The relationship between chewing ability and sarcopenia in Japanese community-dwelling elderly subjects

Correspondence to be sent to:

Hirohiko Hirano, DDS, PhD

Research Team for Promoting Independence of the Elderly

Tokyo Metropolitan Institute of Gerontology

35-2 Sakae-cho, Itabashi-ku, Tokyo 173-0015, Japan

E-mail: hhirano@tmig.or.jp

Tel: +81 3 3964 3241

Fax: +81 3 3964 2316

Authors:

Masaharu Murakami[1], Hirohiko Hirano[2], Yutaka Watanabe[3], Katsuhiko Sakai[1], Akira Katakura[1]

[1]Department of Oral Medicine, Oral and Maxillofacial Surgery, Tokyo Dental College, 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

Short title running head: Relate to chewing ability and sarcopenia

Authors` running head: M Murakami *et al.*

Abstract

Aim: It has been reported that if nutrient intake is unbalanced, muscle mass, muscle strength and physical performance declines, and therefore it is important to maintain chewing ability to keep a balanced nutrient intake. However, the relationship between chewing ability and sarcopenia has not been previously reported. Therefore, this study investigated the relationship between chewing ability and sarcopenia in addition to known sarcopenia-related factors.

Methods: We examined 761 subjects (average age 73.0 ± 5.1 years), who lived in the Itabashi city of Tokyo. Our research was designed to examine the relationship between chewing ability and sarcopenia. We performed regression analysis to analyze the relationship with sarcopenia-related factors with consideration of the age of the subjects.

Results: The 761 subjects were divided into two groups in terms of the stage of sarcopenia according to whether there was a deterioration of muscle strength or physical performance. Furthermore, we performed logistic regression analyses on the value as a dependent variable, including known sarcopenia-related factors. There were significant correlations of sarcopenia with age (odds ratio (OR) = 2.37, 95% CI = 1.52-3.70), BMI (OR = 0.75, CI = 0.69-0.81) and chewing ability (OR = 2.18, CI = 1.21-3.93).

Conclusions: This study shows that chewing ability is related to sarcopenia、 which is equal to the relationship with the known factor of age by odds ratio.

Keywords: sarcopenia, community, elderly, chewing ability, color-changeable gum

Introduction

Sarcopenia, defined as the degenerative loss of skeletal muscle mass, has recently been considered to result from a decline in muscular strength.[1,2] It has been reported that the age-related loss of skeletal muscle mass leads to a decline in activities of daily living (ADL) in elderly subjects, leading to difficulties in maintaining their quality of life (QOL). Studies have shown that if nutrient intake is unbalanced, muscle mass, muscle strength and physical performance declines[3] and it is important to maintain chewing ability to keep a balanced nutrient intake.[4,5] Enjoying meals is one of the most important factors to support the QOL of senile subjects and it is also important to maintain and promote their health.[6,7]

Several studies have reported on the relationship between chewing ability and grip strength / physical performance,[8,9] and on the relationship between tongue muscle thickness and sarcopenia,[10] but there have been no reports addressing the possible relationship between chewing ability and sarcopenia.

Therefore, we conducted this research on Japanese community-dwelling elderly subjects and investigated the relationship between chewing ability and sarcopenia in addition to known sarcopenia-related factors.

Methods

Participants

The Tokyo Metropolitan Institute of Gerontology (TMIG) sent invitations for a comprehensive geriatric health examination for early detection and early care of geriatric syndrome to 7,015 male and female subjects aged from 65 to 85 years who lived within 9 towns in Itabashi city (Tokyo, Japan), excluding nursing home residents and those who had participated in our previous interventional research studies. Among them, 1,325 people offered to attend and 835 people actually attended. Excluding withdrawals due to the terms of our research and also exclusions of missing values due to people with heart pacemakers and/or walking difficulties, the data of 761 subjects were analyzed in our study.

This research was conducted at the TMIG from 25 September 2012 to 5 October 2012. The subjects attended by walking, driving or being driven by family members or by using public transportation and moreover, they were able to understand and follow our instructions. We received written informed consent from each subject individually. This research was conducted with permission of the TMIG Ethics Committee (Issue #.23-1253 in 2011).

Stages of Sarcopenia

The guidelines of the European Working Group on Sarcopenia in Older People (EWGSOP)[11] were used to classify the severity of sarcopenia (Stage of Sarcopenia: SSp) according to muscle mass (skeletal muscle mass measured by bioelectrical impedance analysis: BIA), muscle strength (grip strength) and physical performance (usual walking speed). In addition, subjects were classified by SSp into a healthy and pre-sarcopenia group in which declines in muscle strength or physical performance were not observed (Maintenance Group: MG) or into a sarcopenia and severe sarcopenia group in which declines in muscle strength or physical performance were significant (Decline Group: DG). The cut-off value was accord to the method established by the Asian Working Group for Sarcopenia (AWGS).[12]

General evaluation

Height: Each subject was advised to keep their heels, buttocks, back and head touching the stadiometer. Making sure that their neck, waist and knees were straight, their height was measured per 0.1 cm.

Weight: Each subject was advised to stand on a weight scale quietly and the stable value of their weight was measured per 0.1 kg.

SMI (Skeletal Muscle mass Index): Body composition was measured with BIA using an InBody720 (Bio Space, Seoul, Korea) and extremity muscle mass (kg) was determined from the sum of the upper and lower extremities.

We divided the measured extremity muscle mass by the squared height (m conversion) and the adjusted extremity muscle mass was used as the SMI. We used the standard value set by the AWGS which is less than 7.0 kg/m^2 for men and less than 5.7 kg/m^2 for women for the SMI cut-off value of sarcopenia.[12]

Nutrition evaluation: The BMI was measured as an indicator of the nutritional status of each subject. We divided the measured extremity height (m) and the weight was used as the BMI.

Physical function evaluation

Physical function was measured following the Functional improvement manual issued by the Ministry of Health, Labor and Welfare.[13]

Grip strength: Grip strength was used as an indicator of muscle strength, and was measured using a Smedley dynamometer (As one Co., Ltd., Osaka, Japan). Measurements were performed twice and the higher value was used.[14,15] The cut-off value of grip strength was set as the lowest of quartile value, according to the method of the AWGS which is less than 26.0kg for men and less than 18.0kg for women.[12]

Usual walking speed (walking ability): Subjects walked along a walking path with a 3 m acceleration zone, a 5 m measurement zone and a 3 m deceleration zone and the time each subject's feet were in the swing phase (the foot apart from the ground) was measured from the start point of the measurement zone to the end point of the measurement zone. Measurements were taken twice and the faster time was used in the analysis. The cut-off value of the walking speed was set as the lowest of quartile value, according to the method of the AWGS which is less than 1.0 m/s.[12]

Oral examination

Oral examinations were carried out by two dentists and five dental hygienists who had standardized their methods before the study.

Chewing ability: A color-changeable chewing gum (Masticatory performance evaluating gum Xylitol®; Lotte Co., Ltd., Saitama, Japan) was used to examine chewing ability. After chewing the gum for 1 minute, the subject spit the gum on a piece of white paper and the gum was analyzed with a color chart into 5 levels by testers.[16] Levels 1 and 2, which were approximately the lowest of quartile value, were classified as "Poor" and levels 3, 4 and 5 were classified as "Good".

Number of existing teeth: The number of existing intraoral erupted teeth was counted, excluding the residual roots.

Number of functional teeth: The number of prosthetic treatment bridges, plate dentures (removal dentures) and implants (artificial roots) of defect sites and the number of existing teeth were counted.

Occlusal force: An occlusal force measurement system film was used, Dental Prescale 50H Type R (Fuji Photo Film Co., Ltd., Tokyo, Japan) and an Occuluser (Fuji Photo Film Co., Ltd., Tokyo, Japan). Following the method of Matsui et al.,[17] each subject sat on a chair, making sure that the Frankfurt horizontal plane and the floor were as parallel as possible and then was asked to bite down on the prescale at the intercuspal position as hard as possible.[17] Occlusal force was measured in newtons (N).

Statistical analysis

The Mann–Whitney U test was performed to assess differences between continuous variables in the two groups. For the categorical variable, the Chi-square (χ^2) test was used. Logistic regression analysis was used for the purpose of researching factors related to DG. All statistical analyses were done using SPSS20.0J for Windows and a risk ratio of less than 5% is considered a significant difference.

Results

Basic attributes of the subjects

The basic attributes of the subjects in this study are shown in Table 1. There were 761 subjects (average age, 73.0 years old ± 5.1), 314 males (73.7 years old ± 5.5) and 447 females (72.6 years old ± 4.9). Females had higher values for the number of existing teeth ($P=0.040$). Males had higher values for age ($P=0.011$), BMI ($P<0.001$), SMI ($P<0.001$), grip strength ($P<0.001$) and occlusal force ($P=0.011$).

The rate of MG and DG of SSp was; males 14.0%, females 16.1%. However, the percentage of DG was not significantly different between males and females.

SSp Comparisons

Comparisons of each variable between MG and DG of SSp are shown in Table 2. The ages of the subjects were higher with DG ($P<0.001$). BMI ($P<0.001$), SMI ($P<0.001$), grip strength ($P<0.001$), usual walking speed ($P<0.001$), number of existing teeth ($P<0.001$), occlusal force ($P<0.001$) and chewing ability ($P<0.001$) declined in subjects with DG. Among patients aged less than 75 years old, 10.6% had DG. Among subjects aged more than 75 years old, 22.5% had DG ($P<0.001$).

Logistic regression analysis

The results of the logistic regression analysis are shown in Table 3. The dependent variable was 0 for MG and 1 for DG. As a result, age, BMI, number of existing teeth, occlusal force and chewing ability were selected as independent variables. Age (OR = 2.37, 95%Cl: 1.52-3.70), BMI (OR = 0.75, 95%Cl: 0.69-0.81) and chewing ability (OR = 2.18, 95%Cl: 1.21-3.93) were significant factors of sarcopenia.

Discussion

There have been many reports about sarcopenia, regarding the concept of the Frail model proposed by Fried et al.[18] It has been reported that sarcopenia decreases the ADL of elderly subjects, makes it difficult to maintain their QOL[1,2] and it is important to intake a good balance of nutrition to prevent a decline in muscle mass, muscle strength and physical performance.[3] It has been reported that it is essential to maintain the ability to chew to keep a good balance of nutrient intake.[4,5] From these understandings, a strong relationship between chewing ability and sarcopenia has been inferred, but this hypothesis has not been previously tested. Thus, in this study we examined the relationship between chewing ability and sarcopenia in addition to known sarcopenia-related factors.

Validity of subjects

The prevalence of severe sarcopenia in this study was 5.6% (42 subjects), 12.8% (96 subjects) had sarcopenia and 22.5% (169 subjects) had pre-sarcopenia. Three factors of EWGSOP, muscle mass, muscle strength and physical performance were used as a concept of sarcopenia in this study. This EWGSOP consensus guide is used worldwide as diagnostic criteria of sarcopenia intended to unify views of the definition of sarcopenia.[11] However, the basic value of EWGSOP is targeted for white and black subjects in the US and Europe. Therefore, it is difficult to apply that standard to physically different Japanese people.[19] We classified sarcopenia according to cut-off values and basic values of SMI, grip strength and usual walking speed targeted for Asian people by the AWGS.[12] In addition, the BMI significantly decreased in the DG group. Several studies have reported that the BMI significantly decreases in subjects with sarcopenia,[20] and since we obtained similar results in this study, we believe that our research results are valid.

Validity of chewing ability evaluation using a color-changeable chewing gum

A color-changeable chewing gum was used to evaluate chewing ability.

With this evaluation method, the chewing ability of each subject can be evaluated easily and in a short amount of time, and it has been correlated with other chewing ability evaluation methods.[21] One previous study reported that results from color charts, like the one used in our study, correlated well with results using a color difference meter.[16] We used the same cut-off value for chewing ability as the lowest quartile used for the cut-off value for grip strength and walking speed established by the EWGSOP.[11] As a result, out of 5 stages of chewing ability, it was matched with the lowest of quartile, by setting 1 and 2 as "Poor" and the percentages as 14.1%. In a previous study with a color-changeable chewing gum,[22] the percentages of "Poor" were similar to our results and this supports the validity of our results.

Results of logistic regression analysis

To make the SSp dependent variable, we set the cut-off value between pre-sarcopenia and sarcopenia. This is because it is considered that not only a decline in muscle mass, but also declines in muscle strength and physical performance exist in the stage between pre-sarcopenia and sarcopenia. It is considered to be a turning point of the decline in the QOL of elderly subjects, since it has been reported that a decline in muscle strength of the knees and ankles are related to the balance ability of the extremities in daily life and a decline in walking speed.[23] It has also been reported that a decline in general function can be a predictive factor for worsening of the health status.[24]

We performed a logistic regression analysis on sarcopenia-related factors, which confirmed that sarcopenia is related to age and BMI, similar to previous reports.[25] Depressed metabolism and depressed appetite could be caused due to a decline in general function. It was considered that if daily nutritional intake is lacking, a negative cycle of decline in BMI, muscle mass and general function occurs.

This study showed that there is a relationship between chewing ability and sarcopenia. Three factors of EWGSOP; muscle mass, muscle strength and physical performance, were used for the concept of sarcopenia in this study. There have been many reports of the relationship between these three factors and age and nutrition.[2,3] It has also been reported that both muscle strength and physical performance have a relationship with chewing ability. Moriya et al. reported the relationship between chewing ability and grip strength regardless of the number of existing teeth.[9] Takata et al. also reported the relationship between chewing ability and general function regardless of the number of existing teeth.[8] There has been no report about the relationship between general muscle mass and chewing ability, while there have been reports about the relationship between chewing ability related tongue thickness and brachial muscle mass.[10] Many muscles related to sarcopenia components, muscle strength and physical performance are antigravity muscles and it was reported that a decline in the strength of antigravity muscles occurs all over the body.[26] Since many muscles related to chewing ability are classified as antigravity muscles,[27] it is considered that a decline in muscle strength occurs simultaneously. It has been also reported that a decline in muscle mass causes a decline in muscle strength and the decline in muscle strength then causes atrophy of muscles and a decline in function.[28] From these studies, it was considered that the reason for a notable relationship between chewing ability and sarcopenia in consideration of age and nutrition, could be related to changes in general muscle mass and muscle mass related to chewing ability. In addition, it was seen that occlusal force and number of existing teeth have relationship with occlusal function, but not directly with sarcopenia. Unlike a single evaluation index such as occlusal force or number of teeth, occlusal function is a global evaluation index related with muscle of mastication, tongue, teeth and nerves. Similarly, sarcopenia is globally evaluated from muscle mass, muscle strength and general function[29], therefore, it could be considered that this is the background of why the relationship with sarcopenia was seen.

The present research revealed a relationship between chewing ability and sarcopenia, which will be meaningful to consider solutions to suppress sarcopenia in elderly subjects in terms of dentistry in the future.

Future prospects

This study has several limitations. First, the subjects in this study actively attended a geriatric health examination, thus they are possibly highly conscious of their health and can walk by themselves or attend the examination with assistance, and therefore they are a highly independent group. Therefore, these research findings might not apply to less independent groups. Second, this study is cross-sectional and did not prove a causal relationship between sarcopenia and chewing ability in consideration of time course changes.

In this study, we examined whether chewing ability is related to sarcopenia, but it could be considered that chewing-related muscle function declines due to sarcopenia and leads to the aggravation of chewing ability. In addition, it could be considered that a lower amount or less quality of muscle of mastication leads to a decline in chewing ability. More details on the causal relationship need to be determined through longitudinal research and intervention research in the future.

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Disclosure statement

None of the authors has a conflict of interest to declare.

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Table 1. Basic attributes of Japanese community-dwelling elderly

		Total (n: 761)	Male (n: 314)	Female (n: 447)	P-value
		Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)		73.0 ± 5.1	73.7 ± 5.5	72.6 ± 4.9	0.011 (u)
BMI (kg/m^2)		22.9 ± 3.3	23.7 ± 3.1	22.4 ± 3.3	<0.001 (u)
SMI (kg/m^2)		6.5 ± 1.0	7.3 ± 0.9	5.9 ± 0.6	<0.001 (u)
Grip strength (kg)		24.3 ± 8.2	31.2 ± 7.1	19.4 ± 4.7	<0.001 (u)
Usual walking speed (m/s)		1.4 ± 0.2	1.4 ± 0.2	1.4 ± 0.3	0.689 (u)
No. existing teeth		19.9 ± 8.9	19.0 ± 9.4	20.5 ± 8.6	0.040 (u)
No. functional teeth		27.0 ± 3.0	26.8 ± 3.5	27.1 ± 2.6	0.386 (u)
Occlusal force (N)		529 ± 342	576 ± 383	497 ± 305	0.011 (u)
Chewing ability	Good	85.8 = 653/761	87.6 = 275/314	84.6 = 378/447	0.241 ($χ^2$)
	Poor	14.2 = 108/761	12.4 = 39/314	15.4 =69/447	
Stages of sarcopenia	MG	84.8 = 645/761	86.0 = 270/314	83.9 = 375/447	0.429 ($χ^2$)
	DG	15.2 = 116/761	14.0 = 44/314	16.1 = 72/447	

Value are mean ± standard diviation. BMI, Body Mass Index; SMI, Skeletal Muscle mass Index; Chewing ability (Divided the color changes of color-changeable gum into 5 stages, 1 and 2 with less color changes into Poor and 3, 4 and 5 with more color changes into Good); MG, Maintenance Group; DG, Decline Group; u, Mann-Whitney U-test; χ2, χ2-test. SD, standard diviation.

Table2. Comparison between SSp and each factor

n=761		MG			DG			
		Total (645)	Male (270)	Female (375)	Total (116)	Male (44)	Female (72)	
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	P-value
Age (years)		72.6 ± 5.0	73.0 ± 5.2	72.3 ± 4.8	75.7 ± 5.2	77.9 ± 4.9	74.4 ± 4.9	<0.001 (u)
Early-elderly		64.2 = 414/645	61.1 = 165/270	66.4 = 249/375	42.2 = 49/116	20.5 = 9/44	55.6 = 40/72	<0.001 (χ^2)
Late-elderly		35.8 = 231/645	38.9 = 105/270	33.6 = 126/375	57.8 = 67/116	79.5 = 35/44	44.4 = 32/72	
BMI (kg/m^2)		23.3 ± 3.2	24.0 ± 3.1	22.8 ± 3.3	20.9 ± 2.7	21.6 ± 2.1	20.4 ± 2.9	<0.001 (u)
SMI (kg/m^2)		6.6 ± 1.0	7.5 ± 0.9	6.0 ± 0.6	5.7 ± 0.7	6.4 ± 0.5	5.2 ± 0.4	<0.001 (u)
Grip strength (kg)		25.6 ± 8.1	32.9 ± 6.1	20.3 ± 4.4	17.1 ± 4.5	21.1 ± 3.7	14.7 ± 3.0	<0.001 (u)
Usual walking spee		1.4 ± 0.2	1.4 ± 0.2	1.4 ± 0.2	1.2 ± 0.3	1.2 ± 0.3	1.2 ± 0.3	<0.001 (u)
No. existing teeth		20.3 ± 8.8	19.8 ± 9.2	20.7 ± 8.5	17.5 ± 9.4	13.7 ± 9.1	19.8 ± 8.9	<0.001 (u)
No. functional teetl		27.0 ± 2.9	26.9 ± 3.5	27.1 ± 2.4	26.7 ± 3.6	26.4 ± 4.0	26.9 ± 3.4	0.693 (u)
Occlusal force (N)		551 ± 347	610 ± 388	509 ± 308	407 ± 280	368 ± 276	431 ± 282	<0.001 (u)
Chewing	Good	88.7 = 572/645	8.9 = 24/270	86.9 = 326/375	69.8 = 81/116	65.9 = 29/44	27.8 = 20/72	<0.001 (χ^2)
	Poor	11.3 = 73/645	91.1 = 246/270	13.1 = 49/375	30.2 = 35/116	34.1 = 15/44	72.2 = 52/72	

Value are mean ± standard diviation. MG, Maintenance Group; DG, Decline Group; Early-elderly, under 75 years old;Late-elderly, upper 75 years old; BMI, Body Mass Index; SMI, Skeletal Muscle mass Index; Chewing ability (Divided the color changes of color-changeable gum into 5 stages, 1 and 2 with less color changes into Poor and 3, 4 and 5 with more color changes into Good); u, Mann-Whitney U-test; χ^2, χ^2-test, SD, standard diviation.

Table3. Logistic regression analysis
Dependent variable；Cut off SSp at MG and DG
Independent variable; age (early elderly and late elderly), BMI, number of existing teeth, occlusal force (evaluated by newton with dental prescale) and chewing ability (Divided the color changes of color-changeable gum into 5 stages, 1 and 2 with less color changes into Poor and 3, 4 and 5 with more color changes into Good)

	OR	95% CI	P-value
Age (Early elderly= 0, Late elderly = 1)	2.37	(1.52-3.70)	<0.001
BMI (/kg/m^2)	0.75	(0.69-0.81)	<0.001
No. existing teeth (/tooth)	1.01	(0.98-1.04)	0.523
occlusal force (/N)	1.00	(1.00–1.00)	0.007
Chewing ability (Good =0, Poor = 1)	2.18	(1.21-3.93)	0.010

BMI, body mass index; Early elderly, under 75 years; Late elderly, upper 75 years old