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Original Article

Development of the Japanese version of the Council on Nutrition Appetite Questionnaire and its simplified versions, and evaluation of their reliability, validity, and reproducibility

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ABSTRACT

Background: Because few Japanese questionnaires assess the elderly's appetite, there is an urgent need to develop an appetite questionnaire with verified reliability, validity, and reproducibility.
Methods: We translated and back-translated the Council on Nutrition Appetite Questionnaire (CNAQ), which has eight items, into Japanese (CNAQ-J), as well as the Simplified Nutritional Appetite Questionnaire (SNAQ-J), which includes four CNAQ-J-derived items. Using structural equation modeling, we examined the CNAQ-J structure based on data of 649 Japanese elderly people in 2013, including individuals having a certain degree of cognitive impairment, and we developed the SNAQ for the Japanese elderly (SNAQ-JE) according to an exploratory factor analysis. Confirmatory factor analyses on the appetite questionnaires were conducted to probe fitting to the model. We computed Cronbach's α coefficients and criterion-referenced/-related validity figures examining associations of the three appetite battery scores with body mass index (BMI) values and with nutrition-related questionnaire values. Test–retest reproducibility of appetite tools was scrutinized over an approximately 2-week interval.
Results: An exploratory factor analysis demonstrated that the CNAQ-J was constructed of one factor (appetite), yielding the SNAQ-JE, which includes four questions derived from the CNAQ-J. The three appetite instruments showed almost equivalent fitting to the model and reproducibility. The CNAQ-J and SNAQ-JE demonstrated satisfactory reliability and significant criterion-referenced/-related validity values, including BMIs, but the SNAQ-J included a low factor-loading item, exhibited less satisfactory reliability and had a non-significant relationship to BMI.
Conclusions: The CNAQ-J and SNAQ-JE may be applied to assess the appetite of Japanese elderly, including persons with some cognitive impairment.
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Introduction

In Japan, the prevalence of under-/malnutrition or body mass index (BMI) ≤20 was reported to be 16.8% among the community-dwelling elderly ≥65 years of age according to the National Health and Nutrition Survey, 2013.[1] The estimated prevalence in adults ≥85 years of age was reported to be 29.6%, and the figure among patients institutionalized in health-care facilities was 77.9%.[2]

One of the major factors leading to deterioration of a healthy life among the elderly seems to be under-/malnutrition, which is triggered by loss of appetite (LOA; i.e., anorexia) caused not only by age-related physiological factors, including degraded/impaired oral health, sense of smell and taste, digestive functions, and physical activity,[3–7] but also by dysfunctions of clinical parameters,

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including mental/psychological disorders (such as dementia and depression), and effects/side effects of medicines.[8–11] Under-/malnutrition is also associated with socioeconomic factors, including living alone and sparse or loss of family relationships and social/community communication.[12,13]

Furthermore, LOA itself inevitably worsens activities of daily living (ADL) and quality of life (QOL) because meals are basic to as well as prerequisite for enjoyment of life, especially for the elderly. To adequately evaluate appetite seems critical; however, Japanese appetite questionnaires used currently are comprised of one or two yes/no questions, without evidence of reliability, validity, or reproducibility.

In 2005, using the Delphi method, Wilson et al[14] developed the Council on Nutrition Appetite Questionnaire (CNAQ), which includes eight items (eTable 1). Conducting studies on a long-term care group (mean [standard deviation {SD}] age 79.2 [9.0] years) and a community-dwelling group (mean [SD] age 53.5 [20.2] years, including an elderly group [age range >60–102 years] and a young and elderly group [age range >20–60 years]), they verified its reliability and concurrent validity using an external lengthy assessment tool (the Appetite, Hunger and Sensory Perception Questionnaire)[15] as the reference standard. The CNAQ and the Simplified Nutritional Appetite Questionnaire (SNAQ), which retains items #1, #2, #4, and #6 from the CNAQ, are now used for young and elderly people (including patients) worldwide in countries including Australia, Malaysia, Germany, and Korea.[16–19]

In the present study, we translated and back-translated the original CNAQ and SNAQ into Japanese (the CNAQ-J and SNAQ-J, respectively) according to a standardized procedure and developed the SNAQ for the Japanese elderly (SNAQ-JE) using a series of exploratory factor analyses, and we studied fitting to the structural equation modeling (SEM), reliability, criterion-referenced/-related validity, and reproducibility to verify whether those appetite batteries can be applied to the Japanese elderly.

Methods

The original CNAQ and SNAQ

For convenience, we refer to CNAQ items as follows in this article: #1, Appetite; #2, Feeling full; #3, Feeling hunger; #4, Food tastes; #5, Food tastes compared to when younger; #6, Meal frequency per day; #7, Feel sick or nauseated when eating; and #8, Usual mood. The subjects were requested to reply using 1–5 ordinal scales (Likert scales) of each question.

The CNAQ (and corresponding SNAQ) scores of eight items were tallied, and the total scores ranged from 8 to 40 (4–20 for SNAQ). Scores $\leq$28 ($\leq$14 for SNAQ) may predict "at risk," while scores $\geq$29 ($\geq$15 for SNAQ) "low risk at this stage" of 5–10% (*ibid*) body weight loss from their baseline weight over a 6-month period with approximately 80% (70%–90%) sensitivity and specificity.

Development of the Japanese versions of the CNAQ-J and SNAQ-J

We obtained permission from the original article's authors,[14] including the senior author (JEM), for development of the Japanese versions. Using a standardized translation and back-translation method, a Japanese version (CNAQ-J) was developed by two nutrition researchers, a medical doctor, a professor of English, and a Japanese staff member majoring in English. Translation and back-translation were reiterated until equivalent expressions in English were attained. A pilot study of 15 people (aged from 20 s to 90 s, including an elderly person attending a health-care facility) was conducted to examine whether the Japanese expressions adopted for the CNAQ-J were understandable or not. Younger people were also invited to participate in this study because the younger generation can play roles as proxy/surrogate interview-based responders. Minor revisions were added, and the questionnaire was reckoned as feasible and applicable for the main study. The Japanese versions (the CNAQ-J and SNAQ-J) were finalized (eTables 2 and 3).

Study subjects

From July to December 2013, we recruited 816 subjects, including 175 community-dwelling elderly (CE group) attending health promotion classes for a secondary prevention study to improve mild frailties in O City, Aichi Prefecture; 328 receiving meal delivery (MD group) services in N City, Aichi Prefecture; 163 attending day-care (DC group) facilities in O City, Fukuoka Prefecture, and T City, Toyama Prefecture; and 150 staying at group homes (GH group) in Y City, Kanagawa Prefecture.

For a test–retest reproducibility analysis, 54 elderly people (10 CE and 44 DC persons) were invited independently from the main study.

Data collection

We gathered data on subjects' basic characteristics (gender and age), their anthropometric measurements (height, weight, and BMI), the CNAQ-J, the Clinical Dementia Rating (CDR)[20,21] (from the MD, DC, and GH groups), the Mini Nutritional Assessment-Short Form (MNA-SF)[2,22] (from the CE, DC, and GH groups), and the Constipation Assessment Scale-Japanese Version (CAS-J)[23,24] (from the CE and GH groups).

All data, except for anthropometric measurements, were collected using relevant appetite and nutrition-related questionnaires. We obtained self-administered replies from the CE group, self- and/or interview-administered replies by proxy caregivers/family members of the MD group, and self- and/or interview-administered replies by surrogate facility staff of DC and GH groups.

Exploratory factor analyses of the appetite batteries, and development of the SNAQ-JE

We performed exploratory factor analyses of the CNAQ-J and SNAQ-J under the SEM using the maximum likelihood method, and developed the SNAQ-JE, taking into account the distribution of the CNAQ-J item scores, deleting any item having a smaller factor loading, reducing Cronbach's α coefficient, or deploying a higher brain function.

Examination of fitting to the model

We conducted confirmatory factor analyses to scrutinize the goodness of fit index (GFI), adjusted GFI (AGFI), and a root mean square error of approximation (RMSEA) for the three appetite tools.

Appraisal of reliability/internal consistency

We examined reliability/internal consistency of the CNAQ-J, SNAQ-J, and SNAQ-JE.

Criterion-referenced/-related validity

Using the previously mentioned cutoff values of the CNAQ-J and SNAQ-J, along with cutoffs of $\leq$14 or $\geq$15 for the SNAQ-JE score (based on an average value 14.4), we categorized people into a lower-score group and a higher-score group. BMI values were contrasted between the two score groups in a cross-sectional

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manner, and correlations were probed between appetite questionnaire scores and nutrition-related questionnaire values.

Test–retest reproducibility

We studied test–retest reproducibility of appetite questionnaire scores setting an approximately two-week interval.

Statistical analyses

To compare baseline characteristics with the CNAQ-J item scores by subject group, we conducted *t*-tests for two-group comparisons, analysis of variance (ANOVA) with post hoc Bonferroni adjustment for multiple-group comparisons, and χ^2 tests for comparisons of proportions.

Exploratory factor analyses of the appetite batteries were performed adopting the maximum likelihood method, and the SNAQ-JE was developed from these analyses.

Confirmatory factor analyses were then conducted to probe fitting to the model (including GFI, AGFI, and RMSEA) for the CNAQ-J, SNAQ-J, and SNAQ-JE.

Reliability/internal consistency was appraised calculating Cronbach's α coefficient.

For a criterion-referenced/-related validity study, the BMI difference between a higher-score group vs a lower-score group was examined by *t*-test. We also explored correlations of appetite questionnaire scores with nutrition-related instrument indices by age- and gender-adjusted Pearson correlation coefficients.

Test–retest reproducibility of appetite tool scores was verified adopting intraclass correlation coefficients (ICCs).

For statistical analyses, SPSS ver. 22 (IBM Corp., Armonk, NY, USA) and Amos were used, and $P < 0.05$ (two-tailed) was assumed as statistically significant.

Ethical issues

The present study protocol was submitted to the Committee of Ethics and Conflict of Interest at the National Center for Geriatrics and Gerontology (Number of receipt #648) and approved. All participants/proxies/surrogates were fully informed about the study and gave written consent.

Results

Study subjects

After excluding 167 individuals (7 CE, 127 MD, 19 DC, and 14 GH group participants) having incomplete information from the 816 subjects recruited, we analyzed the data provided by 649 subjects (168 CE, 201 MD, 144 DC, and 136 GH group participants).

There were 230 men (35.4%) and 419 women (64.6%) (Table 1). The average age among men (77.2 [SD, 8.4] years) was younger than among women (82.3 [SD, 7.7] years). Average heights were 162.3 (SD, 6.7) cm for men and 147.3 (SD, 6.9) cm for women. Body weights were 59.1 (SD, 9.4) kg for men and 47.2 (SD, 9.1) kg for women. BMIs were 22.4 (SD, 3.1) kg/m^2 for men and 21.8 (SD, 3.9) kg/m^2 for women.

The CDR study, in which the CE group was excluded, showed that the percentage of participants with no problem (score 0) was 22.7%, with dementia suspected (score 0.5) was 19.6%, and with overt dementia (score 1–3) was 57.7% (34.4% light, 15.3% moderate, and 8.0% severe dementia).

The CNAQ-J scores

The average CNAQ-J score of all subjects was 29.3 (SD, 3.4) (Table 2). The figure of the GH group was highest 30.9 (SD, 3.3), followed by the DC group at 29.8 (SD, 2.6), the CE group at 28.9 (SD, 2.8), and the MD group at 28.2 (SD, 3.8).

Examination of the CNAQ-J structure and development of the SNAQ-JE

An exploratory factor analysis demonstrated that Eigenvalues attenuated as follows: 2.921, 1.006, 0.862, and so forth. Thus, a one-factor (interpreted as appetite) solution appeared reasonable.

First, item #7 exhibited a ceiling effect and was excluded. An exploratory factor analysis of the remaining 7 items deleted item #6 because its factor loading was 0.248 (<0.4). The next analysis

Table 1
Demographic and anthropometric characteristics, and CDR scores by gender and study group.

	All (n = 649)	Men (n = 230)	Women (n = 419)	P[a]	CE[b] (n = 168)		MD[c] (n = 201)		DC[d] (n = 144)		GH[e] (n = 136)		P[f]
	Mean (SD)	Mean (SD)	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		
Age (yrs)	80.4 (8.4)	77.2 (8.4)	82.3 (7.7)	<0.001	73.5 (5.9)	u,v,w[g]	81.2 (8.1)	u,y,z	83.6 (7.5)	v,y	84.4 (7.1)	w,z	<0.001
Height (cm)	152.6 (9.9)	162.3 (6.7)	147.3 (6.9)	<0.001	156.7 (9.3)	u,v,w	153.9 (9.4)	u,y,z	150.5 (10.2)	v,y	147.6 (8.6)	w,z	<0.001
Weight (kg)	51.5 (10.8)	59.1 (9.4)	47.2 (9.1)	<0.001	56.9 (10.5)	u,v,w	50.4 (10.4)	u,x	50.7 (10.7)	v,y	47.2 (9.3)	w,x,y	<0.001
BMI (kg/m^2)	22.0 (3.7)	22.4 (3.1)	21.8 (3.9)	<0.001	23.1 (3.4)	u,v	21.2 (3.3)	u,w	22.3 (4.0)	w	21.7 (3.8)	v	<0.001
CDR score	MD + DC + GH groups				CE (n = 168)		MD (n = 201)		DC (n = 144)		GH (n = 136)		
	All (n = 481)	Men (n = 145)	Women (n = 336)										
0	22.7 (%)	27.8	20.5	0.087[h]	NA		0.3		34.1		0.0		<0.001[h]
0.5	19.6	21.6	18.8		NA		32.0		0.0		11.3		
1	34.4	27.8	37.3		NA		20.7		57.1		42.7		
2	15.3	13.6	16.0		NA		9.3		6.3		34.7		
3	8.0	9.1	7.5		NA		8.7		2.4		11.3		

CDR, Clinical Dementia Rating; CE, community-dwelling elderly; DC, day-care facilities; GH, group homes; MD, meal delivery; NA, not applicable; SD, standard deviation.
[a] Comparisons between sexes using t-test.
[b] Community-dwelling elderly attending health promotion classes.
[c] Elderly receiving meal delivery services.
[d] Elderly attending day-care facilities.
[e] Elderly staying at group homes.
[f] Comparisons across four study groups using ANOVA.
[g] Statistically significant across the same letters (u, v, w, x, y, and z) by ANOVA with post hoc Bonferroni adjustment.
[h] χ^2 test.

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Table 2
CNAQ-J scores by question item, gender, and study group.

Question item	All (n = 649)	Men (n = 230)	Women (n = 419)	P[a]	CE[b] (n = 168)		MD[c] (n = 201)		DC[d] (n = 144)		GH[e] (n = 136)		P[f]
	Mean (SD)	Mean (SD)	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		
#1 Appetite	3.5 (0.8)	3.5 (0.8)	3.5 (0.8)	0.746	3.4 (0.7)	u,v[g]	3.4 (0.8)	w,x	3.7 (0.7)	u,w	3.8 (0.7)	v,x	<0.001
#2 Feeling full	3.8 (0.6)	3.8 (0.7)	3.7 (0.6)	0.748	3.7 (0.6)	u	3.7 (0.7)	v,w	3.8 (0.5)	v	3.9 (0.5)	u,w	<0.001
#3 Feeling hungry	2.8 (1.0)	2.9 (1.0)	2.8 (1.0)	0.167	2.8 (0.9)		2.9 (1.0)		2.7 (1.2)		2.9 (0.8)		0.115
#4 Food tastes	3.6 (0.7)	3.6 (0.7)	3.7 (0.7)	0.088	3.5 (0.6)	u,v,w	3.4 (0.7)	u,x,y	3.9 (0.7)	v,x	3.8 (0.6)	w,y	<0.001
#5 Food tastes compared to when younger	3.1 (0.6)	3.0 (0.6)	3.1 (0.6)	0.819	3.1 (0.6)		3.0 (0.6)		3.0 (0.5)	u	3.2 (0.7)	u	<0.01
#6 Meal frequency a day	4.0 (0.5)	4.0 (0.5)	4.0 (0.4)	0.246	4.0 (0.4)	u	4.0 (0.6)	v	4.2 (0.5)	u,v,w	4.0 (0.1)	w	<0.001
#7 Feeling sick or nauseated when eating	4.6 (0.6)	4.5 (0.6)	4.7 (0.6)	0.018	4.6 (0.5)	u,v	4.4 (0.8)	u,w,x	4.8 (0.4)	v,w	4.7 (0.7)	x	<0.001
#8 Usual mood	3.7 (0.7)	3.7 (0.6)	3.6 (0.7)	0.238	3.7 (0.6)		3.5 (0.7)	u	3.7 (0.7)	u	3.6 (0.8)		<0.05
Total	29.3 (3.4)	29.1 (3.4)	29.4 (3.3)	0.339	28.9 (2.8)	u	28.2 (3.8)	v,w	29.8 (2.6)	v,x	30.9 (3.3)	u,w,x	<0.001

CE, community-dwelling elderly; DC, day-care facilities; GH, group homes; MD, meal delivery; SD, standard deviation.
[a] Comparisons between sexes using t-test.
[b] Community-dwelling elderly attending health promotion classes.
[c] Elderly receiving meal delivery services.
[d] Elderly attending day-care facilities.
[e] Elderly staying at group homes.
[f] Comparisons across four study groups using ANOVA.
[g] Statistically significant across the same letters (u, v, w, x, y, and z) by ANOVA with post hoc Bonferroni adjustment.

showed that all items had factor loading >0.4, but item #3 was omitted since it was a Cronbach's α coefficient reducer. Item #5 (Food tastes compared to when younger), which required the use of memory and judgment of the past, was considered to be inadequate for the elderly with higher brain dysfunction. The SNAQ-JE ultimately consisted of 4 items (#1, #2, #4, and #8) (eTable 4).

Comparison of the results of exploratory factor analyses

The factor loadings of item #6 were 0.257 and 0.279 for the CNAQ-J and SNAQ-J, respectively, and the factor loading values for the SNAQ-JE were all >0.5 (Table 3). The explained variances for respective factor 1 were 28.22, 33.66, and 37.70 for the CNAQ-J, SNAQ-J, and SNAQ-JE, in that order.

Fitting to the model

The GFI and AGFI values for the CNAQ-J, SNAQ-J, and SNAQ-JE were all >0.9, exhibiting a good fit to the model using confirmatory factor analyses (Table 4). The RMSEAs of the CNAQ-J, SNAQ-J, and SNAQ-JE were 0.063, <0.001, and 0.085, respectively.

Reliability/internal consistency

Cronbach's α coefficients for all subjects were 0.733, 0.640, and 0.700 for the CNAQ-J, SNAQ-J, and SNAQ-JE, respectively (Table 5). Cronbach's α coefficients by sex and study group for the SNAQ-JE were uniformly greater than those of the SNAQ-J.

Criterion-referenced/-related validity

The lower-score group according to the CNAQ-J and SNAQ-JE, but not the SNAQ-J, had significantly lower BMIs compared with a higher-score group ($P < 0.01$) (Table 6). CNAQ-J scores were significantly correlated to the MNA-SF values ($r = 0.124$) and to the CAS-J values ($r = -0.335$). SNAQ-J scores were significantly associated with the CAS-J indices ($r = -0.314$), but not with the MNA-SF

Table 3
Comparison of the results of exploratory factor analyses.

Question item[a]		CNAQ-J	SNAQ-J	SNAQ-JE
		Factor 1[b]	Factor 1	Factor 1
		Factor loading	Factor loading	Factor loading
#1	Appetite	0.675	0.760	0.715
#4	Food tastes	0.664	0.600	0.633
#2	Feeling full	0.619	0.576	0.587
#5	Food tastes compared to when younger	0.522		
#8	Usual mood	0.494		0.500
#7	Feel sick or nauseated when eating	0.476		
#3	Feeling hunger	0.410		
#6	Meal frequency a day	0.257	0.279	
Sum of (factor loading values)^2		2.258	1.346	1.507
Explained variance (%) for respective factor 1		28.22	33.66	37.70

CNAQ-J, Council on Nutrition Appetite Questionnaire; SNAQ-J, Simplified Nutritional Appetite Questionnaire; SNAQ-JE, Simplified Nutritional Appetite Questionnaire for Japanese Elderly.
[a] Listed according to the order of factor loading values of the CNAQ-J.
[b] Factor extraction method: Maximum likelihood method.

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Table 4
Comparison of values for fitting to the structural equation model.

	GFI	AGFI	RMSEA
CNAQ-J	0.973	0.951	0.063
SNAQ-J[a]	0.999	0.998	<0.001
SNAQ-JE[b]	0.991	0.955	0.085

AGFI, adjusted goodness of fit index; CNAQ-J, Council on Nutrition Appetite Questionnaire; GFI, goodness of fit index; RMSEA, root mean square error of approximation; SNAQ-J, Simplified Nutritional Appetite Questionnaire; SNAQ-JE, Simplified Nutritional Appetite Questionnaire for Japanese Elderly.
[a] Including items #1, #2, #4, and #6 of CNAQ-J.
[b] Including items #1, #2, #4, and #8 of CNAQ-J.

values. SNAQ-JE scores were significantly correlated with the MNA-SF values (r = 0.178) and the CAS-J figures (r = −0.357).

Test–retest reproducibility

For 54 elderly people independently recruited for a separate test–retest reproducibility sub-study (10 CE persons [aged 73.9 {SD, 4.2} years] and 44 DC persons [aged 80.4 {SD, 4.2}] years), the ICCs of test–retest reproducibility for the CNAQ-J, SNAQ-J, and SNAQ-JE were 0.787, 0.693, and 0.702, respectively ($P < 0.001$) (Table 7).

Discussion

We translated and back-translated the CNAQ into Japanese (the CNAQ-J), along with its simplified version (the SNAQ-J). An exploratory factor analysis demonstrated that the CNAQ-J was constructed of one factor (appetite). According to a step-by-step exploratory factor analysis, we developed the SNAQ-JE, which uses four questions derived from the CNAQ-J. The CNAQ-J, SNAQ-J, and SNAQ-JE showed similar fitting to the model and test–retest reproducibility. The CNAQ-J and SNAQ-JE demonstrated satisfactory reliability and significant criterion-referenced/-related validity values with BMIs, whereas the SNAQ-J manifested less satisfactory reliability, and non-significant criterion-referenced/-related validity with BMIs or MNA-SF values. Additionally, the SNAQ-J included item #6, which had a factor loading of only 0.279. Thus, the SNAQ-JE, instead of the SNAQ-J, may be better suited for use among Japanese elderly.

The SNAQ-JE reached a satisfactory level of Cronbach's α coefficient (0.700) in the present study, but the SNAQ-J did not (0.640). The Cronbach's α coefficient of the SNAQ-J in the present study was comparable to figures for a long-term care group in the original SNAQ study (0.51),[14] geriatric patients in Malaysia (0.58), Brazilian participants in the Cardiopulmonary and Metabolic Rehabilitation Program (0.61), and community-dwelling Japanese elderly (0.55).[25–27] The lower internal consistency values may be due to the fact that most replies to item #6 were aggregated to “three meals a day” (>80% of responses in the present study) with smaller variance, reflecting in part its low factor loading value (<0.4); indeed, the reliability figure improved when the item was excluded.[26]

LOA unduly drives down meal amount, causing weight loss and frailty in the elderly. Wilson et al[14] reported that a CNAQ score ≤28 (the SNAQ score ≤14) may predict being “at risk” of a 5%–10% weight reduction with approximately 80% sensitivity and specificity. Due to the limited observation period and research scheme, we were unable to assess sensitivity and specificity of the SNAQ-JE. Instead, using the SNAQ-JE average value (mean) of 14.4, we observed significantly reduced BMIs among the lower SNAQ-JE score (≤14) group compared with those of the higher-score (≥15) group, but not for the SNAQ-J, in a cross-sectional analysis. Thus, the scores ≤14 and ≥ 15 could be used for the SNAQ-JE cutoff values.

Table 6A
Criterion-referenced/-related validity analyses. Comparison of BMI values according to appetite questionnaire score.

	CNAQ-J			SNAQ-J[a]			SNAQ-JE[b]		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
Lower-score group[c]	233	21.6	3.4	222	21.7	3.6	267	21.6	3.6
Higher-score group[d]	414	22.3	3.8	425	22.2	3.7	380	22.3	3.7
p[e]	0.009			0.063			0.008		

CNAQ-J, Council on Nutrition Appetite Questionnaire; SD, standard deviation; SNAQ-J, Simplified Nutritional Appetite Questionnaire; SNAQ-JE, Simplified Nutritional Appetite Questionnaire for Japanese Elderly.
[a] Including items #1, #2, #4, and #6 of CNAQ-J.
[b] Including items #1, #2, #4, and #8 of CNAQ-J.
[c] The score of CNAQ ≦ 28, SNAQ and SNAQ-JE ≦ 14.
[d] The score of CNAQ ≧ 29, SNAQ and SNAQ-JE ≧ 15.
[e] Using *t*-test.

Table 6B
Criterion-referenced/-related validity analyses. Pearson correlation coefficient[a] of appetite questionnaire scores with nutrition-related questionnaire indices.

	Nutrition-related questionnaire			
	MNA-SF	p	CAS-J	p
	(n = 448)		(n = 304)	
CNAQ-J	0.124	0.030	- 0.335	<0.001
SNAQ-J[b]	0.091	0.113	- 0.314	<0.001
SNAQ-JE[c]	0.178	0.002	- 0.357	<0.001

CAS-J, Constipation Assessment Scale-Japanese Version; CNAQ-J, Council on Nutrition Appetite Questionnaire; MNA-SF, Mini Nutritional Assessment-Short Form; SNAQ-J, Simplified Nutritional Appetite Questionnaire; SNAQ-JE, Simplified Nutritional Appetite Questionnaire for Japanese Elderly.
[a] Age- and gender-adjusted value.
[b] Including items #1, #2, #4, and #6 of CNAQ-J.
[c] Including items #1, #2, #4, and #8 of CNAQ-J.

Table 5
Cronbach's α coefficients by appetite questionnaire and study group.

Appetite questionnaire	All	Men	Women	CE[a]	MD[b]	DC[c]	GH[d]
	(n = 649)	(n = 230)	(n = 419)	(n = 168)	(n = 201)	(n = 144)	(n = 136)
CNAQ-J	0.733	0.731	0.735	0.668	0.810	0.507	0.771
SNAQ-J[e]	0.640	0.599	0.665	0.560	0.702	0.408	0.645
SNAQ-JE[f]	0.700	0.683	0.711	0.598	0.773	0.507	0.740

CE, community-dwelling elderly; DC, day-care facilities; GH, group homes; MD, meal delivery; SD, standard deviation.
[a] Community-dwelling elderly attending health promotion classes.
[b] Elderly receiving meal delivery services.
[c] Elderly attending day-care facilities.
[d] Elderly staying at group homes.
[e] Including items #1, #2, #4, and #6 of CNAQ-J.
[f] Including items #1, #2, #4, and #8 of CNAQ-J.

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Table 7
Test–retest reproducibility of appetite questionnaire scores in community-dwelling elderly[a] and elderly attending day-care facilities[b] (n = 54).

Appetite questionnaire	Score at first self-administration/ interview	Score at second self-administration/ interview	ICC	*P*
	Mean (SD)	Mean (SD)		
CNAQ-J	29.5 (3.2)	28.6 (3.4)	0.787	<0.001
SNAQ-J[c]	15.2 (1.5)	14.8 (1.7)	0.693	<0.001
SNAQ-JE[d]	15.0 (2.0)	14.7 (2.0)	0.702	<0.001

ICC, intraclass correlation coefficient; SD, standard deviation.
[a] Community-dwelling elderly (n = 10, aged 73.9 (4.2)).
[b] Elderly attending *day-care* facilities (*n* = 44, aged 80.4 (4.2)).
[c] Including items #1, #2, #4, and #6 of CNAQ-J.
[d] Including items #1, #2, #4, and #8 of CNAQ-J.

As noted, the lower-score groups had significantly lower BMI values compared with respective higher-score groups on the CNAQ-J and SNAQ-JE, but not on the SNAQ-J. We observed that the three appetite battery scores were negatively associated with the CAS-J values, with statistical significance. The SNAQ-J and SNAQ-JE scores were significantly correlated with MNA-SF values (with age- and gender-adjusted Pearson correlation coefficients of 0.124 and 0.178, respectively), although both correlation coefficients were <0.3 observed in Japanese elderly people.[27] The SNAQ-JE acceptability as a screening instrument should be further investigated to verify the test performance (sensitivity, specificity, and receiver-operating characteristic [ROC] curve analyses) in comparison with nutrition-related questionnaires, including the Malnutrition Universal Screening Tool (MUST) and the Seniors in the Community: Risk Evaluation for Eating and Nutrition (SCREEN)[14,28,29] in addition to the MNA-SF.

Wilson et al[14] developed the SNAQ by deleting "reliability reducers" (supported by a principal components analysis) from the CNAQ, but the authors included item #6, which had a skewed distribution and a factor loading <0.4 in the present study. We developed the SNAQ-JE using a series of exploratory factor analyses, deleting the items showing a ceiling effect, having a smaller factor loading, being an internal consistency reducer, and requiring the use of a higher brain function. Ultimately, fitting to the model, associations with BMIs and CAS-J scores, and reproducibility values were almost equivalent between the SNAQ-J and SNAQ-JE, but the SNAQ-JE reliability and criterion-referenced/-related validity compared to MNA-SF values were uniformly and consistently (significantly/non-significantly) more favorable than those of the SNAQ-J, which included the low-factor-loading item #6. Thus, the evidence-based SNAQ-JE (including items #1, #2, #4, and #8) may be adopted to assess the appetite of other ethnic elderly people worldwide instead of the original SNAQ, although the instrument was primarily developed for the Japanese elderly.

In view of public health nutrition, it appears critical to manage the appetite of elderly people to detect LOA and to prevent LOA-related disorders/syndromes in the early phase using pertinent appetite questionnaires. Wilson et al[14] conducted surveys on a wide range of people (aged >20–102 years) but excluded persons having moderate-to-severe dementia (Mini-Mental State Examination [MMSE] score <18), because their instruments were self-administered by the subjects. However, biases may still exist when obtaining information from the elderly with impaired cognitive function and obtaining replies with proxy/surrogate interview-based assistance. Question items should be *a priori* confined to basic physiologic perception related to an appetite, excluding items requiring deployment of a higher brain function. Meanwhile, reports have demonstrated that the proxy/surrogate respondent's information on dementia/Alzheimer's disease was satisfactorily valid and reliable, without systematic biases.[30–32] Such appeared also to be the case in the present study: the CNAQ-J scores of the MD, DC, and GH groups with proxy (caregivers/family members) or surrogate (facility staff) aids were not uniformly greater/lower than those of CE group self-administered without assistance, suggesting that relevant proxy/surrogate supports may serve to enhance validity and reproducibility.

There are some limitations in the present study. As discussed above, the participants were comprised of heterogeneous Japanese elderly with respect to cognitive function, as seen in the proportions of participants with no problems (22.7%), suspected dementia (19.6%), and apparent dementia (57.7%) in the CDR analysis. These observations reflect the real-world evidence that some proportion of elderly people have a certain degree of higher brain dysfunction. However, under the present study scheme, we were unable to incisively relate cognitive levels to appetite questionnaire scores by gender, age, and instrument administration method (self-administered vs. interview-based with proxy/surrogate assistance). These issues of interest warrant further clarification using a specific research protocol.

Because we here investigated possible associations of appetite tool scores with BMIs and with nutrition-related questionnaire indices in a cross-sectional setting where causes and effects coexist at a certain point of time, we should be deliberate to draw causal inferences. Under a long-term prospective approach, with a ≥6-month observation period and sensitivity, specificity, and ROC curve analyses, we could precisely determine cutoff values, verify possible factors related to LOA, quantify its long-term effect on weight changes, and detect weight loss-associated disorders/syndromes at an early stage.

In conclusion, we developed the Japanese versions of appetite instruments: the CNAQ-J, SNAQ-J, and SNAQ-JE. Of these, the CNAQ-J and SNAQ-JE could be applied to Japanese elderly people, including those who have some cognitive impairment. Because no appreciable discrepancies were noted in reliability, validity, or reproducibility values between the two appetite tools, the SNAQ-JE appeared more feasible and practicable than the CNAQ-J for assessing appetite among the elderly, predicting declining body weight, and screening for LOA-related diseases/syndromes in the premature phase. Thus, the present data-based appetite questionnaires may contribute to elderly people's quality of life and well-being.

Conflicts of interest

None declared.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.je.2016.11.002.

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eTable 1. Council on Nutrition Appetite Questionnaire (CNAQ)

Administration Instructions: Ask the subject to complete the questionnaire by circling the correct answers and then tally the results based upon the following numerical scale: a=1, b=2, c=3, d=4, e=5. The sum of the scores for the individual items constitutes the CNAQ score. CNAQ score ≦28 indicates significant risk of at least 5% weight loss within six months.

1. My appetite is
   a. very poor
   b. poor
   c. average
   d. good
   e. very good
2. When I eat
   a. I feel full after eating only a few mouthfuls
   b. I feel full after eating about a third of a meal
   c. I feel full after eating over half a meal
   d. I feel full after eating most of the meal
   e. I hardly ever feel full
3. I feel hungry
   a. rarely
   b. occasionally
   c. some of the time
   d. most of the time
   e. all of the time
4. Food tastes
   a. very bad
   b. bad
   c. average
   d. good
   e. very good
5. Compared to when I was younger, food tastes
   a. much worse
   b. worse
   c. just as good
   d. better
   e. much better
6. Normally I eat
   a. less than one meal a day
   b. one meal a day
   c. two meals a day
   d. three meals a day
   e. more than three meals a day
7. I feel sick or nauseated when I eat
   a. most times
   b. often
   c. sometimes
   d. rarely
   e. never
8. Most of the time my mood is
   a. very sad
   b. sad
   c. neither sad nor happy
   d. happy
   e. very happy

eTable 2. 日本語版 CNAQ（CNAQ-J）

ここ1ヵ月間の食生活を思い出し、A～Hの質問に対し当てはまる番号の１つに○印をつけてください。

A. 食欲はありますか？

1. ほとんどない
2. あまりない
3. ふつう
4. ある
5. とてもある

B. 食事を、どのくらい食べると満腹感を感じますか？

1. 数口で満腹
2. 3分の１ほどで満腹
3. 半分ほどで満腹
4. ほとんど食べて満腹
5. 満腹になることはほとんどない

C. 空腹感がありますか？

1. めったに感じない
2. たまに感じる
3. 時々感じる
4. よく感じる
5. いつも感じる

D. 食事の味はいかがですか？

1. とてもまずい
2. おいしくない
3. ふつう
4. おいしい
5. とてもおいしい

E. 若いころと比べて、食事の味はどうですか？

1. とてもまずい
2. おいしくない
3. 変わらない
4. おいしい
5. とてもおいしい

F. 食事は、1日何回食べますか？

1. 1日 1回未満
2. 1日 1回
3. 1日 2回
4. 1日 3回
5. 1日 4回以上

G. 食事中に気分が悪くなったり、吐き気を感じることがありますか？

1. いつも感じる
2. よく感じる
3. 時々感じる
4. まれに感じる
5. まったく感じない

H. ふだん、どのような気持ちですか？

1. とても沈んでいる
2. 沈んでいる
3. 沈んでもなく、楽しくもない
4. 楽しい
5. とても楽しい

eTable 3.　日本語版 SNAQ（SNAQ-J）

ここ1ヵ月間の食生活を思い出し、A～Dの質問に対し当てはまる番号の１つに〇印をつけてください。

A. 食欲はありますか？

1. ほとんどない
2. あまりない
3. ふつう
4. ある
5. とてもある

B. 食事を、どのくらい食べると満腹感を感じますか？

1. 数口で満腹
2. 3分の１ほどで満腹
3. 半分ほどで満腹
4. ほとんど食べて満腹
5. 満腹になることはほとんどない

C. 食事の味はいかがですか？

1. とてもまずい
2. おいしくない
3. ふつう
4. おいしい
5. とてもおいしい

D. 食事は、1日何回食べますか？

1. 1日 1回未満
2. 1日 1回
3. 1日 2回
4. 1日 3回
5. 1日 4回以上

eTable 4. 高齢者用日本語版 SNAQ（SNAQ-JE）

ここ1ヵ月間の食生活を思い出し、A～Dの質問に対し当てはまる番号の１つに〇印をつけてください。

１．食欲はありますか？

1. ほとんどない
2. あまりない
3. ふつう
4. ある
5. とてもある

２．食事を、どのくらい食べると満腹感を感じますか？

1. 数口で満腹
2. 3分の１ほどで満腹
3. 半分ほどで満腹
4. ほとんど食べて満腹
5. 満腹になることはほとんどない

３　食事の味はいかがですか？

1. とてもまずい
2. おいしくない
3. ふつう
4. おいしい
5. とてもおいしい

４．ふだん、どのような気持ちですか？

1. とても沈んでいる
2. 沈んでいる
3. 沈んでもなく、楽しくもない
4. 楽しい
5. とても楽しい

（資料３）

Original Article

Relationship between Masseter Muscle Thickness and Skeletal Muscle Mass in Elderly Persons Requiring Nursing Care in North East Japan

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Keywords :
elderly person requiring nursing care, skeletal muscle mass, masseter muscle thickness, sarcopenia, masticatory function

Abstract

Maintenance and improvement of masticatory function in nursing care elderly persons (NC) is an important issue, and it is speculated that sarcopenia is related to declining masticatory function. The decrease in skeletal muscle index (SMI), a major diagnostic criterion for sarcopenia, has been reported to be associated with swallowing function in NC. However, the relationship between SMI and masticatory function is unknown. Therefore, we investigated the relationship between masseter muscle thickness (MMT) and SMI, with the aim of examining the specific relationship between decreased masticatory function and sarcopenia in NC. MMT and SMI were measured by ultrasonography and bioelectrical impedance analysis in 275 NC participants in Omori Town, Yokote City, Akita Prefecture in the Tohoku region in Japan. Cognitive functions measured from all participants using questionnaire. Participants were classified into low-MMT or high-MMT group based on the median of each of MMT, and SMI and related items in each gender. In addition, to examine the factors related to MMT, logistic regression analysis was conducted by entering age, sex, SMI, nutrition status, severity of dementia, and other items as explanatory variables and MMT as objective variable. SMI in high-MMT group were significantly higher than low-MMT group (high-MMT: $4.8 \pm 1.4\,kg/m^2$, low-MMT: $4.4 \pm 1.4\,kg/m^2$, $P=0.010$). Furthermore, logistic regression analysis indicated that SMI were significantly associated with a MMT (Odds Ratio=0.83, 95% Confidence Interval=0.69-0.99, $P=0.049$). Our result suggested that the mass of the masseter muscles decreased with NC due to sarcopenia, possibly contributing to a decrease in masticatory function.

Introduction

In Japan where the aging population is increasing annually, maintenance and amelioration of masticatory function in elderly persons are extremely important issues for maintaining not only nutritional status but also quality of life (QOL) through the enjoyment of eating. A decrease in various physical functions is seen in elderly persons requiring nursing care (NC), and masticatory function is no exception. Decreased masticatory function in these elderly persons is a critical issue that is linked with worsening of QOL, nutritional status, etc. (1). Especially, it is said that there is a decrease of oral function (Oral-frail) is contributed by "Frail" in elderly persons in recent years (2).

Strategies for ameliorating masticatory function in elderly persons include treatment of caries and periodontal disease in remaining teeth and prosthetic replacement of missing teeth. In recent years, several studies have reported that the decreased function of masticatory factors other than the teeth (e.g., masticatory muscles and the tongue) is responsible for the difficulty in mastication (3). We believed that sarcopenia might be a background factor for the decreased function in masticatory muscles and the tongue. Sarcopenia is primarily characterized by generalized muscle weakening

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in elderly persons (4) and has been reported to be a risk factor for increased mortality of elderly patients in the acute care ward (5). It has also been mentioned that poor nutritional status is a cause of sarcopenia (4), and maintenance of masticatory function may prevent sarcopenia through the maintenance of nutritional status (6). The relationship between masticatory function and sarcopenia in healthy elderly persons has been previously reported (6); however, to our knowledge, there are no studies that have examined the relationship between masticatory function and sarcopenia in NC. NC are different from healthy elderly persons, as they have decreased cognitive function and systemic disease, and it is unclear if a similar relationship exists in healthy elderly persons. Furthermore, early discovery and prevention of decreased masticatory function are extremely important because decreased masticatory function leads to disturbance of bolus formation and the risk of difficulty in swallowing is higher compared with healthy elderly persons. The swallowing function, which is one of oral function items, and skeletal muscle mass has evidence of significant relationship (7). However, the relations between other oral functions (e.g., mastication) and skeletal muscle mass, remain unclear. The principal aims of the present study were to elucidate the relationship between masseter muscle thickness (MMT), which is the muscle that influences masticatory function the most, and skeletal muscle index (SMI), a diagnostic criterion of sarcopenia, and we also examined the specific relationship between decreased masticatory function and sarcopenia.

Materials and Methods

This study was conducted as part of a survey on NC conducted by Tokyo Metropolitan Institute of Gerontology (TMIG). This project was entitled "Study on Improvement of NC's Oral Function and Oral Health Condition and Improvement of Dietary Life", and supported by a Health and Labor Sciences Research Grant (H25-Choju-Ippan-005).

Participants

The target population was 399 NC, aged 65 to 98 years old, who lives in Omori Town, Yokote City, Akita Prefecture in the Tohoku region of Japan. The population aging rate in this area is 33.1% as of 2014, and it is higher than national average in Japan. The investigation was complete enumeration of all of the NC who live in this area. Participants were resident of visitors at disability ward, medical ward, health center for the elderly, special nursing home, dementia group home, and day care facility at Omori public hospital, Akita. Among 275 persons (60 men and 215 women; mean age, 85.6 ± 6.5 years) who had agreed to the study participated, analysis were carried out with no missing value in measurement items. The investigation was conducted in February 2014. The reasons for excluding 124 participants are as follows, (1) Pacemaker user, (2) Persons with contracture or loss of limbs, and (3) Residents unable to investigate by entering the facility due to infectious.

Investigation parameters

For each item, we administered a preliminary survey to the primary caregivers and performed preliminary training of the dentists and dental hygienists who performed the measurements using the methods described below. The selection of items other than the primary investigation items in present study was performed based on previous studies of oral function and appendicular skeletal muscle mass in elderly persons requiring nursing care (7,8).

(Primary Investigation Items)

Masseter muscle thickness (MMT): This was the primary investigation item of the present study. Based on the method by Ohara et al. (9), we used the ultrasonography device 'Miru-Cube' (Global Health Co., Ltd., Kanagawa, Japan) to perform the measurements. The masseter muscle thickness was measured in a relaxed state. The image display mode was B-mode, and the probe frequency was 6 MHz. After palpating the masseter muscle, we placed the probe parallel to the region corresponding to the masseter muscle on a line extending from the corner of the mouth to the mandibular plane and measured the thickness of the masseter muscle twice at rest using the measurement computer screen and calculated the mean score.

Skeletal Muscle Index (SMI): This was the evaluation point of interest of the present study. We used bioelectrical impedance analysis (BIA) to measure skeletal muscle mass. Then we divided the measured muscle mass by the squared height (m), and the adjusted extremity skeletal muscle mass was used as the skeletal muscle index (SMI). InBody®S10 (InBody Corporation, Seoul, Korea) was used for the measurement.

(Preliminary Investigation Items of the Questionnaire)

Basic attributes: We investigated sex, age, and degree of long-term nursing care.

Medical history: We investigated whether there was a past

history of cerebrovascular disease, Parkinson's disease and other neurological disease, depression, and diabetes.

Body Mass Index (BMI): This is the index of adult physique that is calculated as body weight divided by height squared. The cut-off value was based on the 1994 criteria of the World Health Organization (WHO) of 18.5 kg/m^2, and subjects with scores less than this value were assigned to the low body weight group (10).

Barthel Index: This is the index of Activities of Daily Living (ADL). The index that assesses the degree of autonomy of 10 items (meals, moving from the wheelchair to the bed, grooming, toilet, bathing, moving, climbing the stairs, dressing, and bowel and bladder control) in several stages (11).

MNA®-SF (Mini Nutrition Assessment Short Form): This is the index of nutrition status. This is a simple screening method to assess nutritional status in elderly persons aged 65 years or older using six items ('decreased food intake', 'decreased body weight', 'mobility', 'mental stress and acute disease', 'dementia', 'depression', and 'BMI') (12).

MNA®-SF is registered trademarks of Société des Produits Nestlé S.A.

(Items Measured by the Investigators)

Number of present teeth/number of functional teeth: The number of present teeth was set as the number of remaining teeth, excluding residual dental roots, and the number of functional teeth was set as the number of present teeth in addition to the number of prosthetic teeth (e.g., dentures, bridge pontic, and implants).

Use of dentures: We confirmed the use of dentures (total or partial dentures) at time of the investigation.

Clinical Dementia Rating (CDR): Method to assess the severity of dementia. The primary caregivers who sufficiently understood the daily life of the subjects evaluated six items (memory, orientation, judgment and problem solving, social adaptation, and family situation) using a five-stage scale, and based on the results, the researchers (professionals such as physicians or nurses) made an evaluation based on a five-point scale (0, 0.5, 1, 2, or 3) (13).

Statistical analysis

Regarding the primary investigation items and other items, the participants were assigned to two groups (low and high MMT groups) based on the median MMT separated by sex, and intergroup comparisons were performed. Because previous studies did not indicate a clear cut-off value for MMT (9). We adopted the median men and women scores as the cut-off values in the present study. The Mann-Whitney U test was performed to examine continuous variables between the groups and chi-square test was conducted to examine categorical variables.

Based on the results of intergroup comparison, we performed binary logistic regression analysis with stepwise method (variable elimination method) in order to extract the low and high scores of MMT as objective variables and factors influencing them. The selection criteria for independent variables were a significant probability of less than 0.1 and a correlation coefficient less than 0.8 in the simple comparison of high-MMT group and low-MMT group. Because age and sex were adjustment factors, they were included regardless of the significance of probability in the simple comparison. SPSS Statistics 20.0 (IBM Corporation, USA) was used for statistical analysis, and statistical significance was set at 5%.

Ethical considerations

The present study was approved by the institutional review boards of Tokyo Metropolitan Institute of Gerontology (approval number: 23-1253) and Nihon University School of Dentistry at Matsudo (approval number: EC14-027), and consent was obtained in writing from all subjects and their family members or primary caregiver after receiving individual explanations in writing.

Results

Basic attributes (Table 1)

The number of men and women participants in the present study was as follows: 60 men (21.8%) and 215 women (78.2%). The mean ages of men and women were 83.9±8.0 and 86.1±6.0 years, respectively. SMI (men: 5.8±1.3, women: 4.3±1.2, $P<0.001$), number of present teeth (men: 5.2±7.5 teeth, women: 3.1±5.8 teeth, $P=0.040$), MNA®-SF score (men: 10.4±2.6 points, women: 9.3±2.6 points, $P=0.004$), and Cerebrovascular disease (men: 56.7 %, women: 29.8 %, $P<0.001$) revealed significantly lower scores in the women in comparison with the men. The median MMT of men and women were 10.1 mm and 9.5 mm. Thereafter, participants were assigned to two groups based on the median MMT.

Comparison of high-MMT and low-MMT groups (Table 2)

First, the low and high MMT groups comprised 132

Table 1. Participants characteristics and sex differences

		Men (n = 60)		Women (n = 215)		U-test
		Mean	SD	Mean	SD	*P*-value
Age (years)		83.9	8.0	86.1	6.0	0.065
BMI		22.3	4.4	21.3	4.4	0.101
MNA®-SF total score		10.4	2.6	9.3	2.6	0.004
Barthel Index		41.5	32.4	37.8	33.0	0.341
SMI (kg/m^2)		5.8	1.3	4.3	1.2	<0.001
CDR		1.6	0.9	1.9	0.9	0.057
Masseter muscle thickness (mm)		10.1	3.5	9.8	3.1	0.441
No. present teeth		5.2	7.5	3.1	5.8	0.040
No. functional teeth		18.7	11.2	16.9	12.1	0.645
		Men (n = 60)		Women (n = 215)		χ^2-test
		n	%	n	%	*P*-value
Cerebrovascular disease	Absence	26	43.3%	151	70.2%	<0.001
	Onset	34	56.7%	64	29.8%	
Parkinson's disease	Absence	59	98.3%	208	96.7%	1.000
	Onset	1	1.7%	7	3.3%	
Neuropathy	Absence	58	96.7%	211	98.1%	0.615
	Onset	2	3.3%	4	1.9%	
Depression	Absence	58	96.7%	202	94.0%	0.535
	Onset	2	3.3%	13	6.0%	
Diabetes	Absence	50	83.3%	175	81.4%	0.851
	Onset	10	16.7%	40	18.6%	
BMI (High/Low)	High	49	81.7%	156	72.6%	0.181
	Low	11	18.3%	59	27.4%	
Denture	Yes	41	68.3%	145	67.4%	1.000
	No	19	31.7%	70	32.6%	

Values are mean ± standard daviation. BMI, body mass index; SMI, Skeletal Muscle Index; CDR, clinical dementia rating.

participants (48.0%) and 143 participants (52.0%), respectively. The mean SMI score in the high and low-MMT groups was 4.8 ± 1.4 kg/m^2 and 4.4 ± 1.4 kg/m^2, respectively, and a significantly higher score was noted in the high-MMT group compared with the low-MMT group (P=0.010). Furthermore, BMI (high-MMT group: 22.6 ± 4.6, low-MMT group: 20.3 ± 4.0, P<0.001), number of functional teeth (high-MMT group: 19.0 ± 11.4 teeth, low-MMT group: 15.4 ± 12.2 teeth, P=0.020), Barthel Index (high-MMT group: 43.1 ± 32.5 points, low-MMT group: 33.8 ± 32.6 points, P=0.017), and total MNA®-SF score (high-MMT group: 10.0 ± 2.7 points, low-MMT group: 9.1 ± 2.5 points, P=0.003) revealed significantly higher scores in the high-MMT group in comparison with the low-MMT group. Compared with the high-MMT group, CDR was significantly higher in the low-MMT group (high-MMT group: 1.7 ± 1.0, low-MMT group 2.0 ± 0.9). Examination of categorical variables revealed a higher BMI score in the high-MMT group compared with the low-MMT group (P=0.026). In addition, although insignificant, age (high-MMT group: 85.1 ± 6.6 years, low-MMT group: 86.2 ± 6.4 years, P=0.152) tended to be higher in the low-MMT group compared with the high-MMT group.

Examination of factors related to masseter muscle thickness (Table 3)

As a result of binary logistic regression analysis using the stepwise method, we extracted SMI as a significant factor related to MMT (OR=0.83, 95% CI=0.69-0.99, P=0.049). Furthermore, although the number of functional teeth (OR=0.98, 95% CI=0.96-1.00, P=0.065) was also not significant, we extracted the items that had the best fit in the final step.

Discussion

In the present study, we elucidated the relationship between MMT and SMI, with the aim of examining the specific relationship between decreased masticatory function and sarcopenia. Therefore, we conducted a cross-sectional study targeting NC. The results revealed a relationship between MMT and SMI. Previous studies have indicated a relationship between masticatory function and sarcopenia in healthy elderly persons (6) in addition to a relationship between swallowing function and SMI in NC (7). To the best of our knowledge, there are no studies that examined the relationship between masticatory function and related factors in NC. Thus, it is our opinion that the findings in the present study are novel. Because it has been

Table 2. Comparison of high and low MMT group

		high-MMT (n = 143)		low-MMT (n = 132)		U-test
		Mean	SD	Mean	SD	*P*-value
Age (years)		85.1	6.6	86.2	6.4	0.152
BMI		22.6	4.6	20.3	4.0	<0.001
MNA®-SF total score		10.0	2.7	9.1	2.5	0.003
Barthel Index		43.1	32.5	33.8	32.6	0.017
SMI (kg/m^2)		4.8	1.4	4.4	1.4	0.010
CDR		1.7	1.0	2.0	0.9	0.009
No. present teeth		3.8	6.7	3.2	5.8	0.729
No. functional teeth		19.0	11.4	15.4	12.2	0.020
		high-MMT (n = 143)		low-MMT (n = 132)		χ^2-test
		n	%	n	%	*P*-value
Sex	Men	30	21.0%	30	22.7%	0.771
	Women	113	79.0%	102	77.3%	
Cerebrovascular disease	Absence	94	65.7%	83	62.9%	0.706
	Onset	49	34.3%	49	37.1%	
Parkinson's disease	Absence	138	96.5%	129	97.7%	0.724
	Onset	5	3.5%	3	2.3%	
Neuropathy	Absence	140	97.9%	129	97.7%	1.000
	Onset	3	2.1%	3	2.3%	
Depression	Absence	134	93.7%	126	95.5%	0.602
	Onset	9	6.3%	6	4.5%	
Diabetes	Absence	114	79.7%	111	84.1%	0.434
	Onset	29	20.3%	21	15.9%	
BMI (High/Low)	High	115	80.4%	90	68.2%	0.026
	Low	28	19.6%	42	31.8%	
Denture	Yes	97	67.8%	89	67.4%	1.000
	No	46	32.2%	43	32.6%	

Values are mean ± standard daviation. MMT, masseter muscle thickness; BMI, body mass index; SMI, Skeletal Muscle Index; CDR, clinical dementia rating.

Table 3. Examination of between various items and masseter muscle thickness

		Step 1			**Step 6**		
Variable	Cutoff	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Sex	0:Men 1:Women	0.57	0.29-1.15	0.117			
Age		1.02	0.98-1.06	0.356			
SMI		0.82	0.64-1.07	0.147	0.83	0.69-0.99	0.049
Functional teeth		0.98	0.96-1.01	0.192	0.98	0.96-1.00	0.065
Barthel Index		1.00	0.99-1.02	0.597			
MNA®-SF total score		0.95	0.84-1.09	0.486			
CDR		1.12	0.77-1.61	0.557			
BMI	0:High 1:Low	1.18	0.60-2.31	0.632			

stepwise logistic regression analysis

OR, odds ratio; CI, confidence interval; SMI, Skeletal Muscle Index; CDR, Clinical Dementia Rating.

shown that the number of NC who have impairment of masticatory function of the tongue, etc., is increasing regardless of the maintenance of number of present teeth (3), the results of our study may provide a useful hint in elucidating the cause of impairment.

The SMI, which was examined in the present study, is widely utilized around the world as the diagnostic criterion for sarcopenia; measurement using the BIA method is adopted by the Asian Sarcopenia Consensus(14). However, while the masseter muscle is the representative masticatory muscle, it is also easily accessible for measurement of thickness using an ultrasonography device from the body surface and is suitable for use in large-scale studies. A relationship between MMT and occlusal strength has been demonstrated in past research(15), and MMT is thought to be an effective indicator for predicting the relationship with masticatory function. Furthermore, the merits of investigating this parameter in NC are as follows: it represents an

objective index that is not significantly influenced by the degree of cooperation of subjects, and it can be conducted in elderly persons who have dementia.

At first, as a basic attribute of the participants, men showed significantly higher scores of SMI, MNA-SF, number of present teeth, and cerebrovascular disease than women. Generally it is said that men have more SMI, and this result is considered to represent the universality of the participants.

The results of the present study revealed that SMI was significantly higher in the high-MMT group in comparison with the low-MMT group and SMI was extracted as a related factor for MMT. The relationship between swallowing function and SMI in NC has been previously reported by Murakami et al. (7). Furthermore, decrease in activity, deterioration of nutritional status, increase in inflammatory cytokines, oxidative stress, and reduced growth and sex hormones (e.g., testosterone) have also been reported as factors related to decreased muscle mass (16). That is, it appears that decreased muscle mass observed in NC who have decreased physical functions occurs systemically rather than at local sites. Therefore, it is natural that the decrease in muscle mass also develops in the masseter muscle, which is a skeletal muscle similar to those in the extremities. Conversely, it is possible that estimate the SMI from the MMT in NC.

Although the results of the present study revealed that the number of functional teeth was not statistically significant factors, the results of binary logistic regression analysis using stepwise method suggest a relationship with MMT. In previous study by Bhoyar et al., concerning edentulous participants, it was reported that prosthetic treatment was effective in inducing recovery of MMT (17). The number of present teeth of participants in the present study was small (mean number: 3.5 teeth), and 67.6% (186 participants) wore dentures, because many participants used a prosthetic device such as dentures or bridge. These results suggest that maintenance and recovery of occlusion through the use of prosthetics may be useful in preventing the weakening of the masseter muscle.

MNA®-SF, which is used to evaluate the risk of poor nutritional status, was not extracted as a related factor by binary logistic regression analysis; however, the results of simple comparison revealed that in comparison with the low-MMT group, the score in the high-MMT group was significantly higher. A study concerning Japanese NC reported that poor nutritional status is a risk factor for sarcopenia in NC because the score was significantly lower in the sarcopenia group compared with the non-sarcopenia group (18). The results of the present study support these previous findings. Also, CDR and BI were not extracted as a related factor. However, the results of simple comparison revealed that in comparison with the low-MMT group, the score in the high-MMT group was significantly higher. Takagi et al. reported that Alzheimer's disease is a risk factor for decreasing SMI (8). Therefore, it is possible that CDR has some influence on masseter muscle.

In the present study, the number of present teeth, which was previously shown to be a factor related to MMT (19), was not extracted as a related factor. Muscle strength generated by the masticatory muscles is finally output as occlusal force through the jawbone and teeth; however, many previous studies examined the relationship between masticatory function and the masseter muscle in younger subjects in whom the number of present teeth was maintained to a certain extent. In contrast, the small mean number of present teeth in participants in the present study and the use of prosthetic devices may have influenced the relationship with the number of present teeth.

A relationship between poor nutritional status and mortality risk has been reported in NC (20). Based on the results of the present study, sarcopenia affects the masticatory muscles, and due to a reduced number of present teeth, masticatory function decreases, and a poor nutritional status develops as a result. Therefore, increased exacerbation of sarcopenia and mortality are possible risks in this elderly group. As mentioned previously, it is possible that the use of a prosthetic device such as dentures may prevent the weakening of the masseter muscle; however, since the use of dentures is difficult in NC due to decreased physical ability, dementia, etc., such persons are unable to use dentures (21). By contrast, in an interventional study involving elderly persons residing in facilities, Kanehisa et al. reported that the use of dentures is effective in ameliorating nutritional status (22). When compared with the results of the present study, it may be possible to prevent weakening of the masseter muscle in NC by maintaining the number of functional teeth through the use of prosthetics. As a result of maintenance of masticatory function, poor nutritional status and aggravation of sarcopenia may be ameliorated. Also, this result indicate the prevention of sarcopenia is may be an important factor for the maintenance of masticatory

function.

Several limitations of the present study should be mentioned. First, because the present study was a cross-sectional survey, it could not elucidate a specific causal relationship between decreased MMT and decreased appendicular skeletal muscle mass. For this reason, in order to elucidate a specific causal relationship, it is necessary to conduct a long-term longitudinal study. Secondary, measurement of MMT was performed by multiple investigators who received prior training; however, the possibility of inter-rater error cannot be completely excluded. Many of the participants used a prosthetic device such as dentures; however, the fit of the dentures was not considered. Moreover, NC have various background factors such as systemic disease and decreased cognitive function, so a further study that takes into account other factors such as medication use and long-term care status is needed. In the future, we plan to address these issues by conducting a longitudinal study. Nevertheless, the present study is complete enumeration, and the significance is large.

Conclusion

In conclusion, among NC, SMI was significantly higher in the group with high MMT compared with the low-MMT group. Furthermore, decreased SMI and decreased number of functional teeth were extracted as related factors of decreased MMT, there is a possibility that decreasing muscle mass arise from sarcopenia also develops in the masticatory muscles in NC.

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