Summary

Epidemiology of Hypertension in Ladakh; Interaction of Altitude and Lifestyle Change

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The prevalence of hypertension in 2800 people in Ladakh was studied cross-sectionally from 2007 to 2011. We found 37.0% crude prevalence rate in the total subjects. The associated factors with hypertension were aging, overweight, dwelling at higher altitude, engagement in modernized sedentary occupation, and rural-to-urban migration. There was the interaction of both altitude and lifestyle change for the effect of hypertension.

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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Association between level of brachial-ankle pulse wave velocity and onset of activities of daily living impairment in community-dwelling older individuals

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Aim: The purpose of the present study was to clarify the longitudinal association between brachial-ankle pulse wave velocity (baPWV) and the onset of impairment in activities of daily living (ADL) among community-dwelling individuals.

Methods: Deaths and the onsets of ADL impairment during 3 years were followed for 450 individuals without ADL impairment at entry who were aged 65 years or older (men : women 181:269; mean age 77 years). They were dichotomized on the median baPWV value at entry.

Results: Within 3 years, 28 died and 60 had an onset of ADL impairment. The high baPWV group had a higher incidence of deaths (high baPWV group *vs* low baPWV group, 9.3% *vs* 3.1%) and ADL impairment (high baPWV group *vs* low baPWV group, 20.7% *vs* 9.3%). After adjustment for age, sex and systolic blood pressure, as compared with the low baPWV group, the high baPWV group had increased risk for mortality (adjusted odds ratio 3.22; 95% confidence interval 1.26–8.22) and the onset of ADL impairment (adjusted odds ratio 1.94; 95% confidence interval 1.03–3.63). When the onset of ADL impairment was grouped according to medical conditions that preceded/accompanied the onset of ADL impairment, elevated baPWV was associated with increased risk for the onset of ADL impairment after/accompanying fall/fracture.

Conclusions: The assessment of arterial stiffness by baPWV contributes to identifying functionally independent community-dwelling older individuals at risk for ADL impairment, in particular ADL impairment associated with fall/fracture, as well as for mortality. **Geriatr Gerontol Int 2015; 15: 840–847.**

Keywords: activities of daily living impairment, arterial stiffness, brachial-ankle pulse wave velocity, fall, mortality.

Introduction

Arterial stiffness, which increases with advancing age, is known to lead to cardiovascular disease.[1] Pulse wave velocity (PWV), known as an indicator of arterial stiffness, is frequently assessed by determining carotid-femoral PWV (cfPWV) or brachial-ankle PWV (baPWV).[2] Increased cfPWV has been reported to be associated with increased risks of total or cardiovascular mortality in individuals with chronic conditions, such as patients with end-stage renal disease,[3] hypertension[4,5] or diabetes.[6] as well as in community-dwelling individuals.[7–10] Some studies have reported that an elevated level of baPWV was associated with an increased risk of total or cardiovascular mortality in hemodialysis patients,[11] patients with acute coronary syndrome,[12] type 2 diabetic patients with coronary artery disease[13] and in the general population.[14–16] In community-dwelling older individuals, a few reports including the authors' report[15] have shown that both baPWV[14,15] and cfPWV[7] were associated with total or cardiovascular mortality.

In older individuals, it is important to predict not only mortality, but also impairment in activities of daily living (ADL). In Japan, the major causes of impairment in ADL include cerebrovascular diseases, dementia, falls,

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fracture and disuse syndrome.[17] Arterial stiffness, as determined by cfPWV, has been reported to be associated with the incidence of stroke in a longitudinal study.[7] In addition, a cross-sectional study reported that elevated PWV was related to increased prevalence of cognitive dysfunction[18–21] and reduced thigh muscle mass.[22] However, there are no reports regarding an association between baPWV and the onset of ADL impairment.

The purpose of the present study was therefore to evaluate the relationship between baPWV level and onset of ADL impairment during 3 years among community-dwelling older individuals. In order to explore the mechanisms between baPWV and the onset of ADL impairment, ADL impairment was grouped according to medical conditions that might be associated with the incidence of ADL impairment.

Methods

Study population

All the participants were chosen from those registered in the Kahoku longitudinal study, which was designed to prolong healthy life expectancy by providing health screening, counseling and educational services to older individuals living in Kahoku, a rural town in Japan.[23,24] In this community of 5596 residents, 2092 (37.4%) were aged 65 years and older in 2000. In each year from 2000 to 2003, all individuals aged 65 years or older were invited to the annual health check-up organized by the municipal health center. Without considering duplicates, the number of individuals who participated in the check-up was 348 in 2000, 337 in 2001, 384 in 2002 and 361 in 2003. The first visit to the check-up service was defined as entry into the present longitudinal study. Of the 577 individuals who entered the study, 18 who had lumbar pain and/or gibbosity were excluded, because valid measurement of baPWV was impossible for individuals with such conditions. The remaining 559 individuals (26.7% of the number of Kahoku residents aged 65 years or older in 2000; 220 men and 339 women; mean ± standard deviation [SD] of age at entry 76.6 ± 5.6 years) were invited to the baPWV measurement. Of the 559 individuals, 109 were excluded from the present analysis for the following reasons: 80 had self-reported impairment in ADL items in the baseline questionnaire, 15 had atrial fibrillation, five had medical history of arteriosclerosis obliterans (ASO) and nine had an abnormal ankle-brachial pressure index (ABI) of less than 0.9 as determined by plethysmography. Therefore, the effective sample of the present study included 450 participants (181 men and 269 women; mean ± SD of age at entry 76.6 ± 5.7 years).

The study protocol was approved by the research ethics committee of Kochi Medical School, Japan.

Study variables

Medical history and examinations

Medical history and occurrences of new medical conditions were self-reported and confirmed by a physician at the health check-up at study entry, and 12, 24 and 36 months. Participants were defined as having a medical history of cardiovascular disease (CVD) if they had a history of stroke and/or heart disease, including ischemic heart disease, heart failure and arrhythmia at study entry. Height and bodyweight were measured in the health check-up at entry. Body mass index (BMI) was defined as weight (kg) divided by the square of height (m^2). Participants had their blood pressure (BP) measured in the morning in the health check-up venue. BP and pulse rate were measured by sphygmomanometer (BP-203I; Colin, Komaki, Japan) according to the cuff-oscillometric method. Measurement of BP and pulse rate was carried out twice in the upper arm with an appropriately sized cuff at the level of the heart in a sitting position after a rest of at least 5 min. For the analysis, the mean of two measurements were used for both BP and pulse rate.

Brachial-ankle pulse wave velocity measurements

Measurements of baPWV and ABI were carried out automatically by a form PWV/ABI instrument (Colin), as previously described.[25,26] This device has four cuffs matched with oscillometric sensors, and the cuffs were wrapped around the upper arms and ankles. The volume pulse forms of the bilateral brachial and tibial arteries were monitored during continuous deflation of the cuffs. The baPWV value was calculated by time-phase analysis of the brachium and the ankle of both sides. The ABI value was calculated as the ratio of systolic blood pressure in the leg to that in the arm on each side. Each participant lay in a supine position for at least 5 min before having baPWV/ABI measurements. The measurements were carried out twice consecutively, and the mean of the two measurements was used. Because there were significant positive correlations between the left and right measurements both for baPWV and ABI (baPWV: Pearson's correlation coefficient = 0.940, $P < 0.001$, ABI: Pearson's correlation coefficient = 0.659, $P < 0.001$), the right measurement was used both for baPWV and ABI.

The participants were dichotomized according to a median value of baPWV and that of ABI.

Laboratory variables

All participants had blood drawn in the health check-up at entry. The blood samples were placed in cold storage immediately after collection and were analyzed within

48 h. The levels of blood sugar, hemoglobin A1c, total cholesterol, high-density lipoprotein cholesterol and triglycerides were measured.

Follow-up survey for mortality and onset of ADL impairment

Survivorship of the participants for 3 years from entry into the study was followed. No study participant moved out of the municipality during the period. For 28 participants who died during the follow-up period, the date of death was obtained from the death certificate submitted to the municipality.

For all participants, the performance of seven ADL items (walking, ascending stairs, eating, dressing, toilet, bathing and grooming) was evaluated through the annual self-administered questionnaires at study entry, and 12, 24 and 36 months.[27] The seven ADL items were rated from 3 to 0 (3, needs no help; 2, needs some help; 1, needs much help; and 0, totally dependent), and summed to yield a total score ranging from 0 to 21. A total of 450 participants with an ADL score ≥20 at study entry were included as the eligible subjects of the present study. The participants who scored ≤19 at 12-, 24- or 36-month follow up were defined as those who experienced the onset of ADL impairment. A total of 13 participants did not return the questionnaire in at least one occasion and had an ADL score ≥20 in the remaining annual surveys. Because of their unknown ADL status for the occasions when the participants did not respond to the questionnaire, the 13 participants were not included in the analysis. After excluding 28 participants who died and 13 participants who had unknown ADL status during the follow-up period, 409 participants (160 men and 249 women; mean ± SD of age at entry 76.4 ± 5.7 years) were used in the analyses regarding the association between baPWV levels and onset of ADL impairment.

The incidence of medical conditions including CVD and fall/fracture were evaluated through the annual questionnaires. Participants who reported the onset of ADL impairment in a specific year were grouped according to whether self-reported occurrences of CVD and/or fall/fractures preceded or accompanied the onset of ADL impairment. For example, among participants who did not have a history of CVD at entry and reported the onset of ADL impairment in a specific annual survey, one who reported an occurrence of CVD in the preceding surveys or in the specific survey was defined as those who experienced the onset of ADL impairment after/accompanying the occurrence of CVD.

Statistical analysis

All continuous variables were expressed as the mean ± SD. The mean values were compared using the Student's *t*-test. The χ^2-test was used to compare the proportions for categorical variables. A multiple logistic regression model was used to describe the association of baPWV levels dichotomized at the median value with mortality and onset of ADL impairment, while adjusting for age, sex and blood pressure levels. The association between baPWV and onset of ADL impairment after/accompanying the occurrence of CVD and/or fall/fracture was analyzed. The odds ratio for the onset of ADL impairment after/accompanying respective conditions for comparing high versus low baPWV was computed by excluding participants who experienced the onset of ADL impairment after/accompanying other conditions. *P*-values less than 0.05 were considered statistically significant. All analyses were carried out using SPSS 18.0J for Windows (SPSS Japan, Tokyo, Japan).

Results

Baseline characteristics

The mean ± SD and median of baPWV were 18.77 ± 4.02 and 18.61 m/s for all participants. There was no significant difference in the mean values of baPWV between men and women (men: 18.64 ± 3.95 m/s; women: 18.86 ± 4.07 m/s; $P = 0.568$). Table 1 shows descriptive statistics of characteristics at study entry according to level of baPWV. The participants with baPWV < 18.61 m/s ($n = 225$) were grouped as the low baPWV, and the participants with ≥18.61 m/s ($n = 225$) as the high baPWV. The high baPWV group was older and a higher proportion were taking antihypertensive medication than the low baPWV group. The means of systolic BP (SBP), diastolic BP (DBP) and heart rate were higher in the high baPWV group as compared with the low baPWV group. For BMI, blood test results, current smoking, medications for diabetes mellitus and hyperlipidemia, and history of CVD, there was no significant difference in means or proportions of specific categories between the two groups of baPWV.

Mortality and onset of ADL impairment according to baPWV level

During 3 years of follow up, 28 participants died and 60 had an onset of ADL impairment. Table 2 shows deaths and onsets of ADL impairment by level of baPWV. The high baPWV group had a higher proportion of participants who died (the high baPWV group *vs* the low baPWV group, 9.3% *vs* 3.1%) and a higher proportion of those who had an onset of ADL impairment (the high baPWV group *vs* the low baPWV group, 20.7% *vs* 9.3%). In contrast, between the high and low ABI groups, dichotomized at the median value of 1.115, there was no significant difference in the proportion of participants who died/had an onset of ADL impairment

Table 1 Descriptive statistics of baseline characteristics of participants by brachial-ankle pulse wave velocity level

	Low baPWV: <18.61 m/s (n = 225)	High baPWV: ≥18.61 m/s (n = 225)	P-value
Age (years)	75.2 ± 5.5	78.0 ± 5.7	<0.001
Sex (men)	91 (40.4)	90 (40.0)	1.000
Body mass index (kg/m^2)	23.1 ± 3.5	22.9 ± 3.7	0.599
Current smoking (yes)	29 (12.9)	22 (9.8)	0.372
Taking antihypertensive medication	78 (34.7)	114 (50.7)	0.001
Taking antihyperglycemic medication	15 (6.7)	19 (8.4)	0.593
Taking antihyperlipidemic medication	30 (13.3)	24 (10.7)	0.469
History of cardiovascular disease	25 (11.1)	20 (8.9)	0.530
Systolic blood pressure (mmHg)	139.0 ± 27.7	153.5 ± 22.2	<0.001
Diastolic blood pressure (mmHg)	77.4 ± 10.4	85.0 ± 11.5	<0.001
Pulse pressure (mmHg)	61.6 ± 25.5	68.5 ± 17.8	0.001
Pulse rate (b.p.m.)	70.9 ± 11.1	75.5 ± 13.0	<0.001
Blood sugar (mg/dL)	115.6 ± 26.6	118.3 ± 31.7	0.336
Hemoglobin A1c (%)	5.3 ± 0.6	5.4 ± 0.7	0.299
Total cholesterol (mg/dL)	194.7 ± 30.5	197.9 ± 35.8	0.314
High-density lipoprotein cholesterol (mg/dL)	52.3 ± 13.7	51.7 ± 13.4	0.633
Triglyceride (mg/dL)	129.6 ± 76.8	140.6 ± 80.9	0.138
baPWV (m/s)	15.73 ± 1.80	21.81 ± 3.25	<0.001

Values are number (proportion) for categorical variables and mean ± standard deviation for categorical variables. baPWV, brachial-ankle pulse wave velocity.

Table 2 Mortality and onset of activities of daily living impairment classified by chronic conditions that preceded/accompanied onset of activities of daily living impairment by brachial-ankle pulse wave velocity level

	Low baPWV	High baPWV	P-value
Mortality			
Participants followed (n)	225	225	
Deaths, n (% of the followed)	7 (3.1)	21 (9.3)	0.010
Onset of ADL impairment			
Participants followed (n)	216	193	
All types of onset of ADL impairment, n (% of the followed)	20 (9.3)	40 (20.7)	0.001
By type of onset of ADL impairment			
Onset of ADL impairment after/accompanying CVD only, n (% of the followed)	2 (0.9)	5 (2.6)	0.168
Onset of ADL impairment after/accompanying fall/fracture only, n (% of the followed)	2 (0.9)	11 (5.7)	0.012
Onset of ADL impairment after/accompanying both of CVD and fall/fracture, n (% of the followed)	5 (2.3)	3 (1.6)	0.721
Onset of ADL impairment following/accompanying neither of CVD or fall fracture, n (% of the followed)	11 (5.1)	21 (10.9)	0.021

Low brachial-ankle pulse wave velocity (baPWV): <18.61 m/s. High baPWV: ≥18.61 m/s. ADL, activities of daily living; CVD, cardiovascular disease.

(the high ABI group *vs* the low ABI group, the proportion of deaths, 5.8% *vs* 6.7%, P = 0.846; the proportion of onsets of ADL impairment, 12.1% *vs* 16.7%, P = 0.206).

Multiple logistic regression models showed that a high baPWV level was significantly associated with an increased risk of mortality (adjusted odds ratio [OR] 3.22, 95% confidence interval [CI] 1.26–8.22), and with an increased risk for onset of ADL impairment (adjusted OR 1.94, 95% CI 1.03–3.63) after adjustment for age, sex and SBP (Table 3). After adjustment for antihypertensive medication in place of SBP, a high baPWV level

Table 3 Results of multiple logistic regression analyses showing associations of brachial-ankle pulse wave velocity level with mortality and onset of activities of daily living impairment during 3-years

	Mortality (n = 450) Adjusted odds ratio‡ (95% confidence interval)	P-value	Onset of ADL impairment (n = 409†) Adjusted odds ratio‡ (95% confidence interval)	P-value
baPWV (high/low)	3.22 (1.26–8.22)	0.014	1.94 (1.03–3.63)	0.040
Age (increase of 1 year)	1.05 (0.98–1.12)	0.197	1.12 (1.06–1.18)	<0.001
Sex (men/women)	2.35 (1.05–5.24)	0.037	0.82 (0.45–1.48)	0.503
Systolic blood pressure (increase of 1 mmHg)	1.00 (0.98–1.01)	0.551	1.00 (0.99–1.01)	0.916

†Analysis for onset of activities of daily living (ADL) impairment was carried out for 409 survivors whose ADL status during the 3-year follow-up period was ascertained. ‡Odds ratios were adjusted for age, sex and systolic blood pressure at baseline. Low brachial-ankle pulse wave velocity (baPWV): <18.61 m/s. High baPWV: ≥18.61 m/s.

Table 4 Results of multiple logistic regression analyses showing associations of brachial-ankle pulse wave velocity level with onsets of activities of daily living impairment classified by chronic conditions which preceded/accompanied onset of activities of daily living impairment

	Onset of ADL impairment after/accompanying CVD only	Fall/fracture only	Both of CVD and fall/fracture	Neither of CVD or fall/fracture
Adjusted odds ratio for high *vs* low baPWV group (95% confidence interval)	3.27 (0.55–19.68)	5.40 (1.11–26.38)	0.56 (0.13–2.51)	1.79 (0.78–4.13)
P-value	0.195	0.037	0.448	0.171

Analysis for onset of activities of daily living (ADL) impairment was carried out for 409 survivors whose ADL status during the 3-year follow-up period were ascertained, with adjustment for age, sex and systolic blood pressure at baseline. Low brachial-ankle pulse wave velocity (baPWV): <18.61 m/s. High baPWV: ≥18.61 m/s. CVD, cardiovascular disease.

was associated with an increased risk for mortality (adjusted OR 3.09, 95% CI 1.25–7.61, P = 0.014) as well as onset of ADL impairment (adjusted OR 1.89, 95% CI 1.03–3.47, P = 0.039). When adjustment was made for a dichotomous variable composed of antihypertensive medication and/or SBP ≥ 140 mmHg versus no medication for hypertension and SBP ≤ 140 mmHg in place of SBP, a high baPWV level was associated with an increased risk for mortality (adjusted OR 4.54, 95% CI 1.71–12.06, P = 0.002) as well as the risk of onset of ADL impairment (adjusted OR 2.11, 95% CI 1.10–4.07, P = 0.025). The variables regarding BP; that is, antihypertensive medication in the second model, and antihypertensive medication and/or SBP ≥ 140 mmHg in the third model, were not associated with either of mortality or onset of ADL impairment. After adjustment for ADL score at entry in addition to age, sex and SBP, a high baPWV level was associated with an increased risk for mortality (adjusted OR 3.19, 95% CI 1.25–8.15, P = 0.015) as well as onset of ADL impairment (adjusted OR 2.16, 95% CI 1.09–4.25, P = 0.027). Multiple logistic regression analysis in which baPWV was entered as a continuous variable, a one m/s increase in baPWV measurement was associated with an increase in the risk for mortality (adjusted OR 1.10, 95% CI 1.00–1.21, P = 0.047) as well as the risk for onset of ADL impairment (adjusted OR 1.09, 95% CI 1.02–1.17, P = 0.018).

Among the 60 participants with onsets of ADL impairment, seven participants (11.7%) reported occurrences of CVD only, 13 participants (21.7%) reported occurrences of fall/fracture only, eight participants (13.3%) reported occurrences of both CVD and fall/fracture, and 32 participants (53.3%) did not report occurrence of either condition in the annual surveys (Table 2). A high baPWV group had an increased risk for the onset of ADL impairment after/accompanying fall/fracture only (adjusted OR 5.40, 95% CI 1.11–26.38; Table 4).

Discussion

The present study showed that high baPWV was predictive of not only mortality, but also the onset of ADL impairment during 3 years in community-dwelling older individuals. In this study, the high baPWV group had a higher proportion of participants with the onset of

ADL impairment after/accompanying fall/fracture as compared to the low baPWV group. It is therefore suggested that high baPWV levels reflect clinical conditions that present risks for falls/fractures. In older individuals, clinical conditions, such as sarcopenia and cognitive impairment, are risk factors for falls/fractures.[28] Possible explanations for the relationship between arterial stiffness, as evaluated by baPWV, and onset of ADL impairment are as follows.

The first possibility is that the association between high baPWV and onset of ADL impairment is mediated by sarcopenia, which is the age-related loss of skeletal muscle mass and strength. Sarcopenia is known to be related to weakened lower extremity performance,[29] and to be a risk factor for falls/fractures and functional disability.[30,31] Recently, high baPWV and cfPWV were reported to be associated with low mid-thigh muscle mass in a cross-sectional[22] and a longitudinal[32] study, respectively. Although the underlying mechanisms of sarcopenia have not been fully clarified, previous studies have suggested that the mechanisms of sarcopenia are related to atherosclerosis.[33,34] Cytokines, such as tumor necrosis factor (TNF)-α and interleukin-6 (IL-6), insulin-like growth factor (IGF)-I and androgens, such as testosterone, were reported to be involved in arterial stiffness.[34–36] It seems that TNF-α and IL-6 might have a role in the inflammatory response in skeletal muscle, and contribute to the sarcopenic phenotype.[37] In skeletal muscle, IGF-I activates complex intracellular signals, which linked to anabolic, anticatabolic, chemotactic and anti-apoptotic responses.[26] Therefore, the age-related decrease in IGF-I might be responsible for the age-related decline in skeletal muscle structure and function. Serum testosterone level was related to muscle strength.[37] These findings show that increases in TNF-α and IL-6, and decreases in IGF-I and androgens might be pathophysiological changes that underlie both of sarcopenia and arterial stiffness. Therefore, the present findings suggested that high baPWV levels might reflect the presence of latent sarcopenia, which elevates a risk for the onset of ADL impairment associated with fall/fracture, in functionally independent older individuals.

The second possibility is that the association between baPWV and ADL impairment is mediated by cerebral small vessel disease. It has been reported that baPWV levels are higher in individuals with a large number of lacunar infarctions as compared with those with a small number of lacunar infarctions in older hypertensive patients.[35] Additionally, baPWV level has been reported to be associated with cerebral white matter lesions (WML), such as periventricular hyperintensities, in community-dwelling older individuals.[36] The presence of lacunar infarctions and WML is related to cognitive impairment[37,38] and gait disturbances.[39] Recently, the level of high baPWV was reported to be associated with cognitive impairment.[18–21] These reports suggest that the individuals with elevated baPWV are more likely to have silent cerebral small vessel diseases. Such diseases could cause cognitive impairment and mobility impairment that elevate risks for the onset of ADL impairment associated with fall/fracture. Orthostatic hypotension, syncope related to arrhythmia and osteoporosis could be related to fall/fracture of older adults, too. Except for orthostatic hypotension with which arterial stiffness has been reported to be associated, the associations between baPWV and such diseases have not been clarified.[40,41]

The level of baPWV is known to increase with advancing age in both men and women. The present study also found that baPWV was significantly associated with age in both of men ($r = 0.242$, $P = 0.001$) and women ($r = 0.382$, $P < 0.001$). The significant associations between baPWV and ADL impairment remained after adjustment for age in this study. The level of baPWV is higher in men than in women at middle age, and the difference in baPWV level between men and women has been reported to disappear at old age.[25] Therefore, no significant difference in baPWV between men and women in the present study could be accounted for by the age-related decrease in the difference in arterial stiffness between men and women in community settings.

The present study had limitations. First, the number of participants was small, and consequently the number of the onsets of ADL impairment was small. Therefore, the analysis of the association between baPWV and onset of ADL impairment should be explored in a large prospective study. Second, 13 participants who had missing data on ADL status during the follow-up period were excluded from the analysis. If such dropouts had severe forms of CVD, an association between baPWV, which is an established risk factor for CVD,[14,15] and onset of ADL impairment after/accompanying CVD might be underestimated among the individuals who completed all of the surveys. Third, the rationale for determining conditions associated with the onset of ADL impairment were weak. The authors considered only the temporality with regard to the plausibility of the association between new occurrences of conditions and onset of ADL impairment. A further study that investigates the association between baPWV and cause-specific ADL impairment is thus necessary. Fourth, the present study did not address changes in ADL score in participants who experienced occurrences of ADL impairment. Because such participants tended to be non-responders to subsequent annual questionnaires, it was difficult to compare the change in severity of ADL impairment between baPWV groups. It is necessary to carry out a further longitudinal study that examines an influence of baPWV on changes in the severity of ADL impairment. Fifth, baPWV value is affected by the presence of arterial diseases, such as aortic aneurysm and

peripheral arterial disease.[42] At entry into the study, participants with these diseases and with ABI < 0.9 were excluded. No participant reported diagnosis of these arterial diseases in the annual questionnaires during the follow-up period. However, latent arterial diseases might be prevalent among the participants. If participants with latent arterial disease were more likely to be present in the high baPWV group, the association between baPWV and onset of ADL impairment would be overestimated.

In conclusion, the present study shows that the assessment of arterial stiffness by baPWV contributes to identifying functionally independent community-dwelling older individuals at risk for ADL impairment, in particular ADL impairment associated with fall/fracture, as well as for mortality. Functionally independent older individuals with elevated levels of baPWV require fall prevention programs from the viewpoint of disability prevention.

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Disclosure statement

The authors declare no conflict of interest.

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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Relationships between each category of 25-item frailty risk assessment (Kihon Checklist) and newly certified older adults under Long-Term Care Insurance: A 24-month follow-up study in a rural community in Japan

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Aim: The 25-item Kihon Checklist (KCL) is the official self-administered questionnaire tool to screen frail older adults, consisting of seven categories: physical strength, nutritional status, oral function, houseboundness, cognitive function, depression risk and a score of more than 9 out of 1–20 items. The aim of the present study was to evaluate the relationships between each category of the KCL and newly certified cases under the Long-Term Care Insurance (LTCI) in Japan during 24 months.

Method: The study population consisted of 883 community-dwelling adults aged 65 years or older uncertified by LTCI completing a questionnaire, which included the KCL and scales of basic/advanced activities of daily living (ADL), quality of life (QOL), and depressive symptoms. The participants were categorized into the risk or non-risk group depending on the official criteria of each KCL category. The outcome was the incidence of newly certified cases by LTCI during 24 months. The difference between the risk and non-risk group was analyzed by Cox regression hazard models.

Results: Scores in basic/advanced ADL and QOL were higher, and the score in the geriatric depression scale was lower in the non-risk than the risk group in KCL criteria. In men, the incidence of newly certified cases was higher in the risk group of the physical strength category after adjusting for age and the other categories of the KCL.

Conclusion: The physical strength category in men was the only significant predictor of the incidence of newly certified cases by LTCI. Further studies are required to improve the assessment item of cognitive function in KCL under LTCI. **Geriatr Gerontol Int 2014; ••: ••–••.**

Keywords: community-dwelling elderly, comprehensive geriatric assessment, Cox regression hazard model, Japan, Kihon Checklist.

Introduction

The Japanese population is aging at an alarming rate; the 2013 census reported that the proportion of older adults aged 65 years and older was 24.1%, and it is estimated to be 38.8% in 2050.[1] The social insurance plan, the Long-Term Care Insurance (LTCI), was introduced in 2000 and, in 2006, the Japanese government implemented wide-ranging reforms of the LTCI. The focus of these reforms was preventative care, which included the identification of frail elderly people likely to require care in the near future. These individuals are identified through screening of elderly individuals aged 65 years and older who have a certification of need of LTCI. The screening is carried out with the Kihon Checklist (KCL), a self-administered questionnaire consisting of 25 items in seven categories: physical strength, nutritional status, oral function, cognitive function, a score of more than 9 out of 1–20 items,

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houseboundness and depression risk.[2] After identification by the KCL, interventions to prevent the decline in activities of daily living (ADL), and to improve physical and psychological functions are implemented.[3] Two studies have examined the effect of these interventions, and found reductions in the KCL scores and cost of care, and improved the cognitive function.[4,5]

There have been academic investigations of the KCL, including cross-sectional and longitudinal studies.[2,6,7] In one of the cross-sectional studies addressing the specificity of each category, Ogawa *et al.*[6] reported the effectiveness of the KCL through a comparison with Fried's frailty criteria[8] and blood chemical examinations. Umegaki *et al.*, in an analysis of the cognitive function category, found that individuals with a negative answer to any of the cognitive function questions had an awareness of overall diminished functioning.[7] Tomata *et al.* concluded that all categories and criteria used for evaluating frail older adults in the KCL were useful for predicting the risk of being certified during a 1-year period, but could not suggest an appropriate cut-off value.[9] We previously showed that the physical and cognitive function categories of the KCL predict the decline in instrumental ADL and in social roles after 2 years.[2] In addition, the KCL has also been validated and used with elderly populations in Brazil.[10]

Despite this wealth of studies, to our knowledge, just a few studies have been published focusing on the relationship between the KCL and newly certified older adults under the LTCI.[9] Therefore, the aim of the present study was to fill this gap in the research through an evaluation of the relationships between each category of the KCL and newly certified cases under the LTCI during 24 months, as well as to consider revising the shorter and more effective version of the KCL in the future.

Methods

Ethical considerations

The present study was approved by the ethical committee of the Faculty of Medicine, Kyoto University, Kyoto, Japan (E-1078). Written informed consent was obtained by all participants.

Participants

The participants were 883 community-dwelling older adults aged 65 years or older who had not been certified under the LTCI at the baseline (350 men, 533 women; mean age 77.1 ± 7.1 years), and who were living in Tosa in Kochi prefecture. Tosa had a population of 4576 in 2008, of which 1829 (39.6%) were aged 65 years or older. With the support of the health staff and volunteers in Tosa, we mailed a comprehensive geriatric assessment questionnaire, including the 25-item KCL, to 1679 people in 2008 (150 long-term institutionalized individuals were excluded). The response rate was 63.1% (n = 1060). After the exclusion of individuals who were already LTCI certified (n = 95) and those with incomplete questionnaires (n = 82), the final number of participants was 883.

Materials

Kihon Checklist (KCL)

The KCL is a 25-item self-administrated questionnaire designed by the study group from the Japanese Ministry of Health, Labor and Welfare (MHLW; Appendix I) to identify frail elderly individuals who are at risk for being newly certified for LTCI in the near future. Validation about the KCL was reported as sensitivity 73.5% and specificity 57.8%.[11] The checklist has seven categories: (i) physical strength; (ii) nutritional status; (iii) oral function; (iv) as score of more than 9 out of 1–20 items; (v) cognitive function; (vi) houseboundness; and (vii) depression risk. Each category was rated on a pass/fail basis, and the sum of all indices ranged from 0 (no frailty) to 25 (high frailty). "Lower physical strength" was defined as three or more negative responses in questions 6–10. "Lower nutritional status" was assessed by answers to questions 11 and 12 with negative answers indicating lower status, and "lower oral function" was defined as two or more negative responses in questions 13–15. "Score more than 9 out of 1–20 items" was defined as elderly participants who answered at least 10 or more negative conditions (questions 1–20). The risk group for "houseboundness" was defined as people who answered "no" to question 16. Question 17 was just only a referring question in the houseboundness category. "Lower cognitive function" referred to participants who had at least one or more negative conditions in questions 18–20, and "depression risk" referred to elderly people who had two or more negative responses (questions 21–25). "Lack of response" was defined as a negative response in any question (Appendix I).[2] The participants were categorized into the risk or non-risk group depending on the criteria of each KCL category. The risk group older adults were defined by the criteria as those who had lower functions, such as lower physical strength, lower nutritional/oral status, lower cognitive function, houseboundness and depression risk. The non-risk group did not have these lower functions.

Comprehensive Geriatric Assessment

We assessed basic activities of daily living (BADL) as seven items: (i) walking; (ii) ascending and descending stairs; (iii) feeding; (iv) dressing; (v) using the toilet; (vi) bathing; and (vii) grooming. These are rated from 0 (completely dependent) to 3 (completely independent), with a full score of 21 indicating complete independence

in BADL.[12] For advanced functional capacity, we used the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC), which consists of 13 items that are answered in a yes/no format. This scale is divided into three subscales. Self-maintenance (IADL) includes the ability to use public transport, to buy daily necessities, to prepare a meal, to pay bills and to handle banking matters. Intellectual activity includes the ability to fill out forms, read newspapers, read books and magazines, and have an interest in television programs or news articles on health-related matters. The final subscale, social role, covers the ability to visit friends, give advice to relatives and friends, visit someone at the hospital, and initiate conversations with younger people.[13]

To assess a depressive mood, the Japanese version of Geriatric Depression Scale (GDS-15) was used, which is a self-rated depressive questionnaire.[14,15] The presence of subjective quality of life (QOL) was evaluated using a 100-mm visual analog scale (VAS), ranging from the lowest QOL on the left end of the scale and the highest on the right[16,17] that assessed two variables: subjective sense of health and happiness.

Statistical analysis

The baseline characteristics were compared across the risk and non-risk groups in each category of the KCL using the Student's *t*-test for continuous variables and the χ^2-test for categorical variables. Cox proportional hazards models were used to examine the associations between the risk and non-risk group on each category of the KCL targeting new certification of care needs during the 24 months of the study. Hazard ratios of the newly certified cases for the LTCI and 95% confidence intervals (CI) were estimated. Statistical analysis was carried out by SPSS version 17 for Windows (SPSS, Chicago, IL, USA). The significance threshold was set at $P < 0.05$.

Results

A comparison of the baseline characteristics for each Comprehensive Geriatric Assessment item between the risk and non-risk group in each category of the KCL is shown in Table 1. The risk group was older, more depressed, had lower scores on basic/advanced ADL and had lower subjective QOL after the adjustment for age. The participants in the risk group with low physical strength, low nutritional/oral function and score more than 9 out of 1–20 items were more likely to be newly certified under the LTCI during the 24 months of the present study compared with the non-risk group. The Cox proportional hazard model showed that only low physical strength was significantly related to the newly certified events after the adjustment for the effect of age and sex (HR 2.26, 95% CI 1.31–3.9, $P = 0.003$; Table 2). Furthermore, low physical strength in men was still significantly related to newly certified events after the adjustment of the other categories in the KCL – lower nutritional/oral function, low cognitive function, housebound status and risk for depression (HR 1.07; 95% CI 1.01–1.13, $P = 0.002$; Table 3).

Men with risk of low physical strength had significantly lower scores in IADL than women with risk (men 3.3 ± 1.9, women 4.2 ± 1.5, $P = 0.014$) at baseline (2008) and with risk (men 3.0 ± 2.2, women 4.0 ± 1.5, $P = 0.0005$) 2 years later (2010).

Figure 1 shows the Kaplan–Meier curves of newly certified cases in each sex between the risk and non-risk groups in the physical strength category during 24 months. In men, the risk group of physical strength had a significantly higher incidence of newly certified cases (17.2%) compared with those in the non-risk group (3.8%). In women, the risk group also had a significantly higher incidence (11.1%) than in those in the non-risk group (5.2%).

Discussion

In the present study, each category of the KCL was reconfirmed as a useful tool for evaluating functional abilities, QOL, and depressive state in community-dwelling older adults aged 65 years and older. Furthermore, in men, only the category of physical strength was significantly related to newly certified cases under the LTCI in the town during the 24 months of the study.

Several cohort studies found factors associated with newly certified events under the LTCI. Tomata *et al.* followed 14 636 older adults, targeting newly certified events during 12 months, and concluded that all KCL categories were associated with newly certified older adults; the physical strength categories were particularly strongly associated with being newly certified under the LTCI.[9] During the 24 months of the present study, only the lower physical strength in men was associated with the LTCI, as shown by the Cox regression hazard model. The difference in the results between Tomata *et al.* and the present authors could be attributable to the difference in statistical power, study design or the study populations.

In general, women are more frail than men, despite lower mortality than men. However, longitudinal sex differences in accumulation of frailty are somewhat controversial. Moriya *et al.* found the ability to stand on one leg with eyes open predicted newly certified events in both sexes under the LTCI.[18] In contrast, Kulminski *et al.* discussed less female vulnerability to the accumulated frailty deficits in relation to the lower mortality rate for women than men despite the fact that women can have a larger frailty index than men.[19] In the present study, only the male risk group in the physical strength category in the KCL was significantly associated with newly certified

Table 1 Comparison of functional abilities in community-dwelling older adults for each category of the "Kihon Checklist"

	(1) Physical strength		(2) Nutritional/Oral function		(3) Score more than 9 out of 1–20 items		(4) Houseboundness		(5) Cognitive function		(6) Depression risk		Total (mean)
	Non-risk group $n = 586$	Risk group $n = 297$	Non-risk group $n = 654$	Risk group $n = 229$	Non-risk group $n = 741$	Risk group $n = 142$	Non-risk group $n = 662$	Risk group $n = 221$	Non-risk group $n = 510$	Risk group $n = 373$	Non-risk group $n = 289$	Risk group $n = 594$	$n = 883$
Mean age (years)	75.4 ± 6.6	80.4 ± 7.3*	76.3 ± 7.1	79.3 ± 7.2*	76.2 ± 6.8	82.0 ± 7.3*	76.2 ± 7.1	79.7 ± 7.2*	75.5 ± 6.6	79.3 ± 7.5*	74.7 ± 6.6	78.3 ± 7.2*	77.1 ± 7.2
Sex (male : female)	263:323	87:210*	264:390	86:143	300:441	50:92	289:373	61:160	192:318	158:215	143:146	207:387*	350:533
New certification LTCI need during 24 months (%)	4.4	12.1*	6.2	9.6*	6.1	12.0*	6.5	8.6	6.1	8.3*	5.2	7.9	7.0
Category of Kihon Checklist (%)													
Lower physical strength			23.9	61.4*	15.2	78.5*	25.1	59.3*	21.2	50.7*	12.1	44.1*	33.6
Lower nutritional/oral function	15.0	47.5*			10.6	63.3*	20.4	42.5*	18.2	36.5*	9.0	34.2*	25.9
Score more than 9 out of 1–20 items	9.4	67.9*	14.4	71.1*			20.6	54.5*	14.1	49.6*	7.3	39.7*	16.1
Houseboundness	15.4	43.9*	19.4	41.0*	16.7	46.9*			18.2	34.3*	8.3	33.2*	25.0
Lower cognitive function	31.4	63.6*	36.2	59.4*	30.0	71.9*	37.0	57.9*			21.2	52.4*	42.2
Depression risk	56.7	88.2*	59.8	88.6*	57.2	91.8*	60.0	89.1*	55.5	83.4*			67.3
Geriatric functions													
Basic ADL (0–21)	20.7 ± 0.9	17.3 ± 4.6*†	20.1 ± 2.2	18.0 ± 4.6*†	20.4 ± 1.5	15.2 ± 5.4*†	20.1 ± 2.4	18.1 ± 4.5*†	20.4 ± 1.5	18.4 ± 4.3*†	20.7 ± 1.1	19.0 ± 3.7*†	19.6 ± 3.2
TMIG-IC (0–13)	11.6 ± 1.8	8.1 ± 4.1*†	10.9 ± 2.9	9.2 ± 3.9*†	11.5 ± 1.8	4.9 ± 3.7*†	11.2 ± 2.5	8.3 ± 4.2*†	11.5 ± 1.9	9.0 ± 4.0*†	11.9 ± 1.8	9.8 ± 3.5*†	10.5 ± 3.2
Self-maintenance (0–5)	4.8 ± 0.7	3.3 ± 1.9*†	4.5 ± 1.3	3.8 ± 1.7*†	4.7 ± 0.7	1.8 ± 1.8*†	4.6 ± 1.0	3.4 ± 2.0*†	4.7 ± 0.8	3.7 ± 1.9*†	4.8 ± 0.7	4.0 ± 1.6*†	4.3 ± 1.4
Intellectual activity (0–4)	3.3 ± 0.9	2.4 ± 1.4*†	3.2 ± 1.1	2.6 ± 1.3*†	3.3 ± 1.0	1.7 ± 1.4*†	3.2 ± 1.0	2.4 ± 1.4*†	3.3 ± 0.9	2.6 ± 1.4*†	3.5 ± 0.9	2.8 ± 1.3*†	3.0 ± 1.2
Social role (0–4)	3.5 ± 0.8	2.4 ± 1.4*†	3.3 ± 1.1	2.7 ± 1.3*†	3.5 ± 0.9	1.5 ± 1.2*†	3.4 ± 1.0	2.5 ± 1.4*†	3.4 ± 0.9	2.7 ± 1.4*†	3.7 ± 0.7	2.9 ± 1.3*†	3.2 ± 1.2
GDS-15 (0–15)	3.7 ± 3.4	7.4 ± 4.1*†	4.2 ± 3.7	7.0 ± 4.3*†	4.2 ± 3.6	9.3 ± 3.5*†	4.3 ± 3.8	6.9 ± 4.1*†	3.8 ± 3.6	6.5 ± 4.0*†	1.6 ± 1.6	6.7 ± 3.8*†	4.9 ± 4.0
Subjective health (0–100)	59.6 ± 18.5	41.1 ± 19.6*†	57.3 ± 19.9	42.2 ± 19.0*†	56.9 ± 19.1	34.2 ± 19.1*†	56.2 ± 19.9	45.0 ± 21.0*†	57.7 ± 19.8	47.8 ± 20.6*†	66.5 ± 16.8	47.1 ± 19.4*†	53.7 ± 20.7
Subjective happiness (0–100)	63.4 ± 20.6	52.9 ± 23.0*†	62.5 ± 20.8	52.3 ± 23.5*†	62.2 ± 21.2	47.2 ± 22.2*†	62.2 ± 20.9	52.6 ± 23.7*†	63.5 ± 20.5	55.0 ± 22.9*†	70.2 ± 18.8	54.7 ± 21.6*†	60.1 ± 21.9

*P-values were <0.05. †After adjustment for age. Table 1 shows the comparison of functional abilities, such as basic/advanced activities of daily living (ADL), depression status and subjective quality of life in older people: high-risk/non-risk for each category of the Kihon Checklist, using the Student's t-test. P-values were calculated using the Student's t-test for continuous variables and the χ^2-test for categorical variables. GDS-15, 15-item Geriatric Depression Scale; LTCI, Long-Term Care Insurance; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence.

events. The main reason for these results was suggested to be that men with lower physical strength in KCL had significantly lower scores of IADL than women with lower physical strength (men 3.3 ± 1.9, women 4.2 ± 1.5, $P = 0.014$) at baseline and (men 3.0 ± 2.2, women 4.0 ± 1.5, $P = 0.0005$) at 2 years later. Accumulated frailty deficits might be larger in the male risk group than the female risk group in the present study population. The male risk group was more disabled than the female risk group at baseline, so the males were supposed to be more significantly associated with newly certified events under the LTCI during the 24 months. Sex differences in frailty might vary in study populations or designs. We should pay attention to the sex differences in varied study population characteristics when we assess KCL under the LTCI.

Honda *et al.* reported that underweight older adults aged 65–74 years were more likely to be a new certification of care needs than those with normal weight.[20] However, in the present study, being underweight was not associated with newly certified events. The definition of underweight used by Honda *et al.* was body mass index <18.5, whereas the KCL definition requires both a body mass index of <18.5 and a loss of weight over 6 months as a risk; therefore, the KCL definition is stricter than the criteria of Honda *et al.* Owing to the use of these more stringent criteria, our population in the low nutritional status category might have been too small to reach statistical significance.

The present study did not find a relationship between low cognitive function and newly certified cases under the LTCI. However, low cognitive function in the KCL was associated with a wide range of functional decline, including malnutrition, decline in IADL and social role, and depressive symptoms, both in our studies and those by Umegaki.[2,8] Such functional declines led to a high-risk status for care need. Despite the lack of a significant correlation with newly certified cases in the present study, the category of low cognitive function in the KCL could play an important role in the assessment of frail older adults. The lack of significant correlations in this area might be explained by two factors. First, the KCL might have a low sensitivity for certification because of cognitive decline. Second, the criteria for deciding the certification of care needs by the LTCI reviewer board might be strict for cognitive functions compared with physical disabilities.

Table 2 Cox proportional hazards analysis of each category of Kihon Checklist for newly certified cases under Long-Term Care Insurance during 24 months after adjusting for age and sex

	HR†	(95% CI)	*P*-value
Physical strength			
Non-risk	1		–
Risk	2.26	1.31–3.90	0.003
Nutritional/oral status			
Non-risk	1		–
Risk	1.35	0.79–2.28	0.27
Score more than 9 out of 1–20 items			
Non-risk	1		–
Risk	1.43	0.78–2.61	0.25
Houseboundness			
Non-risk	1		–
Risk	1.03	0.61–1.74	0.91
Cognitive function			
Non-risk	1		–
Risk	1.13	0.65–1.98	0.66
Depression risk			
Non-risk	1		–
Risk	1.21	0.67–2.22	0.53

Table 2 shows the Cox regression hazard model between the risk and non-risk group on each category of the Kihon Checklist targeting new certification of care needs during the 24 months of the study. Hazard ratios of the newly certified cases of Long-Term Care Insurance (LTCI) and 95% confidence intervals were estimated. †After adjustment for age.

Table 3 Multiple Cox proportional hazards models for newly certified cases under Long-Term Care Insurance during 24 months

	Men			Women		
	HR	(95% CI)	*P*-value	HR	(95% CI)	*P*-value
Age	1.07	1.01–1.13	0.02	1.06	1.02–1.11	0.01
Lower physical strength	3.12	1.14–8.51	0.03	1.90	0.91–3.97	0.09
Lower nutritional/oral status	1.88	0.78–4.54	0.16	0.72	0.32–1.58	0.41
Houseboundness	2.21	0.93–5.21	0.07	0.58	0.26–1.29	0.19
Lower cognitive function	0.61	0.23–1.63	0.33	0.86	0.43–1.74	0.68
Depression risk	0.87	0.33–2.35	0.79	1.21	0.52–2.83	0.66

Table 3 shows the Cox regression hazard model between the risk and non-risk group of the Kihon Checklist in each sex targeting new certification of care needs during the 24 months of the study. Hazard ratios of the newly certified cases of Long-Term Care Insurance and 95% confidence intervals were estimated. HR were adjusted for age and the other category of Kihon Checklist.

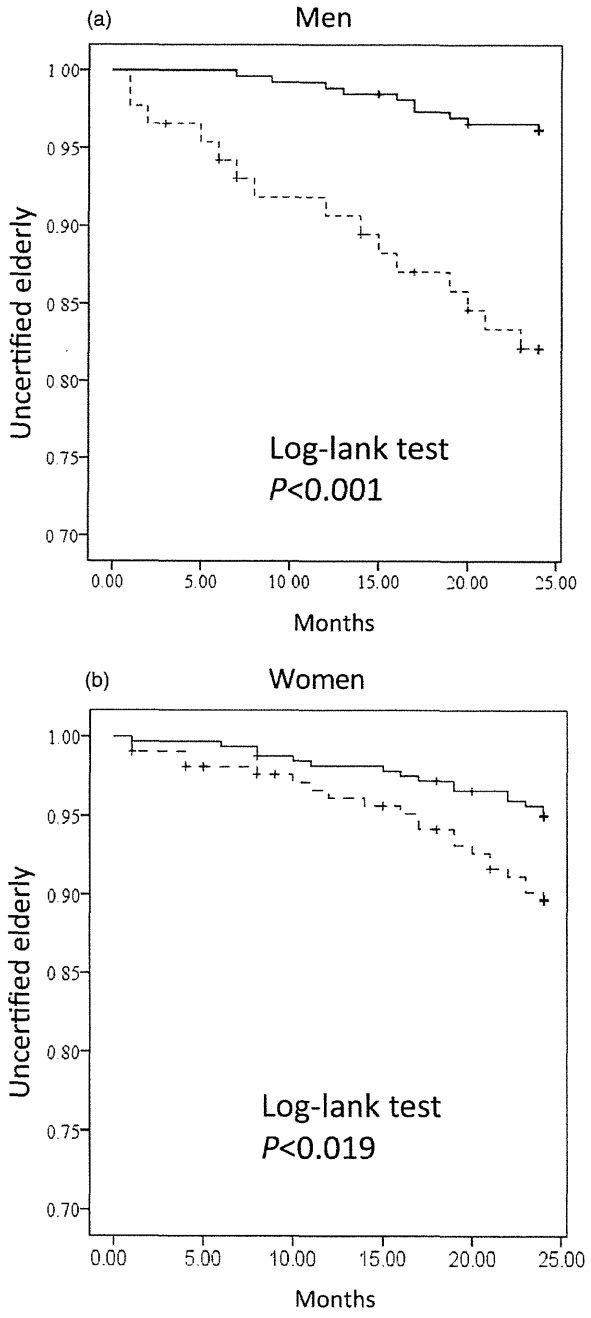

Figure 1 The Kaplan–Meier curve shows the percentage of the physical strength category of the 25-item Kihon Checklist in each sex who was not certified under the Long-Term Care Insurance at baseline. (a) During the study, 17.2% of men in the risk group were newly certified under the Long-Term Care Insurance. (b) Approximately 11.1% of women in the risk group were newly certified. The study was carried out from 2008 to 2010. ⌐, Non-risk group; –, risk group.

We could not find previous studies focusing on the association between other geriatric functions, such as oral function, housebound status or depressive symptoms, and newly certified outcomes under the LTCI. Those factors could be only weakly related to newly certified events.

Under the current LTCI system in Japan, insured persons or their families can apply to the municipality to obtain a certification of requiring the LTCI, and care managers[21] tend to encourage such applications for frail older adults. The present study found a relationship between physical strength and newly certified events under the LTCI, not cognitive function, and these findings might reflect the reasons that individuals and their families apply for the LTCI. Community-dwelling older adults with low physical strength might be recognized more easily as candidates requiring needs of care under the LTCI compared with those with low cognitive function.

The prevalence of dementia is sharply increasing in Japan. According to the MHLW, elderly persons with dementia accounted for approximately 15% of the elderly population in 2010.[22] Despite the non-significant results in the present study, we suggest that targeting a decline in cognitive function in community-dwelling older adults might be very important for the LTCI system.

First, assessing "cognitive function" is regarded to be of high importance for community-dwelling older adults. Several previous studies showed lower cognitive status was closely associated with overall diminished functioning, the development of dementia and newly certified older adults under the LTCI.[7,23–25]

Second, in 2012, Japanese MHLW notified all local governments of a 5-year plan, the so called "Orange Plan," for people with dementia to be detected early, to be treated and to be cared for suitably, not only in hospital, but also by community-based support. This notification by MHLW is of importance for Japanese local governments and communities as well as academic societies.[26] Our previous study also reported that many community-dwelling older people want to access the preventive program for cognitive impairment in the current prevention plan.[27]

As the KCL is the only official screening tool for evaluating frail community-dwelling older adults, a reconsideration of the cognitive function category in the KCL is required in order to usefully screen high-risk elderly people to be certified under the LTCI.

Some limitations of the present study should be noted. First, this study was carried out in one rural town, which leads to problems with generalizability. However, the study clearly charted the actual situation in a typical rural town where the total population is declining, but the super-aged population is increasing. Second, we could not follow individuals who did not respond.

In conclusion, the KCL has been reconfirmed as a useful tool for screening frail older adults in the community. The KCL category of physical strength, but not

that of cognition, was strongly associated with newly certified male older adults under the LTCI. We should pay more attention to sex-related differences when we assess the functions of older adults with the KCL. Further studies are also required to improve the assessment of cognitive function under the LTCI.

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Disclosure statement

The authors declare no conflict of interest.

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Appendix I. Criteria of High Risk in each category of "25-item Kihon Check List (KCL)" defined by Japanese MHLW

1	Do you use public transportation (bus or train) to go out on your own?	Q.1–20 Score more than 9 out of 1–20 items (risk group ≥10 negative answers)
2	Do you shop for daily necessities?	
3	Do you manage financial matters such as savings or deposits by yourself?	
4	Do you visit the homes of friends?	
5	Do you give advice to friends or family members who confide in you?	
6	Are you able to go up stairs without using handrails or the wall for support?	Q.6–10 Physical strength (risk group ≥3 negative answers)
7	Are you able to stand up from a sitting position without support?	
8	Are you able to walk continuously for 15 min?	
9	Have you experienced a fall in the past year?	
10	Do you feel anxious about falling when you walk?	
11	Has your weight declined by 2–3 kg in the past 6 months?	Q.11–12 Nutritional status (risk group = 2 negative answers)
12	Height: cm Weight: kg BMI	
13	Have you experienced more difficulty chewing tough foods than you did 6 months ago?	Q.13–15 Oral function (risk group ≥2 negative answers)
14	Do you ever experience choking or coughing when drinking tea or soup?	
15	Are you bothered by feelings of thirst or dry mouth?	
16	Do you go out at least one time a week?	Q.16 Houseboundness (risk group = answered negatively in Q.16 . Q.17 is referred question.
17	Do you go out less often than you did last year?	
18	Do others point out your forgetfulness or tell you "You always ask the same thing."	Q.18–20 Cognitive function (risk group ≥1 negative answers)
19	When you want to make a call, do you usually search for the telephone number and call on your own?	
20	Do you sometimes not know what the date is?	
21	(In the past 2 weeks) You feel no sense of fulfilment in your life.	Q.21–25 Depression risk (risk group ≥2 negative answers)
22	(In the past 2 weeks) You cannot enjoy things that you enjoyed before.	
23	(In the past 2 weeks) Things that you could do easily before are now difficult.	
24	(In the past 2 weeks) You do not feel that you are a useful person.	
25	(In the past 2 weeks) You feel exhausted for no apparent reason.	

The Kihon Checklist consists of seven categories; physical strength, nutritional status, oral function, cognitive function, houseboundness, score more than 9 out of 1–20 items and depression risk. BMI, body mass index.

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Depression and subjective economy among elderly people in Asian communities: Japan, Taiwan, and Korea

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ABSTRACT

The objective of this study is to investigate the cross-cultural relationship between depressive state and subjective economic status, as well as subjective quality of life (QOL) and activities of daily living (ADL) among elderly people in communities in Japan, Taiwan, and Korea. We studied 595 subjects aged 65 years or older in three Asian communities (261 subjects in T town in Japan, 164 in D town in Taiwan, and 170 in H town in Korea). The Geriatric Depression Scale-15, a self-rating questionnaire assessing ADL, subjective QOL, social situations, and past and current medical status, was used. Depression of the elderly was associated with dependence in basic ADL, subjective QOL, and subjective sense of low economic status. After adjusting for the effects of age, sex, and basic ADL, subjective sense of low economic status was closely associated with depression in community-living elderly people in all three communities in Asia. In conclusion, absolute and objective economic status is an important contributing factor to depressive state or psychosocial deterioration, however, we should pay more attention to the roles of perception of low economic status in determining depressive state in community-dwelling elderly people.

1. Introduction

Economic condition substantially influences depression. The waves of recession and unemployment are associated with suicide rate (Matsubayashi et al., 2010; Motohashi, 2012). In addition to absolute economic status, studies showed that economic inequality is associated with depression or harmful psychosocial effects, which were thought to be caused by invidious social comparisons (Kawachi & Kennedy, 1999; Muramatsu, 2003). In fact, self-perceived social standing is related to depression (Adler, Epel, Castellazzo, & Ickovics, 2000; Hu, Adler, Goldman, Weinstein, & Seeman, 2005). These studies showed that subjective low socioeconomic status increases psychological distress. Specifically, subjective economic condition has been shown to be associated with depression. Pu, Huang, Tang, and Chou (2011) showed that subjective financial satisfaction was related to depression. Butterworth, Rodgers, and Windsor (2009) assessed financial hardships by measuring specific behavioral consequences of a lack of financial resources, and found that financial hardships were associated with depression. Similarly, Chou and Chi (2002) showed that financial strain negatively correlated with life satisfaction, which can be mitigated by life management. However, these studies did not fully consider other variables related to depression, such as medical condition and physical activities of daily living (ADL). These are essential influencing factors for depression, especially in the elderly population (Egede, 2007; Lyness, Yu, Tang, Tu, & Conwell, 2009).

To address this important issue in a cross-sectional study, we attempted to clarify how much subjective economic status, adjusting for medical situations and physical ADL, is associated with depression in elderly people living in culturally different communities in Japan, Taiwan, and Korea.

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Taiwan and Korea are newly developed countries in Asia that maintained high economic growth rates and rapid industrialization during the 1960s and the 1990s. The 2010-estimated real GDP growth rates of Taiwan and Korea were 6.1% and 10.8%, respectively, which surpassed that of Japan (3.9%). Japan, Taiwan, and Korea have similar changes in unemployment rates, although Korea alone experienced a high unemployment rate in 1998, likely due to the Asian financial crises (International Monetary Fund, 2011). Moreover, the three countries have similar economic challenges: they are all dependent on exports.

The objective of this study is to investigate the relationships between depressive state and subjective economic status, as well as ADL, subjective quality of life (QOL), and socioeconomic status of elderly people in the communities of Japan, Taiwan, and Korea.

2. Materials and methods

2.1. Subjects

The study population that participated in our health checkup program consisted of 395 elderly people in T town in Japan, 176 in D town in Taiwan, and 176 in H town in Korea. Participants who completed the Geriatric Depression Scale-15 (GDS-15) were included in our final analysis: 261 (66.1% of the study population, male (M):female (F) = 52.4:47.6, mean (SD) age: 76.9 (6.2) years) in T town in Japan; 164 (93.2%, M:F = 42.7:57.3, age: 73.7 (5.5) years) in D town in Taiwan; and 170 (96.6% of the study population, M:F = 37.5:62.5, mean age: 72.9 (5.3) years) in H town in Korea. The same standardized questionnaires were used throughout the three communities' surveys. The questionnaires included the GDS-15; a self-rating questionnaire for ADL impairment; a quantitative and subjective QOL scale using a visual analog scale; living conditions; social background; and past and current medical situations.

2.1.1. Studied towns

T town is situated in the midpoint of Shikoku, Japan, and was studied in 2006. Its main industries are agriculture and forestry. The town had a population of 4600, and 1730 (37.6%) residents were aged 65 years or older. The local government distributed self-rating questionnaires to all the elderly people aged 65 years or older, and participants mailed their answers to the local government.

D town in Tainan, located south of Taiwan, was studied in 2011. Its main industries are agriculture and traditional commodity production. D town had a population of 5003, with 548 (11.0%) residents aged 65 or older. The town leader announced to the entire town that elderly people 65 years or older could receive a health checkup including blood tests, blood pressure measurement, and consultation with a physician, and distributed interview-based questionnaires to those who came to the health checkup. Medical staff at health checkups interviewed all the elderly participants.

H town is located east of Seoul, Korea; the survey there was carried out in 2007. Its significant local products are rice, corn, Asian ginseng, and beef. It had a population of 8512, with 1622 (19.1%) residents aged 65 or older. The town leader announced to the entire town that elderly people aged 65 years or older could receive a health checkup including blood tests, blood pressure measurement, and consultation with a physician and distributed interview-based questionnaires to those who came to the health checkup. Medical staff at the health checkup interviewed all the elderly participants.

2.2. Measurements

2.2.1. Depressive state

The GDS-15 was used for depression screening. The GDS-15 is composed of 15 items and was developed to exclude the effects of non-specific somatic symptoms, which are frequently observed in the elderly population (Gerety et al., 1994; Lyness et al., 1997; Sheikh and Yesavage, 1986; Yesavage, 1988; Yesavage et al., 1982). Each item is answered on a yes-or-no basis, and the highest possible score is 15, which indicates the worst depressive state. The validated Japanese version of GDS-15 shows a sensitivity of 0.973 and specificity of 0.959 (Schreiner, Hayakawa, Morimoto, & Kakuma, 2003). The validated Korean version of the GDS-15 shows a sensitivity of 0.952 and specificity of 0.413 (Bae & Cho, 2004). The validated Chinese version of GDS-15, using the cutoff point of five, showed that the prevalence of depressive mood in community-dwelling elderly people was 26–30% (Mui, 1996).

2.2.2. Socioeconomic status and medical condition

Socioeconomic status, age, sex, years of education completed, loss of partner, living alone, and subjective sense of economic status (rich–middle–poor) were assessed. Histories of stroke, cardiac disease (including ischemic heart disease), orthopedic disease, cancer, diabetes mellitus (DM), and current use of anti-hyperlipidemia or anti-hypertensive medicine were recorded in order to assess each subject's current medical condition. Hypertension was defined as systolic pressure over 140 mmHg, diastolic pressure over 90 mmHg, or use of anti-hypertensive medication. Diabetes was defined as a fasting glucose level over 126 mg/dl, post-prandial glucose level over 200 mg/dl, or use of DM medication.

2.2.3. Physical disability

Each subject rated his or her independence with respect to seven items of daily functioning (walking, ascending, and descending stairs, feeding, dressing, going to the toilet, bathing, and grooming) using the basic activities of daily living (BADL) assessment (Matsubayashi et al., 1996). Each BADL item was evaluated using four levels ranging from 0 (completely dependent) to 3 (completely independent). The scores on the seven BADL items were summed to a total score (0–21). A score of 21 in BADL indicated complete independence.

2.2.4. Quality of life

Subjective QOL was assessed using a 100-mm visual analog scale (worst QOL on the left end of the scale, and best on the right) for the following five items: subjective sense of health, relationship with family, relationship with friends, subjective sense of financial state, and subjective happiness (Matsubayashi, Okumiya, Osaki, Fujisawa, & Doi, 1997; Matsubayashi et al., 1994; Morrison, 1983).

2.3. Statistical analysis

Statistical analysis was performed using SPSS ver. 19.0 (IBM Inc., Armonk, NY USA). Student's *t*-tests were used for continuous variables, chi-squared tests were used for categorical variables, and Mann–Whitney *U* tests were used for ordinal variables in the comparisons between the two groups. Bonferroni tests were used for post hoc analysis of continuous variables, and Games-Howell tests were used for post hoc analysis of categorical and ordinal variables, in comparisons between the three groups. Logistic regression analysis was conducted by setting dichotomized GDS score as the dependent variable and other confounding factors as the independent variables. QOL scores were defined as low if they were below the median score for each community-subjects. *P*-values less than .05 were considered significant.

2.4. Ethical consideration

This study was approved by the Ethical Committee of the Faculty of Medicine, Kyoto University, Japan (E-18). Participation

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Table 1
Basic demographic characteristics, ADL, socioeconomic factors, medical conditions, and QOL in each region.

	H in Korea (n=170)	D in Taiwan (n=164)	T in Japan (n=261)	P-value
Basic demography				
Age, mean (SD)	72.9 (5.3)	73.7 (5.5)**	76.9 (6.2)***	<.001
Male, %	52.4	42.7**	37.5***	.01
Education, mean (SD)	5.4 (3.9)*	3.2 (3.2)**	6.5 (3.3)***	<.001
Activities of daily living (0–21)				
% of Dependence on others for BADL	40.6	25.6**	19.5***	<.001
Depressive state				
GDS (0–15)	6.0 (4.3)*	3.9 (2.6)	4.5 (3.6)***	<.001
GDS ≥6, %	47.1*	19.5**	36.0	<.001
GDS ≥10, %	22.4*	6.1	10.7***	<.001
Socio-economic factors (%)				
Living alone	16.5*	8.5**	19.8***	.008
Loss of partner	28.6	30.7	34.3	n.s.
Sense of low economic status	24.9*	13.0**	32.9	<.001
Past medical history (%)				
Stroke	7.7	7.3	9.3	n.s.
Cardiac disease	12.4	22.0	23.1***	.02
Orthopedic disease	67.5*	39.9	44.0***	<.001
Cancer	4.1*	0**	5.4	.01
Current medical condition (%)				
Hypertension	38.8*	65.9	60.8***	<.001
Diabetes mellitus	22.4	29.9**	18.4	.02
Use of anti-hyperlipidemia medicine	4.1*	15.2	18.1***	<.001
Use of antidepressive medicine	3.0	0**	3.3***	n.s.
Use of hypnotic medicine	8.9	7.3**	27.7***	<.001
QOL subscales (0–100), mean (SD)				
Subjective health	58.9 (25.0)	59.0 (21.3)	57.8 (18.8)	n.s.
Family relationship	79.3 (21.7)	77.9 (18.5)	78.8 (18.5)	n.s.
Friend relationship	75.1 (21.0)	73.6 (20.1)	77.4 (18.1)	n.s.
Financial satisfaction	54.3 (26.2)	54.2 (20.8)	51.9 (22.2)	n.s.
Subjective happiness	65.7 (25.8)	67.9 (22.8)	63.1 (19.5)	n.s.

Bonferroni tests were used for the numerical variables and Games-Howell tests for ordinal and categorical variables as the methods of post hoc analysis.
* Statistically significant difference between H in Korea and D in Taiwan.
** Statistically significant difference between D in Taiwan and T in Japan.
*** Statistically significant difference between T in Japan and H in Korea.

in this survey was voluntary, and written informed consent was provided by each participant.

3. Results

Baseline characteristics of the elderly population in the three studied communities are shown in Table 1. The participants from T town in Japan were significantly older than those in D town in Taiwan and in H town in Korea, and the proportion of female residents was significantly higher in T town in Japan than in the other two towns. The percentage of people who were dependent in BADL in T town in Japan (19.5%) was lower than that in D town in Taiwan (25.6%) and H town in Korea (40.6%). D town in Taiwan had the lowest percentages of subjects with scores of 6 or higher and 10 or higher on the GDS-15 (19.5%, 6.1%, respectively), percentage of people living alone (8.5%), and subjective sense of low economic status (13.0%). The percentage of elderly subjects with orthopedic disease was significantly higher in H town in Korea (67.5%) than in the other two communities. There were no elderly subjects with prior histories of cancer in D town in Taiwan. D town in Taiwan had the highest proportion of people with hypertension or diabetes (65.9%, 22.4%, respectively). T town in Japan had the highest proportions of people using anti-hyperlipidemia medicine and hypnotic medicine (18.1%, 27.7%, respectively). There were no significant differences in QOL scores between the three communities.

Table 2 shows the comparison of basic demographics and associated factors between subjects with GDS-15 scores of 6 or over (depressive group) and those with GDS-15 scores of less than 6 (non-depressive group) in these three towns. The proportion of elderly subjects with a sense of low economic status was significantly higher in depressive groups than in non-depressive groups in each town. Almost all of the QOL scores were significantly higher in the non-depressive groups than in the depressive groups, except for the QOL item of friend relationship in D town in Taiwan. Dependence rates in BADL were higher in the depressive group than in the non-depressive group across the three towns.

Table 3 shows the results of logistic regression analysis conducted by setting depressive state (defined by a score of 6 or higher on the GDS-15) as the dependent variable and other factors as the independent variables. Each analysis was adjusted for the effects of age and sex. The sense of low economic status, BADL dependence, and low scores in terms of subjective health, financial satisfaction, and subjective happiness were significantly associated with high GDS scores in all three communities. However, there were no significant relationships between years of education, past and current medical conditions, and depressive state. The family relationship component of QOL in H town in Korea and the friend relationship component of QOL in D town in Taiwan were not significantly associated with depressive state. In H town in Korea, living alone and loss of partner were associated with depressive state; this pattern was not seen in the other two towns.

Table 4 shows the results of logistic regression analysis setting depressive state as the dependent variable and other factors as the independent variables, after adjustment for the effects of age, sex, and BADL dependence. The associations between dependent and independent variables were almost the same as in Table 3, and the subjective sense of low economic status was significantly related to depressive state in all three communities after the adjustment for BADL dependence.

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