidence interval