mass.[27,28] In addition, there is also an age-dependent decrease in the amount of physical activity and energy intake. These behavioral changes can enhance the age-dependent reduction in skeletal muscle mass.

Interestingly, in those aged over 65 years, age-dependent decreases in total SMI were greater in men than in women. Furthermore, this age-dependent sex difference was more prominent in the arm than in the leg. From 40 to 79 years, the arm SMI decreased by 12.6% in men and by 4.1% in women. This is consistent to the previous studies in Japanese older adults. Kitamura *et al.* reported that the arm lean tissue mass was 5.97 ± 0.75 and 5.01 ± 0.67 in men, and 3.56 ± 0.54 and 3.24 in women aged in their 40s and 70s, respectively.[29] Based on their data, the percentage change in the arm lean tissue mass in men is –16.0% and is –8.9% in women. However, there is no sex difference in the percentage change in the leg lean tissue mass. The mechanism of this sex difference in the arm and leg lean tissue mass change is not clear. In general, older Japanese women frequently use the upper limbs, such as when washing and cooking. However, older Japanese men usually do not carry out such work. Therefore, it is possible that these behavioral differences lead to greater age-dependent decreases in the arm SMI in men than in women. As another possibility, Baumgartner reported that the sex hormone signal is an important factor for muscle mass in men, but not in women; however, physical activity is an important factor for muscle mass in both sexes.[30] Furthermore, previous studies have shown that 20% of men older than 60 years, 30% of men older than 70 years, and 50% of men older than 80 years have serum testosterone levels below the normal range.[31] Thus, it is also possible that the sex hormone-dependent changes in muscle mass are greater in men than in women. Therefore, age-dependent gender differences in the SMI might be influenced by daily activity or alterations in sex hormone levels.

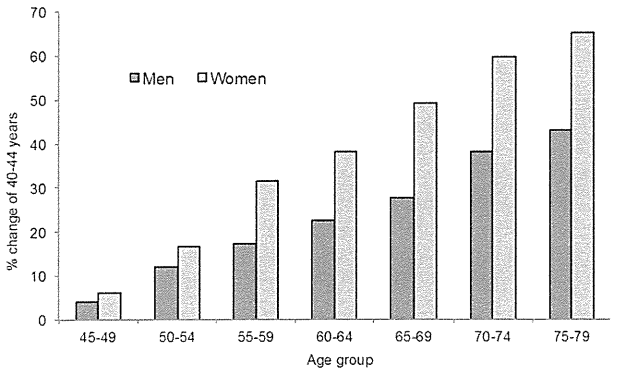

Figure 3 The percentage of change in the visceral fat area in each sex and each age group using 40–44 years-of-age as a reference.

The present data show that aging is associated with a progressive increase in visceral fat area in both sexes. From 40 to 79 years of age, the visceral fat area increased by 42.9% in men and by 65.3% in women. Furthermore, the SMI was negatively associated with the visceral fat area when adjusted for age and body weight in both sexes. The visceral adipose tissue produces many catabolic factors, such as TNF-α and IL-6.[22] Therefore, the age-dependent increases in both visceral adipose tissue and inflammatory cytokines might lead to a loss of skeletal muscle mass. Recently, sarcopenic obesity has been defined as both low muscle mass and high adipose tissue in older adults, and the health-related risk is higher in sarcopenic obesity than in sarcopenia.[32] The current data show that the age-dependent changes in body composition can accelerate sarcopenic obesity. These results suggest that it is very important to begin prevention of sarcopenia and sarcopenic obesity as early as possible.

According to our analysis of this cohort, we found that the 20th percentile of total SMI in men and women aged 65–79 years was 7.02 kg/m^2 and 5.61 kg/m^2, respectively. These values were slightly higher than those determined by the young adult mean in our database (men 6.75 kg/m^2; women 5.07 kg/m^2).[18] That these values were lower than the 20th percentile of total SMI

Table 3 Multiple regression analysis for the association with skeletal muscle mass index in both sexes

Independent variables	Men Adjusted R^2 value = 0.781** standard regression value	Women Adjusted R^2 value = 0.627** standard regression value
Visceral fat area (cm^2)	–0.586**	–0.627**
Age (year)	0.212**	0.252**
Weight (kg)	1.180**	1.169**

**$P < 0.01$.

is probably because we did not use the data of SMI in participants aged 80 years and older. Other studies on sarcopenia in Asia also show that the cut-off of SMI is 6.08–7.27 kg/m^2 in men and 4.79–5.80 kg/m^2 in women,[13,33–35] which is quite consistent with the present results. Thus, the 20th percentile of total SMI in men and women in our data can be used for the cut-off of SMI in Asians; however, further studies are required to address whether these cut-off points are associated with adverse health outcomes in Asian older adults.

There were several limitations to the present study that warrant mention. First, physical performance data were not measured. The European Working Group on Sarcopenia in Older People (EWGSOP) has recommended using the presence of both low muscle function (low physical performance or muscle strength) and low muscle mass to diagnose sarcopenia.[36] Therefore, the prevalence of sarcopenia could not be determined. Second, the study design was cross-sectional, and no outcome data are available. Further research with a longitudinal design will be required to clarify whether low muscle mass can predict adverse health outcomes in older Japanese adults. Third, the SMI measurement was estimated using BIA, which is not a method that is recommended by the EWGSOP for assessing muscle mass. However, it is very challenging to measure muscle mass in community-dwelling older adults using dual-energy X-ray absorptiometry (DXA); thus, BIA is a more practical screening method to use in large samples, especially in a community setting. However, to determine the specific effect of an intervention, a more accurate measurement, such as DXA, computed tomography, or magnetic resonance imaging, should be used in future studies. Serum outcomes were not measured. Therefore, the relationship between the SMI and hormone signals could not be determined. Finally, the participants in the present study were limited to visitors to fitness and community centers. Therefore, the participants of this study might not be a representative sample of community-dwelling adults.

In conclusion, the SMI showed an age-dependent decrease in both sexes, and the total SMI decreased by 10.8% in men and by 6.4% in women aged 40–79 years. Notably, age-dependent sex differences were more pronounced in the arm SMI; from 40 to 79 years, the arm SMI decreased by 12.6% in men and 4.1% in women. These results suggest that the age-dependent loss of skeletal muscle mass begins at approximately 40 years-of-age, and becomes prominent after 50 years-of-age in Japanese adults. Furthermore, the visceral fat area showed an age-dependent increase in both sexes, and the visceral fat area increased by 42.9% in men and by 65.3% in women of 40–79 years-of-age. Finally, the SMI was negatively associated with the visceral fat area in both sexes. Thus far, no studies have reported age-dependent changes and the association of muscle mass and visceral fat in Asian populations. Therefore, the current data could be used as the reference value for Asian adults.

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Disclosure statement

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

Arterial stiffness is associated with low skeletal muscle mass in Japanese community-dwelling older adults

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Aim: To examine whether arterial stiffness, measured by the cardio-ankle vascular index (CAVI), is associated with skeletal muscle mass index (SMI) in Japanese community-dwelling older adults.

Methods: Data were collected from 175 participants through questionnaires and specific tests; the data included demographic, lifestyle and health characteristics, body mass index (BMI), and body composition features determined by the bioelectrical impedance analysis, ankle-brachial index, the Mini-Nutritional Assessment, handgrip strength (GS), walking speed and shuttle walking tests (SW), and arterial stiffness determined by the CAVI. Absolute SMI was dichotomized according to the first quintile, which determined low ($n = 35$) and normal ($n = 140$) SMI.

Results: Participants with low SMI were older ($P = 0.01$), had more polypharmacy ($P = 0.01$), a lower BMI ($P < 0.001$), and fat mass index ($P = 0.02$), and had a greater risk of malnutrition ($P < 0.001$) than the normal group. Additionally, they showed poorer physical performance (GS and SW, $P = 0.007$ and 0.01, respectively) than the normal group. Furthermore, CAVI was associated with SMI even after adjustments (OR 1.82, 95% CI 1.14–2.90, $P = 0.01$).

Conclusions: Our data showed that arterial stiffness is associated with low SMI in community-dwelling older adults, even when adjusting by multiple factors, showing a close interaction of vascular aging and muscle mass decline. **Geriatr Gerontol Int 2014; 14 (Suppl. 1): 109–114.**

Keywords: arterial stiffness, cardio-ankle vascular index, older adults, sarcopenia, skeletal muscle mass.

Introduction

The progressive loss of skeletal muscle mass is the primordial factor to determine sarcopenia, a syndrome that combines low skeletal muscle mass and strength, and can lead to adverse health outcomes, such as physical disability, poor quality of life and mortality.[1] In addition, the elderly might experience several adverse health outcomes as a result of vascular aging, such as increased arterial stiffness, which can contribute to the development of cardiovascular and cerebrovascular diseases.[2] It is known that both the loss of skeletal muscle mass and arterial stiffness worsen with age, and that some of the predisposing factors and mechanisms underlying low muscle mass and sarcopenia; for example, oxidative stress,[3] inflammation,[4] and insulin resistance,[1] are also associated with atherosclerosis.[5] However, only a few studies have been carried out to verify such associations.[5–8] A study showed that arterial stiffness is associated with an increase in the loss of muscle mass index over time independent of age, body fat, peripheral arterial disease, chronic inflammation, and cardiac disease.[6] Other studies have verified the associations of peripheral lean mass and visceral fat mass with atherosclerosis,[7] and the relationships between regional fat and lean mass and large artery properties in young men and women.[8]

A novel measurement tool to assess arterial stiffness is the cardio-ankle vascular index (CAVI), which reflects the stiffness of the aorta, femoral artery, and tibial artery, and involves the measurement of the brachial-ankle pulse wave velocity (baPWV) and blood pressure (BP). The most important feature of CAVI is its independence from BP during examination,[2,9,10] which shows that it is a useful tool to assess those who are

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subject to variation in blood pressure at different times of the day, suffer from masked hypertension or are taking antihypertensive medications.[11]

Therefore, the objective of the present study was to examine whether arterial stiffness, measured by CAVI, is associated with skeletal muscle mass index (SMI) in Japanese community-dwelling older adults. We hypothesized that arterial stiffness is associated with a low SMI independent of sex, nutritional status, and physical performance in community-dwelling older adults.

Methods

The present study had a cross-sectional design.

Participants

The participants of the present study were community-dwelling Japanese older adults ($n = 175$; male = 84, female = 91) recruited through local press announcements requesting healthy volunteers. Recruited participants were 65 years-of-age or older, and were able to carry out the activities of daily living (ADL) and answer the proposed questionnaires. The exclusion criteria at the first screening were the following: (i) moderate cognitive impairment (i.e. Mini-Mental State Examination score ≤21 points); (ii) uncontrolled cardiovascular, pulmonary, or metabolic diseases; (iii) any orthopedic conditions that could restrain the ADL; and (iv) comorbidities associated with a greater risk of falls (e.g. Parkinson's disease and stroke). Additionally, in the present study, none of the participants had peripheral artery disease as evidenced by an ankle-brachial index (ABI) of less than 0.9. All participants were informed of the purpose and procedures of the study, and signed a written consent. The data were collected in November 2012.

The study protocol was approved by the Kyoto University Graduate School of Medicine Ethics Committee (No. E1245, E1583).

Assessments

The participants answered a self-administered questionnaire about demographic, lifestyle, and health characteristics, including age, regular physical activity engagement, alcohol consumption, smoking, current number of medications, and morbidities (i.e. diabetes, hypertension, hyperlipidemia and coronary artery disease; determined by the assumption that the prescribed medications they reported in the analysis were being used for the morbidity).

Additional relevant health indicators, such as (i) body mass index (BMI); (ii) body composition features determined by bioelectrical impedance analysis (Inbody 430; Biospace, Seoul, Korea); (iii) ABI; and (iv) the Mini-Nutritional Assessment short-form (MNA)[12] were also collected.

The bioelectrical impedance instrument made use of octapolar tactile electrodes, two in contact with the palm and thumb of each hand, and two with the anterior and posterior aspects of the sole of each foot. The participants were instructed to stand with their soles in contact with the foot electrodes and to grasp the hand electrodes. The resistance of the arms, trunk, and legs was measured at frequencies of 5, 50, and 250 kHz. The participants' ID number, height (measured with a standard stadiometer), age, and sex were also inserted in the analyzer. Then, body mass and consequently BMI were automatically measured by the "InBody". For classification purposes, the BMI cut-offs used were those proposed by the Japan Society for Study of Obesity (i.e. underweight, BMI <18.5 kg/m^2, normal weight, BMI 18.5–25 kg/m^2, and obese, BMI ≥25 kg/m^2).[13] The bioelectrical impedance examination provided values for absolute skeletal muscle mass, body fat percentage, absolute fat mass, and segmental muscle mass (right and left arms/legs and trunk). From these measurements, absolute skeletal muscle mass and absolute fat mass were posteriorly adjusted by height to determine the SMI and fat mass index (FMI), respectively. The "InBody" system uses direct segmental multifrequency technology, and had previously been validated as having a strong correlation to muscle volume and fat mass as measured by dual energy X-ray absorptiometry.[14,15]

Physical performance was investigated by the following: (i) handgrip strength (GS); (ii) walking speed (WS); and (iii) shuttle walking tests (SW).[16,17]

GS was collected with a standard handgrip dynamometer (Smedlay's Dynamo Meter; TTM, Tokyo, Japan). The participants were asked to stand up and hold the dynamometer with their arms parallel to their bodies without touching their bodies. GS was measured once for each hand, and the higher value was used to characterize his/her maximum muscle strength. GS was expressed in kilograms (kg).

In the WS test, outside marks of 12 m in length were clearly placed on the ground. Inside this distance, another 10 m long delimitation was marked. The participants were asked to walk the entire distance at their usual pace, but only the time to complete the inner 10 m distance was measured. Such measurement was intended to avoid the acceleration and deceleration stages of the participant's walking.

Finally, the SW test was carried out; two cones were placed 10 m apart. The participants were instructed to walk around the cones without stopping at a pace set by a timed signal played on a CD player. The SW test consists of 102 shuttles divided into 12 levels, each lasting approximately 1 min. The first level consists of three shuttles with a subsequent one-shuttle (i.e. 10 m)

increase at each following level. At each level, the speed is increased by 0.17 m/s, with an initial speed of 0.5 m/s rising to a maximum speed of 2.37 m/s.[16,17] The test ended if the participant was unable to continue (due to breathlessness or any other reason) or was unable to reach the next cone before the timer sounded. If none of these mentioned factors occurred, we stopped the test at shuttle 50 (or 500 m, half of the total) to assure the participants' safety due to fatigue issues. Then, the values in meters were included in the analysis. A resting time of at least 3 min was provided between each assessment, and a longer time was provided if the participant claimed fatigue.

CAVI

CAVI was determined using VaSera1500 (Fukuda Denshi, Tokyo, Japan). The procedures started with the participants resting for 5 min in a sitting position. Afterwards, they were placed supine on a standard stretcher. Cuffs were wrapped around both arms and ankles to detect the brachial and ankle pulse waves. An electrocardiogram was carried out, and the heart sound was monitored. The pulse wave velocity (PWV) from the heart to the ankle was determined by measuring the length from the aortic valve to the ankle divided by time, according to the heart sound and the rise of the brachial and ankle pulse wave. The BP was measured at the four limbs alternately, first at the right arm and ankle, and then at the left arm and ankle. This procedure is important not only because it reduces the burden of the examinees, but also because it enables a more accurate measurement. Finally, a scale conversion was carried out using the following formula: $CAVI = a\{(2\rho/\Delta P) \times \ln(Ps/Pd)PWV^2\} + b$ (no unit), in which "ρ" is blood density, "Ps" is systolic blood pressure, "Pd" is diastolic blood pressure, "ΔP" is Ps – Pd, "PWV" is pulse wave velocity, and "a" and "b" are specific constants. This procedure has also been detailed in previous studies.[2,10]

This measurement was carried out once for each participant, and the mean of the right and left values of CAVI for each participant was used for analytical purposes.[18] The validity, reproducibility, and blood pressure-independent nature of this system have been widely documented by other researchers.[2,9,10]

Statistical analysis

The Kolmogorov–Smirnov test was carried out to determine the normality of the data. Absolute SMI was dichotomized according to the first quintile for males (8.81 kg/m^2) and females (7.57 kg/m^2). Then, we arbitrarily assumed that those in the first quintile had a low SMI ($n = 35$), coded 1, and the others were considered normal SMI ($n = 140$), coded 0.

We analyzed the relationship between the two groups using the unpaired *t*-test for the age, BMI, body fat percentage, FMI, and ABI variables, and the Mann–Whitney *U*-test for the SMI, CAVI, GS, WS, and SW tests. Furthermore, the χ^2-test was used for sex, regular physical activity engagement, alcohol consumption, smoking, number of medications, morbidities, and malnutrition. In addition, a univariate logistic regression was carried out to verify the association of each variable and the muscle mass condition, except for the number of medications as a result of missing values in the variable; then, a stepwise multivariate logistic regression was carried out to investigate whether CAVI was associated with low SMI. We assigned the status of muscle mass as the dependent variable, CAVI as the main covariate, and sex, age, BMI, MNA, GS, and SW as adjusted covariates. Differences were considered statistically significant at $P < 0.05$. All analyses were carried out using the Statistical Package for the Social Sciences software (SPSS; IBM, Chicago, IL, USA) version 20.0.

Results

A total of 175 subjects participated in the present study; we divided them into two groups: low SMI older adults ($n = 35$) and normal SMI ($n = 140$) participants. The participants in the first group were older and had more polypharmacy (four or more concurrent medications) than the normal participants. No significant differences were found for the lifestyle characteristics or morbidities (Table 1).

The results of the health indicators showed that low SMI participants had a lower BMI and FMI, and were at a higher risk of malnutrition than the normal group. Additionally, they presented with poorer physical functioning, such as low muscle strength and lower SW test scores. Regarding the CAVI results, the low SMI older adults had higher CAVI (Table 2).

The findings of the multivariate logistic regression showed that females were less likely to have low SMI than males. Similar conditions were verified in the participants with higher BMI and GS. Additionally, CAVI showed an independent association with SMI, even when adjusted for age, sex, BMI, MNA, GS, and SW. Thus, a higher CAVI was associated with low SMI in older adults (Table 3).

Discussion

The present study supported the hypothesis that arterial stiffness (assessed by CAVI) is associated with low SMI in community-dwelling older adults. Other studies have been carried out to ascertain this association;[5–8] however, none of them considered arterial stiffness as measured by CAVI, a non-invasive and BP-independent tool.

Table 1 Bivariate comparisons of the participants' demographic and lifestyle characteristics

Variables	Normal (n = 140)	Low SMI (n = 35)	P
Age (years)	73 [70–77]	76 [71–78]	0.01
Females	52.1 (73)	51.4 (18)	0.94
Regular physical activity[†]	65.4 (83)	63.3 (19)	0.83
Alcohol consumption[‡]	39.4 (52)	36.7 (11)	0.78
Smoking[‡]	9.1 (12)	6.7 (2)	1.00
No. medications[§]	76.6 (95)	52 (13)	0.01
	23.4 (29)	48 (12)	
Morbidities[‡]			
Diabetes	12.1 (16)	10 (3)	1.00
Hypertension	42.4 (56)	36.7 (11)	0.56
Hyperlipidemia	14.4 (19)	20 (6)	0.41
Coronary artery disease	7.6 (10)	10 (3)	0.71

[†]n = 157; [‡]n = 162; [§]n = 149; values are expressed as medians [interquartile range] or valid percentages (n).

Table 2 Bivariate comparisons of the participants' health indicators

Variables	Normal (n = 140)	Low SMI (n = 35)	P
BMI (kg/m^2)	23.6 ± 2.71	20.7 ± 2.61	<0.001
SMI (kg/m^2)	9.00 [8.20–9.81]	7.54 [7.39–8.43]	<0.001
Body fat percentage	29.0 ± 7.72	28.1 ± 8.80	0.56
FMI (kg/m^2)	7.06 ± 2.37	6.03 ± 2.42	0.02
ABI	1.10 ± 0.07	1.08 ± 0.07	0.10
MNA at risk	20.0 (28)	51.4 (18)	<0.001
Handgrip strength (kg)	28.7 [25–35]	24.5 [22.5–31]	0.007
Walking speed (m/s)	1.39 [1.25–1.50]	1.39 [1.22–1.48]	0.48
Shuttle walking (m)	400 [360–470]	360 [300–440]	0.01
CAVI	9.13 [8.52–9.71]	9.57 [8.93–10.4]	0.008

Values are means ± SD, medians [interquartile range] or valid percentages (n). ABI, ankle-brachial index; BMI, body mass index; CAVI, cardio-ankle vascular index; FMI, fat mass index; MNA, mini-nutritional assessment; SMI, skeletal muscle mass index.

A previous study investigated the occurrence of a specific association between arterial stiffening (analyzed by baPWV) and peripheral skeletal muscle mass, and concluded that arterial stiffness was associated with a higher loss of muscle mass index over time independent of age, total body fat, peripheral arterial disease, chronic inflammation, or cardiac disease. Ochi *et al.* hypothesized that age-related decline of muscle mass and atherosclerosis share common pathological processes and interact with each other. In fact, the authors verified a direct association with baPWV and thigh muscle sarcopenia in men, but that association was not confirmed in women.[5] Furthermore, Kohara *et al.* found that men with sarcopenic obesity had higher baPWV than normal, sarcopenic, or obese men.[19] In theory, changes in arterial stiffness might mediate the association between body composition and cardiovascular risk.[8] However, it is unclear how arterial stiffness and the loss of muscle mass relate to each other. Authors suggested that because basal limb blood flow declines with aging, in part due to arterial stiffening, dysfunction in blood vessel dynamics could have a predictive role in muscle mass decline.[6]

Some researchers have linked the higher prevalence of low muscle mass in men[20] to their findings of arterial stiffness in men, but not in women.[5,19] To examine any sex effect on CAVI, we carried out further analysis and verified that men had higher CAVI than women (data

Table 3 Stepwise multivariate logistic regression considering skeletal muscle mass index (normal or low condition) as dependent variable and cardio-ankle vascular index, age, gender, body mass index, Mini-Nutritional Assessment, handgrip strength, and shuttle walking as covariates

Variables	OR (95% CI)	*P*
Sex		
Female	0.23 (0.61–0.90)	0.03
BMI	0.71 (0.59–0.85)	<0.001
Handgrip strength	0.83 (0.74–0.94)	0.002
CAVI	1.82 (1.14–2.90)	0.01

Values are odds ratio (95% confidence interval). BMI, body mass index; CAVI, cardio-ankle vascular index; SMI, skeletal muscle mass index.

not shown). However, in our fully adjusted analysis, we verified the association of CAVI and low SMI independent of sex.

Regarding physical performance, those with normal muscle mass presented better physical functioning, such as a higher GS, higher SW test scores, and a lower CAVI, than the group with low SMI. GS is a representative measure of strength and is an important screening tool for sarcopenia,[1] whereas SW represents aerobic capacity.[16,17] Regarding SW, a previous study showed that endurance-trained older men demonstrated lower arterial stiffness than their sedentary age peers despite similar systolic blood pressures, suggesting that age-associated augmentation of arterial stiffness might be mitigated by regular aerobic exercise.[21]

Furthermore, polypharmacy was observed more frequently among participants in the low SMI group. Although we did not deeply investigate the classes of medications to which they were exposed, our results were in agreement with previous studies that identified the association of concomitant medications and impaired physical functioning in older adults.[22]

Based on the present results, we would like to emphasize the importance of physical activity, mainly the combination of progressive resistance exercise and aerobic exercise,[23] in accordance with well-balanced nutrition in relation to low SMI and arterial stiffness, especially because the participants with low SMI in the present study had lower physical performance, lower BMI, and a higher risk for malnutrition. Nutritional status is widely known to be associated with both muscular and vascular health. Thus, aiming to reverse low muscle mass, Yamada *et al.* verified that a diet rich in proteins and vitamin D in combination with resistance exercise was more effective at improving muscle mass than resistance exercise alone.[24] In addition, evidence showed that lower levels of 25-hydroxyvitamin D, an established marker of vitamin D status, are associated with abnormalities in the indices of arterial stiffness.[25]

Although the low SMI participants had lower BMI and FMI than the normal group, both groups presented similar results for body fat percentage. This result might show that lean body mass is lost, and fat could be preserved or even increased in people with low muscle mass or sarcopenia. As intramuscular and visceral fat increase, and subcutaneous fat decreases with age,[1,4] the association with muscle mass decline and arterial stiffness might also be perceived from the standpoint of the relationship between fat mass and cardiovascular risks.

Some limitations of the present study should be mentioned: (i) its cross-sectional design did not permit the determination of a cause–effect relationship between CAVI and the low SMI condition; and (ii) the small number of participants limited further group subdivision (i.e. to differentiate pre-sarcopenic and sarcopenic older adults) as a result of the low statistical power achieved when further dividing the groups. However, the present study showed that a relationship between CAVI and low SMI does exist, and might serve as a basis for further studies with a larger sample size, analyzing the time effect on muscle, and physical performance decline, and also investigating the role of sex on such an association.

To our knowledge, this is the first study to verify the interaction of CAVI and total SMI in Japanese older adults. The main clinical advantage of the present study was that it clearly showed the important relationship between arterial stiffness and low SMI in community-dwelling older adults as measured by CAVI, a non-invasive reliable method and blood pressure independent measure. It would be useful to perform further health analyses in older adults with arterial stiffness, including body composition features and physical performance measurements, to aid in the early detection of people with the risk of developing sarcopenia; and also to verify arterial stiffness in older adults already in a progressive muscle loss condition. We believe that a suitable intervention for the promotion of improvements in vascular and muscular parameters would be aimed at increasing physical fitness levels and improving nutrition; this combined intervention might reduce the probability of a person developing systolic hypertension and the associated risk of cardiovascular events, and could help maintain SMI and function, especially in older adults.

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Disclosure statement

The authors declare no conflict of interest.

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Original Study

Prevalence of Sarcopenia in Community-Dwelling Japanese Older Adults

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A B S T R A C T

Background: Sarcopenia, the age-dependent loss of skeletal muscle mass, is highly prevalent among older adults in many countries; however, the prevalence of sarcopenia in healthy Japanese community-dwelling older adults is not well characterized.
Objective: The aim of this study was to evaluate the prevalence of sarcopenia and to examine the association of sarcopenia with falls and fear of falling in community-dwelling Japanese older adults.
Design: This is a cross-sectional study.
Setting and Subjects: Healthy men (568) and women (1314) aged 65 to 89 years participated in this research.
Measurements: For all participants, 3 measurements were taken: skeletal muscle mass measurement using bioelectrical impedance, 10 m at a usual walking speed, and handgrip strength. Sarcopenia was defined as the presence of both poor muscle function (low physical performance or low muscle strength) and low muscle mass.
Results: The prevalence of sarcopenia, determined using the European Working Group on Sarcopenia in Older People–suggested algorithm, in men and women aged 65 to 89 years was 21.8% and 22.1%, respectively. The prevalence of sarcopenia increased age-dependently, especially in those older than 75 years in both genders. In the young old, the prevalence of sarcopenia was higher in women than in men; however, in those older than 85 years, the prevalence of sarcopenia was lower in women than in men ($P < .05$). In addition, fall incidents and fear of falling were more prevalent in sarcopenic older adults than in nonsarcopenic older adults ($P < .05$).
Conclusions: These results suggest that sarcopenia is highly prevalent in community-dwelling Japanese older adults and is related to falls and fear of falling.

In 1989, Rosenberg[1] proposed the term sarcopenia to describe the age-dependent loss of skeletal muscle mass. In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) recommended using the presence of both low muscle function (low physical performance or muscle strength) and low muscle mass to diagnose sarcopenia.[2] Numerous epidemiological studies showed that sarcopenia is highly prevalent and is a serious problem in older adults.[3,4] Sarcopenia is considered to be characterized by an impaired state of health with mobility disorders, increased risk of falls and fractures, impaired ability to perform activities of daily living, disabilities, and loss of independence.[5–7]

The mechanism of sarcopenia remains unclear; however, it may be related to the age-dependent loss of skeletal muscle mass due to multifactorial processes, such as physical inactivity, malnutrition, oxidative stress, and changes in endocrine function.[2] Additionally, age-dependent increases in inflammatory cytokines, such as interleukin-6 and tumor necrosis factor alpha, can result in increased skeletal muscle breakdown.[8] In contrast, the age-dependent decrease in anabolic hormones, such as testosterone, estrogen, growth hormone, and insulinlike growth factor-1 (IGF-1), may lead to loss of skeletal muscle mass.[9,10]

The aged population in Japan is increasing faster than in any other country. Frailty in older adults is a serious problem in aging countries, such as Japan. A recent cross-sectional study showed that sarcopenia is highly prevalent in Japanese older adults with hip fracture (men, 81.1%; women, 44.7%).[11] Especially in older adults with hip fracture, the prevalence of sarcopenia increased with age. However, age-dependent changes in the prevalence of sarcopenia in Japanese community-dwelling healthy older adults are not well established.

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The primary aim of this study was to evaluate the prevalence of sarcopenia in community-dwelling Japanese older adults by gender and age. The secondary aim was to determine the prevalence of falls and fear of falling in sarcopenic older adults and to compare these with nonsarcopenic older adults.

Methods

Participants

Participants were recruited by an advertisement in the local press and by public ads. We recruited community-dwelling older adults in the Kyoto prefecture and the Hyogo prefecture in Japan. The inclusion criteria were an age of 65 to 89 years, living in the community, and the ability to walk independently (including with a cane). The exclusion criteria were certification of frailty status by the long term care insurance service in Japan and artificial implants, such as cardiac pacemakers and joints, which did not allow the potential subject to receive bioimpedance. An interview was also used to identify those with the following exclusion criteria: severe cognitive impairment; severe cardiac, pulmonary, or musculoskeletal disorders; and co-morbidities associated with greater risk of falls, such as Parkinson disease or stroke. This study was conducted in accordance with the guidelines of the Declaration of Helsinki, and the study protocol was reviewed and approved by the Ethics Committee of the Kyoto University Graduate School of Medicine.

Healthy men (n = 568) and women (n = 1314) aged 65 to 89 years participated in this study. The male participants were divided into 5 groups according to age: 65 to 69 (n = 76), 70 to 74 (n = 190), 75 to 79 (n = 172), 80 to 84 (n = 82), and 85 to 89 (n = 48) years. The female participants were also divided into 5 groups according to age: 65 to 69 (n = 278), 70 to 74 (n = 372), 75 to 79 (n = 414), 80 to 84 (n = 180), and 85 to 89 (n = 70) years. The prevalence of sarcopenia in each age and gender group was then determined.

Skeletal Muscle Mass Index

A bioelectrical impedance data acquisition system (Inbody 720; Biospace Co, Ltd, Seoul, Korea) was used to determine bioelectrical impedance.[12] This system uses electrical current at different frequencies (5, 50, 250, 500, and 1000 kHz) to directly measure the amount of extracellular and intracellular water in the body. Participants stood on 2 metallic electrodes and held metallic grip electrodes. Using segmental body composition and muscle mass, a value for the appendicular skeletal muscle mass was determined and used for further analysis. Muscle mass was converted into the skeletal muscle mass index (SMI) by dividing by weight by height squared (kg/m^2). This index has been used in several epidemiological studies.[13,14] Reference value (SMI) for low muscle mass in each gender was defined as a value 2 SDs below the gender-specific means of the study reference data for young adults aged 18 to 40 years.[15] The study population included young adults (19,797 men and 18,302 women) aged 18 to 40 years, to determine the reference values. The SMIs in young men and women aged 18 to 40 years old were 8.11 ± 0.68 kg/m^2 and 6.35 ± 0.64 kg/m^2, respectively. Therefore, the reference values for low muscle mass in Japanese men and women using bioelectrical impedance analysis (BIA) were 6.75 kg/m^2 and 5.07 kg/m^2, respectively.

Measurement of Physical Performances

For all participants, the following 2 measures of physical performance were obtained: 10 m usual walking speed[16] and handgrip strength (HGS).[17] If a walking aid was normally used at home, this aid was used during the 10-m walking speed test.

In the walking speed test, participants were asked to walk 15 m at a comfortable pace. A stopwatch was used to record the time required to reach the 10-m point (marked in the course). The time recorded in 2 trials was averaged to obtain the data for the present analyses. A cutoff point of less than 0.8 m/s identified participants with low physical performance.[2]

In the HGS test, participants used a handheld dynamometer. Participants kept their arms by the sides of their body. The participant squeezed the dynamometer with the dominant hand using maximum isometric effort. No other body movement was allowed. The HGS score was defined as the better performance of 2 trials. Low muscle strength was defined as handgrip strength less than 30 kg in men and 20 kg in women.[2]

Definition of Sarcopenia

We defined sarcopenia using the EWGSOP-suggested diagnostic algorithm to assess the presence of both low muscle function (low physical performance or low muscle strength) and low muscle mass.[2]

Fall Incidents and Fear of Falling

Fall events in the previous year were recorded based on an interview with family members. A fall was defined as "an event that results in a person coming to rest inadvertently on the ground or other lower level regardless of whether an injury was sustained, and not as a result of a major intrinsic event or overwhelming hazard."[18] The date, number, characteristics (eg, while rising from a lying or sitting position, while turning in the opposite direction, while tripping over an obstacle), and consequences (eg, bruise, fracture) of the falls were recorded using a standardized questionnaire. Fear of falling was assessed by asking the yes-or-no question, "Are you afraid of falling?"

Statistical Analysis

Differences in the prevalence of sarcopenia, muscle mass, strength, and physical performance among 5 age groups by gender were evaluated using the chi-square test. The prevalence of sarcopenia and the corresponding 95% confidence intervals (CIs) were calculated for men and women and compared using the chi-square test in each age group. The results were presented as odds ratios (ORs) with 95% CIs.

The incidence of falls and the prevalence of fear of falling were calculated for participants with or without sarcopenia and were compared using the chi-square test. The results were presented using ORs with 95% CIs. The physical performances of sarcopenic and nonsarcopenic older adults were compared by gender using the Student *t* test. The data were managed and analyzed using SPSS (Statistical Package for the Social Sciences, Windows version 18.0; SPSS, Inc., Chicago, IL). A *P* value less than .05 was considered to indicate statistical significance for all analyses.

Results

The mean age of study participants was 74.9 ± 5.5 years, and 1314 (69.8%) participants were women. According to the EWGSOP-suggested algorithm, the prevalence of low physical performance in older adults aged 65 to 89 years was 4.1% in this cohort. The prevalence of low muscle strength in older adults with normal physical performance was 31.9%. The prevalence of low muscle mass with low physical performance or muscle strength was 22.0%. Thus, the prevalence of sarcopenia using the EWGSOP-suggested algorithm for

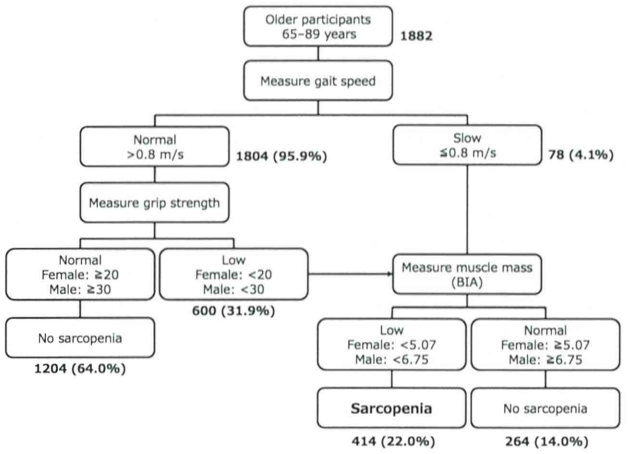

Fig. 1. The prevalence of sarcopenia, low muscle mass, poor physical performance, and low muscle strength according to the EWGSOP-suggested algorithm for sarcopenia in our study participants (n = 1882).

sarcopenia in men and women aged 65 to 89 years was 21.8% and 22.1%, respectively (Figure 1).

The prevalence of sarcopenia showed an age-dependent increase after 75 years in both genders. The prevalence of sarcopenia in men was 2.6%, 5.3%, 23.3%, 43.9%, and 75.0% and in women it was 11.5%, 11.8%, 27.1%, 35.6%, and 54.3% for those aged 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 to 89 years, respectively (Figure 2). In those younger than 75 years, the prevalence of sarcopenia was higher in women than in men (65–69 years: OR = 4.81, 95% CI = 1.12–20.55; 70–74 years: OR = 2.41, 95% CI = 1.18–4.91). However, in those aged 85 to 89 years, the prevalence of sarcopenia was lower in women than in men (OR = 0.39, 95% CI = 0.17–0.88) (Figure 3).

The prevalence of low muscle mass also showed an age-dependent increase after age 65 years in both genders. The prevalence of low muscle mass in men aged 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 to 89 years was 21.1%, 28.4%, 37.2%, 58.5%, and 75.0%, respectively, and 24.5%, 30.1%, 43.0%, 55.6%, and 71.4% in women of the same age groups (Table 1). The prevalence of low strength was increasingly age dependent after 75 years in both genders. The prevalence of low HGS was 13.2%, 14.7%, 40.7%, 61.0%, and 87.5% in men, and 23.0%, 19.4%, 41.1%, 62.2%, and 71.4% in women aged 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 to 89 years, respectively. The prevalence of low physical performance increased in those older than 80 years in both genders. In men aged 65 to 69, 70 to 74, 75 to 79, 80

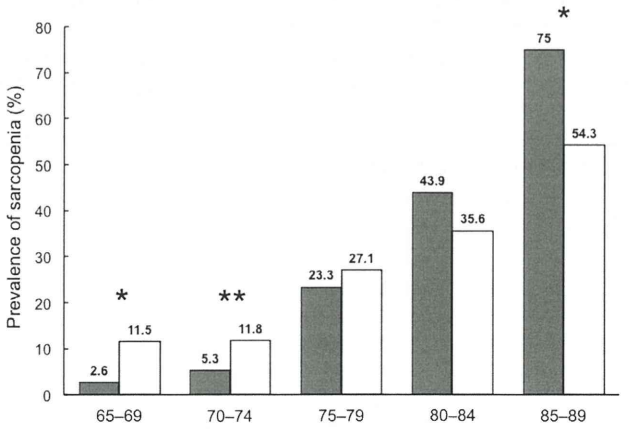

Fig. 2. The prevalence of sarcopenia is shown in each gender and each age group. Closed column: men; open column: women. *$P < .05$, **$P < .01$, men versus women.

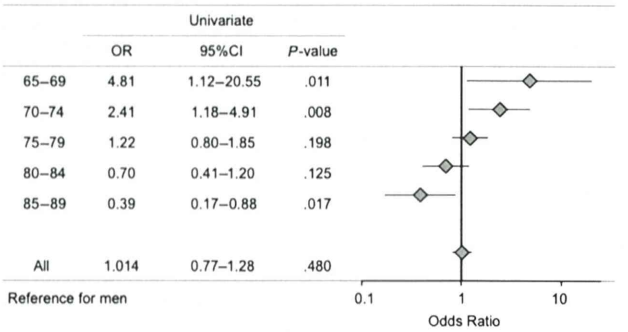

Fig. 3. Odds ratio of the prevalence of sarcopenia in men versus women in each age group.

to 84, and 85 to 89 years, the prevalence of slow walking speed was 0.0%, 1.1%, 3.5%, 9.8%, and 16.7%, respectively, and in women of the same age, it was 3.6%, 1.6%, 1.9%, 8.9%, and 20.0%, respectively.

In men, 48 (38.7%) in the sarcopenia group and 74 (16.7%) in the nonsarcopenia group experienced a fall in the previous year. The OR for falls in the sarcopenia group relative to the nonsarcopenia group was 3.16 (95% CI = 2.04–4.89). The OR for fear of falling in the sarcopenia group (67.7%) versus the nonsarcopenia group (25.2%) was 6.23 (95% CI = 4.04–9.60). In women, 94 (32.4%) in the sarcopenia group and 254 (24.8%) in the nonsarcopenia group experienced a fall in the previous year. The OR for falls in the sarcopenia group relative to the nonsarcopenia group was 1.45 (95% CI = 1.09–1.93). The OR for fear of falling in the sarcopenia group (84.1%) versus the nonsarcopenia group (50.0%) was 5.30 (95% CI 3.78–7.43) (Table 2). The sarcopenic participants showed significantly lower scores for all physical performance tests than those without sarcopenia ($P < .05$).

Discussion

The current cross-sectional study was performed to evaluate the prevalence of sarcopenia in Japanese older adults. The prevalence of sarcopenia using the EWGSOP-suggested algorithm for sarcopenia in men and women was 21.8% and 22.1%, respectively. Previous epidemiological studies of sarcopenia in several countries show a prevalence of sarcopenia of 5% to 40% in older men and 7% to 70% in older women.[14,19–32] In general, the prevalence of sarcopenia is approximately 25% in older men and 20% in older women. Our data are located around the mean of these previous studies in both genders. Therefore, we believe our study had no sampling bias or overestimation/underestimation in the measurement of BIA.

In those younger than 75 years, the prevalence of sarcopenia was higher in women than in men; however, the opposite trend was observed in those older than 85 years. This phenomenon was also found in previous studies in Caucasian and Chinese elderly.[23,29] The mechanism of this important finding is unclear. However, IGF-1 might play an important role in this phenomenon. IGF-1 is the most important mediator of muscle growth and repair. In women older than 65 years, the IGF-1 level did not show age-related changes; however, in men older than 85 years, the IGF-1 level is decreased.[33] Thus, in septuagenarians, the IGF-1 level is higher in men than in women, but in those older than 85 years, it is lower in men than in women. This trend is quite consistent with the prevalence of sarcopenia. Therefore, the gender difference in the prevalence of sarcopenia may well be dependent on the IGF-1 level.

Sarcopenic older adults showed significantly lower scores in all physical performance tests than those without sarcopenia. In addition, sarcopenic older adults had a higher incidence of falls (men, OR = 3.16; women, OR = 6.23) and greater fear of falling (men, OR = 1.45; women,

Table 1
Prevalence of Sarcopenia and Low Muscle Mass, Strength, and Physical Performance

	Men						
	Overall	65–69	70–74	75–79	80–84	85–89	*P* for Trend
	n = 568	n = 76	n = 190	n = 172	n = 82	n = 48	
Sarcopenia	124 (21.8)	2 (2.6)	10 (5.3)	40 (23.3)	36 (43.9)	36 (75.0)	<.001
Low muscle mass	218 (38.4)	16 (21.1)	54 (28.4)	64 (37.2)	48 (58.5)	36 (75.0)	<.001
Low strength	200 (35.2)	10 (13.2)	28 (14.7)	70 (40.7)	50 (61.0)	42 (87.5)	<.001
Low physical performance	24 (4.2)	0 (0.0)	2 (1.1)	6 (3.5)	8 (9.8)	8 (16.7)	<.001
	Women						
	Overall	65–69	70–74	75–79	80–84	85–89	*P* for Trend
	n = 1314	n = 278	n = 372	n = 414	n = 180	n = 170	
Sarcopenia	290 (22.1)	32 (11.5)	44 (11.8)	112 (27.1)	64 (35.6)	70 (54.3)	<.001
Low muscle mass	508 (38.7)	68 (24.5)	112 (30.1)	178 (43.0)	100 (55.6)	50 (71.4)	<.001
Low strength	468 (35.6)	64 (23.0)	72 (19.4)	170 (41.1)	112 (62.2)	50 (71.4)	<.001
Low physical performance	54 (4.1)	10 (3.6)	6 (1.6)	8 (1.9)	16 (8.9)	14 (20.0)	<.001

Values are in n (%).

OR = 5.30) than nonsarcopenic older adults. In a similar study conducted in Italy, 27.3% of participants with sarcopenia and 9.8% of participants without sarcopenia experienced falls over a 1-year period (hazard ratio = 3.45).[34] Studies have identified physical frailty as the risk factor for falls and fear of falling in older adults.[35,36] It is possible that a vicious cycle of sarcopenia can lead to lower physical performance and the resulting changes in physical ability can lead to a higher incidence of falls and greater fear of falling.

Sarcopenia is associated with adverse health outcomes. For example, Janssen et al[37] showed that the estimated direct health care cost related to sarcopenia was $18.5 billion in the United States in 2000. Furthermore, Landi et al[38] showed that 67.4% of participants with sarcopenia and 41.2% of participants without sarcopenia died during a 7-year follow-up in a study of older adults aged 80 years and older (hazard ratio = 2.95). Our study showed that sarcopenia is highly prevalent among adults aged 80 years and older. Because older adults are the greatest consumers of health care and have a high risk of death, it is very important to begin prevention of sarcopenia early, possibly before the age of 65.

There were several limitations to this study that warrant mention. First, the study design was cross-sectional and no outcome data are available. Further research with a longitudinal design is required to clarify whether sarcopenia determined by our algorithm can predict adverse health outcomes in Japanese older adults. Second, the SMI measurement was estimated using BIA, a method not recommended to assess muscle mass by the EWGSOP. However, it is not feasible to measure muscle mass in community-dwelling older adults using dual-energy x-ray absorptiometry (DEXA), so BIA is a more practical screening method to use in large samples, especially in a community setting. However, to determine the specific effect of an intervention, a more accurate measurement, such as DEXA, computed tomography, or magnetic resonance imaging, should be used in future studies. Third, serum data were not measured. Therefore, the relationship between sarcopenia and IGF-1 could not be determined. Finally, the presence of sarcopenia might not be able to predict falls in older adults, as this study was based on the participants having experienced a fall in the previous year. Further study is required to confirm our findings in participants with sarcopenia who do not experience falls.

In conclusion, the prevalence of sarcopenia using the EWGSOP-suggested algorithm for sarcopenia in men and women was 21.8% and 22.1%, respectively, and the prevalence of sarcopenia increased age dependently in those older than 75 years in both genders. The prevalence of sarcopenia in men and women showed an opposite trend in the young old and in the old old (those older than 85 years). In addition, participants with sarcopenia had an increased risk for falls and a greater fear of falling. Outcome studies are needed to determine the diagnosis of sarcopenia and the cutoff values for walking speed, HGS, and muscle mass.

Table 2
Characteristics and Physical Performance in Study Participants With or Without Sarcopenia by Gender

	Men					Women				
	Sarcopenia		Nonsarcopenia			Sarcopenia		Nonsarcopenia		
	n = 124		n = 444			n = 290		n = 1024		
	Mean	SD	Mean	SD	*P* value	Mean	SD	Mean	SD	*P* value
Demographic										
Age	81.1	4.8	74.0	4.8	<.001	77.6	5.4	73.9	5.3	<.001
Body mass index	22.2	2.7	23.4	3.0	<.001	22.3	3.3	23.0	3.2	.002
Skeletal muscle mass index	5.53	0.73	7.16	1.01	<.001	4.23	0.46	5.65	0.94	<.001
Fall related										
Fall incidents, n (%)	48 (38.7)		74 (16.7)		<.001	94 (32.4)		254 (24.8)		.006
Fear of falling, n (%)	84 (67.7)		112 (25.2)		<.001	244 (84.1)		512 (50.0)		<.001
Physical performance										
10-m walking time, s	10.0	3.3	7.7	1.8	<.001	10.0	3.1	7.8	2.0	<.001
Timed up and go test, s	10.2	3.5	6.6	1.9	<.001	9.1	3.0	7.1	1.8	<.001
Functional reach, cm	23.4	6.6	29.8	6.2	<.001	23.9	7.2	26.7	5.8	.011
One leg stand, s	9.5	9.2	20.2	18.3	<.001	12.8	17.5	19.9	15.1	<.001
Five chair stand, s	9.3	1.7	8.2	2.0	.004	9.0	2.1	8.2	2.6	.032
Handgrip strength, kg	23.0	5.4	34.0	5.7	<.001	15.9	2.7	22.9	4.6	<.001

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Validation and translation of the Kihon Checklist (frailty index) into Brazilian Portuguese

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Aim: To translate the Japanese Kihon Checklist (frailty index) into the Portuguese language, and to validate the use of the checklist for the assessment of the elderly Brazilian population.

Methods: A semantic analysis was carried out, along with pretesting of bilingual participants. The checklist was validated against the Edmonton Frail Scale.

Results: A total of 188 Brazilian older adults (mean age 69.5 ± 7.47 years) participated in the present study. In the semantic analysis, six elderly participants reported no difficulty with responding to the Portuguese version of the Kihon Checklist. During pretesting with 21 bilingual participants, we found a strong correlation between the total scores of the original version of the Kihon Checklist in Japanese and the translated version in Portuguese ($r = 0.764$, $P < 0.001$). According to the validation process, which involved 161 participants, there was a significant correlation between the total scores of the Kihon Checklist and the Edmonton Frail Scale ($r = 0.535$, $P < 0.001$), and between each domain of the checklist with the total score of Edmonton Frail Scale (lifestyle $\tau = 0.429$, $P < 0.001$; physical strength $\tau = 0.367$, $P < 0.001$; nutrition $\tau = 0.211$, $P = 0.002$; eating $\tau = 0.213$, $P = 0.001$; socialization $\tau = 0.269$, $P < 0.001$; memory $\tau = 0.285$, $P < 0.001$; and mood $\tau = 0.359$, $P < 0.001$). Furthermore, the Portuguese version of the Kihon Checklist showed satisfactory internal consistency (Cronbach's α coefficient: 0.787).

Conclusions: The Portuguese language version of the Kihon Checklist presented good internal consistency and validity. Therefore, we encourage its application in the elderly Brazilian population with an aim of monitoring their frailty to prevent or delay the functional dependence and any other adverse health outcomes. [Correction added on 14 January 2013, after first online publication: the phrase 'loss of' has been deleted from the preceding statement.] **Geriatr Gerontol Int 2014; 14: 561–569.**

Keywords: community-dwelling older people, Edmonton Frail Scale, frailty, Kihon Checklist, validation.

Introduction

The rapid increase in the number of frail older adults is considered a major healthcare challenge.[1,2] In recent years, the term "frailty" has been repeatedly discussed in the research literature, and several definitions have been proposed.[3] However, there is insufficient evidence to accept a single definition of frailty, and no single definition is currently considered to be a gold standard.[4] In general, there are two predominant approaches to defining frailty: (i) frailty is treated as a count of health impairments;[5,6] and (ii) the frailty phenotype is identified to detect people who find themselves between the independent and the dependent life stages.[7]

Independent of the adopted approach, valid and low-cost frailty assessment tools are required for both research and clinical purposes.[8] Therefore, the Japanese Ministry of Health, Labor and Welfare proposed a frailty index named the "Kihon Checklist" (KCL) that identifies vulnerable older adults as those with a higher risk of becoming dependent.[9,10] The KCL is used for screening frail older adults and is based on the needs of the Japanese long-term care insurance system.[11] The KCL has 25 yes/no questions divided into domains: lifestyle, physical strength, nutrition, eating, socialization, memory and mood (Table 1). A subject is identified as showing frailty if they score 10 points or more in the lifestyle domain. In addition, the results of the KCL can be analyzed separately by each domain. Scoring three

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Table 1 Kihon Checklist

1	Do you use public transport (bus or train) to go out by yourself?	0.Yes	1.No
2	Do you shop for daily necessities?	0.Yes	1.No
3	Do you manage financial matters such as savings or deposits by yourself?	0.Yes	1.No
4	Do you visit the homes of friends?	0.Yes	1.No
5	Do you give advice to friends or family members?	0.Yes	1.No
Physical strength			
6	Are you able to go up stairs without using handrails or the wall for support?	0.Yes	1.No
7	Are you able to stand up from a sitting position without support?	0.Yes	1.No
8	Are you able to walk continuously for 15 minutes?	0.Yes	1.No
9	Have you experienced a fall in the past year?	1.Yes	0.No
10	Do you feel anxious about falling when you walk?	1.Yes	0.No
Nutrition			
11	Has your weight declined by 2–3 kg in the past 6 months without dieting?	1.Yes	0.No
12	Height:_____ m Weight:_____ kg †BMI less than 18.5?	1.Yes	0.No
Eating			
13	Have you experienced more difficulty chewing tough foods than you did 6 months ago?	1.Yes	0.No
14	Do you ever experience choking or coughing when drinking soup or tea?	1.Yes	0.No
15	Do you feel uncomfortable feelings of thirst or dry mouth?	1.Yes	0.No
Socialization			
16	Do you go out at least once a week?	0.Yes	1.No
17	Do you go out less often than you did last year?	1.Yes	0.No
Memory			
18	Do others point out your forgetfulness or tell you "you always ask the same thing"?	1.Yes	0.No
19	When you want to make a call, do you usually search for the telephone number and call on your own?	0.Yes	1.No
20	Do you sometimes not know what the date is?	1.Yes	0.No
Mood			
21	(in the past 2 weeks) You feel no sense of fulfilment in your life.	1.Yes	0.No
22	(in the past 2 weeks) You cannot enjoy things that you enjoyed before.	1.Yes	0.No
23	(in the past 2 weeks) You feel reluctant to do things that you could do easily before.	1.Yes	0.No
24	(in the past 2 weeks) You do not feel that you are a useful person.	1.Yes	0.No
25	(in the past 2 weeks) You feel exhausted for no apparent reason.	1.Yes	0.No
Lifestyle comprises questions 1–20.			

†If body mass index (BMI; weight / height^2) < 18.5, the respondent scores: yes/1 point.

points or more indicates low physical strength in the respective domain, and scoring two points indicates low nutritional status in the respective domain. Scoring two points or more in the eating domain suggests low oral function. A negative answer on question number 16 indicates "house-boundedness", one point or more in the memory domain suggests low cognitive function, and finally, scoring two points or more in the mood domain indicates depression risk.[12,13]

The KCL has been used in several Japanese studies. Ogawa *et al.* concluded that the KCL showed a good concurrent validity against the Fried's criteria for evaluating frailty.[14] The KCL in that study had a sensitivity of 60% and a specificity of 86.4%. Fukutomi *et al.* showed that the risk groups in all categories in the KCL were associated with lower activities of daily living, lower subjective quality of life scores and higher scores on the geriatric depression scale.[12] Another study used the

KCL as an important assessment tool for investigating the cost-effectiveness of a community-based exercise program that reduced and prevented the necessity for care and disability in frail Japanese older adults.[15] Considering the contributions of the KCL to the research, clinical and policy-making spheres, it is an important and versatile measurement that should be extended to countries such as Brazil, which is lacking in frailty assessment tools, that can be easily applied to the aged population and that can be applied to communities where the number of elderly (in Brazil, determined by the chronological age of 60 years or older) is rapidly increasing as other developing countries. Between 1999 and 2009, the number of the country's residents who are aged at least 60 years grew from 9.0% to 11.4%, reaching 21 million inhabitants, according to the Brazilian Institute of Geography and Statistics;[16] and this number is expected to rise to 29.8% of Brazil's total population by the year 2050.[17] Therefore, our purpose was to develop the KCL for use with elderly Brazilian adults by translating a version into Brazilian Portuguese and adapting it to the Brazilian culture.

Methods

This was an epidemiological observational study.

Participants

The participants were recruited by municipal health units and by a recreational club in Curitiba, Paraná State. The inclusion criteria were living in the community, aged 60 years or older and being able to respond to the questionnaire. The additional inclusion criterion for the pretest of the beta version was being bilingual (Japanese and Brazilian Portuguese speaker); and for the validation of the Kihon Checklist – Brazilian Portuguese version was being able to carry out the physical tests. The participants who did not match these criteria or those who did not want to participate in research procedures voluntarily were excluded from the present study. The southern area of the country was chosen because of the large population of Japanese subjects in the region.

The municipal health units regularly organize meetings to promote health education, physical exercise practice, group activity and other activities, and the units were chosen because of their direct contact with a variety of community-dwelling elderly adults. The second recruitment location was a recreational club that promotes Japanese culture with activities directed at all community members, not exclusively Japanese ones. Considering the number of older adults engaged in the activities offered by the health units and the recreational club, the estimated number of members potentially eligible to participate in this research was 120 subjects from the first recruitment location and 250 subjects from the second location.

The subjects were recruited from April to June 2012; the older adults' members of those institutions received oral and written explanation about the research procedures by the researchers themselves and the leaders of the recreational groups offered by those institutions. Participation in the present study was voluntary, and all participants signed an informed consent form. A total of 218 participants were recruited to participate in this research (99 older adults from the health units and 119 members from the recreational club); however, we excluded 30 subjects (15 in each institution) from the analysis because of age lower than 60 years and poor responses in questionnaires, leaving 188 community-dwelling Brazilian older adults (84 from the health units and 104 from the recreational club; Table 2).

Data collections were carried out in June 2012. The study protocol was approved by the Kyoto University Graduate School of Medicine Ethics Committee (E-1575).

Procedures

In accordance with previous validation studies,[18–20] the procedures of the present study consisted of semantic analysis with six volunteers along with pretesting of 21 bilingual participants (Japanese and Brazilian Portuguese speakers), and the validation procedure involved 161 participants.

Translation of Kihon Checklist original version to Brazilian Portuguese language

The translation of the KCL into Brazilian Portuguese was carried out by two native Brazilians members of this study project. Each researcher prepared a Brazilian Portuguese translation, discussed both versions and then prepared an initial Brazilian Portuguese version of the KCL (KCL-PT). This version was then reviewed by a native Brazilian specialist in the Portuguese language.

Next, the KCL-PT was back translated into Japanese by two Brazilian Japanese language experts who were not previously aware of the KCL-PT. The translators received the initial translated version and translated it back into Japanese. After each translator prepared a version, they discussed their translations and then prepared the final KCL-PT back-translated version that was submitted for analysis by a Japanese committee of specialists.

The committee of specialists aimed to verify if the KCL-PT back translation contained any questions with different meanings compared with the original Japanese-language version of the KCL. When the specialists approved the back-translated version, assured of the content similarity between both versions, the version translated into Brazilian Portuguese was

Table 2 Participant characteristics

Variables		Total $n = 188$ Valid % (n)	Semantic $n = 6$ Valid % (n)	Bilinguals $n = 21$ Valid % (n)	Validation $n = 161$ Valid % (n)
Age	Mean ± SD	69.52 ± 7.47	67 ± 9.91	73.81 ± 8.98	69.05 ± 7.0
Sex	Female	74.5 (140)	100 (6)	71.4 (15)	73.9 (119)
Marital status	Single	4.8 (9)	0	4.8 (1)	5 (8)
	Married	54.0 (101)	16.7 (1)	47.6 (10)	56.3 (90)
	Divorced	7.0 (13)	16.7 (1)	4.8 (1)	6.9 (11)
	Widowed	34.2 (64)	66.7 (4)	42.9 (9)	31.9 (51)
Living situation	Alone	17.6 (33)	33.3 (2)	14.3 (3)	17.4 (28)
	With partner	30.3 (57)	0	23.8 (5)	32.3 (52)
	With child	21.8 (41)	16.7 (1)	23.8 (5)	21.7 (35)
	With partner and child	24.5 (46)	16.7 (1)	28.6 (6)	24.2 (39)
	Other	5.3 (10)	33.3 (2)	9.5 (2)	3.7 (6)
Educational level	Elementary school	42.3 (77)	50 (3)	33.3 (6)	43 (68)
	Junior high school	15.4 (28)	33.3 (2)	16.7 (3)	14.6 (23)
	High school	12.6 (23)	0	22.2 (4)	12 (19)
	University	25.8 (47)	0	16.7 (3)	27.8 (44)
	Other	3.8 (7)	16.7 (1)	11.2 (2)	2.6 (4)
Japanese descent	Yes	51.1 (95)	0	100 (21)	46.5 (74)
Activity	Work	22.9 (40)	66.7 (4)	10 (2)	22.8 (34)
	Volunteer	10.9 (19)	0	20 (4)	10.1 (15)
	Retirement	66.3 (116)	33.3 (2)	70 (14)	67.1 (100)
Medication	Yes	82.4 (155)	100 (6)	71.4 (15)	83.2 (134)
No. medications	Mean ± SD	2.68 ± 2.24	4 ± 1.41	3.4 ± 1.96	3.23 ± 2.07
Frequency of medical consultation (past 6 months)	None	12.5 (23)	0	14.3 (3)	12.7 (20)
	1–2 times	59.8 (110)	40 (2)	76.2 (16)	58.2 (92)
	3–4 times	17.9 (33)	20 (1)	9.5 (2)	19 (30)
	5 times or more	9.8 (18)	40 (2)	0	10.2 (16)
Hospitalization (last year)	Yes	12.4 (23)	16.7 (1)	4.8 (1)	13.2 (21)
Self-rated health	Very good to good	48.1 (90)	16.7 (1)	52.3 (11)	48.8 (78)
	Normal	34.8 (65)	33.3 (2)	33.3 (7)	35 (56)
	Not so good to bad	17.1 (32)	50 (3)	14.3 (3)	16.3 (26)
Life satisfaction	Very satisfied to satisfied	87.7 (165)	66.7 (4)	90.4 (19)	88.2 (142)
	Nor satisfied neither unsatisfied	6.9 (13)	16.7 (1)	4.8 (1)	6.8 (11)
	A bit unsatisfied to unsatisfied	5.3 (10)	16.7 (1)	4.8 (1)	4.9 (8)
BMI	Mean ± SD	26.15 ± 4.55	32.59 ± 5.25	24.24 ± 2.79	26.16 ± 4.5

BMI, body mass index.

designated the KCL-PT alpha version, and the study proceeded to semantic analysis.

Semantic analysis of the Kihon Checklist Brazilian Portuguese alpha version

The study volunteers were asked to answer the KCL-PT alpha version and a feedback report. The report was analyzed to verify if there was any topic in the checklist that was difficult to understand. If there was a topic with such a problem, we modified the checklist and restarted the semantic analysis. When the feedback reports indicated satisfaction with the modified checklist, we designated the modified version as the beta version (Table 3) and submitted it for pretesting with bilingual participants.

Pretest of beta version with bilingual participants (Japanese and Brazilian Portuguese speakers)

The volunteers were asked to answer the two KCL versions (the KCL original version in Japanese and the KCL-PT beta version in Portuguese). When both checklists correlated significantly (see statistical analysis section for further details), we designated the Portuguese version as the KCL-PT and submitted it for validation.

Table 3 Kihon Checklist Brazilian Portuguese beta version

1	Você consegue usar ônibus ou trem sem necessidade de ajuda?	0.Sim	1.Não
2	Você faz compras para o seu dia a dia sem necessidade de ajuda?	0.Sim	1.Não
3	Você administra sua conta/poupança bancária sozinho (a)?	0.Sim	1.Não
4	Você visita à casa de seus amigos?	0.Sim	1.Não
5	Você conversa com seus familiares ou amigos?	0.Sim	1.Não
6	Você sobe escada sem o apoio de corrimão ou parede?	0.Sim	1.Não
7	Você se levanta da cadeira sem usar o braço da mesma como apoio?	0.Sim	1.Não
8	Você caminha mais do que 15 minutos?	0.Sim	1.Não
9	Você sofreu alguma queda (caiu) no último ano?	1.Sim	0.Não
10	Você sente medo de cair?	1.Sim	0.Não
11	Nos últimos 6 meses, você emagreceu 2 a 3 quilos (sem estar de dieta)?	1.Sim	0.Não
12	Qual a sua altura?_____m Qual o seu peso? _____kg †IMC menor que 18.5?	1.Sim	0.Não
13	É correto afirmar que "você não consegue comer alimentos de consistência dura tão bem como 6 meses atrás"?	1.Sim	0.Não
14	Você se engasga quando toma chá ou sopa?	1.Sim	0.Não
15	Você se sente desconfortável com a sensação de boca seca?	1.Sim	0.Não
16	Você sai de casa mais do que uma vez por semana?	0.Sim	1.Não
17	Em comparação ao último ano, você tem saído menos de casa?	1.Sim	0.Não
18	As pessoas tem chamado sua atenção quanto ao seu esquecimento, como: "você faz as mesmas perguntas o tempo todo"?	1.Sim	0.Não
19	Você faz ligações telefônicas checando você mesmo o número de telefone?	0.Sim	1.Não
20	É correto afirmar que "às vezes, você não sabe que dia ou mês é hoje"?	1.Sim	0.Não
21	Nas últimas 2 semanas, você está insatisfeito com sua vida diária?	1.Sim	0.Não
22	Nas últimas 2 semanas, você acha sem graça as atividade com as quais você se divertia antes?	1.Sim	0.Não
23	Nas últimas 2 semanas, você sente dificuldade ao fazer coisas que antes achava fácil de fazer?	1.Sim	0.Não
24	Nas últimas 2 semanas, você sente que não é mais útil para os outros?	1.Sim	0.Não
25	Nas últimas 2 semanas, você se sente exausto sem razão?	1.Sim	0.Não

†Se Índice de Massa Corporal (=peso / altura^2) < 18.5, o respondente assinala: sim/1 ponto.

Validation of the Kihon Checklist Brazilian Portuguese version

The participants were asked to carry out two assessments that measure frailty, the KCL-PT and the Edmonton Frail Scale (EFS), which was chosen because it has already been translated to Portuguese, adapted to Brazilian culture and successfully validated in Brazil.[18] In addition, the EFS was chosen because it has potential as a practical and clinical measure of frailty with good construct validity, good reliability, and acceptable internal consistency.[21] The EFS addresses cognition, balance and mobility, mood, functional independence, medication use, social support, nutrition, healthy attitudes, continence, burden of medical illness, and quality of life. Higher levels of frailty on the EFS are represented by higher scores, with a maximum possible score of 17 points.[18]

Statistical analysis

The Kolmogorov–Smirnov test was used to verify the normality of the data. Descriptive analysis was used to verify the feedback reports during the semantic analysis. We used Spearman's correlation analysis to investigate the correlation between the total scores of the original Japanese version of the KCL and the KCL-PT during pretesting with bilingual participants, and to verify the correlation between the KCL-PT and the EFS during the validation process. In addition, we used Kendall's Tau to verify the correlation between each KCL-PT domain with the total score of the EFS. The bivariate comparisons of the EFS total score between the KCL-PT frail participants and non-frail participants were analyzed with the Mann–Whitney *U*-test. Multiple regression analysis was used to verify the contributions of the KCL-PT to the EFS. Finally, we calculated a Cronbach's α coefficient to verify the internal consistency of the KCL-PT. All analyses were carried out using the Statistical Package for the Social Science (SPSS; IBM, Chicago, IL, USA), version 20.0.

Results

Translation process

After the analysis by the Japanese specialists, it was suggested that we modify question number 14 of the

back-translated KCL-PT version. The newly generated version was submitted for a second analysis and was subsequently approved.

Semantic analysis

In the semantic analysis, a total of six community-dwelling Brazilian older women (mean age 67.0 ± 9.91 years) answered the KCL-PT alpha version and the feedback report. The majority of participants (66.7%) required approximately 10–15 min to respond to the KCL-PT alpha version, and the language used in the checklist was considered to be very easy or easy to understand, according to their reports. In addition, the participants reported that the checklist contained no questions that were difficult to answer or uncomfortable. All participants reported that the checklist included their main questions regarding frailty.

Bilingual participants

A total of 21 participants (mean age 73.8 ± 8.98 years) answered both versions of the KCL. The median scores of the original Japanese KCL was 2 points (minimum 0 to maximum 9), and the median scores of the KCL-PT beta version in Brazilian Portuguese language was also 2 points (minimum 0 to maximum 6). There was a strong correlation between the total mean scores of both versions ($r = 0.764$, $P < 0.001$).

Validation process

A total of 161 participants (mean age 69.1 ± 7.0 years) answered the KCL-PT and the EFS. The median score of the KCL-PT was 3.5 points (considered to represent non-frailty according to the reference score, min 0–max 13), and the median score of the EFS was 3 points (considered to represent non-frailty according to the reference score, minimum 0 to maximum 10). Furthermore, the total scores of the KCL-PT and EFS presented a significant correlation ($r = 0.535$, $P < 0.001$) when analyzed with Spearman's correlational analysis and scatter plot (Fig. 1).

The KCL-PT (25 items) showed a satisfactory internal consistency (Cronbach's α coefficient: 0.787). The median score for the various domains was as follows: lifestyle, 3 points (minimum 0 to maximum 13); physical strength, 1 point (minimum 0 to maximum 5); nutrition, 0 points (minimum 0 to maximum 1); eating, 1 point (minimum 0 to maximum 3); socialization, 0 points (minimum 0 to maximum 2); memory, 1 point (minimum 0 to maximum 3); and mood, 0 points (minimum 0 to maximum 5).

Furthermore, all the domains of the KCL-PT correlated with the total score of EFS. The KCL-PT score explained approximately 39% of the EFS score

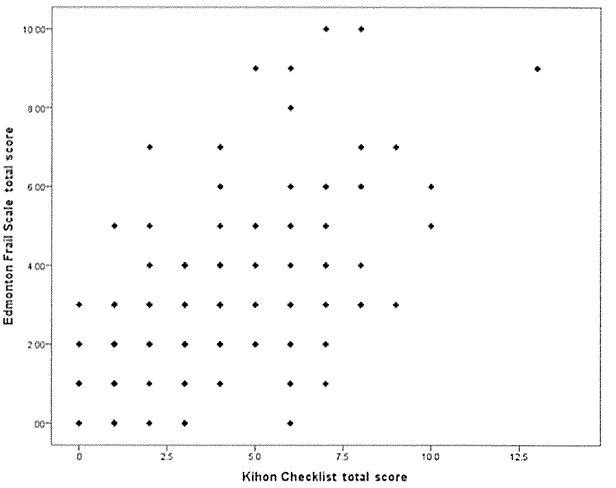

Figure 1 Correlation between the total scores of the Kihon Checklist and the Edmonton Frail Scale.

($R^2 = 0.387$, $P < 0.001$). The domain with the highest influence on the EFS score was physical strength (coefficient β = 0.330, $P = 0.03$), followed by mood (coefficient β = 0.196, $P = 0.01$; Table 4).

The participants were divided into non-frail and frail groups according to the KCL-PT frailty score cut-off points, and we verified that the EFS total score differed significantly between the groups. The KCL-PT frail group was also frailer than the non-frail group according to the EFS, as they presented higher total scores (Table 5).

Discussion

The results of the translation and validation of the KCL-PT procedures were satisfactory. The total score of the Brazilian Portuguese language beta version strongly correlated with the original version of the KCL ($r = 0.764$, $P < 0.001$), as we observed in the results of the pretesting with bilingual participants. In the validation procedure, the total scores of the KCL-PT and the EFS were moderately correlated ($r = 0.535$, $P < 0.001$), and all domain scores of the KCL-PT were correlated with the EFS total score. Furthermore, there was a difference in EFS total scores between the participants who were considered frail and those who were considered non-frail according to the KCL-PT.

The KCL-PT domain with the highest influence on the EFS total score was physical strength (coefficient β = 0.330, $P = 0.03$). Several studies consider that physical function is a particularly important aspect when determining frailty, and have reported that a decline of muscle mass, mobility and balance is associated with becoming frail.[22–24] Therefore, it is valuable to focus on physical function to prevent disabilities in carrying out