ORIGINAL ARTICLE

Association between hypertension status and the screening test for frailty in elderly community-dwelling Japanese

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To clarify the possible association of frailty with hypertension prevalence, treatment and blood pressure (BP) control in the elderly, we conducted a screening survey of 1091 elderly community-dwelling subjects aged ⩾65 years, using data from public health check-ups and frailty was determined by a 25-item questionnaire, the Basic Checklist for Frailty (BCF). The significance of differences in the association of BCF categories or BCF items with each hypertension status was analyzed using multiple logistic regression analysis after adjusting for age, sex and possible confounding underlying chronic conditions. A total of 63% of subjects were hypertensive (BP⩾140/90 mm Hg), and of those, 85% were receiving antihypertensive treatment, and 56.0% of those receiving treatment had controlled BP (<140/90 mm Hg). BCF categories that showed an independent association with hypertension status were 'impaired walking status' and absence of 'impaired nutritional status' for prevalence of hypertension, 'impaired instrumental activity of daily living status' and 'impaired nutritional status' for untreated hypertension among hypertensives and 'impaired oral function' for BP-uncontrolled hypertension among treated hypertensives. In addition, BCF items that showed an independent association were 'inability to walk for more than 15 min without rest' and absence of 'Body mass index (BMI) <18.5 kg m^{-2}' for prevalence of hypertension, 'weight loss of more than 2–3 kg in the past 6 months' for untreated hypertension, and 'difficulty eating hard food' for BP-uncontrolled hypertension. These observations indicate that assessment of these specified frailty categories and/or items may be useful for evaluating hypertension status in elderly community-dwelling subjects.

INTRODUCTION

Providing high quality care to older adults with hypertension is growing in importance because of improved survival of patients with hypertension into old age and a growing older population at risk of developing hypertension.[1] Many large-scale intervention trials have proven the necessity of treatment of hypertension in the elderly, including isolated systolic hypertension. Meta-analyses of large-scale intervention trials for elderly hypertensive patients aged 60 years and older,[2] as well as for those aged 80 years and older,[3] have revealed significant reductions in morbidity and/or mortality of cerebro-cardiovascular disease by antihypertensive treatment. Moreover, the Hypertension in the Very Elderly Trial directly and clearly revealed a beneficial effect of antihypertensive treatment even in those aged 80 years and older.[4]

Trends in hypertension prevalence, treatment and control over time have been reported in US adults,[5] including those aged 60 and older[6] using data from two independent national surveys: the National Health and Nutrition Evaluation Survey (NHANES) III (1988–1994) and the current NHANES (1999–2004). The older population with

hypertension has been reported to have poorer blood pressure (BP) control than younger populations in the US.[7,8] The prevalence of hypertension in community-dwelling Japanese has also been reported to increase with age from 20 years through 80 years, reaching 50% and higher at 75 years of age and older in both sexes.[9] However, little is reported about trends in the treatment and BP-control of hypertension in elderly community-dwelling subjects in Japan.

On the other hand, hypertension is also known to be linked with frailty in the elderly, as assessed by weight loss, low activities of daily living (ADL), low instrumental ADL (IADL) and low physical activity.[10,11] In Japan, the public long-term care insurance system provides services to older adults who have been certified as requiring support (levels 1–2) or care (levels 1–5). Uncertified older adults with impaired health who are considered at high risk for needing support/ care (frail elderly) are provided with preventive care services by municipalities.[12] Uncertified elderly subjects are given an annual health check-up by the local government, and frailty is examined using the Basic Checklist for Frailty (BCF), a yes-no questionnaire

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consisting of simple assessments for seven categories of frailty; impaired IADL status (five items), impaired walking status (five items), impaired nutritional status (two items), impaired oral function (three items), staying indoors (two items), impaired memory status (three items) and depressed mood (five items). However, few studies have examined the association of hypertension prevalence, treatment and BP-control with frailty in the elderly. Therefore, this study examined the relationship between hypertension status, and BCF categories or items in elderly community-dwelling subjects. We also studied whether this relationship could be explained by underlying chronic conditions.

METHODS
Subjects
In April 2008, the Regional Comprehensive Support Center of Uchinada-Town, Ishikawa, Japan distributed the BCF to all uncertified elderly community-dwelling subjects aged ⩾65 years. The local government also provided a Public Health Center-based annual health check-up to these elderly subjects. Data were collected by the Uchinada-Town local government after depersonalizing participant data to ensure anonymity. We excluded elderly subjects who were already certified for long-term care insurance at the baseline. The study was formally approved by the Clinical Research Ethics Committee of Kanazawa Medical University.

Baseline examinations
A self-administered questionnaire that included medical history, smoking condition (yes/no), regular alcohol drinking (yes/no) and time since the last meal[13] was completed at baseline. BMI, $kg\,m^{-2}$ was calculated as weight divided by height squared. The blood condition was defined as fasting if blood was collected more than 8 h after the last meal. Serum levels of Cr, total cholesterol, HDL-cholesterol, triglycerides and glucose were measured using an automated spectrometer. Chronic kidney disease (CKD) was defined as an estimated glomerular filtration rate, calculated by the Modification of Diet in Renal Disease equation[14] with coefficients modified for Japanese patients,[15] $194 \times Cr^{-1.094} \times age^{-0.287}$ ($\times 0.739$ if female), $<60\,ml\,min^{-1}$ $1.73\,m^{-2}$. Diabetes mellitus was defined as a fasting blood glucose ⩾7.0 mmol l^{-1} (126 mg dl^{-1}), a non-fasting glucose level ⩾11.1 mmol l^{-1} (200 mg dl^{-1}), HbA1c ⩾6.5% by a standardized method, or use of hypoglycemic agents and/or insulin.[16] Dyslipidemia was defined as fasting plasma total cholesterol level ⩾5.72 mmol l^{-1} (220 mg dl^{-1}), triglycerides ⩾1.70 mmol l^{-1} (150 mg dl^{-1}), high-density lipoprotein cholesterol <1.04 mmol l^{-1} (40 mg dl^{-1}), or use of lipid-lowering agents.[17]

Hypertension status
Baseline BP was measured at least twice from the right arm of seated participants who had rested for more than 5 min, by trained observers using standard mercury sphygmomanometers. When the difference in the two measurements of systolic BP was greater than 5 mm Hg, another measurement was performed.[18] The mean of the last two stable measurements was used for analyses. Hypertension was defined as systolic BP ⩾140 mm Hg, diastolic BP ⩾90 mm Hg, or current antihypertensive drug treatment. Treatment was defined as reported current use of antihypertensive drug therapy. BP-control was defined as antihypertensive drug treatment associated with systolic BP <140 and diastolic BP <90 mm Hg.

Statistical methods
For comparison of two groups, we used univariate analysis including χ^2 test (Fisher's exact test when needed) for comparing categorical variables and nonparametric Mann–Whitney U statistics for comparing the distributions of ordinal variables. Logistic regression analysis was used to identify frailty factors independently associated with any of prevalence of hypertension among all elderly subjects, untreated hypertension among hypertensive subjects and BP-uncontrolled hypertension among treated hypertensive subjects, after adjustment for age, sex and associated variables by univariate analysis. Common pitfalls associated with multivariate regression were avoided as described by

Concato et al.[19] Associated variables were selected from the data sets of status of smoking and alcohol intake, past history of stroke and ischemic heart disease, presence of CKD, diabetes mellitus and dyslipidemia and either the seven BCF categories (model-1) or the 25 questionnaire items (model-2), according to their univariate analysis P-value (<0.20) to avoid common pitfalls associated with multivariate regression.[19] Estimates for odds ratio and corresponding two-sided 95% confidence interval demonstrating statistical significance were derived from the regression model. Data were analyzed using SPSS (v. 16.0, Chicago, IL, USA). A probability of $P<0.05$ was taken as statistically significant.

RESULTS
Study population
A primary screening questionnaire survey was conducted on all 4050 uncertified elderly community-dwelling subjects, aged ⩾65 years, living in a town in Ishikawa, Japan. Out of 3150 (77.8%) subjects who replied to the questionnaire, 1091 (427 men and 664 women) supplied complete information on all study variables, including the health check-up and were included in our study. The age of subjects (mean ± s.d.) was 73.5 ± 6.1 years (65–94 years). In the 1091 included individuals, the significance of differences in clinical factors was analyzed using univariate (Table 1) and multivariate (Tables 2 and 3) comparisons of hypertensives ($n=683$) and normotensives ($n=408$), untreated ($n=104$) and treated ($n=579$) hypertensives and BP-uncontrolled ($n=255$) and BP-controlled ($n=324$) treated hypertensives (Figure 1). A total of 62.6% of subjects were hypertensive, and of those, 84.8% were receiving antihypertensive drug treatment and BP was controlled in 56.0% of those undergoing treatment. Overall, 47.4% of hypertensive patients had controlled BP.

Baseline factors and BCF categories and items
Compared with non-hypertensive elderly subjects, hypertensive subjects were older, and showed a higher prevalence of concomitant diabetes mellitus and dyslipidemia in univariate analysis (Table 1). Moreover, hypertensive subjects were less active and less thin than non-hypertensive subjects, as shown by associations with 'impaired walking status' and absence of 'impaired nutritional status' in the BCF categories, and associations with six BCF items including one IADL item, four items of 'impaired walking status' and absence of 'BMI $<18.5\,kg\,m^{-2}$' in univariate analysis (Table 1). Multiple logistic analysis using these BCF categories selected by univariate P-values <0.20 (model-1) revealed that two BCF categories, 'impaired walking status' and absence of 'impaired nutritional status', besides older age and diabetes mellitus, showed statistically significant association with prevalence of hypertension in elderly subjects (Table 2). In multiple logistic analysis using model-2 sets, two BCF items, 'inability to walk for more than 15 min without rest' and absence of 'BMI $<18.5\,kg\,m^{-2}$', besides older age and diabetes mellitus, showed statistically significant association with prevalence of hypertension in elderly subjects (Table 3).

In contrast to the entire hypertensive subjects, untreated hypertensive subjects were associated not only with clinical factors, namely absence of CKD or dyslipidemia and female sex, but also with one BCF category, 'impaired nutritional state' and with eight BCF items, including four out of five IADL items: 'able to stand up', 'weight loss of more than 2–3 kg in the past 6 months', 'going out more than once a week' and 'able to make a phone call', compared with treated hypertensive subjects in univariate analysis (Table 1). Logistic regression analysis using model-1 sets revealed that two BCF categories, 'impaired IADL status' and 'impaired nutritional

Table 1 Characteristics of subjects according to hypertension, drug treatment and control of hypertension in community-dwelling elderly Japanese

	Hypertension			Treatment			Control		
	No	Yes	P	No	Yes	P	No	Yes	P
Clinical background	*n* = 408	*n* = 683		*n* = 104	*n* = 579		*n* = 255	*n* = 324	
Age (years)	72.0 (6.0)	74.4 (6.1)	<0.001	75.1 (6.0)	74.3 (6.1)	0.142	73.6 (6.0)	74.8(6.1)	0.015
Sex (% female)	58.3	62.4	0.186	71.2	60.8	0.048	63.9	58.3	0.172
Current smoker (%)	18.6	13.9	0.038	6.7	15.2	0.022	16.8	13.9	0.323
Regular alcohol drinker (%)	25.6	30.6	0.073	21.1	26.4	0.257	26.7	26.2	0.907
Systolic BP (mm Hg)	122 (12)	139(14)	<0.001	148 (10)	137 (14)	<0.001	149 (11)	127 (8)	<0.001
Diastolic BP (mm Hg)	74 (8)	79 (9)	<0.001	84 (8)	78 (9)	<0.001	83 (9)	75 (7)	<0.001
Clinical findings on admission									
Past history of stroke (%)	3.9	5.9	0.154	8.7	5.4	0.204	4.0	6.5	0.198
Ischemic heart disease (%)	1.8	3.4	0.135	2.9	3.5	0.745	4.0	3.1	0.545
CKD (%)	34.8	35.9	0.721	23.1	38.2	0.003	35.3	40.4	0.206
Diabetes mellitus (%)	11.0	20.4	<0.001	13.5	21.6	0.058	19.6	23.1	0.304
Dyslipidemia (%)	21.7	27.3	0.042	10.6	30.4	<0.001	26.7	33.2	0.094
Category of BCF									
Impaired instrumental activity of daily living (five items)	0.58 (1.05)	0.63 (1.10)	0.381	0.97 (1.55)	0.56 (0.99)	0.064	0.63 (1.06)	0.51 (0.93)	0.188
Impaired walking status (five items)	0.81 (1.18)	1.14 (1.36)	<0.001	1.37 (1.57)	1.10 (1.32)	0.179	1.13 (1.33)	1.08 (1.32)	0.741
Impaired nutritional status (two items)	0.22 (0.45)	0.17 (0.40)	0.049	0.28 (0.51)	0.15 (0.38)	0.004	0.14 (0.38)	0.16 (0.38)	0.532
Impaired oral function (three items)	0.57 (0.78)	0.61 (0.83)	0.590	0.67 (0.92)	0.60 (0.82)	0.615	0.67 (0.88)	0.54 (0.76)	0.195
Staying indoors (two items)	0.21 (0.47)	0.24 (0.49)	0.198	0.31 (0.57)	0.27 (0.47)	0.222	0.23 (0.47)	0.23 (0.48)	0.785
Impaired memory status (three items)	0.30 (0.58)	0.36 (0.67)	0.207	0.49 (0.85)	0.34 (0.63)	0.253	0.33 (0.59)	0.32 (0.66)	0.816
Depressed mood (five items)	0.77 (1.35)	0.86 (1.37)	0.210	0.95 (1.56)	0.85 (1.34)	0.994	0.86 (1.32)	0.83 (1.35)	0.814
Questionnaire items of BCF									
Do you go out alone using transportation? (% no)	13.0	15.8	0.203	24.0	14.3	0.013	16.5	12.7	0.193
Do you shop for daily necessities by yourself? (% no)	4.9	8.6	0.021	17.3	7.1	0.001	8.6	5.9	0.198
Do you manage your bank account on your own? (% no)	10.5	11.7	0.553	18.3	10.5	0.024	12.9	8.6	0.094
Do you visit your friends alone? (% no)	17.2	16.7	0.842	22.1	15.7	0.107	16.1	15.4	0.832
Are you consulted by your family or friends? (% no)	12.7	9.8	0.132	15.4	8.8	0.038	8.2	9.3	0.666
Do you climb the stairs without holding on to handrails or walls? (% no)	22.8	32.9	<0.001	33.7	32.8	0.867	33.3	32.4	0.814
Do you stand up without assistance? (% no)	10.5	16.4	0.007	24.0	15.0	0.022	15.7	14.5	0.693
Can you walk for more than 15 min without rest? (% no)	6.6	13.0	0.001	15.4	12.6	0.443	12.9	12.4	0.841
Have you fallen within the past year? (% yes)	15.7	16.4	0.757	19.6	15.5	0.155	16.9	14.5	0.437
Are you anxious about falls? (% yes)	25.2	35.6	<0.001	42.3	34.4	0.120	33.7	34.8	0.772
Have you lost more than 2–3 kg in weight in the past 6 months? (% yes)	10.8	11.1	0.861	18.3	9.8	0.012	9.4	10.2	0.756
BMI <18.5 kg m^{-2} (% yes)	11.3	5.7	0.001	8.7	5.2	0.160	4.7	5.6	0.647
Do you have difficulty eating hard food? (% yes)	20.6	22.8	0.385	24.0	22.6	0.752	27.5	18.8	0.014
Do you choke when you swallow liquid? (% yes)	16.7	19.0	0.327	18.3	19.2	0.829	19.6	18.8	0.813
Do you have problems with a dry mouth? (% yes)	19.9	19.2	0.786	25.0	18.1	0.102	18.8	17.6	0.703
Do you go out more than once a week? (% no)	5.1	4.8	0.816	8.7	4.1	0.048	3.9	4.3	0.811
Do you go out less frequently than last year? (% yes)	15.6	19.3	0.121	21.6	18.9	0.526	19.4	18.4	0.760
Are you told that you repeatedly ask the same questions? (% yes)	12.3	15.7	0.120	20.2	14.9	0.168	14.1	15.4	0.659
Do you look up telephone numbers, dial and make phone calls without help? (% no)	4.4	4.5	0.922	10.6	3.5	0.001	2.7	4.0	0.407
Do you sometimes forget the date? (% yes)	13.0	16.4	0.128	19.2	15.9	0.397	16.5	15.4	0.734
Have you felt unfulfilled with daily life (in the last two weeks)? (% yes)	11.8	12.0	0.905	16.3	11.2	0.139	12.5	10.2	0.371
Have you not enjoyed your life as much as you used to (in the last 2 weeks)? (% no)	8.4	9.5	0.518	11.5	9.2	0.445	8.6	9.6	0.697
Do you feel more bothered about daily matters than you did before (in the last 2 weeks)? (% yes)	20.3	25.2	0.068	25.0	25.2	0.963	25.1	25.3	0.954
Have you felt that you are not useful (in the last 2 weeks)? (% no)	15.7	15.7	0.979	16.3	15.5	0.836	16.5	14.8	0.585
Have you felt tired for no reason (in the last 2 weeks)? (% yes)	21.4	23.9	0.344	26.0	23.5	0.586	23.5	23.5	0.984

Abbreviations: BP, blood pressure; BCF: basic checklist for frailty; CKD, chronic kidney disease. Results for continuous variables are expressed as mean ± s.d. and compared using Mann–Whitney U analysis. Discrete variables are reported as percentages and compared by χ^2-analysis.

status', besides absence of CKD or dyslipidemia, showed a statistically significant association with untreated hypertension in elderly hypertensive subjects (Table 2). In addition, logistic regression analysis using model-2 sets revealed that 'weight loss of more than 2–3 kg in the past 6 months' among these BCF items, besides

absence of CKD or dyslipidemia, showed statistically significant association with untreated hypertension in elderly hypertensive subjects (Table 3).

Among treated hypertensive subjects, hypertensive subjects with uncontrolled BP (>140/90 mm Hg) showed a similar profile of

factors in baseline examinations and in BCF categories and items, except one BCF item, 'difficulty eating hard food', compared with hypertensive subjects with controlled BP in univariate analysis (Table 1). Logistic regression analyses revealed that 'impaired oral function' among the BCF categories in model-1 analysis (Table 2) and 'difficulty eating hard food' among the BCF items in model-2 analysis (Table 3) showed a statistically significant association with untreated hypertension in elderly community-dwelling subjects.

DISCUSSION

The present study newly disclosed an emerging profile of hypertension status and frailty in elderly community-dwelling subjects based on data from a Public Health Center survey and Regional Comprehensive Support Center in a town in Japan. The prevalence of hypertension (62.6%) in the present study in elderly community-

dwelling Japanese subjects aged 65 years and older was comparable to the result (67%) in those aged 60 years and older in NHANES 1999–2004 in the US[6] and to that ($\geqslant$50%) in those aged 75 years and older in Japan.[9] On the other hand, the rate of untreated hypertension in the present study, 15.2% of elderly hypertensive subjects aged 65 years and older, was rather low compared with the results in the US; 33% of those aged 60 years and older in NHANES 1999–2004[6] and 52% of those $\geqslant$18 years of age (mean age 58–60

Table 2 Results of BCF categories and clinical factors by multiple logistic analysis

|	Wald	OR	95%CI	P
For hypertension among all subjects				
Age (years)	20.626	1.061	1.034–1.088	<0.001
Diabetes mellitus	10.048	1.862	1.268–2.736	0.002
Impaired nutritional status (two items)	8.300	0.645	0.479–0.869	0.003
Ischemic heart disease	3.332	2.288	0.940–5.568	0.068
Impaired walking status (five items)	3.269	1.107	0.991–1.236	0.070
Regular alcohol drinker	2.367	1.303	0.930–1.825	0.123
Dyslipidemia	2.296	1.272	0.931–1.737	0.129
Past history of stroke	1.499	1.473	0.792–2.740	0.220
Female sex	1.464	1.221	0.883–1.689	0.226
Current smoker	0.111	1.070	0.718–1.593	0.739
For treatment among hypertensive subjects				
Dyslipidemia	17.829	0.235	0.120–0.461	<0.001
CKD	9.754	0.438	0.261–0.735	0.002
Impaired IADL status (five items)	8.674	1.331	1.100–1.610	0.003
Impaired nutritional status (two items)	6.794	1.868	1.167–2.988	0.009
Current smoker	3.167	0.441	0.179–1.086	0.075
Diabetes mellitus	3.018	0.568	0.300–1.075	0.082
Female sex	2.239	1.534	0.875–2.689	0.134
Past history of stroke	1.499	1.677	0.733–3.836	0.220
Impaired walking status (five items)	0.080	0.974	0.813–1.166	0.776
Age (years)	0.042	1.004	0.963–1.047	0.836
For BP-control among treated hypertensive subjects				
Impaired oral function (three items)	3.957	1.236	1.003–1.523	0.047
Age (years)	3.790	0.968	0.933–1.001	0.053
Impaired IADL status (five items)	3.189	1.169	0.984–1.389	0.074
Dyslipidemia	3.036	0.712	0.486–1.043	0.081
Female sex	2.598	1.413	0.927–2.153	0.106
Past history of stroke	1.560	0.604	0.274–1.331	0.211

Abbreviations: BP, blood pressure; CI, confidence interval; CKD, chronic kidney disease; IADL, instrumental activity of daily living; OD, odds ratio. Adjusted by age, sex and variables selected according to their univariate analysis *P*-value (*P*<0.20).

Table 3 Results of BCF items and clinical factors by multiple logistic analysis

	Wald	OR	95%CI	P
For hypertension among all subjects				
Age (years)	23.338	1.067	1.039–1.096	<0.001
BMI <18.5 kg m^{-2}	14.355	0.392	0.242–0.637	<0.001
Diabetes mellitus	9.821	1.863	1.262–2.749	0.002
Able to walk for more than 15 min (no)	4.345	1.732	1.033–2.904	0.037
Consulted by family or friends (no)	3.251	0.655	0.414–1.037	0.071
For treatment among hypertensive subjects				
Dyslipidemia	18.017	0.222	0.111–0.445	<0.001
CKD	9.699	0.434	0.257–0.734	0.002
Losing more than 2–3 kg in weight	7.546	2.518	1.302–4.868	0.006
Diabetes mellitus	3.802	0.526	0.275–1.003	0.051
Current smoking	2.889	0.450	0.179–1.130	0.089
Female sex	2.749	1.641	0.913–2.948	0.097
For BP-control among treated hypertensive subjects				
Difficulty eating hard food	6.283	1.690	1.121–2.548	0.012
Age (years)	3.683	0.968	0.938–1.001	0.055
Female sex	2.897	1.444	0.945–2.207	0.089
Able to manage bank account (no)	3.051	1.695	0.937–3.067	0.080

Abbreviations: BMI, body mass index; BP, blood pressure; CI, confidence interval; CKD, chronic kidney disease; OR, odds ratio. Adjusted by age, sex and variables selected according to their univariate analysis *P*-value (*P*<0.20). BCF items and clinical factors with multiple logistic analysis *P*-values $\geqslant$0.1 are not shown.
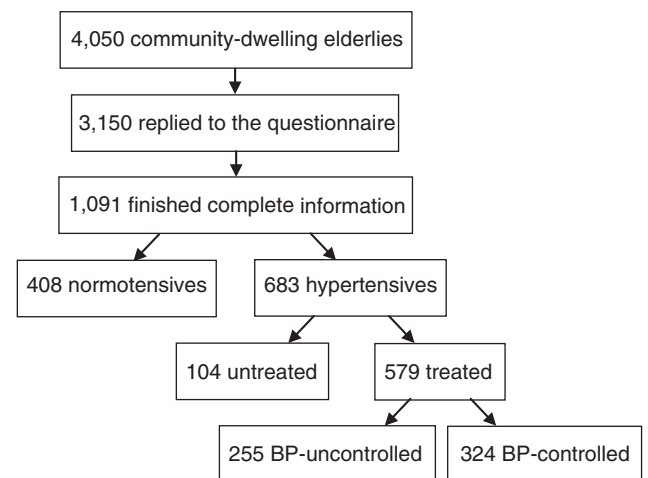
Figure 1 Study profile. Number of subjects per group shown for each status of hypertension.

years) in NHANES 1988–2008.[5] Moreover, the rate of BP-uncontrolled hypertension in the present study, 44% of treated hypertensive subjects aged 65 years and older, was also low compared with that in the US; 57% of those aged 60 years and older[6] and 53–73% of those ⩾18 years of age.[5] These differences may be reflected by the major fall of BP level recently achieved in community-dwelling subjects in Japan.[20]

Clinical factors independently associated with the prevalence of hypertension and with untreated hypertension in the present study were similar to those previously reported in community-dwelling subjects in the US, namely older age[6] and presence of diabetes mellitus[6] for prevalence of hypertension and absence of CKD[5,6] and absence of dyslipidemia[5] for untreated hypertension.

Logistic regression analysis in the present study also revealed that specified BCF categories and/or items were independently associated with hypertension status. First, two BCF categories, 'impaired walking status' and absence of 'impaired nutritional status', besides presence of diabetes mellitus, were independently associated with prevalence of hypertension in elderly subjects in logistic analysis using model-1 data sets. In addition, two BCF items, 'inability to walk for more than 15 min without a rest' and absence of 'BMI $<18.5\,\mathrm{kg\,m^{-2}}$', were further shown to have an independent association with prevalence of hypertension in elderly subjects in logistic analysis using model-2 data sets. A possible explanation for the association of 'impaired walking status' or 'inability to walk for more than 15 min without rest' with prevalence of hypertension is that hypertension itself may cause physical frailty resulting in a decline in walking ability in the elderly, since elderly subjects with frailty syndrome with low physical activity had higher BP than the non-frailty group,[11] and since hypertension was independently associated with shorter distance on the 6-minute walk test in elderly subjects.[21] Another possible explanation is that daily practice of walking may prevent hypertension even in the elderly population, since subjects walking 1 hour or more per day had a lower prevalence of hypertension in a large population of frail and very old subjects living in the community.[22] On the other hand, the observation in the present study of the independent association of thinness (BMI $<18.5\,\mathrm{kg\,m^{-2}}$) with lower prevalence of hypertension in the elderly is partly compatible with a previous report of an association of being underweight (BMI $<20\,\mathrm{kg\,m^{-2}}$) with lower prevalence of hypertension in elderly subjects,[23] although it is well-known that BMI greater than the reference value ($25\,\mathrm{kg\,m^{-2}}$) is independently associated with a greater likelihood of hypertension in the elderly.[6]

Second, two BCF categories, 'impaired IADL status' and 'impaired nutritional status', besides absence of CKD or dyslipidemia, were independently associated with untreated hypertension in hypertensive elderly subjects. The latter finding was further supported by the independent association of 'weight loss of more than 2–3 kg in the past 6 months' in model-2 logistic analysis using BCF items (Table 3). Although the precise mechanism of the association of 'impaired IADL status' with untreated hypertension in the elderly is unknown, IADL is a well-known indicator of the ability to live independently in the community. Okamura et al.[24] reported that elderly residents with systolic hypertension ($⩾160\,\mathrm{mm\,Hg}$) in two communities located in Akita and Kochi Prefectures showed a 3.41 times higher odds ratio for having low IADL scores than those with normal BP. Hayakawa et al.[25] reported a significant relationship between decrease in IADL score and cardiovascular risk factors including hypertension, dyslipidemia, diabetes mellitus and smoking, in a cohort in Japan. The present observation of an association between decline in IADL score and untreated hypertension is, at least in part, compatible with the reports of Okamura et al.[24] and Hayakawa et al.[25] Therefore, active treatment of hypertension in elderly community-dwelling subjects may be linked to prevention of future decline in IADL in Japanese elderly, allowing them to live a healthy and active life. On the other hand, the precise mechanism of the independent association of weight loss (of more than 2–3 kg in the past 6 months) with untreated hypertension in hypertensive elderly subjects is also unknown. One of the possible explanations for this is that weight loss as opposed to weight gain may often be overlooked as a problem linked to hypertension by healthcare providers, the public and elderly subjects themselves, as BMI $<25\,\mathrm{kg\,m^{-2}}$ compared with BMI $⩾25\,\mathrm{kg\,m^{-2}}$ was reported to be independently associated with a greater likelihood of untreated hypertension in elderly subjects in the US.[6] Another possibility is that weight loss more often observed in elderly subjects with untreated hypertension might be caused by past antihypertensive drug treatment and result in cessation of drug treatment by elderly subjects themselves, as unintended weight loss in the elderly may be caused by polypharmacy through dysgeusia and anorexia due to many individual medications.[26]

Third, 'impaired oral function' in the BCF categories and 'difficulty eating hard food' in the BCF items were independently associated with BP-uncontrolled hypertension in treated hypertensive elderly subjects in respective logistic regression analysis models. One of the possible explanations for this is that oral dysfunction may directly cause trouble swallowing pills, resulting in underuse of antihypertensive medication in these subjects.[27] Another possibility is that periodontal disease may cause both 'difficulty eating hard food' and BP-uncontrolled hypertension. The severity of periodontal disease[28,29] and tooth loss due to the disease[30] were significantly related to hypertension independent of age, although inconsistent results were also reported in middle-aged men.[31] Moreover, periodontal disease is reported to contribute to poor BP control in subjects aged 70 years and older.[32]

In the present study, specified BCF categories and/or items were newly identified as factors independently associated with prevalence of hypertension, untreated hypertension and BP-uncontrolled hypertension in elderly community-dwelling subjects. These frailty categories and items may be useful for evaluating hypertension status in elderly community-dwelling subjects. However, in view of the single community model, care must be taken in interpreting these results, and further evaluation in multi-regional trials is needed. Frailty assessed by comprehensive geriatric assessments and a precise health examination should be included in future studies to elucidate the mechanisms of the individual associations of BCF categories/items and hypertension status. Stratified sampling of BCF scores according to the kinds of antihypertensive drugs used, including renin-angiotensin blockers, is also needed in future studies, because the renin-angiotensin system is thought to have a crucial role in aging and/or frailty.[33]

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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