Table 1 Kihon Checklist

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

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

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

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

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

Methods

This was an epidemiological observational study.

Participants

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

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

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

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

Procedures

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

Translation of Kihon Checklist original version to Brazilian Portuguese language

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

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

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

Table 2 Participant characteristics

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

BMI, body mass index.

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

Semantic analysis of the Kihon Checklist Brazilian Portuguese alpha version

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

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

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

Table 3 Kihon Checklist Brazilian Portuguese beta version

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

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

Validation of the Kihon Checklist Brazilian Portuguese version

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

Statistical analysis

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

Results

Translation process

After the analysis by the Japanese specialists, it was suggested that we modify question number 14 of the back-translated KCL-PT version. The newly generated version was submitted for a second analysis and was subsequently approved.

Semantic analysis

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

Bilingual participants

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

Validation process

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

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

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

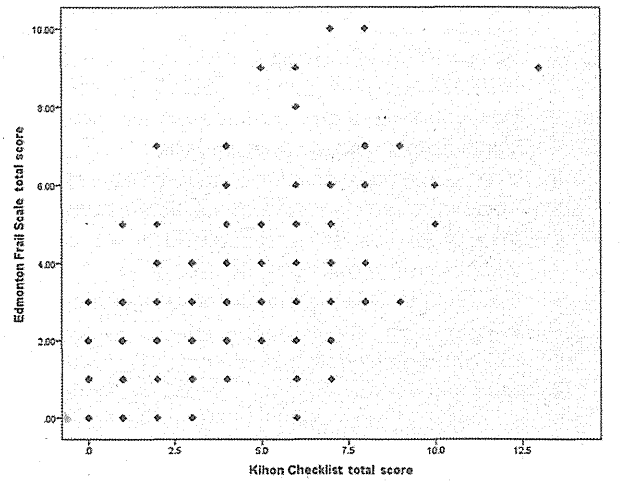

Figure 1 Correlation between the total scores of the Kihon Checklist and the Edmonton Frail Scale.

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

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

Discussion

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

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

Table 4 Relationship between the Kihon Checklist Brazilian Portuguese version and the Edmonton Frail Scale score (n = 161)

Edmonton Frail Scale total score Kihon Checklist Domain Factors	Kendall's τ Coefficient	P value	Regression coefficient β R^2 = 0.387	P-value <0.001
Lifestyle	0.429	<0.001	0.073	0.788
Physical strength	0.367	<0.001	0.330	0.031
Nutrition	0.211	0.002	0.090	0.267
Eating	0.213	0.001	−0.005	0.966
Socialization	0.269	<0.001	0.075	0.433
Memory	0.285	<0.001	0.145	0.167
Mood	0.359	<0.001	0.196	0.014

Table 5 Differences of the Edmonton Frail Scale total score according to the frailty condition by Kihon Checklist cut-off points (n = 161)

Kihon Checklist Domains	Edmonton Frail Scale total score Non-frail Median (min–max), n	Frail Median (min–max), n	P-value
Lifestyle	3 (0–10), 157	6 (5–9), 4	0.015
Physical strength	2 (0–10), 138	4 (2–10), 23	<0.001
Nutrition	3 (0–10), 161	–	–
Eating	2 (0–10), 121	3 (0–10), 40	0.012
Socialization	3 (0–10), 113	5 (3–9), 48	0.002
Memory	2 (0–9), 77	3 (0–10), 84	<0.001
Mood	2 (0–9), 138	4 (1–10), 23	<0.001

Analyzed using Mann–Whitney U-test.

activities of daily living and also in instrumental activities of daily living, which is one of the principal factors for institutionalization and is also associated with mortality among older adults.[25,26] However, frailty is not unidimensional; the focus must be extended to include aspects such as cognition, mood and social support.[21] In the present study, we verified the contribution of the mood domain score of the KCL-PT to EFS total score (coefficient β = 0.196; P = 0.01). Evidence suggests that depression in the aged population is also associated with functional impairment and increased mortality.[27,28]

The EFS does not directly address the lifestyle, eating or socialization domains that are addressed by the KCL-PT. Those differences might explain the low regression coefficients of these domains with the EFS total score. It was intriguing that the nutrition and memory domains of the KCL-PT, which have corresponding domains in the EFS, did not present a significant regression coefficient for the EFS total score. However, when we analyzed just the specific domains, and not the total EFS total score, we verified a significant correlation between those domains (nutrition domain Kendall's τ coefficient = 0.483, P < 0.001 and memory domain, Kendall's τ coefficient =0.221, P = 0.002).

Although the KCL-PT domains presented a significant regression coefficient with EFS, the value could be considered low (R^2 = 0.387, P < 0.001). The EFS domains, such as general health state, social support, medication use and continence, that were not directly investigated by the KCL-PT could represent the remaining coefficient value that is unexplained by KCL-PT. Despite these differences, the essences of both frailty assessments were deemed similar because their total scores were significantly correlated, suggesting that the EFS was a suitable assessment of frailty for use in validating the Kihon Checklist in Brazil.

Although this is a pioneer study using the KCL in Brazil, we unfortunately could not compare our results with other Brazilian studies present in the literature. Despite this limitation, we believe that the quality of the KCL-PT was satisfactory in terms of internal consistency (Cronbach's α coefficient = 0.787), and the

KCL-PT is considered a valid frailty index for use with elderly Brazilian adults because its results correlated with those of the already-validated EFS. Therefore, we suggest the use of the KCL-PT to screen and monitor the elderly Brazilian population's frailty conditions.

Even though frailty confers morbidity, mortality and healthcare costs,[1,7] causing an increased strain on all healthcare systems and family structures, this type of syndrome can be avoided or delayed with identification and early intervention.[1] The awareness of this syndrome and its risks can be useful in supporting the care of frail elderly patients by healthcare workers, and thus can decrease patients' risks for adverse health outcomes.[29] Therefore, the ability to measure frailty is critical for this process at a healthcare policy level, as well as clinically, and information about frailty can support program planners by identifying the range of services that might be required, and the anticipated level of need for those services. Clinically, frailty stratification can help in planning interventions or predicting a patient's risk of death or need for institutional care.[30] The KCL-PT can be used to answer this emergent and emergency demand in screening the frailty of the elderly Brazilian population as a first step in facing and confronting frailty in this population.

The present study had several limitations, including the limited sample size and possible bias as a result of the choice of recruitment location. We suggest future studies that recruit a larger sample size, include different regions of Brazil and different institutional settings, such as communities for the elderly (urban and rural areas), nursing homes and other settings. Furthermore, additional studies to verify the association of the KCL-PT with other measures of health are necessary.

We successfully translated the KCL into Brazilian Portuguese and validated the instrument's application in an elderly Brazilian population. We encourage the application of the KCL-PT to investigate frailty in older adults with an aim of preventing or delaying functional dependence and other adverse health outcomes caused by the aging process. Given the simple 25 yes/no question structure of the KCL-PT, the checklist is suitable for clinical application, research and the needs of policy makers.

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Disclosure statement

The authors declare no conflict of interest.

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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Self-reported quality of sleep is associated with bodily pain, vitality and cognitive impairment in Japanese older adults

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Aim: Poor sleep can affect physical and mental health, and consequently people's quality of life (QOL); however, only a few studies have addressed the potential associations of physical and mental health with quality of sleep (QOS) in Japan. The present study aimed to investigate the association of QOS with sociodemographic and lifestyle characteristics, cognitive status, nutrition, depression, seclusion, and QOL in Japanese community-dwelling older adults.

Methods: Data were collected through self-administered questionnaires and other specific tests in 145 (age 73 years [range 70–77 years]) participants. The χ^2-test or Fisher's exact test were used to compare categorical variables stratified by QOS, and the Mann–Whitney *U*-test was used for continuous variables. Furthermore, logistic regression analyses were carried out to verify the associations with QOS.

Results: The poor QOS group had more males ($P < 0.05$), a shorter self-reported sleep duration ($P < 0.001$), higher body mass index ($P < 0.05$) and higher risk of depression ($P < 0.05$), whereas the good QOS group showed higher scores in the QOL summary and domains of physical component ($P < 0.01$), general health ($P < 0.001$), bodily pain ($P < 0.001$) and vitality ($P < 0.001$). In the logistic regression model, cognitive status (OR 0.13, 95% CI 0.03–0.55), bodily pain (OR 0.91, 95% CI 0.84–1.00) and vitality (OR 0.82, 95% CI 0.73–0.92) were associated with QOS.

Conclusion: The present study provides evidence that QOS is linked to cognitive status, bodily pain and vitality in Japanese older adults. We maintain that screening a person's sleep characteristics in a community setting might be relevant to identify those older adults at risk of a poor QOL and frailty in the early phase, triggering further health analyses. **Geriatr Gerontol Int 2013; ••: ••–••.**

Keywords: bodily pain, cognitive status, quality of life, quality of sleep, vitality.

Introduction

Sleep is a key factor for the restoration, maintenance and improvement of a person's health. Because sleep disturbance can affect physical and mental health, it consequently affects people's quality of life (QOL). Studies have identified that poor sleep quality is associated with chronic health dysfunctions[1] and depression,[2] and can be an early sign of physical[3] and cognitive decline.[4,5] Such conditions are observed especially in older adults who might experience changes in both the qualitative and quantitative aspects of their sleep pattern and distribution.[6]

Researchers have been challenged to develop research protocols to assess sleep characteristics in older adults due to the complex interactions and several confounding factors that are associated with the aging process; however, the importance of the studies related to this theme remains clearly relevant for public health.[6] Several methods are used for assessing sleep, including objective and subjective measurements; the "gold standard" of objective sleep measurement is polysomnography. Unfortunately, its use in research is not always feasible because of the intensive cost and labor. Overall, a common method to assess sleep includes self-report methods; however, one of the concerns about subjective reports regards its validity. Generally, the association between the objective and subjective sleep measures appears to be modest,[7] but studies have

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shown that the subjective assessment is more sensitive to detect differences in one's sleep characteristics than the objective measurements. Regarding this, a study found significant differences of quality of sleep (QOS) between older chronic pain patients and a control group without sleep complaints, as assessed by their subjective sleep reports; however, with the exception of sleep duration, the groups did not differ in the actigraphically obtained measures of QOS.[8]

Hence, considering the modest results in the literature regarding the subjective quality of sleep and QOL of Japanese older adults, we carried out a study to investigate the self-reported QOS and its associated factors, such as sociodemographic and lifestyle characteristics, cognitive status, nutrition, depression, seclusion and QOL, in Japanese community-dwelling older adults. We hypothesized that sleep characteristics are related to important health measurements, and thus their screening in a community setting can be useful to identify older adults at risk of a poor QOL and frailty in the early phase, trigger further health analyses and determine the required approaches.

Methods

This study had a cross-sectional design.

Participants

The participants were community-dwelling Japanese older adults, recruited in western Japan through local press advertisements requesting healthy community-dwelling volunteers to collaborate in this research. We met all the subjects willing to participate on a specific day in November 2012; we explained the research protocol and then carried out the data collection, excepting pedometer. During tests, the participants were assisted by trained assistants. We recruited people aged 65 years or older who could carry out normal activities of daily living (ADL) and fill out the questionnaires. We excluded those individuals who had any of the following: (i) moderate or severe cognitive impairment (i.e. Mini-Mental State Examination [MMSE] score ≤21 points); (ii) uncontrolled cardiovascular, pulmonary or metabolic diseases; (iii) any orthopedic conditions that could restrain normal ADL; (iv) any type of surgery during the previous 3 months; (v) forced bed rest during the previous 3 months; or (vi) current treatment for cancer. All participants were informed of the purpose and procedures of the study, and written consent was obtained. A total of 179 participants were recruited to participate in this research; however, 34 of them were excluded from the analysis because they were aged lower than 65 years and/or missing data in questionnaires. A total of 145 participants met the criteria for the study and were willing to carry out the study procedures. Research procedures started in July, and data were collected in November 2012.

The study protocol was approved by the Kyoto University Graduate School of Medicine Ethics Committee (No. E1470, 2012).

Quality of sleep

The QOS was determined through a single question, "During the past month, how do you rate your sleep quality?", and the answers were provided on a four-point Likert scale with the following options: (i) very good; (ii) good; (iii) poor; and (iv) very poor. We dichotomized the QOS measure into very good/good (good; coded as 0) versus poor/very poor (poor; coded as 1).

General assessments

The participants answered a self-administered questionnaire regarding: (i) sociodemographic characteristics, such as age, living situation, educational level, current work and financial satisfaction; (ii) lifestyle and health condition regarding the frequency of smoking and alcohol consumption, number of medical consultations in 6 months, number of medications and morbidities; and (iii) other relevant health indicators, such as self-reported sleep duration, body mass index (BMI), regular practice of physical activity, pedometer counts in 14 days, MMSE, Mini-Nutritional Assessment (MNA), Geriatric Depression Scale (GDS), the Life-Space Assessment (LSA) and QOL.

The participants were asked about the presence of several morbidities (e.g. lower back pain, diabetes, osteoporosis, hypertension, hyperlipidemia, arthropathy and respiratory disease); their report was considered in the analysis when they were assumed to use prescribed medications for the specific morbidity. In addition, the presence of more than one chronic condition was included for analytical purposes.

The self-reported sleep duration referred to the time when the participants slept at night during the past month. Height and weight were measured, and the BMI was calculated as the bodyweight divided by height squared. For classification purposes, the considered BMI cut-offs were those proposed by the Japan Society for the Study of Obesity (i.e. underweight, BMI <18.5 kg/m^2; normal weight, BMI 18.5 to 25 kg/m^2; and obese, BMI ≥25 kg/m^2).[9]

Furthermore, regarding the pedometer data (Yamax Powerwalker EX-510; Yamasa, Tokyo, Japan), the participants were instructed to wear the instrument in the morning and register the number of steps in a diary at the end of the day. After 2 weeks, they were asked to send the pedometers and the diary record by mail to the researchers. The diary record was then matched with the pedometer memory, and the average of the step counts during the 2 weeks was used for the analysis.

Furthermore, well-recognized health screening tools in the health sciences literature were used to better identify the participants' general health characteristics: MMSE, for cognitive function in older adults;[4] MNA, for a rapid nutritional assessment;[10] GDS, for psychological characteristics;[11] and LSA, related to seclusion and decline in ADL and physical function.[12] QOL was verified by the Short-Form 8 items (SF-8), which is an abbreviated version of SF-36 and consists of eight questions (domains) regarding general health, physical functioning, role-physical, bodily pain, vitality, social functioning, mental health and role-emotional. Such domains were also considered as physical and mental component summaries, as previously specified.[13] A higher score in the SF-8 indicates a better QOL score.

Statistical analysis

The Kolmogorov–Smirnov test was used to verify the normality of the data. The data are presented as the median (interquartile range) or respective percentage. The χ^2-test or Fisher's exact test were used to compare groups stratified by QOS with respect to sex, education, living situation, work, financial satisfaction, smoking, alcohol, number of consultations in 6 months, number of medications, morbidities, comorbidities and regular physical activity categories. Additionally, the χ^2-test was used to compare the pedometer counts and LSA categorized according to values above or below the median (6562 steps/day and 86, respectively) due to their skewed characteristics, and the MMSE, MNA and GDS scores were categorized according to their respective cut-offs (i.e. 24, 12 and five, respectively). The Mann–Whitney *U*-test was used to compare age, BMI, self-reported sleep duration, and the SF-8 component summaries and domains. Logistic regression was carried out to analyze the potential associations for QOS in Japanese older adults. Sociodemographic, lifestyle and health condition variables were analyzed one by one as covariates in a partially adjusted model by sex and self-reported sleep duration. Finally, variables that reached $P < 0.1$ in the partially adjusted model (e.g. comorbidities, MMSE, GDS, LSA, SF8 physical and mental component summaries, general health, bodily pain, vitality, social functioning, and mental health) were inserted in a fully adjusted model, and analyzed as covariates considering QOS as a dependent variable. Statistical significance was set at $P < 0.05$. All analyses were carried out using the Statistical Package for the Social Science program version 20.0 (SPSS; IBM, Chicago, IL, USA).

Results

A total of 145 subjects participated in the present study; they were then divided according to their QOS report into good sleep ($n = 115$) and poor sleep ($n = 30$) groups. In addition, the data in tables are also presented as the total sample. Their sociodemographic characteristics are shown in Table 1. No significant difference was found with respect to age; however, regarding sex, more males had a poor QOS ($P < 0.05$). Additionally, no significant differences were found for educational level, living situation, current work or financial satisfaction.

Regarding lifestyle and health conditions, the current number of smokers was less than 10% of the total participants, and less than 50% of the participants drank alcohol. There were no differences in the consultation frequency in 6 months, number of medications or morbidities (Table 2).

We found significant differences in the self-reported sleep duration ($P < 0.001$), BMI ($P < 0.05$), GDS ($P < 0.05$), SF-8 – physical component summary ($P < 0.01$), general health ($P < 0.001$), bodily pain ($P < 0.001$) and vitality ($P < 0.001$) between those individuals who evaluated their QOS as good and as poor. The poor QOS group had a shorter self-reported sleep duration, higher BMI and higher risk of depression than the good QOS group.

Furthermore, the good QOS group showed significantly higher scores in the different QOL summaries and domains: SF-8 – physical component ($P < 0.01$), general health ($P < 0.001$), bodily pain ($P < 0.001$) and vitality ($P < 0.001$). No significant differences were found regarding regular physical activity, pedometer counts or other variables (Table 3).

In the partially adjusted model (by sex and self-reported sleep duration), BMI and GDS failed to remain significantly different between groups. However, having a normal cognitive condition appeared to be a protective factor against poor QOS (odds ratio 0.24, 95% confidence interval [CI] 0.07–0.83). The SF-8 physical component summary, general health, bodily pain and vitality domains remained significant. Comorbidities ($P = 0.06$), LSA ($P = 0.05$), SF-8 mental component summary ($P = 0.06$) and mental health ($P = 0.05$) showed a tendency towards significance. Those individuals with higher QOL scores were less likely to assess their QOS as poor (Table 4).

In Table 5, a fully adjusted model was analyzed in a stepwise logistic regression method. Considering this model, MMSE (odds ratio 0.13, 95% CI 0.03–0.55), bodily pain (odds ratio 0.91, 95% CI 0.84–1.00) and vitality (odds ratio 0.82, 95% CI 0.73–0.92) were then confirmed as protective factors for participants who evaluated their QOS as poor.

Discussion

To our knowledge, only a few studies have investigated QOS in Japanese older adults, and none have directly analyzed the associations of QOS with a broad range of

Table 1 Subjects' general characteristics (total sample and stratified by quality of sleep)

Variables	Total (n = 145)	Self-reported quality of sleep Good (n = 115)	Poor (n = 30)	P
Age (years)	73 (70–77)	73 (70–77)	74 (70.7–77)	0.78
Female (%)	53.1	57.4	36.7	0.04
Educational level (%)				0.59
Elementary school	2.1	1.7	3.3	
Junior high school	30.3	29.6	33.3	
High school	52.4	51.3	56.7	
Technical school	4.8	5.2	3.3	
University	10.3	12.2	3.3	
Living situation (%)				0.57
Alone	9.0	9.6	6.7	
Only spouse	47.6	46.1	53.3	
Spouse and child	22.8	20.9	30.0	
Only child	7.6	8.7	3.3	
Other	13.1	14.8	6.7	
Work (%)				0.96
Does not work/retired	43.7	44.6	40.0	
Volunteer	4.2	4.5	3.3	
Regular work	4.2	4.5	3.3	
Farm work	42.3	41.1	46.7	
Other	5.6	5.4	6.7	
Financial satisfaction (%)				0.17
Satisfied	68.3	70.4	60.0	
Normal	17.9	14.8	30.0	
Dissatisfied	13.8	14.8	10.0	

Values are median (interquartile range) or percentages.

important health indicators as we did herein. The present study supported the hypothesis that QOS is associated with important health indicators, such as lifestyle characteristics, cognitive status, nutrition, depression, seclusion and QOL in Japanese community-dwelling older adults. In the present study, more males had a poor QOS, and no other significant differences were found for sociodemographic information between the groups. In addition, we found a small number of smokers and alcohol consumers, who accounted for less than half of our total participants (such differences were also not associated with QOS), and the participants presented similar characteristics regarding their health conditions.

A study carried out in Japan found that poor perceived QOS was associated with advancing age, and that more females complained of poor QOS than males; however, QOS in men decreased considerably at an older age.[14] We might be able to explain why males showed poorer QOS in the present study if we consider the intrinsic characteristics of these participants. Although the present study was not designed to specifically identify sex differences, we verified no statistical differences between males and females in all the health indicators and QOL variables (data not shown). However, when comparing only males according to their QOS, we found that those with poor QOS had shorter sleep duration, higher BMI and lower QOL (considering general health, bodily pain and vitality) than those with good sleep (data not shown). In the USA, a study verified an inverse linear association between sleep duration and higher BMI in adults,[15] and another study ascertained that short sleep duration was strongly associated with greater adiposity in older men and women.[16] In Japan, studies have found contrasting results regarding sleep and weight; one found an association of short sleep duration with reduced weight, whereas another found no association.[17,18] However, such studies did not specifically address QOS, focusing instead on sleep duration. Although the relationship between BMI and QOS is still not clear, we believe that it might have influenced our outcome.

Furthermore, Gu *et al.* found that living arrangements (living with a spouse or family member compared with living alone) appeared to be associated with QOS; moreover, current alcohol drinkers had a 27% higher odds ratio of reporting good QOS compared with those who did not drink alcohol.[19] Those discrepancies with other

Table 2 Bivariate comparisons for the subjects' lifestyle and health conditions (total sample and stratified by quality of sleep)

Variables	Total (n = 145)	Self-reported quality of sleep		P
		Good (n = 115)	Poor (n = 30)	
Smoking (%)	8.3	7.8	10.0	0.71
Alcohol drinking (%)	38.6	37.4	43.3	0.55
No. consultations in 6 months (%)				0.72
No	15.3	15.8	13.3	
Once or twice	20.1	21.1	16.7	
Three or four times	14.6	15.8	10.0	
Five or six times	26.4	23.7	36.7	
Seven or more	23.6	23.7	23.3	
No. medicines (%)				0.12
No	19.3	20.8	13.8	
One	19.3	18.9	20.7	
Two	21.5	18.9	31.0	
Three	11.1	14.2	–	
Four or more	28.9	27.4	34.5	
Morbidities (%)				
Lower back pain	10.3	10.4	10.0	1.00
Diabetes	12.4	12.2	13.3	1.00
Osteoporosis	8.3	7.0	13.3	0.27
Hypertension	44.1	42.6	50.0	0.46
Hyperlipidemia	15.2	14.8	16.7	0.77
Arthropathy	4.8	6.1	–	0.34
Respiratory problems	2.8	2.6	3.3	1.00
Comorbidities (%)	23.4	22.6	26.7	0.64

Values are percentages.

studies might be a result of the homogenous characteristics of the participants that we studied, as no differences were found for many conditions.

The term QOS is widely used in the literature; however, its use involves different interpretations (e.g. some studies consider it as an insomnia occurrence, whereas others use a subjective rate approach). Therefore, we will discuss QOS in a general approach, considering sleep disturbances and duration as interference factors in QOS. When comparing the QOS groups, a difference was found in the self-reported sleep duration, with a longer sleep duration indicating a better QOS. Studies suggested that older adults who slept 7–9 h per day (similar to the values that we found – good QOS 7 [6.5–8]) were more likely to be healthy than those with shorter (≤6 h) or longer (≥10 h) sleep durations.[19] In addition, older adults with a shorter sleep duration had sleep complaints more frequently, especially night-time complaints and feeling unrested in the morning. In contrast, a longer sleep duration was associated with daytime sleepiness, independent of health status.[20] Furthermore, both longer and shorter sleep durations were associated with mortality in Japanese adults.[17]

Although BMI and depression became non-significant when the analyses were adjusted by sex and sleep duration, associations were found in an unadjusted comparison. Studies have identified the association of sleep and BMI, as discussed earlier; however, it is not a consensus.[15–18] Additionally, Kang *et al.* verified that patients with depression had a significantly higher frequency of poor sleep.[2]

In terms of cognitive conditions, having a normal cognitive status (≥24 on MMSE) appeared to be a protective factor for a better QOS (odds ratio 0.24, 95% CI 0.07–0.83), which is consistent with other studies. A 1-year longitudinal study found that the sleep disturbances score was significantly associated with incident general cognitive impairment in women, and more so with incident non-amnestic cognitive impairment. In men, the global sleep condition was significantly associated with incident general cognitive impairment.[4] Furthermore, cognitive decline was associated with sleep disturbance in non-demented community-dwelling older women in a 15-year follow-up study carried out by Yaffe *et al.*[5] Such interactions might be explained by the strength of the circadian/homeostatic interaction on modulating sleep and cognition, which are deteriorated in older healthy people.[21]

For the QOL assessment, the physical component summary, and the domains of general health, bodily

Table 3 Bivariate comparisons for the subjects' health indicators and quality of life

Variables	Total (n = 145)	Self-reported quality of sleep Good (n = 115)	Poor (n = 30)	P
Self-reported sleep duration (h)	7 [6–7.5]	7 [6.5–8]	6 [5–7]	<0.001
BMI (kg/m^2)	23.1 [21.2–25.3]	23 [20.8–24.7]	23.7 [22.2–26.4]	0.04
Regular physical activity (%)	65.2	67	58.6	0.40
Pedometer count† (%)	50.3	49.6	53.3	0.71
MMSE (% at mild cognitive impairment)‡	19.0	10.4	23.3	0.07
MNA (% at risk of malnutrition)‡	24.8	27	16.7	0.24
GDS (% at risk of depression)‡	29.7	25.2	46.7	0.02
LSA† (%)	56.6	53	70	0.09
SF-8 Physical component summary	47.5 [42.9–51.1]	47.8 [43.5–51.8]	44.3 [40.7–48.7]	0.01
SF-8 Mental component summary	51.3 [47.6–55.2]	51.7 [47.9–55.3]	50.7 [46.2–53.2]	0.14
SF-8 General health	50.7 [50.7–50.7]	50.7 [50.7–50.7]	50.7 [41.1–50.7]	<0.001
SF-8 Physical functioning	48.5 [41.9–53.6]	48.5 [41.9–53.6]	48.5 [41.9–53.6]	0.41
SF-8 Role-physical	48.4 [42.5–53.9]	48.4 [42.5–53.9]	48.4 [42.5–53.9]	0.56
SF-8 Bodily pain	46.1 [46.1–60.2]	51.7 [46.1–60.2]	46.1 [44.1–46.1]	<0.001
SF-8 Vitality	54.4 [45.2–54.4]	54.4 [54.4–54.4]	45.2 [45.2–54.4]	<0.001
SF-8 Social functioning	54.7 [45.2–54.7]	54.7 [45.2–54.7]	45.2 [38.4–54.7]	0.26
SF-8 Mental health	50.2 [50.2–57.4]	50.2 [50.2–57.4]	50.2 [44.9–57.4]	0.09
SF-8 Role-emotional	49.0 [49–54.3]	54.3 [49–54.3]	49.0 [47.9–54.3]	0.46

Values are median (interquartile range) or percentages. †Percentage of those below the median (pedometer count – 6562 steps/day; Life-Space Assessment [LSA] – 86). ‡Cut-off score for Mini-Mental State Examination (MMSE): 24; Mini-Nutritional Assessment (MNA): 12; Geriatric Depression Scale (GDS): 5. BMI, body mass index; SF-8, Short-Form 8.

pain and vitality were significantly different in the partially adjusted model (by sex and sleep duration). Those individuals with higher scores in such QOL domains were less likely to have a poor QOS. Our results regarding general health were in accordance with another study that verified that older adults with poor self-rated health were less likely to have good QOS (odds ratio 0.54, 95% CI 0.50–0.59).[22] However, in the fully adjusted model, only bodily pain and vitality remained significant.

Regarding bodily pain, a study stated that chronic pain and sleep difficulties were common in the older population living in the community; the authors observed strong and consistent associations between more severe and disseminated chronic pain and heterogeneous sleep complaints.[22] In a review study, Smith *et al.* also concluded that consistent evidence suggested that pain negatively impacts sleep both in the short- and long-term, and some evidence suggested that the relationship between pain and sleep might be reciprocal.[23] The direct relationship between pain and sleep quality is not often explored in clinical studies. Patients with chronic pain appear to be often prescribed analgesics at night or sedative pain medications, with most of the analgesics used for chronic pain and many of the sedative hypnotics used to promote sleep; however, both have direct analgesic and soporific effects.[23] Thus, the consideration of medications for pain and QOS might raise important concerns regarding the confounding effects. Moreover, medications often lead to a series of adverse drug reactions that health promoters might want to avoid, especially as a result of overdoses and polypharmacy in older adults.[24]

Furthermore, we did not find any evidence regarding vitality and QOS in the literature, and most of the articles investigated sleep with respect to the duration aspect. Goldman *et al.* found that individuals who slept ≤6 h/night had a 4.3% higher fatigue score than those who slept 7 h/night. Individuals with complaints of awakening too early in the morning had a 5.5% higher fatigue score than those without these complaints.[25] Such associations remained significant even after multivariate adjustment for multiple medical conditions. In such studies, the concept of fatigue used also included the levels of energy, vitality and strength.

Although the good QOS group had more people engaged in regular physical activity (good QOS group: 67% *vs* poor QOS group: 58.6%), we did not find significant differences regarding the practice of regular physical activity or pedometer counts, which could be as a result of our cross-sectional design. We believe that physical exercise is an appropriate therapeutic intervention to promote sleep benefits. A review study mentioned several lines of evidence: (i) moderate intensity endurance training in older sedentary men and women with sleep complaints was found to subjectively improve sleep quality; (ii) the duration of exercise was a consistent moderator variable on the acute effects of exercise

Table 4 Partially adjusted (by sex and sleep duration) multivariate logistic regression considering quality of sleep as a dependent variable, and sociodemographic, lifestyle and health condition variables as covariates

Variables	OR (95% CI)	P
Age	1.03 (0.93–1.14)	0.50
Smoking	1.29 (0.23–6.98)	0.76
Alcohol drinking	0.79 (0.29–2.17)	0.66
Comorbidities	2.81 (0.93–8.48)	0.06
BMI	1.10 (0.94–1.28)	0.20
Regular physical activity	0.55 (0.20–1.47)	0.23
Pedometer count†	0.68 (0.27–1.71)	0.41
MMSE‡	0.24 (0.07–0.83)	0.02
MNA‡	0.53 (0.17–1.69)	0.29
GDS‡	2.21 (0.86–5.65)	0.09
LSA†	0.38 (0.14–1.02)	0.05
SF-8 Physical component summary	0.92 (0.86–0.99)	0.03
SF-8 Mental component summary	0.92 (0.84–1.00)	0.06
SF-8 General Health	0.85 (0.78–0.94)	0.001
SF-8 Physical functioning	0.98 (0.93–1.03)	0.55
SF-8 Role-physical	0.96 (0.89–1.02)	0.23
SF-8 Bodily pain	0.91 (0.85–0.97)	0.01
SF-8 Vitality	0.81 (0.73–0.90)	<0.001
SF-8 Social functioning	0.95 (0.89–1.00)	0.09
SF-8 Mental health	0.91 (0.83–1.00)	0.05
SF-8 Role-emotional	0.95 (0.87–1.03)	0.28

†Analyzed values were categorized as above or below the median. ‡Analyzed values were categorized according to respective cut-offs. Variables were analyzed one by one together with sex and sleep duration in a multivariate logistic regression model. CI, confidence interval; OR, odds ratio; SF-8, Short-Form 8.

Table 5 Stepwise logistic regression considering quality of sleep as a dependent variable and comorbidities, Mini-Mental State Examination, Geriatric Depression Scale, Life-Space Assessment, Short-Form 8 Physical and Mental component summaries, Short-Form 8 General health, Short-Form 8 Bodily pain, Short-Form 8 Vitality, Short-Form 8 Social functioning and Short-Form 8 Mental health as covariates (with sex and self-reported sleep duration inserted as adjusted covariates)

Variables	OR (95% CI)	P
MMSE	0.13 (0.03–0.55)	0.006
SF-8 Bodily pain	0.91 (0.84–1.00)	0.05
SF-8 Vitality	0.82 (0.73–0.92)	0.001

CI, confidence interval; MMSE, Mini-Mental State Examination; OR, odds ratio; SF-8, Short-Form 8.

on sleep; and (iii) in middle-aged to elderly subjects, a reduced likelihood of having a disorder in maintaining sleep and of having a sleep complaint has been associated with regular weekly activity.[26] Alfano *et al.* also suggested that physical activity was consistently related to better physical functioning, and to reduced fatigue and bodily pain in cancer survivors.[27] Furthermore, physical activity appeared to be related to vitality in Japanese individuals.[13]

Several limitations may accompany the present study, and should be considered when interpreting the results: (i) the cross-sectional design; (ii) the predominance of participants in the good QOS group that might indicate some bias as a result of the selection of healthy volunteers; and (iii) the collected sleep information in the present study considered basic sleep patterns with a self-reported approach. More specific questions, such as those regarding a wide range of sleep problems experienced by older persons, should be included. In addition, the use of specific sleep medication was not verified, and such medications might play an important role in QOS.[14] Thus, we were unable to investigate potential confounding factors resulting from sleep medications, other drugs or even caffeine consumption, considering that they would affect sleep. However, such bias might not restrict our general conclusions. In summary, the present study provides evidence that QOS is particularly linked with cognitive status, bodily pain and vitality in Japanese community-dwelling older adults. However, further research that controls for our limitations is warranted.

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Disclosure statement

None of the authors have a conflict of interest or financial disclosures.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1 Bivariate comparisons according to quality of sleep for the males' health indicators and quality of life.
Table S2 Bivariate comparisons according to quality of sleep for the females' health indicators and quality of life.
Table S3 Bivariate comparisons according to sex for the participants' health indicators and quality of life.
Table S4 Bivariate comparisons according to quality of sleep by sex for the participants' health indicators and quality of life.

Original Article

Arterial Stiffness Determined According to the Cardio-Ankle Vascular Index (CAVI) is Associated with Mild Cognitive Decline in Community-Dwelling Elderly Subjects

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Aims: The purpose of this study was to determine the cross-sectional relationship between the cognitive function and cardio-ankle vascular index (CAVI) in Japanese community-dwelling elderly subjects.

Methods: A total of 179 Japanese community-dwelling elderly subjects were recruited for this study. The age, height, weight, gender and past medical history (cardiovascular disease, hypertension, diabetes mellitus, hyperlipidemia) of each participant was recorded. In addition, the degree of arterial stiffness was determined according to the CAVI, while the cognitive function was assessed using the Mini-Mental State Examination (MMSE). After dividing the cohort into two groups according to the MMSE score (≤26, >26), we used a multiple regression analysis to assign the level of the cognitive function as a dependent variable.

Results: The data were statistically analyzed for the 174 participants (84 men and 90 women) who completed the data collection process without omissions. A multivariate logistic regression analysis showed that a higher weight (Odds Ratio [OR]: 1.05, 95% Confidence Interval [95% CI]: 1.00-1.11, $p=0.03$), male gender (OR: 3.13, 95% CI: 1.05-9.34, $p=0.04$) and lower CAVI (OR: 0.68, 95% CI: 0.48-0.96, $p=0.03$) were significantly correlated with a higher MMSE score. We also found significant correlations between the MMSE and weight (OR: 1.11, 95% CI: 1.03-1.19, $p=0.01$) and CAVI (OR: 0.57, 95% CI: 0.33-0.98, $p=0.04$) in elderly men only using a gender-specific analysis.

Conclusions: We found that the elderly subjects with a high CAVI exhibited a worse cognitive function even after adjusting for age, height, weight and gender. This finding therefore indicates the usefulness of the CAVI in the early detection of dementia.

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Key words: Cognitive function, Arterial stiffness, Community-dwelling elderly

Introduction

Dementia can drastically influence daily life and is currently one of the most common diseases in the elderly. The World Health Organization estimated that 35 million people worldwide suffered from dementia in 2012, and people with dementia have been shown to be frail due to their poor mobility and body composition. Approximately 48% of people with Alzheimer's disease (AD), the most common form of dementia, are estimated to live in Asia, and this percentage will grow to 59% by 2050[1]. The transitional stage between normal aging and AD is called mild cognitive impairment (MCI), and more than half of MCI cases progress to dementia within five years[2, 3]. Therefore, preventing cognitive decline is crucial.

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Identifying risk factors that can predict cognitive decline will help to prevent such decline. Although many studies have attempted to address this issue, evidence supporting the role of modifiable risk factors remains limited[4-6]. Meanwhile, vascular risk factors have received attention in recent years[7, 8]. High blood pressure[9], dyslipidemia[9], obesity[10] and diabetes mellitus[10] have been proposed to be risk factors for cognitive decline. Among these factors, arterial stiffness, specifically, is a comparatively easy-to-modify risk factor. It has been reported that systemic atherosclerosis plays a role in the cognitive function and is directly linked to the pathology of Alzheimer's disease[11]. In one European study, it was found that functional changes in the arterial system may be involved in the onset of dementia[12].

Arterial stiffness is one of the most easily measured vascular risk factors in community-dwelling elderly subjects due to its noninvasive nature. The brachial-ankle pulse wave velocity (baPWV) is widely used for this purpose. In a cross-sectional study of 370 middle-aged Korean participants, the baPWV was found to be significantly correlated with the cognitive function[13]. In addition, in a Japanese study, a high baPWV was shown to be a risk factor for a poor cognitive function in 352 community-dwelling elderly subjects[5]. However, there are several problems associated with the measurement of baPWV, as the value of the parameter depends on the blood pressure (BP) at the time of measurement[14]. Therefore, it is difficult to evaluate arterial stiffness in patients treated with antihypertensive medications or those with masked hypertension. In contrast, the cardio-ankle vascular index (CAVI) is a novel BP-independent parameter of arterial stiffness[15, 16]. This parameter is adjusted for the PWV according to the systolic and diastolic blood pressure and blood density and is therefore a theoretically BP-independent index. Clinicians can ensure the validity of arterial stiffness measurements using this parameter. However, no studies have so far evaluated the relationship between the cognitive function and arterial stiffness using the CAVI. In addition, few studies have evaluated this relationship in community-dwelling elderly patients.

The purpose of this study, therefore, was to determine the cross-sectional relationship between the cognitive function and the CAVI in Japanese community-dwelling elderly subjects.

Methods

Participants

Participants were recruited for this study through local press requesting healthy community-dwelling volunteers, resulting in a total of 179 Japanese participants 65 years of age or older and currently living in the community. Interviews were then performed 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 the use of psychotropic drugs. Written informed consent was obtained from each participant for the trial in accordance with the guidelines approved by the Kyoto University Graduate School of Medicine and the Declaration of Human Rights, Helsinki, 1995. The study protocol was approved by the ethical committee of the Kyoto University Graduate School of Medicine.

Measurements

Demographic Data

Age, height, weight, gender, past medical history (cardiovascular disease, hypertension, diabetes mellitus, hyperlipidemia), smoking status (number of cigarettes smoked per day and total number of years smoked) and educational background (elementary school, junior high school, high school, career college and university) were recorded as demographic data. All data were collected at the onset of data collection. We surveyed age and gender from the participant directly and measured the height and weight using standardized height and weight scales.

CAVI

The CAVI was determined using the VaSera-1500 (Fukuda Denshi Co., Ltd., Tokyo, Japan). The procedure has been detailed previously[15, 16]. Briefly, after the participants had rested for five minutes in a sitting position, they were placed in a supine position. Then, cuffs were wrapped around both brachia and ankles to detect the brachial and ankle pulse waves. Electrocardiograms and heart sounds were monitored. The PWV from the heart to the ankle was calculated by measuring the length from the aortic valve to the ankle and dividing by time, which was determined according to the heart sounds and the rise of the brachial and ankle pulse waves. Blood pressure was also measured at the brachial artery. Finally, scale conversion was performed using the following formula:

$$\text{CAVI} = a\{(2\rho/\Delta P) \times \text{In}(Ps/Pd)PWV^2\} + b \text{ (no unit)}$$

ρ: blood density, Ps: systolic blood pressure, Pd; diastolic blood pressure, ΔP: Ps-Pd, PWV: pulse wave velocity, a and b: constants.

The validity, reproducibility and blood pressure-independent nature of this experiment have been well

Table 1. Differences in each variable between the MMSE high/low score groups

	All (n=174)			Men (n=84)			Women (n=90)		
	Low MMSE (≤26) n=56	High MMSE (>26) n=118	p	Low MMSE (≤26) n=30	High MMSE (>26) n=54	p	Low MMSE (≤26) n=26	High MMSE (>26) n=64	p
MMSE	24.6±1.3	28.7±1.1	<0.01**	24.8±1.0	28.8±1.1	<0.01**	24.5±1.5	28.6±1.1	<0.01**
Age, year	74.2±4.6	73.4±4.3	0.26	73.8±5.2	73.8±4.2	0.94	74.5±3.7	73.0±4.4	0.12
Height, cm	155.5±8.7	156.1±8.1	0.65	162.2±5.3	162.8±6.0	0.64	147.8±4.6	150.5±4.7	0.02*
Weight, kg	54.0±8.8	57.3±9.7	0.03*	57.6±9.3	63.6±8.7	0.01*	49.9±6.1	52.0±7.1	0.19
Gender, male	30 (53.6%)	54 (45.8%)	0.21	–	–	–	–	–	–
Mean CAVI	9.61±1.30	9.13±1.16	0.02*	9.97±1.52	9.38±0.87	0.03*	9.19±0.85	9.03±0.93	0.47
Cardiovascular disease	8 (14.3%)	8 (6.8%)	0.16	6 (20.0%)	4 (7.4%)	0.16	2 (7.7%)	4 (6.3%)	1.00
Hypertension	21 (37.5%)	50 (42.4%)	0.62	13 (43.3%)	23 (42.6%)	1.00	8 (30.8%)	27 (42.2%)	0.35
Diabetes mellitus	6 (10.7%)	14 (11.9%)	1.00	2 (6.7%)	8 (14.9%)	0.47	4 (15.4%)	6 (9.4%)	0.47
Hyperlipidemia	8 (14.3%)	18 (15.3%)	1.00	4 (13.3%)	5 (9.6%)	0.72	4 (15.4%)	13 (20.3%)	0.77
Brinkman index	0 (0-762.5)	0 (0-356.3)	0.70	0 (0-787.5)	0 (0-637.5)	0.50	0 (0-612.5)	0 (0-2.25)	0.23
Educational background			n.s.			n.s.			n.s.
Elementary school	2 (3.6%)	1 (0.8%)		2 (6.7%)	1 (1.9%)		0 (0.0%)	0 (0.0%)	
Junior high school	26 (46.4%)	28 (23.7%)		16 (53.3%)	15 (27.8%)		10 (38.5%)	13 (20.3%)	
High school	26 (46.4%)	69 (58.5%)		11 (36.7%)	30 (55.6%)		15 (57.7%)	39 (60.9%)	
Career college	0 (0.0%)	7 (5.9%)		0 (0.0%)	1 (1.9%)		0 (0.0%)	6 (9.4%)	
University	2 (3.6%)	13 (11.0%)		1 (3.3%)	7 (13.0%)		1 (3.8%)	6 (9.4%)	

Mean CAVI = the mean value of the right and left CAVI scores; Mean ± SD values are shown for age, height, weight and mean CAVI; n (%) is shown for gender, cardiovascular disease, hypertension, diabetes mellitus, hyperlipidemia and educational background; Median (25% quartile-75% quartile) is shown for the Brinkman index; n.s.: not significant.
*: $p<0.05$, **: $p<0.01$

documented by several studies[15, 16]. The measurements were obtained once, and the mean value of the right and left CAVI scores for each patient was used for the analysis[17].

Cognitive Function Measurement

The cognitive function was assessed using the Mini-Mental State Examination (MMSE)[18]. The MMSE is a short screening test that consists of five areas of possible cognitive impairment: orientation; registration; attention and calculation; and language. The scores ranged from 0 to 30, with a higher score indicating a better cognitive performance. We tested the participants individually based on the generalized method and used 26/27 as the cutoff score, according to Spering CC *et al.*[19].

Statistical Analysis

The participants were divided into two groups based on the MMSE score: ≤26 or >26. This cutoff of 26/27 has been shown to be a better balanced score of estimates of diagnostic accuracy for educated individuals[19]. Because our participants were community-dwelling and highly educated and all lived independently, we adopted this 26/27 cutoff.

We statistically analyzed the differences between the two groups using the unpaired t-test for age, height, weight and the mean CAVI on both sides, the χ^2 test for gender, past medical history and educational background and the Mann Whitney U-test for the Brinkman index (number of cigarettes smoked per day × total number of years smoked). A multivariate logistic regression model was performed to investigate whether the CAVI was independently associated with the MMSE score. We assigned a high MMSE score as the dependent variable adjusted for age, height, weight and gender. A value of $p<0.05$ was considered to be statistically significant for all analyses.

Results

In total, there were 179 elderly participants (85 men and 94 women) in this study. Of the 179 patients, 84 men and 90 women completed the data collection without omissions, for a total of 174 data points.

We assigned 56 elderly subjects (30 men and 26 women) into the low MMSE group and 118 elderly subjects (54 men and 64 women) into the high MMSE group. **Table 1** shows the differences in each variable between the two groups. While there were no significant differences in age, height, gender or past medical history, a higher weight was associated with a higher MMSE score ($p=0.03$). In addition, the low MMSE group had significantly higher CAVI values than the high MMSE group (**Fig. 1**, the low group: 9.61 ± 1.30, the high group: 9.13 ± 1.16, $p=0.02$).

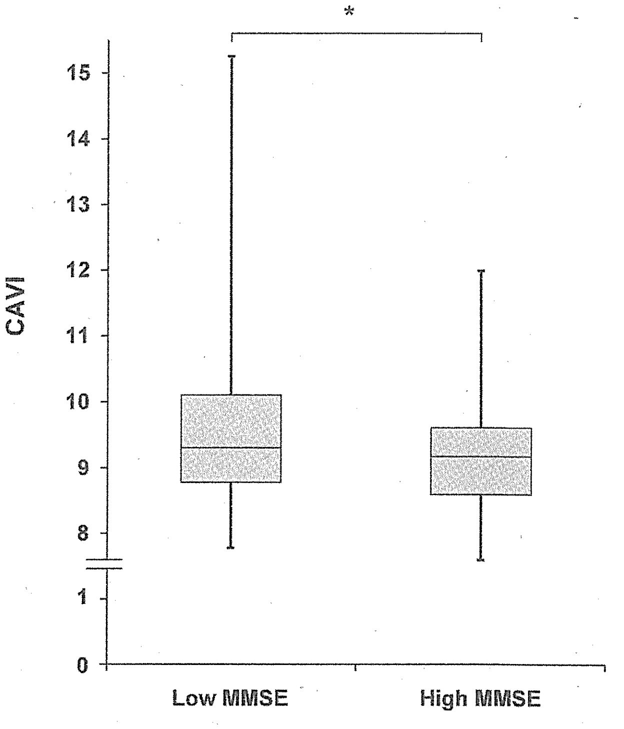

Fig. 1. Differences in the mean CAVI values between the high and low MMSE groups.

We statistically analyzed the differences between the two groups using the unpaired t-test for the mean CAVI on both sides.
*: $p=0.02$

The multivariate logistic regression analysis showed that a higher weight (odds ratio [OR]: 1.05, 95% confidence interval [95% CI]: 1.00-1.11, $p=0.03$), female gender (OR: 3.13, 95% CI: 1.05-9.34, $p=0.04$) and lower CAVI (OR: 0.68, 95% CI: 0.48-0.96, $p=0.03$) were significantly correlated with a higher MMSE score (**Table 2**), indicating that elderly subjects with a higher CAVI have a lower cognitive function, even after adjustment for age, height, weight and gender. In the multivariate logistic regression analysis of each gender, we found a significant correlation between the MMSE score and weight (OR: 1.11, 95% CI: 1.03-1.19, $p=0.01$) and CAVI (OR: 0.57, 95% CI: 0.33-0.98, $p=0.04$) in the elderly men only (**Table 2**).

Discussion

We analyzed the relationship between the cogni-