

Association between anorexia of ageing and sarcopenia among Japanese older adults

Kota Tsutsumimoto* , Takehiko Doi, Sho Nakakubo, Minji Kim, Satoshi Kurita, Hideaki Ishii & Hiroyuki Shimada

Section for Health Promotion, Department of Preventive Gerontology, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, Aichi, Japan

Abstract

Background Malnutrition plays an essential role in the mechanism of pathogenesis for sarcopenia. In late life, both food consumption and energy intakes decline. One of key factors for reduced energy intakes is anorexia of ageing. The aim of this study is to examine the association between anorexia of ageing and sarcopenia among community-dwelling elderly Japanese individuals.

Methods This uses population-based, cross-sectional cohort study of elderly Japanese individuals. Anorexia of ageing was assessed via a simplified nutritional appetite questionnaire. Handgrip strength and walking speed were tested, and skeletal muscle mass was assessed using a bio-impedance analysis device. Subjects with sarcopenia were defined as those who met the criteria of the Asian Working Group for Sarcopenia. The association between anorexia of ageing and sarcopenia was then analysed via multiple regression analysis.

Results In total, 9,496 elderly Japanese individuals were evaluated (mean age 74.1 ± 5.4 years; male, 47.0%). The prevalence of anorexia of ageing was 9.8% ($n = 927$) in the present study. The prevalence of sarcopenia in men was 1.1%, 1.8%, 6.1%, 10.1%, and 21.2% and was 1.6%, 3.3%, 3.6%, 4.8%, and 7.4% in women aged 65–69, 70–74, 75–79, 80–84, and 85 years and older, respectively. The prevalence of anorexia also showed an age-dependent increase in both sexes ($P < 0.001$, respectively). The prevalence of anorexia in men was 8.3%, 6.3%, 9.8%, 13.6%, and 12.9% and was 7.9%, 9.4%, 10.5%, 17.6%, and 17.1% in women aged 65–69, 70–74, 75–79, 80–84, and 85 years and older, respectively. In multivariable logistic regression model adjusted for the covariates except for albumin, anorexia of ageing was independently associated with sarcopenia (OR: 1.45, 95% CI: 1.07 to 1.95; $P = 0.015$). This significant association remained even after adjusting for all covariates including nutritional status (OR: 1.42, 95% CI: 1.06 to 1.92, $P = 0.020$).

Conclusions Anorexia of ageing is associated with sarcopenia among Japanese elderly individuals. Further studies are needed to determine whether a causal association exists between anorexia and sarcopenia.

Keywords Anorexia of ageing; Sarcopenia; Older people

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*Correspondence to: Kota Tsutsumimoto, Section for Health Promotion, Department of Preventive Gerontology, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, 7-430 Morioka-cho, Obu City, Aichi Prefecture 474-8511, Japan. Tel: +81-562-44-5651; Fax: +81-562-46-8294. Email: k-tsutsu@ncgg.go.jp

Introduction

Sarcopenia has been described as an age-related decline in skeletal muscle mass as well as muscle function¹ and leads to serious health problems, including disability.^{2–4} It is important for the elderly to shorten the period of having a disability and prolong the period of being healthy.⁵ Thus, the

modifiable risk factors were particularly focused on that likely to contribute to develop intervention from sarcopenia.

Malnutrition plays an essential role in the mechanism of pathogenesis for sarcopenia.⁶ In late life, the people has lower levels of physical activity and a reduction in energy needs, then both food consumption and energy intakes decline. In fact, a meta-analysis showed that calculated

reduction in energy intakes fell into quite a narrow range at 16–20% in older groups (aged ~70 years) compared with younger groups (aged ~26 years).⁷ Although there are various pathways for the reduced energy intakes, one of key factors is anorexia of ageing.⁸

Anorexia of ageing is supposed as the beginning of various geriatric syndromes. Fried proposed the *frailty cycle*, in which, the decrease in dietary intake coupled with a decrease in physical exercise leads to a decline in muscle mass that in turn makes older individuals more vulnerable and develop secondary complications such as sarcopenia.⁹ Anorexia of ageing is considered to be the precursor of sarcopenia, which means that anorexia of ageing may lead to sarcopenia. However, there have been few studies on the association between anorexia of ageing and sarcopenia, and the association between anorexia of ageing and sarcopenia remains unclear. Thus, this study aimed to elucidate whether anorexia of ageing is associated with sarcopenia.

Materials and methods

Participants

This prospective cohort study evaluated community-dwelling older adults enrolled in the National Center for Geriatrics and Gerontology–Study of Geriatric Syndromes,¹⁰ who were recruited from either Nagoya City or Obu City. The inclusion criteria were residence in either Nagoya City (July 2013–December 2013) or Obu City (February 2015–August 2016) and age 65 years or older at the time of examination. A thousand five hundred fourteen participants were excluded according to exclusion criteria: (i) disability in basic activities of daily living ($n = 23$); (ii) severe neurological disease [dementia ($n = 45$), cerebrovascular disease ($n = 652$), Parkinson's disease ($n = 27$)]; (iii) general cognitive impairment [Mini-Mental State Examination (MMSE) score ≤ 18] ($n = 105$), and (iv) missing data [sarcopenia status ($n = 416$), simplified nutrition assessment questionnaire ($n = 91$), education history ($n = 3$), medication ($n = 41$), hypertension ($n = 2$), diabetes ($n = 5$), hyperlipidaemia ($n = 4$), physical activity ($n = 9$), Geriatric Depression Scale ($n = 31$), blood nutrition data ($n = 60$)].

This study was approved by the ethics committee of the National Center for Geriatrics and Gerontology. All participants voluntarily provided informed consent before inclusion in the study.

Assessment of sarcopenia

Sarcopenia was assessed based on muscle mass, muscle strength, and physical performance according to the recommendations of the Asian Working Group for Sarcopenia (AWGS).¹ According to the AWGS, individuals had sarcopenia

if they were aged >60 years and had a low handgrip strength (<26 kg in men and <18 kg in women) and/or a lower walking speed (<0.8 m/s) with a low skeletal muscle mass index (<7.0 kg/m² in men and 5.7 kg/m² in women).

Skeletal muscle mass was examined using a multi-frequency bioelectrical impedance analyser (MC-980A; TANITA, Tokyo, Japan), which is a tool for assessing whole and segmental body composition. The surface of the hand electrode was placed in contact with each of the participants' five fingers, and their heels and forefeet were placed on the circular-shaped foot electrode. The participants held out their arms and legs so that they would not contact any other body parts during the measurements. Measurements were carried out by well-trained staff and completed within 30 s. The appendicular skeletal muscle mass was then calculated using the following formula developed by the National Center for Geriatrics and Gerontology: appendicular skeletal muscle mass (men) = $(0.197 \times \text{height}^2/50 \text{ kHz resistance}) + (0.179 \times \text{weight}) - 0.019$, appendicular skeletal muscle mass (female) = $(0.221 \times \text{height}^2/50 \text{ kHz resistance}) + (0.117 \times \text{weight}) + 0.881$. Then, the skeletal muscle mass was converted into the skeletal muscle mass index by dividing the muscle mass by the height of the subject squared (kg/m²).

Participants walked on a flat and straight surface at a comfortable walking speed. Two markers were used to indicate the start and end of a 2.4 m walking path, with a 2 m section to be traversed before passing the start marker, such that participants were walking at a comfortable pace by the time they reached the timed path. Participants were asked to continue walking for an additional 2 m past the end of the path to ensure a consistent walking pace while on the timed path. Walking time was measured over a 2.4 m distance in seconds using a stopwatch, and the participants' walking speed (m/s) was calculated. Handgrip strength was measured using a Smedley-type handheld dynamometer (Takei Ltd., Niigata, Japan).

Anorexia of ageing

All participants completed the Japanese version of the simplified nutritional appetite questionnaire (SNAQ). SNAQ has been evaluated to be sufficiently reliable and valid for examining appetite among community-dwelling older adults in Japan.¹¹ The original SNAQ is a 4-item single-domain questionnaire; responses were made using a 5-point, verbally labelled Likert-type scale: (i) My appetite is (A. *very poor*, B. *poor*, C. *average*, D. *good*, E. *very good*); (ii) 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*); (iii) I feel hungry (A. *rarely*, B. *occasionally*, C. *some of the time*, D. *most of the time*, E. *all the time*); and (iv) Food tastes (A. *very bad*, B. *bad*, C. *average*, D. *good*,

E. *very good*). The total SNAQ score is the sum of each item score, with lower scores indicating more appetite deterioration. Nakatsu *et al.* showed that the Cronbach's α coefficient for the SNAQ was 0.55.¹¹ Also, analysis of construct validity showed the SNAQ correlated moderately Mini Nutritional Assessment–Short Form ($r = 0.30, P < 0.05$) and 15-item Geriatric Depression Scale (GDS) ($r = -0.43, P < 0.001$).¹¹ The total score range from 4 (worst) to 20 (best), with 13 score and lower considered to indicate anorexia of ageing.¹²

Sociodemographic variables and covariates

The participants' sociodemographic characteristics (i.e. age, sex, and educational level), medical history [i.e. number of medications and chronic diseases (hypertension, diabetes, and hyperlipidaemia)], smoking habit (i.e. current, stopped, or never smoked), and drinking habit (i.e. current, stopped, or never drank) were assessed via face-to-face interviews. The examined covariates were as follows: depressive symptoms, muscle strength, physical activity, blood nutritional data (i.e. total protein and albumin), and history of falls.

Physical activity was evaluated using the following questions: (i) "Do you engage in moderate levels of physical exercise or sports aimed at health?" (ii) "Do you engage in low levels of physical exercise aimed at health?" Participants who answered *no* to both of these questions were classified as being physically inactive.¹³ Cognitive function was assessed using the MMSE, which is a 30-point scale. Higher scores indicated a greater ability to maintain cognitive function.¹⁴ Depressive symptoms were measured using the 15-item GDS,¹⁵ which contains 15 *yes/no* question items and gives a score between 0 and 15.¹⁶ Higher score means having more depressive symptoms. Venous blood was collected by well-trained nurses, and serum was prepared from blood samples within 24 h. To obtain serum, whole blood samples were allowed to coagulate at room temperature for 30 min and then centrifuged at room temperature for 5 min at 3000 revolutions per minute. Total protein and albumin were measured by trained staff using an automatic analyser (JCA-BM6070. JEOL Ltd.) in a laboratory at Good Life Design Co., Ltd., Aichi-ken, Japan.

Statistical analysis

Statistical analyses were performed using SPSS (version 20.0). Significant level was set at $P < 0.05$ in all analysis. First, Student's *t*-test and χ^2 test were used to compare the variables between the participants with/without anorexia of ageing. The previous studies showed that the prevalence of sarcopenia was significantly difference between sex or age group,^{17,18} thus the prevalence of sarcopenia and anorexia was examined stratified by sex and age group using the

Cochran–Armitage test. Multiple logistic regression models were then used to examine the association between anorexia of ageing and sarcopenia, with sarcopenia as the dependent variable. Three models, namely, cure model, Adjusted Model 1, and Adjusted Model 2, were made. Adjusted Model 1 was adjusted for the covariates (age, sex, education, body mass index, polypharmacy, chronic disease, drinking and smoking habits, depressive symptoms, weakness in muscle strength, and decline in cognitive function) except for blood nutritional status, while Adjusted Model 2 was adjusted for the covariates including blood nutritional status. The odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Total protein and albumin levels were categorized into approximate quartiles (albumin, Q1: ≤ 4.2 g/dL vs. Q2–Q4: > 4.2 g/dL; total protein, Q1: ≤ 7.0 g/dL vs. Q2–Q4: > 7.0 g/dL). Polypharmacy, cognitive decline, and depression symptoms were defined using cut-offs drawn from previous studies (polypharmacy, five or more medications¹⁹; cognitive decline, a maximum MMSE score of 23¹⁴; depression symptoms, six or higher score on GDS¹⁵).

Results

Patient characteristics

Of the 11 010 participants, 1514 were excluded and thus data from 9496 older adults [mean age 74.1 ± 5.4 years (range, 65–96 years); 4465 men, 5031 women] were analysed in the current study. The prevalence of anorexia of ageing was 9.8% ($n = 927$) in the present study, then the participants were divided into two groups (without anorexia of ageing or with anorexia of ageing group). *Table 1* presents each group's demographic characteristics and scale scores. The participants with anorexia of ageing was likely to be sarcopenia [6.6% ($n = 61$)], compared with those without anorexia of ageing [3.7% ($n = 318$)] ($P < 0.001$). The mean age, education level, number of medications, MMSE score, GDS score, and albumin levels varied significantly between groups. The proportion of male participants and those with hyperlipidaemia was lower among participants with anorexia of ageing. Meanwhile, the proportion of participants who had hypertension was higher in the participants with anorexia of ageing. There were significant differences in smoking habit and physical inactivity between the groups, while total protein did not vary significantly between the groups. Further, the proportion of participants who had hyperlipidaemia, diabetes, or drinking habit did not vary significantly between the groups.

Prevalence of anorexia of ageing and sarcopenia

According to the suggested algorithm of the AWGS, the prevalence of sarcopenia and anorexia of ageing in older adults

Table 1 Participant characteristics

	Overall cohort N = 9496	Without anorexia of ageing group N = 8569 (90.2%)	With anorexia of ageing group N = 927 (9.8%)	P value
Age, years \pm SD	74.1 \pm 5.4	73.9 \pm 5.3	75.3 \pm 5.8	<0.001
Male, number (%)	4465 (47.0)	4070 (47.5)	395 (42.6)	0.005
Education, years \pm SD	11.9 \pm 2.5	12.0 \pm 2.5	11.2 \pm 2.5	<0.001
Medication, number \pm SD	3.0 \pm 2.8	3.0 \pm 2.7	3.8 \pm 3.2	<0.001
Chronic disease, number (%)				
Hypertension	4245 (44.7)	3792 (44.3)	453 (48.9)	0.007
Diabetes	1244 (13.1)	1118 (13.0)	126 (13.6)	0.64
Hyperlipidaemia	3620 (38.1)	3274 (38.2)	346 (37.3)	0.599
Drinking habit, number (%)				
Never drinkers	4995 (52.6)	4482 (52.3)	513 (55.3)	0.213
Stopped drinking	2328 (24.5)	2114 (24.7)	214 (23.1)	
Current drinkers	2173 (22.9)	1973 (23)	200 (21.6)	
Smoking habit, number (%)				
Never smokers	5824 (61.3)	5252 (61.3)	572 (61.7)	< 0.001
Stopped smoking	2959 (31.2)	2709 (31.6)	250 (27)	
Current smokers	713 (7.5)	608 (7.1)	105 (11.3)	
Physical inactivity	2028 (21.4)	1771 (20.7)	257 (27.7)	< 0.001
MMSE, score \pm SD	26.6 \pm 2.5	26.7 \pm 2.5	25.8 \pm 2.7	<0.001
GDS, score \pm SD	2.6 \pm 2.6	2.5 \pm 2.5	4.1 \pm 3.3	<0.001
Blood nutritional data, g/dL \pm SD				
Total protein	7.31 \pm 0.42	7.31 \pm 0.42	7.3 \pm 0.44	0.438
Albumin	4.37 \pm 0.29	4.37 \pm 0.28	4.32 \pm 0.32	<0.001
SNAQ, score \pm SD	15.3 \pm 1.4	15.6 \pm 1.2	12.5 \pm 0.8	<0.001
Sarcopenia, number (%)	379 (4.0)	318 (3.7)	61 (6.6)	<0.001

GDS, Geriatric Depression Scale; MMSE, Mini-Mental State Examination; SD, standard deviation.

aged 65 to 96 years was 4.0% and 9.8% in this cohort, respectively. The proportion of participants with sarcopenia was significantly higher in the anorexia of ageing group (Table 1). The prevalence of sarcopenia showed an age-dependent increase in both sexes ($P < 0.001$, respectively). The prevalence of sarcopenia in men was 1.1%, 1.8%, 6.1%, 10.1%, and 21.2% and was 1.6%, 3.3%, 3.6%, 4.8%, and 7.4% in women aged 65–69, 70–74, 75–79, 80–84, and 85 years and older, respectively (Figure 1A). The prevalence of anorexia also showed an age-dependent increase in both sexes ($P < 0.001$, respectively). The prevalence of anorexia in men was 8.3%, 6.3%, 9.8%, 13.6%, and 12.9% and was 7.9%, 9.4%, 10.5%, 17.6%, and 17.1% in women aged 65–69, 70–74, 75–79, 80–84, and 85 years and older, respectively (Figure 1B).

Association between anorexia of ageing and sarcopenia

Table 2 shows the association between anorexia of ageing and sarcopenia using the multiple logistic regression models. The crude model indicated that anorexia of ageing had significantly independent association with sarcopenia (OR: 1.83, 95% CI: 1.38 to 2.42, $P < 0.001$). In the model adjusted with the covariates except for nutritional status (total protein and albumin) (Table 2, Adjusted Model 1), anorexia of ageing was independently associated with sarcopenia (OR: 1.45, 95% CI: 1.07 to 1.95, $P = 0.015$). Similar results were obtained in the model adjusted for all covariates including nutritional status (OR: 1.42, 95% CI: 1.06 to 1.92, $P = 0.020$).

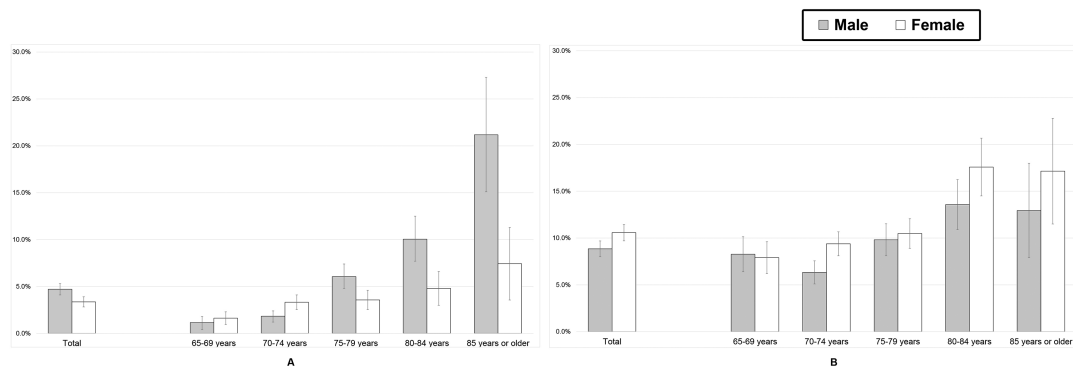


Figure 1 Prevalence of sarcopenia (A) and anorexia of ageing (B) among Japanese older adults according to age group.

Table 2 Association between anorexia of ageing and sarcopenia on multiple logistic regression models

	Crude model		Adjusted Model 1		Adjusted Model 2	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Anorexia of ageing	1.83 (1.38 — 2.42)	<0.001	1.45 (1.07 — 1.95)	0.015	1.42 (1.06 — 1.92)	0.020
Sociodemographic data						
Age (vs. 74 years or younger)			2.80 (2.23 — 3.53)	<0.001	2.68 (2.13 — 3.38)	<0.001
Male (vs. female)			1.62 (1.19 — 2.20)	0.002	1.62 (1.19 — 2.20)	0.002
Education (vs. 10 years or longer)			1.01 (0.80 — 1.27)	0.948	1.01 (0.80 — 1.27)	0.945
Medical information						
Polypharmacy (vs. four medications or less)			1.56 (1.22 — 1.99)	<0.001	1.52 (1.19 — 1.95)	0.001
Hypertension			0.44 (0.34 — 0.55)	<0.001	0.45 (0.35 — 0.56)	<0.001
Diabetes			0.91 (0.67 — 1.25)	0.571	0.92 (0.67 — 1.25)	0.581
Hyperlipidaemia			0.72 (0.56 — 0.91)	0.006	0.74 (0.59 — 0.95)	0.016
Lifestyle factor						
Drinking habit						
Never drinker			Reference		Reference	
Stopped drinking			0.69 (0.52 — 0.90)	0.007	0.69 (0.52 — 0.91)	0.008
Current drinker			0.49 (0.36 — 0.67)	<0.001	0.49 (0.36 — 0.67)	<0.001
Smoking habit						
Never smoker			Reference		Reference	
Stopped smoking			0.93 (0.68 — 1.26)	0.632	0.91 (0.67 — 1.24)	0.558
Current smoker			1.02 (0.66 — 1.58)	0.921	1.00 (0.65 — 1.56)	0.990
Physical inactivity			1.63 (1.29 — 2.05)	<0.001	1.62 (1.28 — 2.04)	<0.001
Neuropsychological factor						
Cognitive decline (vs. MMSE score of 24 or higher)			1.31 (1.00 — 1.73)	0.053	1.30 (0.98 — 1.71)	0.064
Depressive symptoms (vs. GDS score of 5 or lower)			1.44 (1.10 — 1.88)	0.009	1.41 (1.07 — 1.84)	0.014
Nutritional status						
Lower total protein (vs. 7.0 g/dL or higher)					0.98 (0.75 — 1.27)	0.854
Lower albumin (vs. 4.2 g/dL or higher)					1.57 (1.24 — 2.00)	<0.001

Note. Adjusted Model 1: Adjusted for sociodemographic factors (age, sex, and education), medical conditions (polypharmacy, hypertension, diabetes, and hyperlipidaemia), lifestyle factors (drinking habit, smoking habit, and physical activity), and neuropsychological factors (cognitive decline and depressive symptoms). Adjusted Model 2: Adjusted for the factors used in Model 1 plus nutritional status (lower total protein and lower albumin).

CI, confidence interval; GDS; Geriatric Depression Scale; MMSE, Mini-Mental State Examination; OR, odds ratio.

Discussion

The present study investigated the association between anorexia of ageing and sarcopenia. The findings show that the prevalence of sarcopenia and anorexia increased with age in both sexes. Anorexia of ageing was independently associated with sarcopenia among older people. Stratified analysis by sex showed that anorexia of ageing was independently associated with sarcopenia in older women, but not in men.

A systematic review reported that the prevalence of anorexia of ageing ranges between 13.0% and 21.2% in community-dwelling older adults.²⁰ Meanwhile, a lower prevalence (9.8%) was observed in this study. One potential explanation is that our participants were relatively younger compared with those in the previous study.²¹ In fact, our findings showed that prevalence of anorexia of ageing was affected by ageing. In addition, there was a methodological difference on assessment for anorexia of ageing between the present study (SNAQ) and the previous study (Minimum Data

Set for Home Care).²¹ Therefore, future research should need to compare SNAQ to the other assessments for identifying anorexia of ageing and to verify which method is appropriate.

The prevalence of sarcopenia was higher in women than that in men among 74 years or younger groups. In contrast, the prevalence of sarcopenia was higher in men than that in women in 75 years or older groups. This finding was line with the previous studies.^{17,18} However, the potential mechanism has remained unclear. One potential explanation is that insulin-like growth factor 1 (IGF-1) has an essential key in this phenomenon. IGF-1 is one of the important mediators for muscle growth and repairing. Albani reported that a sex-specific pattern for IGF-1 attenuation with ageing was found.²² The IGF-1 level in men was significantly reduced in 85 year-over group compared to 70–85 year-old group, which was considered to be affected by ageing. On the other hand, there was no significant change between 70–85 year group and 85 year-old among women. In other words, IGF-1 level of older women might be less affected by ageing. This finding

supports the prevalence of sarcopenia in our results. Thus, the age–sex-specific prevalence of sarcopenia might be dependent on the IGF-1 level.

The current study indicated that anorexia of ageing was independently associated with sarcopenia among community-dwelling Japanese older people. This result is in line with that of a previous study by Landi et al. who used the European Consensus to assess sarcopenia and reported that anorexia is common among community-dwelling old-old people (over 80 years) and that the presence of anorexia is associated with sarcopenia.²³ Anorexia of ageing may be correlated with a high risk of qualitative low intake of single nutrients, in particular, protein and vitamins.²⁴ In turn, elderlies with an acceptable nutritional status may have been shown to have poor protein intake, which leads to frailty that is comprehensive concept including sarcopenia.²⁵ In fact, poor nutritional quality leads to frailty.^{26,27} The anorexia of ageing decreases food intake, which leads to a decline in physical function, muscle mass, and strength as in sarcopenia²⁴. It could be hypothesized that this selective malnutrition is directly correlated with the onset of sarcopenia. Our results, showing a correlation between anorexia and sarcopenia in the subjects without clinical evidence of malnutrition, support this hypothesis.

Sarcopenia is a major geriatric syndrome,¹ and thus, identifying predictive factors may help prevent older people from sarcopenia. Blood nutritional data can identify risk of sarcopenia among older adults,²⁸ however there are many environments where blood collection cannot be performed. In contrast, SNAQ can be conveniently implemented in clinical community setting. In addition, in the present study, albumin and total protein as the blood nutrition data did not significantly associated with sarcopenia among our female participants, whereas SNAQ did: SNAQ cut-off point indicating anorexia of ageing had 1.6 times greater OR of sarcopenia. These findings indicate that SNAQ is also important tool as an assessment of nutrition in the community.

Fried proposed anorexia of ageing contribute wasting or reduced muscle quantity/quality subsequent to frailty.⁹ With ageing, there is a decrease in food intake known as the anorexia of ageing coupled with a decline in muscle mass and an increase in fat mass.²⁹ In fact, the amount of protein intake, the distribution, and the source of protein intake are all important to maximally stimulate postprandial muscle protein synthetic response and muscle mass/quality accretion in the elderly.³⁰ Bourgeois et al. showed that combining measures of skeletal muscle mass and quality will significantly improve prediction of skeletal muscle function.³¹ In other words, both skeletal muscle mass and quality are important for skeletal muscle function in the elderlies. Moreover, the measurement of jump force is more strongly related to bone outcomes.³² Namely, maintain in skeletal muscle function leads to maintain in bone quality. According to these studies, in late life, maintain in appetite (prevention from anorexia of

ageing) is important for elderlies to maintain skeletal muscle function or bone quality.

The major strength of the present study was that the analysis was conducted using a relatively large sample of Japanese older individuals. Nevertheless, there were several limitations in the present study. First, this study was a cross-sectional design; therefore, the results do not show any causal associations between anorexia of ageing and sarcopenia. Second, there was selection bias in the present study. Our participants were healthy elderlies who were have the ability to access health check-ups, which might have led to the underestimation of the prevalence of sarcopenia. Third, sarcopenia was related to many factors (i.e. tumour necrosis factor- α and chronic obstructive pulmonary disease), but we had not measured this information. These covariates should be considered in future studies on the association between anorexia of ageing and sarcopenia. Fourth, some variables were self-reported including anorexia of ageing (e.g. education history, medication, and chronic disease history). These factors and others should be examined in diverse methods in future studies. Fifth, we evaluated skeletal muscle mass using bio-impedance analyser, not dual-energy X-ray absorptiometry (DXA). Although further standardization is needed to ensure that the assessment and cut points are used accurately on all makes and models of DXA systems, DXA provides a precise measure of lean mass.^{33–35} Finally, we could not exclude the participants with short-term or chronic disorders (cancer, heart disease, kidney disease, etc.) which are known to effect appetite. It remains unclear what is the best way to assess and normalize the skeletal muscle mass among overweight or obese patients, particularly chronic kidney disease or end-stage renal disease.³⁶ Because of the invitation-type survey, our participants were the elderly who could visit the health check-ups' site without any problems because there were few participants who have end-stage chronic disease. However, this should be considered in future studies.

In conclusion, the present study showed that anorexia is common among community-dwelling older adults in Japanese. Anorexia is not an inevitable side effect of ageing, but many changes associated with the process of ageing can promote it. Optimizing the nutritional status may decrease the risk of functional decline and sarcopenia in the elderly population. Prospective studies investigating the effect of specific intervention for anorexia on the risk of sarcopenia in larger populations are needed to provide definitive evidence for clinical guidelines.

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Author contributions

Tsutsumimoto planned the study, wrote the first draft of the manuscript, and coordinated the review and editing process leading to the final manuscript. Doi participated in the design of the study and wrote the paper. Nakakubo, Kim, Kurita, and Ishi corrected data and contributed to the editorial process and review of the manuscript. Shimada supervised the study, suggested many ideas that have been pursued in this research, and participated in the planning, editorial, and review processes that led to the final manuscript.

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Conflict of interest

None declared.

Data availability statement

The authors do not have permission to share data.

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