we used the χ^2-test. In the items that showed a significant difference ($P < 0.05$), we dichotomized the items and carried out a χ^2 analysis separately for each category. Additionally, we analyzed the differences of KCL domains (mean scores) among the three groups using ANCOVA adjusted by age.

We calculated the differences in the percentage of frail older women among the groups using the χ^2-test. Furthermore, we carried out a binary logistic regression analysis adjusted by age with each KCL domain as a dependent variable. The Japanese group was determined to be the reference group; for the total KCL score and for each domain, the robust condition was coded as 0 and frailty was coded as 1. Statistical significance was set at $P < 0.05$. All analyses were carried out using the Statistical Package for the Social Sciences (version 21.0; SPSS, IBM, Chicago, IL, USA).

Results

A total of 211 participants completed the research procedures (Brazilian $n = 72$; Brazilian Japanese descendants $n = 55$; Japanese $n = 84$). The Japanese were the oldest (mean age 73.2 ± 4.21 years), whereas the Brazilians were the youngest (mean age 69.0 ± 6.41 years; $P < 0.001$). There were differences in living arrangement ($P = 0.023$), educational level ($P < 0.001$) and work activity ($P < 0.001$) among the three groups. More Brazilian participants were living alone ($P = 0.029$), whereas more Japanese women were living with a partner ($P = 0.015$). Additionally, more than 50% of the Brazilian participants had received education at the elementary school level ($P < 0.001$), whereas the majority of the Japanese participants had finished high school ($P < 0.001$), and the majority of the Brazilian Japanese descendants had a university degree ($P < 0.001$). In terms of employment, a higher proportion of Brazilian and Brazilian Japanese descendants were retired compared with the Japanese women ($P = 0.042$), who were more engaged in informal work ($P < 0.001$; Table 1).

Regarding the health-related characteristics among the groups, there were differences in BMI ($P < 0.001$), number of medications ($P = 0.028$), frequency of medical consultation ($P < 0.001$) and life satisfaction ($P < 0.001$). The Brazilian participants had the highest BMI ($P < 0.001$) and took the greatest number of medications ($P = 0.028$), whereas the Japanese participants had the lowest BMI and took fewer medications. The Japanese women consulted a doctor more frequently ($P < 0.001$) and had a poorer life satisfaction ($P < 0.001$) than the other groups (Table 2).

We compared frailty among the three groups using the KCL (Japanese or Brazilian Portuguese version).

Table 1 Comparison of sociodemographic characteristics among Brazilian, Brazilian Japanese descendants and older Japanese women

Variables	Brazilian ($n = 72$)	Brazilian Japanese descendants ($n = 55$)	Japanese ($n = 84$)	P
Age (years)	69.0 ± 6.41†	70.8 ± 8.38	73.2 ± 4.21†	<0.001
Living arrangement				0.023
Alone	26.4 (19)	14.5 (8)	10.7 (9)	0.029
With partner	23.6 (17)	27.3 (15)	44.0 (37)	0.015
With child	25.0 (18)	27.3 (15)	17.9 (15)	0.369
With partner and child	15.3 (11)	23.6 (13)	13.1 (11)	0.246
Other	9.7 (7)	7.3 (4)	14.3 (12)	0.242
Educational level				<0.001
Elementary school	68.1 (49)	27.5 (14)	–	<0.001
Junior high school	13.9 (10)	17.6 (9)	28.6 (24)	0.053
High school	9.7 (7)	15.7 (8)	56.0 (47)	<0.001
Technical school	–	2.0 (1)	7.1 (6)	0.035
University	6.9 (5)	33.3 (17)	8.3 (7)	<0.001
Other	1.4 (1)	3.9 (2)	–	0.208
Work activity				<0.001
Formal work	6.2 (4)	13.7 (7)	1.4 (1)	0.016
Informal work	12.3 (8)	3.9 (2)	37.8 (28)	<0.001
Volunteer	9.2 (6)	9.8 (5)	5.4 (4)	0.551
Retirement	72.3 (47)	72.5 (37)	55.4 (41)	0.042

Values represent the mean ± standard deviation and valid percentage (n); $n = 211$. Tukey's post-hoc: $^{\dagger}P < 0.001$.

Table 2 Comparison of health-related characteristics among Brazilian, Brazilian Japanese descendants and older Japanese women

Variables	Brazilian (*n* = 72)	Brazilian Japanese descendants (*n* = 55)	Japanese (*n* = 84)	*P*
BMI (kg/m²)	28.1 ± 5.39†‡	23.6 ± 2.50†	22.9 ± 2.84‡	<0.001
On medication	84.7 (61)	85.5 (47)	81.9 (68)	0.831
No. medications	2.9 ± 2.1§	2.7 ± 2.4	2.1 ± 1.5§	0.028
Consultations in 6 months				<0.001
None	17.4 (12)	9.3 (5)	14.5 (12)	0.462
1–2 times	50.7 (35)	61.1 (33)	18.1 (15)	<0.001
3–4 times	21.7 (15)	14.8 (8)	16.9 (14)	0.630
5–6 times	8.7 (6)	13 (7)	32.5 (27)	<0.001
7 times or more	1.4 (1)	1.9 (1)	18.1 (15)	<0.001
Hospitalization in 1 year	14.1 (10)	16.4 (9)	7.5 (6)	0.248
Self-rated health				0.467
Very good	11.1 (8)	20.0 (11)	17.1 (14)	
Good	33.3 (24)	34.5 (19)	35.4 (29)	
Normal	34.7 (25)	32.7 (18)	40.2 (33)	
Not so good	18.1 (13)	12.7 (7)	7.3 (6)	
Bad	1.4 (1)	–	–	
Life satisfaction				<0.001
Very satisfied	43.1 (31)	47.3 (26)	21.7 (18)	0.002
Satisfied	41.7 (30)	52.7 (29)	43.4 (36)	0.405
Normal	9.7 (7)	–	30.1 (25)	<0.001
A bit unsatisfied	5.6 (4)	–	3.6 (3)	0.220
Unsatisfied	–	–	1.2 (1)	0.468

Values represent the mean ± standard deviation and valid percentage (*n*); *n* = 211. Tukey's post-hoc: †‡$P < 0.001$; §$P = 0.027$.

Table 3 Comparison of Kihon Checklist scores by analysis of covariance adjusted by age among Brazilian, Brazilian Japanese descendants and Japanese women

Variables	Brazilian (*n* = 72)	Brazilian Japanese descendants (*n* = 55)	Japanese (*n* = 84)	*P*
Total KCL score	6.22 ± 3.83	3.22 ± 2.75	3.43 ± 2.72	<0.001
IADL domain	0.58 ± 0.84	0.29 ± 0.57	0.18 ± 0.50	<0.001
Physical strength domain	1.58 ± 1.15	1.11 ± 1.18	1.38 ± 1.24	0.047
Nutrition domain	0.35 ± 0.48	0.23 ± 0.47	0.40 ± 0.60	0.252
Eating domain	1.07 ± 0.98	0.51 ± 0.77	0.67 ± 0.90	0.001
Socialization domain	0.39 ± 0.52	0.18 ± 0.39	0.01 ± 0.28	<0.001
Memory domain	0.88 ± 0.84	0.51 ± 0.72	0.36 ± 0.61	<0.001
Mood domain	1.42 ± 1.62	0.40 ± 0.78	0.52 ± 0.93	<0.001

Values represent the mean ± standard deviation; *n* = 211. IADL, instrumental activities of daily living; KCL, Kihon Checklist.

The Brazilian participants had the highest total KCL scores (more frail), whereas the Brazilian Japanese descendants had the lowest scores ($P < 0.001$). Additionally, when we compared each domain adjusted by age, the Brazilian participants showed the poorest condition in IADL ($P < 0.001$), physical ($P = 0.047$), oral ($P = 0.001$), socialization ($P < 0.001$), cognitive ($P < 0.001$) and mood ($P < 0.001$) domains (Table 3).

Reviewing the results that identified frailty using our determined cut-off points, we observed that the Brazilian group had the higher prevalence of frail women according to their total KCL score ($P < 0.001$) compared with the other groups. Furthermore, this group also had more participants with oral dysfunction ($P < 0.001$), seclusion ($P < 0.001$), cognitive impairment ($P < 0.001$) and depression ($P < 0.001$). There were no significant

Table 4 Logistic regression analysis of frail condition among Japanese, Brazilian Japanese descendants and Brazilian participants using Kihon Checklist scores as dependent variables and nationality as covariate – adjusted by age

	Frailty % (*n*)	*P*	OR (95% CI)	*P*
Total KCL score (cut-off >6 points)		<0.001		
Japanese (reference for OR)	16.7 (14)		1	
Brazilian Japanese descendants	10.9 (6)		0.65 (0.23–1.84)	0.417
Brazilian	45.8 (33)		5.97 (2.69–13.3)	<0.001
IADL domain (cut-off >2 points)		0.194		
Japanese (reference for OR)	1.2 (1)		1	
Brazilian Japanese descendants	0		–	–
Brazilian	4.2 (3)		5.15 (0.51–52.2)	0.165
Physical strength domain		0.242		
Japanese (reference for OR)	21.4 (18)		1	
Brazilian Japanese descendants	10.9 (6)		0.44 (0.16–1.22)	0.114
Brazilian	20.8 (15)		0.95 (0.42–2.13)	0.892
Nutrition domain (cut-off BMI<20.5)		0.090		
Japanese (reference for OR)	6 (5)		1	
Brazilian Japanese descendants	1.9 (1)		0.22 (0.018–2.57)	0.226
Brazilian	0		–	
Eating domain		<0.001		
Japanese (reference for OR)	19 (16)		1	
Brazilian Japanese descendants	9.1 (5)		0.45 (0.15–1.33)	0.148
Brazilian	37.5 (27)		3.18 (1.47–6.85)	0.003
Socialization Domain (cut-off >1 point)		<0.001		
Japanese (reference for OR)	8.3 (7)		1	
Brazilian Japanese descendants	18.2 (10)		2.70 (0.95–7.73)	0.063
Brazilian	37.5 (27)		9.15 (3.53–23.7)	<0.001
Memory domain		<0.001		
Japanese (reference for OR)	29.8 (25)		1	
Brazilian Japanese descendants	38.2 (21)		1.49 (0.72–3.08)	0.279
Brazilian	61.1 (44)		3.87 (1.93–7.75)	<0.001
Mood domain		<0.001		
Japanese (reference for OR)	10.7 (9)			
Brazilian Japanese descendants	9.1 (5)		0.89 (0.28–2.83)	0.844
Brazilian	38.9 (28)		6.63 (2.74–16.0)	<0.001

Values represent percentage (*n*) and OR (95% CI); *n* = 211. BMI, body mass index; IADL, instrumental activities of daily living; KCL, Kihon Checklist.

differences regarding IADL performance, and physical and nutritional conditions among the groups (Table 4).

The results of the logistic regression confirmed that older Brazilian women were more inclined to be frail than Japanese women. The Brazilian participants were fivefold more likely to be frail (OR 5.97, 95% CI 2.69–13.3, $P < 0.001$), threefold more likely to have oral dysfunction (OR 3.18, 95% CI 1.47–6.85, $P = 0.003$), ninefold more likely to have seclusion (OR 9.15, 95% CI 3.53–23.7, $P < 0.001$), threefold more likely to have cognitive impairment (OR 3.87, 95% CI 1.93–7.75, $P < 0.001$) and sixfold more likely to have depression (OR 6.63, 95% CI 2.74–16.0, $P < 0.001$) than the older Japanese women. However, no difference was found between the Japanese and Brazilian Japanese descendants. No difference was found in terms of IADL, physical or nutritional domains among the groups (Table 4).

Discussion

In the present study, we observed a higher prevalence of frail participants in the Brazilian group ($P < 0.001$); and that older Brazilian women were more inclined to be frail than Japanese women (OR 5.97, 95% CI 2.87–13.3, $P < 0.001$). To the best of our knowledge, the present study is the first that compares frailty among Brazilian, Brazilian with Japanese genetic background and older Japanese women. To substantiate our findings, we discussed our observations and results separately, detailing each KCL domain and linking it to the participants' sociodemographic and lifestyle characteristics.

According to the KCL domains, we observed differences regarding the mean scores in IADL ($P < 0.001$) and physical ($P = 0.047$) domains among the three groups; however, such differences failed to remain statistically significant when we dichotomized them according to the cut-off points to determine frailty. A similar pattern was observed in the nutritional domain; no group showed a significantly different risk level to develop frailty. Although no differences were found in the physical and nutritional domains among the groups, we can discuss the significant difference observed in BMI ($P < 0.001$), especially because BMI is an important indicator of physical and nutritional status, and an increased BMI could be an alarming sign of imminent frailty evaluated by both domains. In the present study, the Brazilian participants were more obese (BMI 28.1 ± 5.39 kg/m^2) than the other groups. Although the KCL considers low bodyweight to be a frailty symptom, epidemiological studies show that both overweight and underweight are negative health outcomes associated with a greater risk for morbidity and mortality.[15]

There are some data showing that the Brazilian environment might pose a risk for developing obesity compared with the Japanese environment; a study verified that the risk for developing central obesity was 2.8-fold higher among Japanese Brazilians living in Brazil.[8] Although that study did not include Brazilian natives, there is evidence supporting concurrent increases in obesity in Brazil.[16]

Furthermore, we found that Brazilian participants were threefold more likely to be frail in terms of oral health (eating domain) than the Japanese group (OR 3.18, 95% CI 1.47–6.85, $P = 0.003$). In this case, the educational level of the participants seems to be related to their poor oral condition; considering the evidence that older adults who received elementary school level education had a significantly larger number of missing teeth and significantly fewer healthy gingival units compared with those who received higher than elementary school level education.[17] Another study showed that not only educational level, but also living arrangement influenced the participants' oral health; concluding that poorly educated and divorced women had fewer remaining teeth than better-educated and married women.[18] In the present study, the most favored group in terms of educational and living arrangement conditions was the Japanese cohort that were also more concerned about dehydration (consuming liquids, especially tea, as one of the Japanese habits), another included aspect in the oral domain.

Regarding the socialization domain, the Brazilian participants also showed a greater risk for becoming frail compared with the Japanese participants (OR 9.15, 95% CI 3.53–23.7, $P < 0.001$). A study showed that a partner relationship, such as marriage, might impact women's health status in numerous ways and could confer health-related benefits, such as providing nurturing conditions and socialization through a spouse,[19] and building a network with the partner's family.[20] Furthermore, a relationship possibly includes access to material resources and other social support.[21] These privations could lead Brazilian women to a poorer condition not only in the seclusion domain, but also in the mood domain, as the study concluded that individuals who lack social connections or report frequent feelings of loneliness tend to suffer higher rates of depression as well.[22]

Although the older Brazilian women showed a higher life satisfaction ($P = 0.002$), they presented a higher risk for being frail in terms of depression (OR 6.63, 95% CI 2.74–16.0, $P < 0.001$) than the Japanese group. Evidence showed that living alone or with other(s) than a partner could lead to depression and anxiety disorders in women.[23]

Finally, the results that we found in the memory domain did not differ from those aforementioned. The Brazilian participants were threefold more likely to be frail compared with the Japanese group (OR 3.87; 95% CI 1.93–7.75, $P < 0.001$). It is widely recognized that low education is one of the conditions that affect cognitive performance, especially phonological verbal fluency, calculation and working memory[24,25] that are required when processing the tasks assessed by the KCL cognitive domain. Another factor that might be related to the lowest scores achieved by Brazilian women in the memory domain is their highest number of medication use (Brazilian participants 2.9 ± 2.1 *vs* Japanese participants 2.1 ± 1.5, $P = 0.028$). Although we did not investigate the drug classes, the cognitive impairment is repeatedly reported to be a side-effect among medications prescribed for the elderly.[26,27]

We discerned that the majority of the differences in the present study were shows between Japanese and Brazilian natives. However, we must emphasize that an improved condition in terms of frailty was observed in the Brazilian Japanese descendants. This result might be linked to their higher educational level that predicts a higher-level financial status and better living conditions, which might in turn reflect a better health education, as they showed the lowest total KCL score ($P < 0.001$), and also the lowest mean KCL score in physical strength ($P = 0.047$), eating ($P = 0.001$) and mood ($P < 0.001$) domains.

We emphasize that the native Brazilian participants might be more vulnerable and frail because of the sociodemographic disadvantages that they are exposed to and their adopted lifestyle. However, such conditions are reversible; and an early detection of the frail aspects is essential to reverse it in older adults. For this purpose, the KCL was designed to monitor the health conditions and to detect negative health outcomes at the earliest stage, thereby assuring prompt prevention or rehabilitation interventions, being an accurate, cheap, easy and fast diagnostic tool.

The present study had several limitations: (i) the present study was a cross-sectional design, which did not enable us to determine a cause–effect relationship; (ii) the present study was carried out in only one Brazilian and one Japanese region, which did not allow us to extend our findings to the national level; and finally, (iii) we only analyzed older women with heterogeneous characteristics, which complicated our comparisons. We recommend prospective studies to include a greater sample size, with male participants recruited from several regions of Brazil and Japan, and that future studies investigate important aspects that could be related to frailty, such as the financial situation of the participants.

In summary, we found that Brazilian natives were more frail than Japanese natives, but not Brazilian Japanese descendants. In addition to the environment, we believe that the lifestyle and the sociodemographic conditions could reflect the frailty of older Brazilian women in the present study. Hence, we recommend the dissemination of general health education among these older adults, including incentives for regular engagement in physical activity and a well-balanced diet, the principles of oral health safety and social and cognitive approaches to warrant a healthy aging process.

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Disclosure statement

The authors declare no conflict of interest.

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Original article

Comparison of frailty between users and nonusers of a day care center using the Kihon Checklist in Brazil

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Background/purpose: Day care centers are rapidly expanding in Brazil to meet the needs of the increasing older population. However, health profiles of their clients remain unclear. Therefore, this study aimed to investigate and compare the health conditions of users and nonusers of a day care center using a new frailty index, the Kihon Checklist.

Methods: This was a cross-sectional observational study. We recruited 59 users (mean age 81.1 ± 6.69 years) and 173 nonusers (mean age 69.9 ± 7.39 years). The nonusers were recruited at a recreational club and municipal health units, and the users were recruited at a day care center for the elderly in Brazil. Measurements consisted of questionnaires regarding sociodemographic and health-related characteristics and the Kihon Checklist.

Results: Compared with the nonusers, users had a higher prevalence of frailty ($p < 0.001$) and impairment of all specific domains (instrumental activities of daily living impairment, $p < 0.001$; physical inactivity, $p < 0.001$; seclusion, $p < 0.001$; cognitive deficit, $p < 0.001$; and depression, $p < 0.001$). The users were also more likely to be frail [odds ratio (OR), 14.226; 95% confidence interval (CI), 5.423–37.320; $p < 0.001$], dependence in instrumental activities of daily living (OR, 78.845; 95% CI, 19.569–317.674; $p < 0.001$), physically inactive (OR, 3.509; 95% CI, 1.467–8.394; $p = 0.005$), cognitively impaired (OR, 5.887; 95% CI, 2.360–14.686; $p < 0.001$), and depressed (OR, 5.175; 95% CI, 2.322–11.531; $p < 0.001$) than the nonusers.

Conclusion: The users of the day care center were frailer than nonusers, especially with regard to independence in instrumental activities of daily living, physical strength, cognitive function, and mood. Health care workers should use the Kihon Checklist to verify frequently the condition of elderly patients to prevent worsening of frailty.

1. Introduction

By 2050, the elderly population in Brazil is projected to represent approximately 30% of the total population, making Brazil one of the countries with the largest absolute number of elderly people worldwide.[1,2] These demographic changes will present a new challenge to the Brazilian health care system.[3]

In this context, noninstitutionalized care modalities that assist frail older persons are emerging in Brazil.[4] One example is day care centers that offer programs designed to meet the needs of elderly persons who require supervised care during the day but can return home in the afternoon or evening. Such institutions are rapidly expanding. However, the health profiles of the day care center attendees and their specific needs remain unclear due to the busy work schedule of the center staffs who do not have time required for the massive assessments for older adults.

Hence, this study sought to (1) investigate health conditions of the users of a day care center using a new frailty assessment tool known as the Kihon Checklist (KCL), a comprehensive and fast questionnaire, and (2) compare health profiles of the day care center users with those of elderly community-dwelling nonusers of such facilities.

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2. Methods

This is a cross-sectional observational study.

2.1. Participants

The inclusion criteria were as follows: community-dwelling adults aged 60 years or older, users or nonusers of day care services, who were able to respond to the questionnaire independently or by proxy. Individuals who did not match these criteria or did not want to participate were excluded. All participants received explanations regarding the research procedures and signed an informed consent form.

The nonusers of day care services were recruited at a recreational club and municipal health units, whereas the users were recruited at a day care center for the elderly with a maximum capacity of 30 participants per day. The prior criterion to attend the center included the need for support to perform daily activities. The center's professional team consists of medical doctors, nurses, physical therapists, social assistants, and volunteers. The main objectives of the institution are to provide proper care to the elderly, offering activities that preserve their dignity, and also to improve the quality of life of the participants and their families. All institutions were private and located in the same city in southern Brazil. Patient recruitment and data collection were carried out from June 2012 to April 2013.

The study protocol was approved by the Ethics Committee at Kyoto University Graduate School of Medicine, Kyoto, Japan (E-1575).

2.2. Assessments

The collected data were as follows: (1) sociodemographic information, including age, gender, living structure, educational level, and working status; (2) health-related characteristics, including body mass index (BMI), use and number of medications, frequency of medical consultation in the past 6 months, hospitalization in the past year, and life satisfaction; and (3) the translated and validated Brazilian Portuguese version of the KCL.[5]

The KCL was developed by the Japanese Ministry of Health, Labor, and Welfare, based on the needs of the Japanese long-term care insurance system. This checklist is used to screen frail older adults and identify those at higher risk of becoming dependent.[6–8] The checklist is a self-administered questionnaire that comprises 25 yes/no questions divided into instrumental activities of daily living (IADLs), physical strength, nutrition, eating, socialization, memory, and mood domains. A higher score indicates a frailer health condition. We determined the following cutoff points: for the KCL total score (sum of the scores of all questions) $\geq$7 points; IADL domain $\geq$3 points; physical domain $\geq$3 points, representing physical inactivity; nutrition domain score = 2 points, indicating malnutrition; additionally in question number 12, regarding body composition in the same domain, we adopted a cutoff of BMI <20.5; oral domain $\geq$2 points, suggesting oral dysfunction; socialization domain $\geq$1 point, representing seclusion; memory domain $\geq$1 point, suggesting cognitive impairment; and finally, mood domain $\geq$2 points, indicating depression. These cutoff points were adopted based on our previous findings that determined the KCL cutoffs associated with an elevated risk of requiring long-term care insurance service.[7,9] The time required to answer the KCL is approximately 15 minutes. Further details of the KCL have been described previously.[5]

2.3. Statistical analysis

Regarding sociodemographic and health-related characteristics, we analyzed the differences in age, BMI, and number of medications between users and nonusers of the day care service using an unpaired *t* test. For categorical variables (i.e., gender, living structure, educational level, working status, use of medication, medical consultation, hospitalization, and life satisfaction), we used the Chi-square test. For the variables that exhibited a significant difference ($p < 0.05$; i.e., living structure, working status, and life satisfaction), we dichotomized each item and conducted a Chi-square analysis separately for each category. Additionally, we analyzed the differences in KCL domains (mean scores) between groups using analysis of covariance (ANCOVA) adjusted for age.

We calculated the differences in the percentage of frail older adults (according to the KCL cutoff points) between the groups using the Chi-square test. We also performed a binary logistic regression analysis adjusted for age and gender, using each KCL domain as a dependent variable. For the total KCL score and for each domain, the robust condition was coded as 0 and frail condition as 1. The nonuser group was the reference group. Finally, to determine the variables with higher influence on day care use, we performed a binary logistic regression analysis (using the stepwise method), adjusted for age and gender, with "use of day care" (nonusers = 0 and users of day care service = 1) as the dependent variable. Dichotomous covariates included were the KCL variables that showed a significance in the previous regression analysis (using the enter method). Statistical significance was set at $p < 0.05$. All analyses were performed using the SPSS (version 21.0, SPSS; IBM Inc., Chicago, IL, USA).

3. Results

3.1. Sociodemographic and health-related characteristics

A total of 232 elderly persons met the criteria for the study (community, $n = 173$, mean age 69.9 ± 7.39 years; day care, $n = 59$, mean age 81.1 ± 6.69 years).

Among the 59 users of day care services, 18.6% utilized the day care center once a week, 48.8% twice a week, 25.6% three times per week, 4.7% four times per week, and 2.3% five times per week.

The users of day care services were older, and the majority lived with their children ($p < 0.001$). By contrast, most of the nonusers lived with their partners ($p = 0.017$). Additionally, most of the users were retired ($p < 0.001$), whereas some of the nonusers were still engaged in volunteer activities ($p = 0.044$). Furthermore, the nonusers of day care services had a higher BMI ($p = 0.004$) and were more satisfied with their lives than the users ($p = 0.013$) (Table 1).

3.2. Frailty condition

Differences were identified in the total mean KCL score ($p < 0.001$) and the mean KCL scores for all the domains between the two groups. Even when results for each domain were adjusted for age, the users of day care services were found to be frailer than the nonusers in terms of IADLs ($p < 0.001$), physical strength ($p < 0.001$), nutrition ($p = 0.001$), eating ($p = 0.01$), socialization ($p < 0.001$), memory ($p < 0.001$), and mood ($p < 0.001$) (Table 2).

Based on the results that identified frailty using the cutoff points, we observed that the users had a higher prevalence of frailty according to the total KCL score ($p < 0.001$) than the nonusers. Moreover, the user group contained more participants with IADL impairment ($p < 0.001$), physical inactivity ($p < 0.001$), seclusion ($p < 0.001$), cognitive deficit ($p < 0.001$), and depression ($p < 0.001$) (Table 3).

Results of the logistic regression, adjusted for age and gender, confirmed that the users of day care services were more likely to be frailer than the nonusers. Compared with nonusers, the day care

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Table 1
Sociodemographic and health-related characteristics of nonusers and users of a day care center.

Variables		Nonusers (n = 173) Valid % (n)	Users (n = 59) Valid % (n)	p
Age	Mean ± SD	69.9 ± 7.39	81.1 ± 6.69	<0.001
Gender	Female	73.4 (127)	71.2 (42)	0.740
Living structure				0.005
	Alone	18.5 (32)	11.9 (7)	0.239
	With partner	31.2 (54)	15.3 (9)	0.017
	With child	20.8 (36)	45.8 (27)	<0.001
	With partner and child	23.1 (40)	18.6 (11)	0.473
	Other	6.4 (11)	8.5 (5)	0.467
Educational level				0.117
	Elementary school	42.6 (72)	55.2 (32)	
	Junior high school	13.6 (23)	12.1 (7)	
	High school	13 (22)	10.3 (6)	
	University	26.6 (45)	12.1 (7)	
	Other	4.2 (7)	10.4 (5)	
Working status				0.006
	Formal Work	11.7 (19)	3.4 (2)	0.079
	Informal Work	9.3 (15)	3.4 (2)	0.179
	Volunteer work	10.5 (17)	1.7 (1)	0.044
	Retirement	68.5 (111)	91.5 (54)	<0.001
BMI	Mean ± SD	26.0 ± 4.53	24.0 ± 5.17	0.004
Medication	Yes	82.1 (142)	84.7 (50)	0.640
Number of medications	Mean ± SD	2.65 ± 2.60	3.39 ± 2.53	0.058
Medical consultation (past 6 mo)				0.862
	None	13.6 (23)	15.3 (9)	
	1–2 times	59.2 (100)	59.3 (35)	
	3–4 times	18.3 (31)	20.3 (12)	
	5 times or more	8.9 (15)	5.1 (3)	
Hospitalization (past 12 mo)	Yes	12.8 (22)	15.3 (9)	0.632
Life satisfaction				0.013
	Satisfied	89.6 (155)	78.0 (46)	0.023
	Fair	6.4 (11)	6.8 (4)	0.910
	Unsatisfied	4.0 (7)	15.3 (9)	0.003

BMI = body mass index.

users were several times more likely to be frail [odds ratio (OR), 14.226; 95% confidence interval (CI), 5.423–37.320; $p < 0.001$], IADL dependent (OR, 78.845; 95% CI, 19.569–317.674; $p < 0.001$), physically inactive (OR, 3.509; 95% CI, 1.467–8.394; $p = 0.005$), cognitively impaired (OR, 5.887; 95% CI, 2.360–14.686; $p < 0.001$), and depressed (OR, 5.175; 95% CI, 2.322–11.531; $p < 0.001$) (Table 4).

We observed that among the five KCL variables found to be significant using the logistic regression analysis enter method (i.e., total KCL score, IADLs, physical strength, memory, and mood), only two were significant in the stepwise model: the KCL total score (OR, 5.201; 95% CI, 1.645–16.445; $p = 0.005$) and the IADL domain (OR, 37.368; 95% CI, 8.823–158.262; $p < 0.001$) (Table 5).

Table 2
Differences in the KCL domains' mean scores between users and nonusers of the day care center, adjusted for age.

Variables	Nonusers (n = 173)	Users (n = 59)	p
Total KCL score	4.51 ± 3.62	10.9 ± 3.93	<0.001
IADL domain	0.40 ± 0.69	2.90 ± 1.36	<0.001
Physical domain	1.25 ± 1.15	2.02 ± 1.50	<0.001
Nutrition domain	0.26 ± 0.46	0.47 ± 0.57	0.001
Eating domain	0.79 ± 0.91	1.10 ± 0.85	0.010
Socialization domain	0.30 ± 0.48	0.66 ± 0.66	<0.001
Memory domain	0.67 ± 0.78	1.63 ± 0.87	<0.001
Mood domain	0.87 ± 1.32	2.12 ± 1.39	<0.001

IADL = instrumental activity of daily living; KCL = Kihon Checklist.

Table 3
Frail individuals in the nonuser and user groups, as determined by cutoff points.

	Frail nonusers (n = 173) Valid % (n)	Frail users (n = 59) Valid % (n)	p
Total KCL score	27.2 (47)	88.1 (52)	<0.001
IADL domain	1.7 (3)	72.9 (43)	<0.001
Physical domain	13.9 (24)	37.3 (22)	<0.001
Nutrition domain	0.6 (1)	3.4 (2)	0.118
Eating domain	23.7 (41)	24.1 (14)	0.946
Socialization domain	28.9 (50)	55.9 (33)	<0.001
Memory domain	49.1 (85)	86.4 (51)	<0.001
Mood domain	23.1 (40)	64.4 (38)	<0.001

IADL = instrumental activity of daily living; KCL = Kihon Checklist.

4. Discussion

As expected, the day care center users were generally frailer than the nonusers, as demonstrated by the differences in the total KCL score; additionally, for all specific aspects of health (functional performance in IADLs, physical strength, nutrition, eating, socialization, memory, and mood), users were more impaired than nonusers, as indicated by the KCL domain mean scores.

However, both groups had similar percentages of participants meeting the cutoffs for frailty regarding nutrition and eating conditions; the participants also had a similar risk of malnutrition and oral disability. These findings may be supported by the BMI measures, which indicated that both groups were in the normal weight range. It was interesting to notice that the KCL mean scores differed between groups; however, when the data were categorized according to the cutoff points, no difference was observed between them. Hence, we suggest that both the mean scores and the cutoff points for the KCL should be used when analyzing such type of data. The mean scores can reveal even slight variations in the data, especially when dealing with small sample sizes, whereas the cutoff points can help manage large sample sizes with regard to the aspects of frailty in the analyzed population.

Participants also had a similar risk of seclusion regardless of the use of the day care center, indicating the importance of these centers to meet the social and emotional needs of the elderly, as such centers can alleviate feelings of loneliness, boredom, and solitude.[10]

The logistic regression results indicated that the need variables for Brazilian users of day care services focus on IADL functional independence, physical strength, cognitive function, and mood (Table 4), and this agrees with other research studies where a day care center is an option for disabled older people, who have functional disabilities, cognitive deficits, or mental frailties.[11,12] Moreover, apart from general frailty, the most relevant determinant of day care center use detected by logistic regression was functional impairment in IADLs. Such functional dependence was already

Table 4
Logistic regression analysis (enter method) adjusted for age and gender (n = 232).

Day care center user group	Odds ratio	95% confidence interval	p
Total KCL score	14.2	5.42–37.3	<0.001
IADL domain	78.8	19.6–318	<0.001
Physical domain	3.51	1.47–8.39	0.005
Nutrition domain	0.630	0.035–11.5	0.755
Eating domain	0.734	0.315–1.71	0.473
Socialization domain	1.75	0.822–3.71	0.147
Memory domain	5.89	2.36–14.7	<0.001
Mood domain	5.18	2.32–11.5	<0.001

IADL = instrumental activity of daily living; KCL = Kihon Checklist.

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Table 5
Logistic regression analysis (stepwise method) adjusted for age and gender ($n = 232$).

Day care center user group	Odds ratio	95% confidence interval	p
Total KCL score	5.20	1.65–16.4	0.005
IADL domain	37.4	8.82–158	<0.001

IADL = instrumental activity of daily living; KCL = Kihon Checklist.

stated as one of the criteria for eligibility for long-term care insurance in Japan.[7] Maintaining or enhancing the ability to perform daily activities and preventing dependence are the primary goals in the care of vulnerable older adults.[13]

Difficulties in performing IADLs preclude independent living, requiring support that is typically initially provided by the family. Such findings may be linked with the difference in living structure between the groups, considering that the majority of users lived with their children ($p < 0.001$), who may be their caregiver, whereas the nonusers lived with their partner ($p = 0.017$). In Brazil, the State attributes to the family the major role in home care for the disabled elderly,[3] exposing the family caregiver to high burdens that were frequently associated with physical disability, cognitive decline and functional impairment.[14–16] In this context, the family, as the primary caregiver, often seeks other sources of support to reduce its burden and distress,[17] and these sources include day care centers.

Interestingly, regardless of day care center use, the use and number of medications, frequency of medical consultation, and frequency of hospitalization were similar in both groups. This finding suggests the important role of day care centers from the societal perspective, as they contribute to curtailing national expenditures by delaying or preventing institutionalization, which is much more expensive.[18]

In brief, we identified differences in general health and also in all specific aspects of health between users and nonusers of a day care service center. The users of the day care center were frailer than the nonusers, and were also more likely to be physically and cognitively frail, to be functionally impaired in IADLs, and to have depression. These aspects of frailty do not seem to represent the main needs of elderly clients, but more so the main concerns of the family caregivers because of the heavy burden associated with these aspects. All these negative outcomes may influence life satisfaction, as our findings showed that the users of day care service centers were more unsatisfied with their lives ($p = 0.003$). Therefore, health care workers may use these findings to prevent worsening of frailty, making an effort to improve not only health but also well-being.

We verified these important differences between users and nonusers of day care service centers using only one type of assessment, the KCL, a fast and easy assessment tool that included all the important domains regarding the needs of the elderly. Therefore, we encourage the use of such assessment method as a fast screening tool for frailty in the elderly population; when the KCL results indicate an alarming condition, we suggest continuation and intensification of the investigation using specific instruments for the respective domain.

This study has several limitations related to its cross-sectional design and recruitment locations. As this study was carried out only in one region of Brazil, the results cannot be generalized to a national population. Additionally, the study included only one day care center. Moreover, we address the possible selection bias that may have occurred considering the predictable higher percentage of frailty in day care center user group; however, recruiting day care center users was the unique methodology to achieve the purpose of the present study. Further studies including more participants and institutions from different regions of Brazil are warranted.

Conflicts of interest

The authors declare no potential conflicts of interest.

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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Effect of physical activity on memory function in older adults with mild Alzheimer's disease and mild cognitive impairment

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Aim: It is very important to maintain cognitive function in patients with mild cognitive disorder. The aim of the present study was to determine whether the amount of physical activity is associated with memory function in older adults with mild cognitive disorder.

Methods: A total of 47 older adults with mild cognitive disorder were studied; 30 were diagnosed with mild Alzheimer's disease and 17 with mild cognitive impairment. The global cognitive function, memory function, physical performance and amount of physical activity were measured in these patients. We divided these patients according to their walking speed (<1 m/s or >1 m/s). A total of 26 elderly patients were classified as the slow walking group, whereas 21 were classified as the normal walking group.

Results: The normal walking group was younger and had significantly better scores than the slow walking group in physical performance. Stepwise multiple linear regression analysis showed that only the daily step counts were associated with the Scenery Picture Memory Test in patients of the slow walking group ($\beta = 0.471$, $P = 0.031$), but not other variables. No variable was significantly associated with the Scenery Picture Memory Test in the normal walking group.

Conclusions: Memory function was strongly associated with the amount of physical activity in patients with mild cognitive disorder who showed slow walking speed. The results show that lower physical activities could be a risk factor for cognitive decline, and that cognitive function in the elderly whose motor function and cognitive function are declining can be improved by increasing the amount of physical activity. **Geriatr Gerontol Int 2014; 14: 758–762.**

Keywords: memory function, mild cognitive disorder, older adults, physical activity, physical performance.

Introduction

Mild cognitive impairment (MCI) is a condition of objective cognitive impairment based on neuropsychological testing in the absence of clinically overt dementia.[1] This condition is of interest for identifying the prodromal and transitional stages of Alzheimer's disease (AD)[2,3] and other types of dementia. Indeed, a study shows that more than half of MCI cases progress to dementia within 5 years.[1] However, it is reported that the cognitive function of people with MCI can recover to normal.[4,5] Indeed, one study showed that 38.5% of older adults with MCI recovered to normal within 5 years.[6] Therefore, it is very important to prevent the deterioration of MCI to dementia. Because no consensus has been established regarding pharmacological intervention for MCI, non-pharmacological intervention is expected. Accordingly, we need to establish a way to prevent deterioration or even improve cognitive function in MCI patients.

Recently, it has attracted attention that increasing the amount of physical activity can prevent the decline of cognitive function. Many studies reported that global cognitive function is associated with the amount of physical activity. Furthermore, previous reports have shown that physical frailty is associated with an increased risk of developing AD and MCI,[8,9] and can predict a future cognitive decline in older adults.[10] Additionally, people with dementia have been shown to be

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frail because of their poor mobility and body composition.[11,12] Thus, cognitive function and physical frailty are interrelated.

Accordingly, the cognitive decline in frail elderly patients can cause further decline of cognitive function and motor function. Therefore, it is important to maintain and improve the cognitive function of the frail elderly with mild cognitive disorder.

Several studies have shown the relationship between cognitive decline that can be observed at the early stage of dementia and the amount of physical activity. However, no study has addressed whether the association between cognitive function and the amount of physical activity depends on the level of motor function in MCI or mild AD patients.

Therefore, the aim of the present study was to determine whether there is an association between memory function and the amount of physical activity in older adults with mild cognitive disorder, stratified by their motor function.

Methods

Participants

We recruited patients from the memory clinic of the Department of Geriatric Medicine in Kyoto University Hospital, Kyoto, Japan. The diagnosis of AD or MCI was made according to the following criteria: AD, *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition, and the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association;[13,14] and MCI, Petersen's criteria.[15] Of the 47 patients with cognitive disorder, 30 were classified as mild AD and 17 as MCI by the criteria. In the present study, we did not set the upper and lower limits of the Mini-Mental State Examination (MMSE) for the diagnosis of MCI. The exclusion criteria used in the present study were vascular dementia, dementia with Lewy bodies, lacunar infarcts, Fazekas grade 3 periventricular hyperintensity/deep white-matter hyperintensity,[16] severe cardiac, pulmonary or musculoskeletal disorders, or the presence of comorbidities associated with an increased risk of falls, such as Parkinson's disease and stroke.

Written informed consent for the trial was obtained from each participant or his/her family members in accordance with the guidelines approved by the Kyoto University Graduate School of Medicine and the Declaration of Human Rights, Helsinki, 1975.

Walking speed

Comfortable 10-m walking time (walking time) is a simple test developed to screen basic mobility performance in frail older adults. It has been reported that the elderly with a walking score greater than 10.0 s can suffer an increased risk of falling.

Therefore, we divided the participants into two groups according to their walking speed (cut-off: 1 m/s); 26 of the older adults were classified as the normal walking group, whereas 21 of the older adults were classified as the slow walking group.

Cognitive function measures

Cognitive function was assessed by the MMSE and the Scenery Picture Memory Test (SPMT). MMSE is a global cognitive test that can be used to systematically and thoroughly assess mental status. It is an 11-question measure that tests five areas of cognitive function: orientation, registration, attention and calculation, recall, and language. The maximum score is 30. A score of 23 or lower is indicative of cognitive impairment. SPMT is a short and simple memory test assessing the visual memory encoded as scenery, combined with verbal answers. Briefly, it uses a line drawing scenery picture of a living room in a house where 23 objects commonly observed in daily life are drawn on an A4 piece of paper. The examinee is instructed to look at the picture for 1 min and remember the items. After this encoding period, we distracted participants by asking them to carry out a brief digits forward test. Participants were then asked to recall the objects in the picture without time limitation. This recall time usually takes less than 1 min. The number of items recalled is the score for SPMT. Higher scores indicate better cognitive function. We have previously shown that SPMT is a quick and effective screen for MCI.[17]

Physical performance measures

The participants were asked to carry out the three motor function tests that are widely used to identify the frail elderly. For each performance task, the participants carried out two trials, and the better performance of the two was used for the analysis. Physical performance assessments, such as walking time,[18] the Timed Up & Go (TUG) test,[19] the Functional Reach test,[20] the one-leg stand (OLS) test,[21] and the five chair stand test (SCS)[22] were carried out as previously described.

Physical activity measures

In physical activity, a valid, accurate and reliable pedometer, the Yamax Power walker EX-510, was used to measure the free-living step counts.[23] The participants were instructed to wear the pedometer in their pocket on the side of their dominant leg for 14 consecutive days except when bathing, sleeping or 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.

Table 1 Comparison of demographic characteristics and measurements with the overall group, normal walking group, and slow walking group

	All (= 47)	Normal walking (= 26)	Slow walking (= 21)	*P*-value
Age (years)	76.9 ± 7.0	74.7 ± 7.2	79.6 ± 5.9	0.016*
Female sex, *n* (%)	28 (59.6%)	17 (65.4%)	11 (52.4%)	0.38
BMI	21.7 ± 3.7	22.1 ± 3.7	21.1 ± 3.8	0.36
Loneliness	5 (10.6%)	2 (7.7%)	3 (14.3%)	0.64
Donepezil treatment	41 (87.2%)	24 (92.3%)	17 (81.0%)	0.39
MMSE	23.4 ± 3.6	23.0 ± 3.1	24.0 ± 4.2	0.37
SPMT	6.5 ± 4.7	6.7 ± 5.1	6.1 ± 4.4	0.68
Physical activity	4371.9 ± 3605.9	5264.0 ± 3476.9	3267.4 ± 3532.5	0.06
10 m walking time	9.9 ± 2.3	8.2 ± 1.0	12.3 ± 1.6	<0.001***
TUG time	9.5 ± 2.7	7.9 ± 1.4	11.4 ± 2.6	<0.001***
OLS	11.9 ± 15.8	16.9 ± 19.3	5.8 ± 6.1	0.01*
5CS	11.1 ± 3.5	10.0 ± 2.2	12.4 ± 4.2	0.016*

5CS, five chair stand test; BMI, body mass index; MMSE, Mini-Mental State examination; OLS, one leg standing; SPMT, Scenery Picture Memory Test; TUG, Timed Up & Go test. *$P < 0.05$ ***$P < 0.001$.

Statistical analysis

The *t*-test and χ^2-test were used to compare the data between the normal and slow walking groups. Multiple linear regression analysis using a stepwise method was carried out to investigate whether physical activity, age, sex, body mass index, TUG, OLS and 5CS were independently associated with SPMT. The data were analyzed using SPSS software Windows version 20.0 (SPSS, Chicago, IL, USA). A *P*-value <0.05 was considered statistically significant for all analyses.

Results

The demographic characteristics of the overall, normal and slow walking groups are summarized in Table 1. A total of 26 patients were classified as the normal walking group, and 21 patients as the slow walking group. There were no significant differences in sex, body mass index, loneliness, donepezil treatment, SPMT or physical activity between the two groups ($P > 0.05$). The normal walking group was younger (normal walking group 74.7 ± 7.2, slow walking group 79.6 ± 5.9, $P = 0.016$), and had significantly better scores than the slow walking group in TUG (normal walking group 7.9 ± 1.4 s, slow walking group 11.4 ± 2.6 s, $P < 0.001$), OLS (normal walking group 24.3 ± 24.3 s, slow walking group 5.8 ± 6.1 s, $P = 0.006$), 5CS (normal walking group 10.0 ± 2.2 s, slow walking group 12.4 ± 4.2 s, $P = 0.016$; Table 1). In the slow walking group, physical activity was significantly correlated with SPMT ($r = 0.471$, $P = 0.031$), as shown in Figure 1, but this correlation was absent in the normal walking group. In addition, there was a correlation between SPMT and physical activity after adjusted by age and sex in the slow walking group ($r = 0.493$, $P = 0.032$).

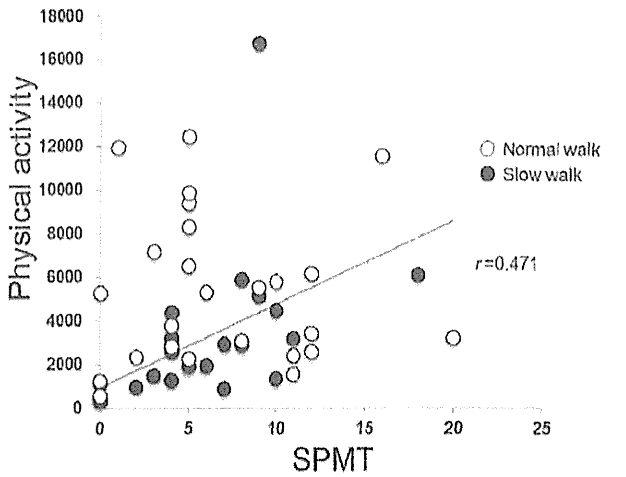

Figure 1 Relationship between physical activity and the Scenery Picture Memory Test (SPMT) in the normal walking and slow walking groups. In the slow walking group, physical activity was correlated significantly with SPMT ($r = 0.471$, $P = 0.031$).

Stepwise multiple linear regression analysis showed that no item was significantly associated with SPMT in the normal walking group, whereas only physical activity ($\beta = 0.471$, $P = 0.031$) was significantly associated with SPMT in the slow walking group (Table 2).

Discussion

The present study showed that memory function is strongly associated with the amount of physical activity

Table 2 Stepwise multiple regression analysis for Scenery Picture Memory Test

	Normal walking		Slow walking	
	β estimates	*P*-value	β estimates	*P*-value
Daily step counts	–	–	0.471	0.031*
Age	–	–	–	–
Sex	–	–	–	–
BMI	–	–	–	–
TUG time	–	–	–	–
OLS	–	–	–	–
5CS	–	–	–	–

Note: 5CS, five chair stand test; BMI, body mass index; OLS, one leg standing; TUG, Timed Up & Go test. $^{*}P < 0.05$.

only in the slow walking group with mild cognitive disorder. The present results show that lower physical activity could be a risk factor for cognitive decline in the elderly, and would strengthen the evidence to show the relationship between the amount of physical activity and cognitive function, as previously reported.[24] Additionally, the present study might show that the cognitive function of the elderly whose motor function and cognitive function are declining can be improved by increasing the amount of physical activity.

Physical activity might have an impact on cognitive function. The reasons why the SPMT, not MMSE, showed a correlation with physical activity might be explained as following. First, SPMT has been developed to screen mild cognitive disorder, whereas the MMSE is usually used for a broad range of cognitive impairment from normal to severe dementia. Because we only included patients with mild cognitive disorder, SPMT might be better to detect small correlated changes with other functions than MMSE. Second, SPMT shows good correlation not only with memory tests, but also with frontal function tests including word fluency test (Takechi *et al.* unpubl. observation). We speculate that efficient reminding of many objects from the scene requires the frontal function. Third, SPMT uses a line drawing scenery picture of a living room familiar to the elderly. It has been reported that aerobic exercise induces beneficial changes in brain structure and function that are correlated with improvements in cognition,[25,26] even in AD patients.[27,28] Physical activity, such as walking in and out of doors, might concomitantly give the patients visual stimulation. Because SPMT uses a picture of a living room familiar to the elderly, the degree of visual stimulation in daily living might have affected the results of SPMT. Thus, physical activity and the capacity to remember a visual scene might have shown a correlation. We suggest that increasing the amount of physical activity might result in beneficial biological changes to the brain structure and function or in beneficial physical changes to mobility and body composition. Therefore, increasing the step counts in a day could help to maintain and improve the cognitive function of older adults with mild cognitive disorder.

In the normal walking group with mild cognitive disorder, we found no significant association between memory function and the other variables. Other studies also show a lack of association of cognitive function with the amount of physical activity in older adults with similar ages to those in the present study.[7,29] Therefore, we need to consider effective strategies for patients with higher physical function.

There were several limitations of the present study. First, our limited sample size might introduce some error of inference, reduce the power of the analysis and limit generalization. Second, the present study was a cross-sectional study. Therefore, the relationship between the memory function and physical activity needs further investigation, such as an increase in physical activity levels for a certain period can improve the scores of SPMT, MMSE and other cognitive tests. Third, the definition of the normal walking group depended only on walking time in the present study. We might have to measure a frailty index, such as the Edmonton frail scale[30] or the Fried frailty assessment,[31] if we can extend our results to the frail elderly. Fourth, we used the SPMT, a visual memory test, as a cognitive test. However, we did not measure other factors, such as visual function and attention, that might have affected the present results. Therefore, it might be impossible to evaluate properly the relationship between physical activity and memory function. Thus, the results of the present study should be interpreted with caution.

In conclusion, the present study shows that cognition is associated with higher levels of physical activity only in patients with mild cognitive disorder who showed a slow walking speed. Our results suggest that increasing the amount of physical activity might prevent the deterioration of cognitive function. Further investigation, such as a prospective study, is required to confirm our results.

Acknowledgments

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Disclosure statement

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

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Shoe-fit is correlated with exercise tolerance in community-dwelling elderly people

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Purpose: Maintenance of physical activity significantly affects quality of life, and the frequency of physical activity depends upon exercise tolerance. However, there is minimal information on the external factors that contribute to exercise tolerance. The aim of this study was to examine the association between exercise tolerance and shoe-fit in community-dwelling elderly people.
Methods: Subjects were 155 elderly, healthy, community-dwelling Japanese volunteers. Exercise tolerance (Shuttle Walk Test [SWT]), 10-m walking time (10mWT), and forced expiratory volume in 1 second (FEV1) were measured. Shoe-fit was assessed and participants were divided into three groups according to the heel-fit of their shoes (Too Loose, Loose, Fit). Group scores in the above variables were compared. Further, a multivariate logistic regression model using a stepwise method was performed to investigate which shoe-fit factors were independently associated with SWT.
Results: No significant differences in age, gender, body mass index, 10mWT, FEV1, or presence or absence of pain sites were observed between the three groups. The Fit ($p = 0.001$) and Loose ($p = 0.008$) groups had significantly higher SWT score than the Too Loose group. Multivariate logistic regression analysis showed that poor heel-fit was significantly correlated with a low SWT score, even following adjustments for age, gender, 10mWT and FEV1 (odds ratio: 0.25, 95% confidence interval: 0.07–0.95, $p = 0.04$).
Conclusions: This study demonstrates that heel-fit is associated with exercise tolerance in community-dwelling elderly people. It is important for elderly people to wear adequate fit shoes in order to enhance physical functions and prevent declining physical functions.

Keywords: shoe-fit; heel; exercise tolerance; shuttle walk test; physical function

Introduction

The maintenance of physical activity has been linked to a higher quality of life, especially in the elderly. Exercise tolerance plays an important role in increasing physical activity (Chmelo et al., 2012) and preventing injuries and complications (Nutt & Russell, 2012). Further, decreased exercise tolerance is associated with physical frailty (Boxer et al., 2010; Pereira et al., 2010) and higher mortality (Boxer et al., 2010). Therefore, exercise tolerance is a crucial factor in the maintenance of a healthy life for elderly people.

Evidence suggests that exercise tolerance is associated with numerous physical functions (Bardin & Dourado, 2012; Gudlaugsson et al., 2013; Léger & Lambert, 1982; Spagnuolo, Jürgensen, Iwama, & Dourado, 2010). Elderly people would likely cease exercising before such improvements would manifest (Silveira et al., 2013). Additional approaches that focus on external factors contributing towards the maintenance of efficient exercise need to be explored.

Shoes are required for many kinds of exercise and have various influences on physical functions. Particularly in the elderly, shoes play an important role in exercise because of age-related changes in foot structure and function. Wearing inadequate shoes increases various problems in the elderly (Arnadottir & Mercer, 2000; Koepsell et al., 2004; Menant, Steele, Menz, Munro, & Lord, 2008, 2009; Menz & Lord, 2001; Menz & Morris, 2005; Menz & Sherrington, 2000; Tencer et al., 2004). Conversely, adequate shoes may improve gait performance (Arnadottir & Mercer, 2000; Nigg, Hintzen, & Ferber, 2006; Ramstrand, Thuesen, Nielsen, & Rusaw, 2010; Shakoor et al., 2013). Further, several researchers investigated shoe-fit, defined as the length and width difference between the foot and the shoe, in the elderly and found that more than half of people wear poor fit shoes (Burns, Leese, & McMurdo, 2002; Menz & Morris, 2005). Thus, wearing well-fitting shoes may enable rapid increases in physical activity in the elderly; however, few studies have addressed the association between shoe-fit and exercise tolerance.

Therefore, the goal of the present study was to examine the association between exercise tolerance and shoe-fit in community-dwelling elderly people.

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Methods

Participants

Participants were recruited for the study through local press that requested healthy community-dwelling volunteers. A total of 155 Japanese people participated in the study. Initial participation requirements stipulated that subjects be 65 years of age or older; community-dwelling; able to walk without assistance; willing to participate in physical fitness assessments; had normal pulmonary function; and met minimum hearing requirements. An interview was subsequently conducted to exclude participants based on the following exclusion criteria: severe cardiac, pulmonary, or musculoskeletal disorders; comorbidities associated with a greater risk of falls, such as Parkinson's disease and stroke; and use of psychotropic drugs. Written informed consent was obtained from each participant in accordance with the guidelines approved by the Kyoto University Graduate School of Medicine and the Declaration of Helsinki. The study protocol was approved by the ethical committee of the Kyoto University Graduate School of Medicine.

Demographic data

Data on age, body mass index (BMI), gender, and presence or absence of pain sites were obtained. All data were collected in a single session. Information on age, gender and presence or absence of pain sites was directly obtained from the participants and BMI was calculated from measured height and weight using standardised height and weight scales.

10-m walking time test and shuttle walking test

A comfortable 10-m walking time test (10mWT; Lopopolo, Greco, Sullivan, Craik, & Mangione, 2006) and a Shuttle Walk Test (SWT; Singh, Morgan, Scott, Walters, & Hardman, 1992) were used to assess physical functions. In the 10mWT, participants walked 15 m at an individually determined comfortable pace. A stopwatch was used to record the time required to reach the 10-m point marked in the middle of the path. The SWT is used to evaluate exercise tolerance. During the SWT, subjects walk back and forth along a 10-m flat course, and progressively increase pace in accordance with audio signals until they are unable to maintain the pace. The SWT ended when the participant could no longer continue or when the 10 m walk had been performed 50 times (maximum score 500). Participants were divided into groups by SWT score: ≤ 390 or > 390. A cut-off of 390 or 400 has been shown to be diagnostically accurate for elderly people (Win et al., 2006).

Pulmonary function

All subjects underwent spirometric evaluation. Forced expiratory volume in 1 second (FEV1) was measured by spirometry (Spiro Sift SP-370; Fukuda Denshi Co., Ltd, Tokyo, Japan). Pulmonary function tests were conducted according to the guidelines of the Japanese Respiratory Society (Tojo, Suga, & Kambe, 2005).

Evaluation of footwear

A shoe-fit checklist was used to assess the adequacy of subjects' habitual shoes. We told the subjects to wear their most common shoes on the day of the test. The evaluated factors included heel-fit, toe space, Width-fit (Width), Sole stiffness, the presence or absence of a heel counter (Counter), adjuster type (Adjuster; i.e., lace, Velcro fastening, and zip fastening), and adjusting (Adjusting). We checked their shoes to exclude participants based on the following exclusion criteria: high heels, not covered upper, high-cut shoes, sandals and boots.

Heel-fit was assessed and designated as too loose (Too Loose), loose (Loose) and fit (Fit) at the indicated points. While in a standing position, subjects were asked to raise their heel while the heel region of their shoe was held by the experimenter. The degree of fit between the heel region and the shoe was then assessed. A shoe was considered too loose if it was separated from the inferior of calcaneal bone. A shoe was deemed merely loose if it was separated from the inferior calcaneus at the rear of the insole. A shoe that adhered to the calcaneal region was considered a good fit (Figure 1). Toe space, Width, and Sole stiffness were assessed with a scale: 1 = loose or soft, 2 = fit, and 3 = tight or hard at the indicated points. Thus, a score of 1 or 3 indicated that a shoe was a poor fit, while a score of 2 indicated a shoe was a good fit. Toe space and Width were assessed by palpating the shoe and evaluating the space between the toes and shoe, and between the dorsum of the foot and the shoe. Intra-rater reliability testing of questionnaire responses revealed kappa coefficients consistency over 0.60 (Toe-space: 0.77, Width: 0.75, Heel: 0.77) for each item, and data ranges suggested we could evaluate with substantial reliability (Landis & Koch, 1977). Sole stiffness was assessed by twisting the shoe. Counter and Adjuster were checked by palpating the shoe. Well fit depends on presence or absence of Counter and Adjuster. Finally, information on Adjusting was obtained directly from participants by asking 'Do you always adjust your adjuster (i.e., lace, Velcro fastening, and zip fastening)?' (Figure 2).

Statistical analyses

The participants were divided into three groups based on heel-fit: Too Loose, Loose, and Fit. Differences between

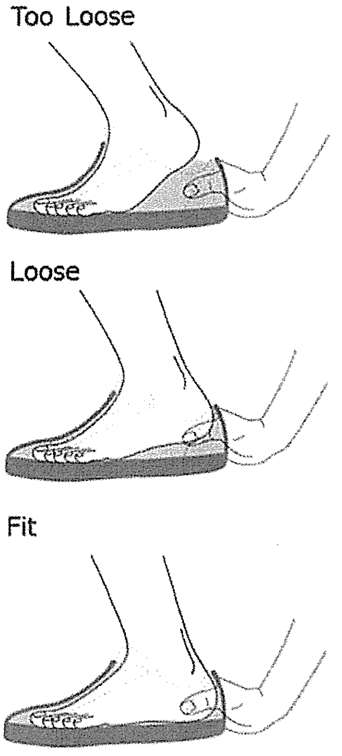

Figure 1. Evaluation method of Heel-fit.

the three groups were assessed using an analysis of variance (ANOVA) for age, BMI, 10mWT and FEV1; a Kruskal-Wallis test for SWT because SWT score is not normally-distributed; and a chi-square test for gender, and presence or absence of pain sites. The Mann-Whitney test was used for post-hoc analysis of SWT. A multivariate logistic regression model using a stepwise method was performed to examine which measurements of shoe-fit were independently associated with SWT. We assigned SWT as a dependent variable and measurements of shoe-fit as independent variables adjusted by age, gender, BMI, 10mWT, presence or absence of pain cites and FEV1. In addition, a chi-square test was performed to investigate which shoe-fit factors were best associated with exercise tolerance.

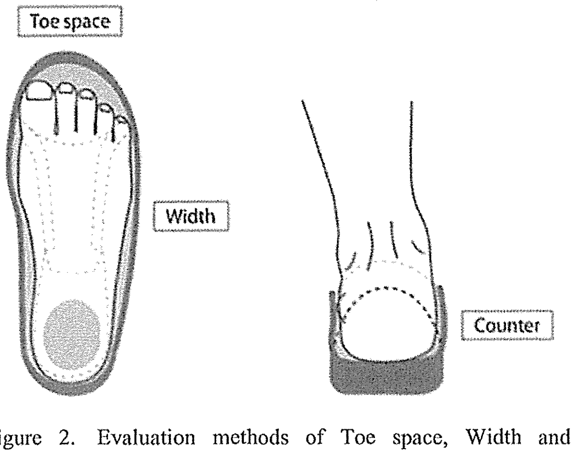

Figure 2. Evaluation methods of Toe space, Width and Counter.

A p-value of < 0.05 was considered statistically significant for the ANOVA, Kruskal-Wallis test, and the multivariate logistic regression model. A p-value of < 0.016 was considered statistically significant for the post-hoc test.

Results

The demographic characteristics of the overall sample and the Too Loose, Loose, and Fit groups are summarised in Table 1. Thirty-one participants were assigned to the Too Loose group, 60 to the Loose group, and 64 to the Fit group. There were no significant differences in age, BMI, 10mWT, FEV1, or presence of pain between the three groups. There was a significant difference in gender, with women making up a high proportion (74%) of the Too Loose group. Adequate heel-fit was associated with a better SWT score than inadequate heel-fit (Too Loose group = 358.7 ± 68.2 m, Loose group = 401.5 ± 78.6 m, Fit group = 415.9 ± 76.9 m, $p = 0.002$; Table 1). In addition, the Fit group had significantly higher SWT scores than the Too Loose group ($p = 0.001$), and the Loose group had higher SWT scores than the Too Loose group ($p = 0.008$), as indicated by a post-hoc Mann-Whitney test.

The multivariate logistic regression analysis showed that inadequate heel-fit (odds ratio: 0.16, 95% confidence interval: 0.04–0.63, $p = 0.009$) was significantly correlated with a low SWT score, even after adjustments for age, gender, 10mWT, presence or absence of pain cites and FEV1 (Table 2).

The chi-square test showed that a better heel-fit was significantly correlated with better Width, better Sole stiffness, presence of Counters, presence of Adjusters, and better Adjusting (Table 3, $p < 0.016$).

Discussion

The present study analysed the relationship between exercise tolerance and shoe-fit in community-dwelling elderly individuals. Results showed that heel-fit is associated with exercise tolerance after adjustment for age, gender, foot pain, physical function, and pulmonary function. There is minimal data on the relationship between shoe-fit and physical function, and the present findings indicate that adequate shoe-fit is associated with exercise tolerance.

We considered that heel-fit has been demonstrated to influence walking efficacy in exercise tolerance tests.

Table 1. Comparison of demographic characteristics and measurements between Overall, Too Loose, Loose, and Fit groups.

	Overall (n = 155) Mean ± SD	Too Loose (n = 31) Mean ± SD	Loose (n = 60) Mean ± SD	Fit (n = 64) Mean ± SD	p-value
Age†	73.6 ± 4.4	74.9 ± 4.7	73.4 ± 4.0	73.2 ± 4.6	0.18
BMI†	23.1 ± 2.7	23.4 ± 2.5	23.0 ± 2.2	22.9 ± 3.3	0.71
10m walking time test†	7.4 ± 1.1	7.6 ± 1.3	7.5 ± 0.9	7.2 ± 1.1	0.10
FEV1†	2.0 ± 0.6	1.7 ± 0.6	2.0 ± 0.6	2.0 ± 0.6	0.052
Shuttle walking test††	399.0 ± 78.3	358.7 ± 68.2	401.5 ± 78.6	415.9 ± 76.9	0.002
	n (%)	n (%)	n (%)	n (%)	
Female gender, n (%)†††	81 (52.3%)	23 (74.2%)	30 (50.0%)	28 (43.8%)	0.019
Pain, n (%)†††	37 (23.9%)	11 (35.5%)	15 (25.0%)	11 (17.2%)	0.14
Hallux valgus, n (%)†††	36 (23.2%)	8 (25.8%)	16 (26.7%)	12 (18.8%)	0.54
Bunionette, n (%)†††	11 (7.0%)	3 (9.6%)	4 (6.7%)	4 (6.3%)	0.82

Note: BMI = Body Mass Index, FEV1 = Forced expiratory volume in 1 second.
†ANOVA, ††Kruskal-Wallis test, †††χ^2 test

Adequate shoe-fit is associated with faster walking speed (Arnadottir & Mercer, 2000; Doi et al., 2010) and better gait performance (Doi et al., 2010). In our study, there was no significant difference in 10mWT between the three groups. However, the three groups' results showed a trend similar to the SWT results. We considered that shoe-fit, particularly heel-fit, is not much influence to walking speed, but more influence to walking test walked long distance. Thus, an adequate heel-fit may enhance the efficiency of walking with each cycle, and support elderly people. Further, heel-fit may influence walking to a greater degree over a prolonged period. It follows that well-fitting shoes may improve exercise tolerance in elderly people. In contrast, we can produce a mindset that people who have inadequate fit shoes are walking at a much slower pace and shorter distances. It is unclear whether adequate shoe-fit enhances exercise tolerance or whether inadequate shoe-fit negatively affects exercise tolerance. However, it is important for elderly people to wear adequate fit shoes in order to enhance physical functions and prevent declining physical functions, and foot problems.

Table 2. Multivariate logistic regression model using a stepwise method to determine the SWT association.

	Odds Ratio	95% CI	p-value
Heel fitting			0.023
Too Loose	0.16	(0.04 – 0.63)	0.009
Loose	0.94	(0.38 – 2.33)	0.90
Fit	1 [reference]	1 [reference]	–
Toe-space	–	–	not significant
Width	–	–	not significant
Sole-stiffness	–	–	not significant
Counter	–	–	not significant
Adjuster	–	–	not significant
Adjusting	–	–	not significant

Adjusted by age, gender, BMI, 10m walking time, pain and FEV1.
Note: BMI = Body Mass Index, FEV1 = Forced expiratory volume in 1 second.

In addition, we demonstrated that heel-fit is associated with Width, Sole stiffness, Counter, Adjuster, and Adjusting. Previous reports have suggested that Sole stiffness affects balance (Menant et al., 2008; Menant et al., 2009). Adequate shoe-fit also depends on the adhesion of both the calcaneal region of the foot and anterior ankle to the heel-counter and adjuster of shoes. Furthermore, suitable shoe width decreases foot movement within the shoes. Thus, these elements of shoe-fit may influence heel-fit. In this study, toe space did not influence heel-fit. This may have resulted from the fact that the majority of participants wore shoes with appropriate toe space, similar to a previous study (Menz & Morris, 2005). Taken together, results of the present study indicate that external contributing factors, such as shoe-fit, may sufficiently be associated with exercise tolerance.

This study had several limitations. First, because this study used a cross-sectional design, further investigation of certain matters, such as whether wearing suitable shoes for an extended period can improve SWT scores and other physical functions, is needed. Also, because direction of causality is unclear, it is unknown whether well-fitting shoes affect exercise tolerance or people who have high exercise tolerance wear well-fitting shoes. Second, a thorough survey of foot complications, such as bunion, hammer toe, high/low arch and neuropathy, and shoe type, which can affect the exercise tolerance level, was not performed. Due to these limitations, the results of the present study should be interpreted with caution.

Table 3. Associations between heel-fit and each shoe-fit measurement.

	Too Loose (i)	Loose (ii)	Fit (iii)	p-value	Post hoc
	Proper (percentage in each group)				
Toe-space	26 (83.9%)	58 (96.7%)	59 (92.2%)	not significant	–
Width	3 (10.7%)	25 (41.7%)	34 (53.1%)	< 0.001	i < ii, iii
Sole-stiffness	8 (25.8%)	28 (46.7%)	40 (62.5%)	0.004	i < iii
Counter	7 (22.6%)	33 (55.0%)	32 (50.0%)	0.01	i < ii,iii
Adjuster	13 (41.9%)	50 (83.3%)	52 (81.3%)	< 0.001	i < ii, iii
Adjusting	1 (3.2%)	13 (21.7%)	19 (29.7%)	0.01	i < iii

Note: Toe-space = the space between the toes and shoe, Width = the space between the dorsum of the foot and the shoe, Sole-stiffness = stiffness of sole by twisting the shoe, Adjuster = presence or absence of adjuster, Adjusting = whether participant adjusts the adjuster.

Conclusion

Results of the present study showed a significant relationship between exercise tolerance and heel-fit. This finding indicates that shoe-fit may positively influence physical function.

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