Physical activity measures

In physical activity, a valid, accurate and reliable pedometer, Yamax Power walker EX-510 (Yamasa, Tokyo, Japan) was used to measure free-living step counts.[31] Participants were instructed to wear the pedometer in their pocket on the side of the dominant leg for 14 consecutive days except when bathing, sleeping and carrying out water-based activities. This pedometer has a 30-day data storage capacity. We calculated the averages of their daily step counts for 2 weeks.

Statistical analysis

The t-test and χ^2-test were used to compare the results of measurements between faller and non-faller groups. The relationship between the global brain atrophy and the other measurements was investigated with the Spearman's correlation coefficient. The partial correlation coefficient between the global brain atrophy and the other measurements were adjusted for age. Multivariate logistic regression analysis using a stepwise method was carried out to investigate whether age, sex, body mass index (BMI), Global Brain Atrophy Index, word fluency animals, CDT, maximum walking time and TUG were independently associated with the fall incident. Data were analyzed using the Statistical Package for Social Science, Windows version 20.0 (SPSS, Chicago, IL, USA).

Results

There were no significant differences in age (fallers 78.2 ± 7.1 years, non-fallers 77.7 ± 5.4 years, $P = 0.53$), percentage of female (fallers 80.0%, non-fallers 71.4%, $P = 0.48$), height (fallers 150.7 ± 11.9 cm, non-fallers 153.2 ± 7.9 cm, $P = 0.37$), weight (fallers 52.9 ± 12.4 kg, non-fallers 50.5 ± 7.8 kg, $P = 0.74$) or BMI (fallers 23.2 ± 3.7, non-fallers 21.5 ± 2.8, $P = 0.39$) between the two groups (Table 1).

The fallers had significantly worse scores than the non-fallers in the Global Brain Atrophy Index (fallers 13.9 ± 8.3, non-fallers 6.8 ± 3.8, $P = 0.01$), CDT (fallers 8.2 ± 1.1, non-fallers 9.3 ± 0.8, $P = 0.01$), Verbal Fluency Test (animal; fallers 6.2 ± 2.7, non-fallers 9.5 ± 3.9, $P = 0.02$), maximum walking time (fallers 10.4 ± 4.4, non-fallers 7.5 ± 1.7, effect size 0.64, $P = 0.03$) and TUG (fallers 13.5 ± 7.0, non-fallers 8.9 ± 1.9, $P = 0.01$). However, the other measurements were not significantly different between the two groups ($P > 0.05$; Table 1, Fig. 1).

Table 1 Comparison of demographic characteristics and measurements between the groups

	Faller $n = 10$		Non-faller $n = 21$		E/S	P-value
	Mean	SD	Mean	SD		
Characteristics						
Age	78.2	7.1	77.7	5.4	0.08	0.53
BMI	23.2	3.7	21.5	2.8	0.45	0.39
Sex (female), n (%)	8 (80.0%)		15 (71.4%)			0.48
Disease (MCI), n (%)	5 (50.0%)		6 (28.5%)			0.32
Brain volume						
Global brain atrophy, %	13.9	8.3	6.8	3.8	0.86	0.01
Cognitive function						
Mini-Mental State Examination, points	24.7	3.8	23.7	2.5	0.27	0.59
Word Fluency Test (animals), number	6.2	2.7	9.5	3.9	0.84	0.02
Letter Fluency Test (ka), number	6.0	2.4	6.0	2.6	0.00	0.88
Clock Drawing Test, points	8.2	1.1	9.3	0.8	0.92	0.01
Trail Making Test Part-A, sec	78.7	43.2	72.3	16.1	0.15	0.53
Physical function						
Comfortable walking time, sec	12.1	4.0	10.1	2.5	0.53	0.07
Maximum walking time, sec	10.4	4.4	7.5	1.7	0.64	0.03
Timed Up & Go Test, sec	13.5	7.0	8.9	1.9	0.65	0.01
Functional Reach, cm	18.8	8.5	22.2	6.4	0.41	0.36
One-Leg Standing time, sec	6.5	11.3	16.7	18.8	0.91	0.06
Five Chair Stands, sec	11.9	2.8	10.5	3.2	0.48	0.18
Activity						
Physical activity, steps	3167.9	2213.1	4499.8	2934.4	0.45	0.21

MCI, mild cognitive impairment.

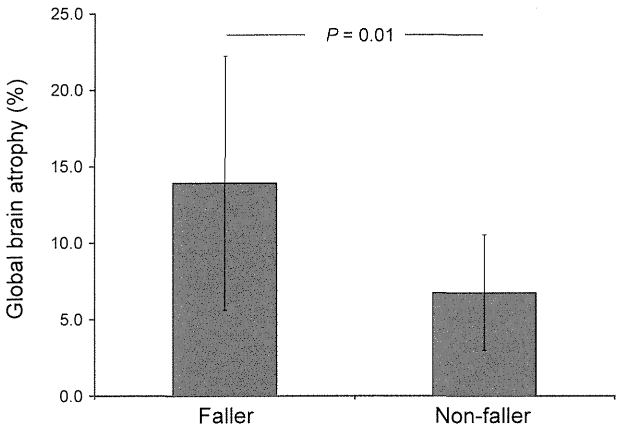

Figure 1 Comparison of Global Brain Atrophy Index (%) between the groups. The fallers ($n = 10$) had significantly worse scores than the non-fallers ($n = 21$) in the Global Brain Atrophy Index.

To determine the association of global brain atrophy with their demography, cognitive function, physical performance and physical activity, we determined Pearson's correlation coefficients. Table 2 shows that the Global Grain Atrophy Index was correlated with age ($r = 0.435$, $P < 0.05$), Verbal Fluency Test (animal; $r = -0.641$, $P < 0.05$), Verbal Fluency Test with letter (ka; $r = -0.320$, $P < 0.05$), CDT ($r = -0.338$, $P < 0.05$), comfortable walking time ($r = 0.555$, $P < 0.05$), maximum walking time ($r = 0.543$, $P < 0.05$), TUG ($r = 0.630$, $P < 0.05$), OLS ($r = -0.581$, $P < 0.05$), 5CS ($r = 0.437$, $P < 0.05$) and physical activity ($r = -0.389$, $P < 0.05$; Table 2).

To age-adjust the association of Global Brain Atrophy Index with their demography, cognitive function, physical performance and physical activity, we analyzed partial correlation coefficients. Table 2 shows that global brain atrophy was correlated with BMI ($r = 0.308$), Verbal Fluency Test (animal; $r = -0.522$, $P < 0.05$), Verbal Fluency Test with letter (ka; $r = -0.337$, $P < 0.05$), CDT ($r = -0.547$, $P < 0.05$), TUG ($r = 0.276$, $P < 0.05$) and 5CS ($r = 0.303$, $P < 0.05$; Table 2).

Stepwise regression analysis showed that the Global Brain Atrophy Index ($\beta = 1.265$, 95% CI 1.022–1.567) was a significant and independent determinant of falls ($R^2 = 0.356$, $P = 0.003$; Table 3).

Table 2 Correlation coefficients for global brain atrophy and other measurements

	Global brain atrophy	Global brain atrophy (adjusted for age)
Characteristics		
Age	0.435	
Cognitive function		
Mini-Mental State Examination	0.019	−0.147
Word Fluency Test (animals)	−0.641	−0.522
Letter fluency Test (ka)	−0.320	−0.337
Clock Drawing Test	−0.338	−0.547
Trail Making Test Part-A	0.067	0.053
Geriatric Depression Scale	0.210	0.181
Physical function		
Comfortable walking time	0.555	0.205
Maximum walking time	0.543	0.221
Timed Up & Go Test	0.630	0.276
Functional reach	−0.121	−0.009
One-Leg Standing time	−0.581	−0.204
Five Chair Stands	0.473	0.303
Activity		
Physical activity	−0.389	−0.169

Table 3 Logistic regression analysis

Independent variables	Adjusted R^2 value = 0.356 Standard regression value	 95% CI
Age	–	–
Sex	–	–
BMI	–	–
Brain atrophy index	1.265	1.022–1.567
Word Fluency (animals)	–	–
Clock Drawing Test	–	–
Maximum walking time	–	–
Timed Up & Go Test	–	–

BMI, body mass index.

Discussions

The present study showed that the fall incident might relate to global brain atrophy in older adults with mild cognitive disorders. The fallers also showed a significantly higher Global Brain Atrophy Index, and lower physical and cognitive performance scores than the non-fallers. Age-adjusted correlation analyses showed that the Global Brain Atrophy Index was weakly correlated with several cognitive and motor performances. Furthermore, stepwise regression analysis showed that the Global Brain Atrophy Index was a significant and independent determinant of the fall incident. Taken together, these findings led us to conclude that measuring global brain atrophy is potentially important to predict falls in patients with mild cognitive disorders.

The mechanisms by which global brain atrophy associates with fall incident and poor physical performance are not well understood. It is possible that global brain atrophy is related to poor neural connectivity. However, we assume that global brain atrophy is mostly attributed to the volume loss in the frontal lobe, because Rosano *et al.* suggested that a smaller prefrontal region was associated with slower gait speed.[32] In contrast, it has been shown that atrophy of dorsolateral prefrontal regions is associated with poorer executive function.[33] Previous imaging research has also shown that brain atrophy is associated with impaired physical and executive functions.[17,34] As expected, physical and executive functions have been associated with an increased fall risk in older adults.[35,36] These reports and the present study suggested that the function of the frontal lobe is associated with the risk of falls, and brain atrophy index can be a biomarker to predict falls.

There are several limitations in the present study. First, the limited sample size might introduce some error of inference, reduce the power of the analysis and limit generalization. Second, global brain atrophy might not be able to predict falls in more robust older adults, as the present study was based on the participants having experienced falls in the previous year. Further study is required to confirm our finding in patients who do not have an experience of falls. Finally, detailed information on falls was lacking. Therefore, the relationship between the decline of frontal lobe function and fall incidents requires further investigation. Thus, the results of the present study should be interpreted with caution.

In conclusion, this is the first study to show that global brain atrophy is associated with fall incident, motor and cognitive performance in older adults with mild cognitive disorders. From the present results, global atrophy might be indicted as one of risk factors for falls in older adults with mild cognitive disorders. Further investigation, such as a prospective study, is required to confirm the present study.

Acknowledgments

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Disclosure statement

None of the authors have conflicts of interest or financial disclosures.

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Original Study

Prevalence of Sarcopenia in Community-Dwelling Japanese Older Adults

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Keywords:
Prevalence of sarcopenia
older adults
Japanese

ABSTRACT

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 authors declare no conflicts of interest.

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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 comorbidities 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

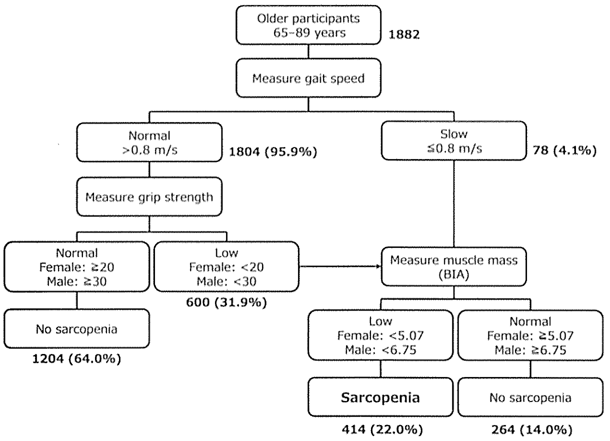


Fig. 1. The prevalence of sarcopenia, low muscle mass, poor physical performance, and low muscle strength according to the EWGSOP-suggested algorithm for sarcopenia in our study participants (n = 1882).

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 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.

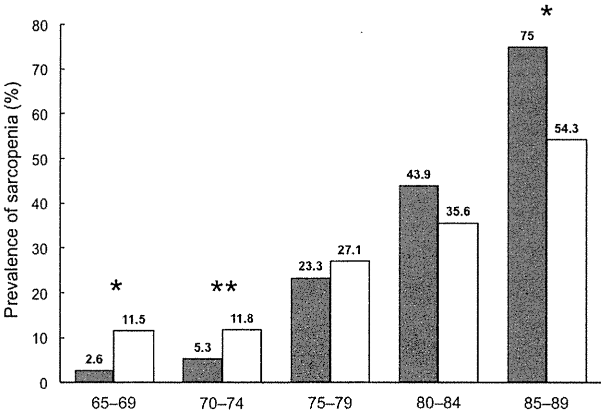
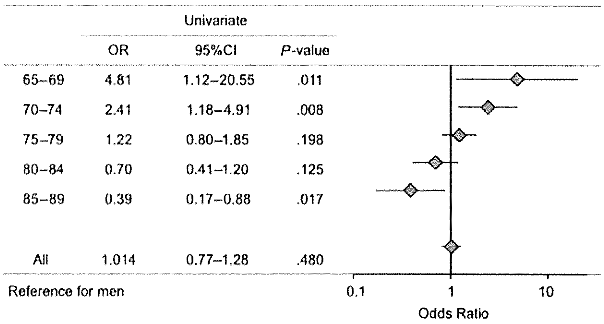


Fig. 2. The prevalence of sarcopenia is shown in each gender and each age group. Closed column: men; open column: women. *P < .05, **P < .01, men versus women.



	Univariate		
	OR	95%CI	*P*-value
65–69	4.81	1.12–20.55	.011
70–74	2.41	1.18–4.91	.008
75–79	1.22	0.80–1.85	.198
80–84	0.70	0.41–1.20	.125
85–89	0.39	0.17–0.88	.017
All	1.014	0.77–1.28	.480

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

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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Original Research Article

Cognitive Decline Predicts Long-Term Care Insurance Requirement Certification in Community-Dwelling Older Japanese Adults: A Prospective Cohort Study

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Key Words
Cognitive decline · Long-term care insurance requirement · Older Japanese adults · Prospective cohort study

Abstract

Aim: The purpose of this prospective cohort study is to examine whether cognitive decline is an independent predictor of new long-term care insurance (LTCI) requirement certifications in Japan. ***Methods:*** A total of 5,765 community-dwelling older Japanese adults who, at baseline, were independent in terms of their activities of daily living participated in this study and were followed up for 18 months. The outcome measure was the number of new LTCI requirement certifications during the 18-month period of the study. We collected demographic information through questionnaires and assessed cognitive skills with the Cognitive Performance Scale (CPS). The participants were divided into 3 groups according to CPS scores (0, 1, and 2 or greater). ***Results:*** During the 18-month period, 399 subjects (6.9%) became newly certified for LTCI services. In a multivariate Cox proportional hazards model, older participants with a CPS score of 1 (adjusted HR: 1.39, 95% CI: 1.08–1.77) and 2 or greater (adjusted HR: 2.27, 95% CI: 1.74–2.96) were significantly more likely to receive an LTCI certification compared to those with a CPS score of 0. ***Conclusions:*** Cognitive decline is an independent predictor of new LTCI requirement certifications and the severity of cognitive decline in elderly adults is positively associated with receiving an LTCI requirement certification in Japan.

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Introduction

Frailty in older adults is a serious problem in countries with increasingly aging populations, such as Japan. In general, frailty is defined as a vulnerable state that places older adults at a high risk for adverse health outcomes, such as falls, hospitalization, and mortality [1].

To help manage an extremely rapidly aging population and care for the frail properly, in April 2000 Japan implemented a long-term care insurance (LTCI) system. Before 2000, long-term care services were provided under a tax-based social welfare system for senior citizens with limited economic resources and family support [2]. However, after the LTCI implementation, the services of this program have been provided to older adults who are certified as requiring support or care according to the certification assessment of their care needs [3]. The selection process for classifying dependent older adults involves evaluations of the persons' current mental and physical condition and objective assessments [4]. Thus, those who are certified as requiring LTCI services have variable risk factors associated with frailty.

A survey by the Japanese Ministry of Health, Labour and Welfare revealed that dementia is one of the main reasons for which people require LTCI services. Dementia affects 5–8% of the population over 65 years of age [5] and up to 30% of people aged 85 years and above [6], and its prevalence is currently increasing. It is clear that dementia and Alzheimer's dementia (AD) are associated with mortality [7]. A previous study reported a positive association between physical frailty and cognitive impairment [8]. Furthermore, physical frailty has been associated with a risk for mild cognitive impairment (MCI) and a rapid rate of cognitive decline with age [9]. It has also been shown that cognitive decline is associated with frailty in Japan, and it is one of the predictors of frailty leading to the need for long-term care [10]. However, no studies have determined whether cognitive decline can be an independent predictor of new LTCI requirement certifications.

To fill this gap, the current prospective cohort study examines whether a new LTCI requirement certification can be predicted by using cognitive performance measures. We focused on whether the level of cognitive decline is related to receiving a new LTCI requirement certification among community-dwelling elderly Japanese people.

Materials and Methods

Subjects

We analyzed a portion of the cohort data from a prospective study, the Japan Multicenter Aging Cohort for Care Prevention (J-MACC). This cohort study investigated the factors associated with the need for LTCI services in community-dwelling Japanese adults aged 65 years or older living in Maibara City, Shiga Prefecture. In 2011, the total population was 39,889, the total area 250.46 km^2, and the rate of the aging population 25.3%. We recruited 8,233 community-dwelling older adults who were independent in their activities of daily living (ADL), and the baseline questionnaires were mailed to participants in April 2011 (response rate of 96%). These questionnaires were mainly self-administered. However, if the participants could not answer questions independently, a family member assisted them or answered the questions on their behalf. Older adults who were already ADL-dependent and already receiving benefits from LTCI services were excluded. Furthermore, in the database, we excluded older adults who had missing baseline questionnaire data. Therefore, our analysis was performed with data from 5,765 older adults who were then followed up for 18 months. 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.

Cognitive Performance

We assessed cognitive performance by using the Cognitive Performance Scale (CPS) [11]. The CPS is based on a decision tree algorithm that includes items assessing daily decision-making, short-term memory, ability to make oneself understood, and ability to feed oneself. Cognitive decline is rated on a scale from 0 to 6 (0 = normal, 1 = borderline intact, 2 = mild, 3 = moderate, 4 = moderate-severe, 5 = severe, and 6 = very severe) [11]. The CPS is positively associated with the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment, which are well-known tools for the detection of cognitive impairment and MCI, respectively [12, 13]. In the present study, we divided participants into 3 groups according to their CPS scores (0 = normal, 1 = borderline intact, and 2 or greater = cognitive impairment), which have been shown to be highly correlated with MMSE scores in previous studies, thus indicating high convergent validity [12, 14].

Outcome Measurement

The outcome measure was the receipt of an LTCI requirement certification during the 18-month study period. Dependent older adults are classified according to the following procedure: first, a 74-item questionnaire is administered to evaluate the person's current mental and physical condition, and responses are analyzed using a computerized algorithm [4]. Subsequently, the person receives a home visit and a recommendation from his or her physician. Based on the questionnaire and home visit data, a long-term care approval board makes the final decision. Individuals who become certified as 'dependent older adults' are subdivided into seven levels (support levels 1 and 2, and care levels 1–5) based on their physical condition. Certified adults are provided home services and community-based or institutional services according to their care needs. Individuals who are not eligible for long-term care or support care may utilize preventive care services. In the present study, the city government recorded the date when individuals had been certified as meeting the LTCI requirements, and we updated our database as appropriate.

Covariate Measurement

In the baseline questionnaires, we obtained demographic information on age, gender, body mass index (BMI), the number of medications used (none, 1, 2, 3, or more), family structure (living alone, living in an elderly household, or other), subjective household economic status (very good, good, fair, or bad), and medical history (musculoskeletal disorder, hypertension, lipid disorder, stroke, diabetes, heart disease, respiratory disease, external injury, and cancer).

Statistical Analysis

The baseline characteristics of the participants who were newly certified or not certified as requiring LTCI services were compared using a Student t test or a χ^2 test. In addition, the differences in demographic variables among the 3 groups stratified by CPS score were examined using ANOVA with a post hoc test or a χ^2 test.

Kaplan-Meier survival curves were calculated for the 3 groups of participants newly certified as requiring LTCI services. Using the Cox proportional hazards model, the hazard ratio (HR) and the 95% confidence interval (CI) were estimated to evaluate, in univariate and multivariate analyses, the impact of cognitive decline on the time of receiving an LTCI requirement certification. In the multivariate analysis, the results were adjusted for age, gender, BMI, medication use, family structure, subjective household economy, and medical

Table 1. Baseline demographic differences in the LTCI service requirement certification during the 18-month follow-up

	LTCI requirement certification (n = 399)	No LTCI requirement certification (n = 5,366)	p
Age, years[a]	80.7±6.9	74.2±6.6	<0.001**
Female gender[b]	237 (59.4)	2,829 (52.7)	0.011*
BMI[a]	22.2±3.5	22.7±3.1	0.012*
CPS score[b]			<0.001**
0	232 (58.1)	4,091 (76.2)	
1	89 (22.3)	942 (17.6)	
2 or greater	78 (19.5)	333 (6.2)	
Number of medications taken[b]			<0.001**
0	41 (10.3)	1,021 (19.0)	
1	35 (8.8)	809 (15.1)	
2	59 (14.8)	943 (17.6)	
3 or more	264 (66.2)	2,593 (48.3)	
Family structure[b]			<0.001**
Single	70 (17.5)	491 (9.2)	
Elderly household	73 (18.3)	1,521 (28.3)	
Other	256 (64.2)	3,354 (62.5)	
Subjective household economic status[b]			0.475
Very good	22 (5.5)	218 (4.1)	
Good	141 (35.3)	2,022 (37.7)	
Fair	167 (41.9)	2,228 (41.5)	
Bad	69 (17.3)	898 (16.7)	
Medical history[b]			
Musculoskeletal disorder	88 (22.1)	685 (12.8)	<0.001**
Hypertension	170 (42.6)	2,452 (45.7)	0.252
Lipid disorder	22 (5.5)	429 (8.0)	0.082
Stroke	25 (6.3)	202 (3.8)	0.022*
Diabetes	40 (10.0)	650 (12.1)	0.231
Heart disease	80 (20.1)	702 (13.1)	<0.001**
Respiratory disease	37 (9.3)	251 (4.7)	<0.001**
External injury	18 (4.5)	158 (2.9)	0.095
Cancer	25 (6.3)	207 (3.9)	0.024*

Values are mean ± SD or n (%). * $p < 0.05$; ** $p < 0.01$. [a] Assessed by Student's t test. [b] Assessed by χ^2 test.

history. Survival time was defined as the time between enrollment (the baseline measurements) and either time of receiving an LTCI service requirement certification or the end of the follow-up period (October 2012).

Statistical analyses were carried out using SPSS version 20.0 (SPSS, Chicago, Ill., USA), with a significance threshold of 0.05.

Results

Demographic Data

During the 18 months of the study, 399 subjects (6.9%) became newly certified as requiring LTCI services (table 1). Those who were certified for LTCI requirement were significantly older (80.7 ± 6.9 vs. 74.2 ± 6.6 years, $p < 0.001$) and had a lower BMI (22.2 ± 3.5 vs.

Table 2. Baseline demographic differences according to CPS scores

	CPS score				
	0 (n = 4,323)	1 (n = 1,031)	2 or greater (n = 411)	p value for trend	post hoc test
Age, years[a]	74.1±6.6	75.3±7.1	77.9±7.3	<0.001**	c–e
Female gender[b]	2,374 (54.9)	501 (48.6)	191 (43.3)	<0.001**	
BMI[a]	22.7±3.1	22.4±3.2	22.2±3.3	0.001**	c, e
Medications[b]				<0.001**	
0	853 (19.7)	154 (14.9)	55 (12.5)		
1	675 (15.6)	141 (13.7)	28 (6.3)		
2	792 (18.3)	156 (15.1)	54 (12.2)		
3 or more	2,003 (46.3)	580 (56.3)	274 (62.1)		
Family structure[b]				0.016*	
Single	401 (9.3)	104 (10.1)	56 (12.7)		
Elderly household	1,216 (28.1)	298 (28.9)	80 (18.1)		
Other	2,706 (62.6)	629 (61.0)	275 (66.9)		
Subjective household economic status[b]				<0.001**	
Very good	664 (15.4)	190 (18.4)	113 (25.6)		
Good	1,765 (40.8)	460 (44.6)	170 (38.5)		
Fair	1,701 (39.3)	341 (33.1)	121 (27.4)		
Bad	193 (4.5)	40 (3.9)	7 (1.6)		
Medical history[b]					
Musculoskeletal disorder	571 (13.2)	140 (13.6)	62 (14.1)	0.557	
Hypertension	1,949 (45.1)	489 (47.4)	184 (41.7)	0.380	
Lipid disorder	358 (8.3)	63 (6.1)	30 (6.8)	0.061	
Stroke	138 (3.2)	43 (4.2)	46 (10.4)	<0.001**	
Diabetes	504 (11.7)	133 (12.9)	53 (12.0)	0.454	
Heart disease	538 (12.4)	169 (16.4)	75 (17.0)	<0.001**	
Respiratory disease	183 (4.2)	63 (6.1)	42 (9.5)	<0.001**	
External injury	109 (2.5)	43 (4.2)	24 (5.4)	<0.001**	
Cancer	151 (3.5)	56 (5.4)	25 (5.7)	0.002**	

Values are mean ± SD or n (%). * $p < 0.05$; ** $p < 0.01$. CPS score: 0 (normal), 1 (borderline intact), 2–6 (cognitive impairment). [a] Assessed by ANOVA. [b] Assessed by χ^2 test. [c] Significant difference between a CPS score of 0 and a CPS score of 1. [d] Significant difference between a CPS score of 1 and a CPS score of 2 or greater. [e] Significant difference between a CPS score of 0 and a CPS score of 2 or greater.

22.7 ± 3.1, p = 0.012) than those who were not certified. More women than men became certified in this cohort (females: 59.4%; males: 52.7%, p = 0.011). In addition, there were significant differences in the rates of high CPS scores, medication use, family structure, and some of the medical history items between the groups (table 1).

The baseline demographic data of the participants stratified into 3 groups according to CPS score are shown in table 2. The number of older adults with a CPS score of 0 was 4,323 (75.0%), with a CPS score of 1 it was 1,031 (17.9%), and with a CPS score of 2 or greater it was 411 (7.1%). ANOVA showed that older adults with a CPS score of 0 were significantly younger (CPS score 0: 74.1 ± 6.6 years vs. CPS score 1: 75.3 ± 7.1 years vs. CPS score 2 or greater: 77.9 ± 7.3 years) and had a higher BMI (CPS score 0: 22.7 ± 3.1 vs. CPS score 1: 22.4 ± 3.2 vs. CPS score 2 or greater: 22.2 ± 3.3) than those with a CPS score of 1 or 2 or greater (p < 0.01). In addition, there were significant differences in gender, medication use, family structure, household economy, and some of the medical history items between the 3 groups (table 2).

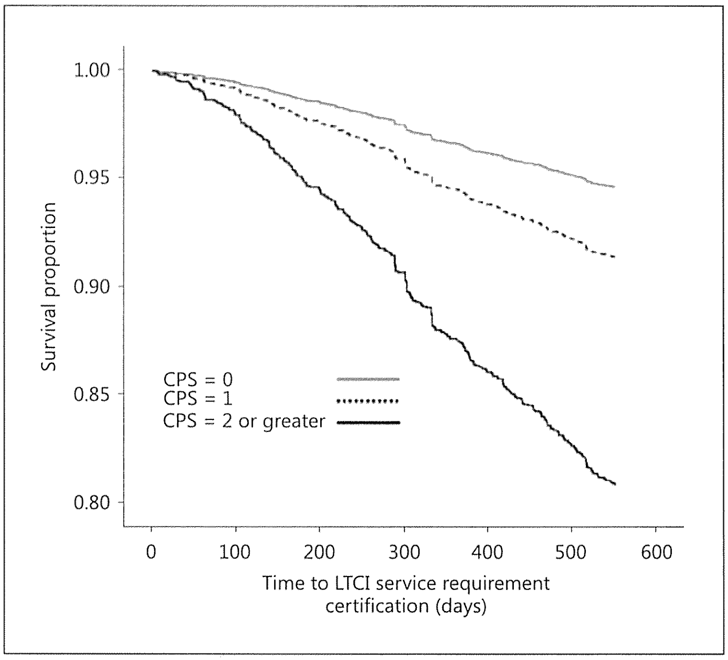

Fig. 1. Kaplan-Meier survival curves illustrating the percentage of subjects who were not certified for LTCI services. During the study period, 232 (5.4%), 89 (8.6%), and 78 (19.0%) subjects with CPS scores of 0, 1, and 2 or greater, respectively, became newly certified for LTCI services.

Table 3. Cox proportional hazards model for the impact of cognitive decline on the time of receiving an LTCI requirement certification

CPS score	Univariate model		Multivariate model	
	HR (95% CI)	p	HR (95% CI)	p
0	1 (ref.)	–	1 (ref.)	–
1	1.64 (1.28–2.09)	<0.001	1.39 (1.08–1.77)	0.009
2–6	3.85 (2.98–4.98)	<0.001	2.27 (1.74–2.96)	<0.001

CPS score: 0 (normal), 1 (borderline intact), 2–6 (cognitive impairment). The multivariate model was adjusted for age, gender, BMI, number of medications taken, family structure, subjective household economy, and past medical history.

Cox Proportional Hazards Model

Figure 1 shows the Kaplan-Meier survival curves during the 18-month follow-up according to new LTCI service requirement certifications, with the participants stratified into 3 groups according to their CPS score. During the 18-month period, 232 (5.4%), 89 (8.6%), and 78 (19.0%) subjects with CPS scores of 0, 1, and 2 or greater, respectively, became newly certified as requiring LTCI services.

Older participants with CPS scores of 1 (adjusted HR: 1.64, 95% CI: 1.28–2.09) and 2 or greater (adjusted HR: 3.85, 95% CI: 2.98–4.98) were significantly more likely to be certified as requiring LTCI services according to the univariate analyses using a CPS score of 0 as the reference (table 3). In multivariate analyses, these results remained significant after adjustment for age, gender, BMI, medication use, family structure, subjective household economy, and past medical history [adjusted HR (CPS score 1): 1.39, 95% CI: 1.08–1.77; adjusted HR (CPS score 2 or greater): 2.27, 95% CI: 1.74–2.96] (table 3).

Discussion

In this study, we showed that cognitive decline was an independent predictor of new certifications for LTCI service requirement after adjusting for personal and social information. Cognitive decline is also associated with impairment of instrumental ADL [15] and gait dysfunction [16, 17] from its early stages. Furthermore, cognitive decline is a major risk factor for falls, which are a serious health problem among older adults with or without cognitive impairment [18]. Even MCI has been viewed as a predictor of falls [19]. Thus, cognitive decline is a risk factor for frailty in older adults, both directly and indirectly.

The current study indicates that a higher CPS score was associated with a greater possibility of certification for LTCI services. This finding is important from a clinical or research perspective. The cognitive assessment used in this study (CPS) consists of questions assessing various parts of subjective cognitive decline. According to several previous studies, this measure is closely associated with objective cognitive status evaluations in cross-sectional analysis [20] and predicts the development of dementia [21, 22]. Therefore, subjective cognitive decline based on the CPS is a valid risk factor for frailty in elderly populations. Furthermore, older participants with a CPS score of 1 may manifest MCI or very early dementia, and older participants with MCI may be more likely to be certified as requiring LTCI. Therefore, older adults should be targets of the preventive care system even before the first stages of cognitive impairment.

Recently, numerous research projects have investigated the impact of interventions designed to prevent the progression of cognitive impairment, such as AD [23]. It has been shown that regular exercise is associated with a delay in dementia and AD onset [24]. Furthermore, a multicomponent exercise program concentrating on aerobics was effective for improving cognitive function in older adults with amnestic MCI [25]. Thus, physical exercise can improve cognitive impairment and may be helpful in delaying or preventing the need for LTCI services. In Japan, community-based exercise programs have been found to have beneficial effects on frail older adults [26]. Hence, preventive programs should become widespread and exercise programs should be utilized by older adults.

This study has several limitations. First, we did not include older adults who had missing baseline questionnaire data. In this population, there may be older adults with more severe cognitive impairment or at a higher risk for frailty. Second, the questionnaires in the current study were primarily self-administered. However, if the participants could not answer questions independently, a family member assisted them or answered the questions on their behalf. We did not analyze the difference between those who could answer questionnaires by themselves and those who could not. The latter group may also have more severe cognitive impairment or a higher risk for frailty. Third, although we assessed subjective cognitive performance by using the questionnaire-based CPS, the participants' global objective cognitive function was not assessed by the MMSE or other objective measures.

In conclusion, our results indicate that cognitive decline is an independent predictor of new LTCI requirement certifications, and the severity of cognitive decline in the elderly is positively associated with receiving an LTCI requirement certification in Japan. Intervention studies are needed to explore whether improvement in cognitive impairment may delay or prevent the need for LTCI services among older adults.

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Disclosure Statement

The authors have no conflicts of interest to disclose.

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Original article

Factors associated with falls in active older adults in Japan and Brazil

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ABSTRACT

Background/Purpose: Aging populations are a global public health concern. The risk of falls increases with age, so fall prevention is becoming an important health issue. However, few studies have focused on cross-cultural analyses of falls. Therefore, we aimed to compare the incidence of falls and compare anthropometric measures and physical function between active Japanese and Brazilian older adults.
Materials and methods: We measured the incidence of falls (investigated by self-reported questionnaire), body mass index (BMI), waist circumference (WC), grip strength (GS), one-legged stance (BALANCE), frequency of physical activity (PA), medication use (MU), and hospitalization history in 114 physically active community-dwelling adults 65 years of age and older in Japan (73.9 ± 4.0 years, $n = 40$) and Brazil (70.7 ± 4.5 years, $n = 74$).
Results: The Japanese elderly were older ($p < 0.01$), but had a better BALANCE score ($p < 0.05$) than the Brazilian elderly. Nevertheless, Brazilian elderly showed higher engagement in PA and had higher BMI and WC ($p < 0.01$). Despite the lack of a difference in the incidence of falls between the two cohorts, Japanese elderly who fell had decreased GS compared to Japanese elderly who did not fall [odds ratio (OR): 0.83, 95% confidence interval (CI) 0.72–0.97, $p < 0.05$]. In Brazil, those who fell had larger WC than those who did not fall (OR: 1.07, 95% CI 1.01 – 1.13, $p < 0.01$).
Conclusion: Our results indicate that physical function (i.e., grip strength) is a more important predictor of falls in Japanese elderly. However, increasing waist size is a predictor of falls in Brazilian elderly. These findings suggest that risk factors for falls are multifactorial and vary according to setting.

1. Introduction

In 2011, the percentage of Japanese adults ≥65 years was 23%, one of the highest percentages in the world.[1] In Brazil, according to some projections, almost 13% of adults will be classified as elderly in 2020.[2,3] Because of this worldwide trend, falls, which are associated with impairment of physical function and decreased quality of life (QOL) in older individuals,[4] are becoming an increasingly important issue. Therefore, initiatives to identify risk factors for falls are considered important preventive public health measures.

Several studies in Japan[5,6] and Brazil[7–9] have been conducted to ascertain the incidence of falls among community-dwelling older individuals. In Japan, the prevalence of falls ranges from 11% to 27%, varying according to the location.[5] In a national survey of 6616 older adults in Brazil, the average prevalence of falls was 28%, ranging from 19% in the northern region to 30% in the southeast region.[7]

Advanced age,[4,8,10] muscle weakness,[11,12] impaired balance,[11] medications,[8–11] physical inactivity,[8,10,12] and hospitalization[8] were identified as important risk factors for falls in older individuals. To our knowledge, there is only one cross-cultural comparison study focused on falls,[10] and there are no data comparing Japan and Brazil. Comparison of these two countries may be important because of the continuous immigration between the two countries. Therefore, the purpose of this study was to compare the effect of anthropometric measures and physical function on the incidence of falls in active older adults in Japan and Brazil.

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2. Materials and methods

2.1. Participants

A convenience sample of 114 physically active, apparently healthy, community-dwelling women age ≥65 years was recruited from participants in community fitness facilities in Japan and Brazil. In Japan, the participants lived in Kyoto, which is located in the western part of the country; in Brazil, the participants lived in São Caetano do Sul, which is located in São Paulo state (São Paulo metropolitan area) in the southern part of the country. Both cities are characterized as urban and industrialized areas with a high human development index, which makes the comparability procedures more reliable.

All volunteers performed physical activities such as dance or aerobics, and strength, balance, and stretching exercises in regular physical fitness classes, for approximately 50 minutes per session at the time of their measurements. All volunteers provided informed consent in accordance with the procedures of the research ethics committees. A preliminary screening that focused on current health status, medications, cigarette use, and habitual physical activity was followed by a detailed history and physical examination covering past and current health status, symptoms of depression, self-reported ability to perform the basic and instrumental activities of daily living, and an assessment of body composition. Volunteers were excluded due to the following factors: (1) uncontrolled cardiovascular, pulmonary, or metabolic diseases; (2) any orthopedic conditions that could limit exercise or be exacerbated by exercise testing; (3) any type of surgery during the previous 3 months; (4) forced bed rest during the previous 3 months; (5) treatment for or a history of cancer; or (6) adherence of less than 75% to physical fitness classes. One hundred and fourteen participants (Japan, $n = 40$, age 73.9 ± 4.0 years; Brazil, $n = 74$, age 70.7 ± 4.5 years) met the criteria for the study, were cleared for participation, and were willing to carry out the study procedures.

2.2. Demographic and clinical history

Demographic information including age, living situation, educational level, medications, and hospitalization history within the previous six months was collected from a self-reported questionnaire.

The World Health Organization definition of a fall was used, specifically “inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest against or on furniture, walls or objects”.[13] This definition was used even if the fall did not lead to injury or ill health. The incidence of falls over the past 12 months was analyzed. Additionally, physical activity (PA) was measured with a self-reported questionnaire and included the activities previously mentioned. The frequency of PA was categorized as almost every day (4–7 days per week), two or three times per week, or once a week.

2.3. Body composition

Height and weight were measured with a stadiometer and a digital scale, respectively. For measurements, volunteers took off their shoes and were dressed in lightweight clothing. Body mass index (BMI) was calculated as body mass divided by height squared.[14] The volunteers were assigned to distinct groups according to the BMI cutoffs proposed by World Health Organization classifications (i.e., underweight, BMI < 18.5 kg/m^2; normal weight, BMI 18.5 to 25 kg/m^2; overweight, BMI 25 to 30 kg/m^2; and obese, BMI ≥ 30 kg/m^2).[14] Waist circumference (WC) was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest.[15]

2.4. Physical function

Physical function was evaluated using grip strength (GS) and balance procedures. Maximal isometric grip strength was measured with an adjustable handgrip dynamometer (Smadley's Dynamometer, TTM, Tokyo, Japan). Each participant was asked to stand and hold the dynamometer with arms parallel to the body; GS was measured for both hands once on each side, and the higher value was used as the maximum muscle strength of the participant, as described elsewhere.[16] To measure balance each volunteer stood on one foot with the contralateral knee flexed to 90°; the arms were crossed over the chest with the head facing forward.[17] Three trials with durations of up to 30 seconds were completed on the dominant leg, separated by 1-minute intervals; the longest duration of maintaining the one-legged stance was used as the score.[17]

2.5. Statistical analysis

The Shapiro-Wilk test was used to verify the normality of the data. The data are presented as means ± standard deviation, absolute frequency, or respective percentage or median (interquartile). Chi-square analyses were used to compare the incidence of falls and the differences in sex, living situation, educational level, medications, hospitalization history, and physical activity between the two countries and intragroup. We also used the Student *t* test to compare age and BMI between countries—age, BMI, WC, and GS according to history of falls in Japan, and age and BMI by history of falls in Brazil. Moreover, the Mann-Whitney U test was used to compare WC, GS, and one-legged stance (BALANCE) between countries— BALANCE according to history of falls in Japan, and WC, GS, and BALANCE by history of falls in Brazil. Logistic regression was carried out to analyze potential risk factors for falls in each country. Statistical significance was set at $p < 0.05$. All analyses were performed using the SSPS version 20.0 (SPSS, IBM Inc., Chicago, IL, USA).

3. Results

Table 1 compares the general characteristics of the participants. The Japanese and Brazilian differed in age, anthropometric measures, and physical function. The Japanese were older ($p < 0.001$) but had better BALANCE scores ($p < 0.05$) than the Brazilian. Brazilian participants were more active but had higher BMI and WC measures (both $p < 0.001$). A larger proportion of Japanese adults had fallen, though the difference between the two groups was not statistically significant.

There was no difference in the prevalence of falls between Japanese and Brazilian older individuals (33% vs. 27%, $p > 0.05$). Japanese elderly who fell had a lower GS than those who did not fall ($p < 0.001$). In Brazil, those who fell were more likely to have larger WC measures than those who did not fall ($p < 0.05$; Table 2).

Logistic regression was carried out to investigate the main risk factors for falls in both countries (Table 3). GS was identified as an important risk factor for falls in Japanese elderly [odds ratio (OR) 0.839; 95% confidence interval (CI) 0.722 – 0.975], whereas WC was a risk factor for falls in Brazilian elderly (OR 1.07; 95% CI 1.018 – 1.13).

4. Discussion

Our study supports the hypothesis that the risk factors for falls differ between older Japanese and Brazilian individuals. Though the prevalence of falls in our Japanese cohort was higher than that of

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Table 1
Bivariate comparison of general characteristics of Japanese and Brazilian participants.

Characteristic	Japan ($n = 40$)	Brazil ($n = 74$)	*p*
Age (y)	73.9 ± 4.0	70.7 ± 4.5	<0.001
Living situation			
Alone	28	24	0.71
With spouse	40	34	
With spouse and/or child	22	23	
With others of the same generation	5	14	
Other	5	5	
Educational level			
Elementary school	20	19	0.88
Junior high school or above	80	81	
Female	80	80	0.97
BMI ($kg{\cdot}m^2$)	22.0 ± 2.1	27.4 ± 3.7	<0.001
Waist circumference (cm [median interquartile])	75.2 (70.9 – 82.3)	87.1 (80.5 – 95.2)	<0.001
Handgrip strength (kgf [median interquartile])	23.7 (20.6 – 28.0)	25 (22 – 31.1)	0.25
Balance (s [median interquartile])	23.6 (7.2 – 30)	13 (6.29 – 24.6)	0.04
Has had a fall	33	27	0.53
On medication	78	89	0.09
Hospitalization history	8	8	0.90
Physical activity	—	—	0.002
Almost every day	28	49	
2 or 3 times a wk	60	51	
Once a wk	13	—	

Data are presented as % or mean ± SD, unless otherwise indicated.
BMI = body mass index; SD = standard deviation.

Japanese national data (26%),[5] it was consistent with data from the same geographical area (35%).[18] The data obtained from our Brazilian cohort are consistent with a nationwide survey of Brazilian community-dwelling older individuals (28%) and older adults from the same geographical area (30%).[7]

Older adults from Brazil had higher BMI and WC measurements than the Japanese elderly. This may be important information because both groups were composed of physically active individuals. Similar results were found in another study of physically active older individuals from Brazil (BMI: 28.1 ±4.3 kg/m^2; fall prevalence: 25%).[19] WC score is considered a risk factor for cardiopulmonary and metabolic diseases[20]; it is associated with postural balance control.[21] In addition, WC is negatively correlated with QOL and mood.[22] Our results also suggest that increasing WC could be considered an important risk factor for falls in older adults in Brazil but not Japan.

However, Japanese adults who fell had decreased GS, which was confirmed to be a risk factor for falls. GS is a clinical predictor of frailty[23] in older individuals that predicts poor outcomes[24] and increased mortality.[25,26] GS could be used to identify which adults are at risk of falling in epidemiological studies.[27]

We found differences in BMI, but not GS, between Japanese and Brazilian elderly. A study found an interaction between GS and BMI on mobility limitation particularly in men, but no such interaction was observed in women.[28] Because most of the participants were women in our study groups, it might explain our negative study results.

Moreover, balance decreases with age.[29] However, in our study, Japanese participants were older, but showed better BALANCE scores than Brazilian elderly, even though both groups were engaged in similar physical activities at the time of their measurements. One possible explanation for this difference may be intrinsic uncontrolled factors in their usual physical activity routine (e.g., Japanese people could be engaged in more balance-related activities than Brazilian people). Finally, both differences in anthropometric measures and physical function might also be linked with the different lifestyle routine in both countries, though lifestyle factors were not investigated in detail.

We also observed a statistically significant difference in the incidence of falls between Japanese men and women (Table 2). It seems that women have 40–60% more injuries related to falls than men of comparable age.[30]

The findings of this study may be useful in community screening trials for identifying risk factors for falls not previously identified by health care professionals. Therefore, we recommend that grip

Table 2
Bivariate comparison of general characteristics of Japanese and Brazilian participants stratified by history of falls.

Characteristic	Japan ($n = 40$)			Brazil ($n = 74$)		
	Fall ($n = 13$)	No fall ($n = 27$)	p	Fall ($n = 20$)	No fall ($n = 54$)	*p*
Age (y)	74.3 ± 3.9	73.8 ± 4.2	0.72	70.3 ± 3.7	70.8 ± 4.8	0.67
Living situation	—	—	0.26	—	—	0.24
Alone	46	19		15	28	
With spouse	31	44		35	33	
With spouse and/or child	8	30		15	26	
With others of the same generation	8	4		25	9	
Other	8	4		10	4	
Educational level	—	—	0.08	—	—	0.13
Elementary school	39	11		30	15	
Junior high school or above	61	89		70	85	
Female	100	70	0.02	85	78	0.49
BMI ($kg{\cdot}m^2$)	21.9 ± 2.0	22.1 ± 2.1	0.81	29 ± 4.3	27 ± 3.4	0.80
Waist circumference (cm)[a]	74.2 ± 6.5	76.3 ± 6.8	0.25	91.0 (84.5 – 101.4)	83.9 (79.2 – 92.2)	0.01
Handgrip strength (kgf)[a]	20.9 ± 4.3	27.4 ± 8.0	<0.001	24.0 (22.0 – 29.0)	26.5 (21.7 – 32.1)	0.46
Balance (s [median interquartile])	15.2 (6.1 – 29.0)	24.1 (9.2 – 30)	0.56	13.9 (3.9 – 23.3)	12.7 (6.5 – 26.2)	0.54
On medication	92	70	0.12	90	89	0.89
Hospitalization history	15	4	0.18	15	6	0.18
Physical activity	—	—	0.19	—	—	0.23
Almost every day	39	22		60	44	
2 or 3 times a wk	62	59		40	56	
Once a wk	0	19		—	—	—

Data are presented as % or mean ± SD, unless otherwise indicated.
BMI = body mass index; SD = standard deviation.
[a] Median (interquartile) for Brazil.

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