Original Article

Home Blood Pressure Is Associated with Depressive Symptoms in an Elderly Population Aged 70 Years and Over: A Population-Based, Cross-Sectional Analysis

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Although several epidemiologic studies have assessed the relationship between low blood pressure and depressive symptoms in geriatric populations, the results have been inconsistent. Because the white-coat phenomenon is observed frequently in patients with depressive symptoms, we have considered that blood pressure measured in nonmedical settings is important in assessing the relationship between blood pressure and depressive symptoms among the geriatric population. The aim of this study was to investigate the relationships between home blood pressure and depressive symptoms in a community-based elderly population aged 70 years and over. We analyzed a cross-sectional survey comprised of 888 community-dwelling Japanese aged 70 years and older. Blood pressure was self-measured at home, and depressive symptoms were evaluated using the 30-item Geriatric Depression Scale (GDS 30) with a cutoff point of 11. The prevalence of depressive symptoms was 34.8%. For all subjects, after adjustments for potentially confounding factors, the odds ratios of having depressive symptoms by increasing quartiles of systolic blood pressure of subjects not taking antihypertensive drugs to subjects taking them were 1.00, 0.97, 0.88, 0.59, and 0.70. Statistically significant inverse relationships were observed in subjects not taking antihypertensive drugs. No apparent association between diastolic blood pressure and depressive symptoms was observed in any subjects or in a stratified analysis of antihypertensive drug use. In this study, a higher home systolic blood pressure was independently and continuously related to a lower prevalence of depressive symptoms in participants not using antihypertensive medication. Further study is required to clarify the causality of this relationship. (*Hypertens Res* 2008; 31: 409–416)

***Key Words*: home blood pressure, depressive symptoms, Japanese, community-dwelling population**

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Introduction

Depression in late life is a recognized public health problem. Population-based estimates of the prevalence of mild and severe depression (using cutoffs of 5/6 on the Geriatric Depression Scale [GDS]-15) among older women in Japan range from 34.2% to 37.0% and among older men range from 29.7% to 35.4% (*1*).

The global burden of hypertension is a leading risk factor for cardiovascular and kidney disease and for mortality (*2–4*). It has overshadowed possible health problems associated with chronic low blood pressure (BP). Hypotension also is common in the general population and is associated with a distinct body habitus (*5*). Low BP was associated with the development of idiopathic chronic fatigue in women (*6*) and with neurasthenic symptoms such as weakness, fatigue, crying, psychological dysfunction, dizziness, and headache (*7–9*). Recent studies also have indicated that low BP reduced cortical activity (*10*), cerebral perfusion, and maladaption of blood flow to cognitive demands (*11*). Since these chronic psychological dysfunctions and/or body symptoms may be associated with depressive symptoms (*9*), it was hypothesized that low BP may be a potential risk factor for depressive symptoms (*12*).

However, in epidemiological studies, observations of the relationship between BP and depression have been inconsistent (*12–20*). Because the white-coat phenomenon has been observed frequently in all psychological types but especially in types having depressive symptoms (*21*, *22*), we have considered that BP measured in nonmedical settings is important in assessing the relationship between BP and depressive symptoms among the geriatric population. BP measurements at home (home blood pressure, HBP) are known to avoid the white-coat phenomenon (*23–25*). However, to our knowledge, no previous study used HBP to examine the association between BP and depressive symptoms among a geriatric population.

Thus, we used HBP to investigate the relationship between BP (including systolic BP [SBP] and diastolic BP [DBP]) and depressive symptoms among community-dwelling elderly aged 70 years and over.

Methods

Study Participants

Our study population was comprised of subjects aged 70 years and older who were living in the Tsurugaya area of Sendai, one of the major cities in the Tohoku area of Japan. At the time of the study in 2002, there were 2,730 individuals aged 70 years and older living in Tsurugaya. All of these individuals were invited to participate in a comprehensive geriatric assessment, which included medical status, physical function, cognitive function, and dental status. Among them, 1,178 did so, giving their informed consent for data analysis. The protocol of this study was approved by the Institutional Review Board of the Tohoku University Graduate School of Medicine.

In this study, the depressive symptoms were assessed with the aid of the GDS (*26*). Out of the 1,178 subjects, 1,169 completed the GDS. Since BP was assessed using data from self-measured BP at home, subjects who did not measure HBP data for more than 3 days during the 4-week study period were excluded ($n=184$; GDS$\geq$11: 41.0%). This criterion was based on a previous observation that average BP values for the first 3 days did not differ significantly from those obtained during the entire study period (*27*, *28*). We also excluded all potential subjects with notable comorbidities, those who were using drugs that could influence the degree of depressive symptoms, those who reported a history of cancer (*29*) ($n=68$), those who were using anti-depressants ($n=16$), and 13 subjects with cognitive dysfunction (Mini Mental State Examination, MMSE, Score (*30*) <18). As a result of these exclusions, the final study population was comprised of 888 subjects (mean$\pm$SD age 75.7$\pm$4.6 yeras, men: 44.0%).

Assessment of Depressive Symptoms

Depressive symptoms were assessed according to the Japanese version (*31*) of the 30-item GDS using a cutoff point (GDS score $\geq$11) indicating relatively mild to severe depressive symptoms (*26*).

Assessment of HBP

HBP was self-measured with an HEM747IC device (Omron Life Science, Tokyo, Japan), which uses the cuff oscillometric method to generate a digital display of SBP and DBP. This device has been validated previously, and satisfies the criteria of the Association for the Advancement of Medical Instrumentation (*32*). The following procedure was used to ascertain the accuracy of the HBP measurement. First, physicians informed the subjects about HBP recording and taught them how to measure their own BP. The daily measurement was made within 1 h after waking up and before breakfast, with the subject seated and having rested for at least 2 min. Subjects taking antihypertensive drugs measured their HBP before taking the drugs. An individual's HBP was defined as the mean of all measurements obtained for that person. The mean ($\pm$SD) number of HBP measurements was 15.7$\pm$10.5 (range, 3–49).

Assessment of Other Variables

Anthropometrics (height, body weight) were recorded by a standardized protocol. Body mass index (BMI) was calculated as weight (kg)/height^2 (m^2).

Sociodemographic variables including gender, age, educational level, and perceived social supports were also assessed.

Table 1. Baseline Characteristics According to Blood Pressure Status

	Subjects non-taking antihypertensive drugs (quartile)				Subjects taking antihypertensive drugs
	SBP				SBP
	81.4–123.6 mmHg	123.7–134.7 mmHg	134.9–147.0 mmHg	147.2–203.3 mmHg	105.7–224.7 mmHg
No. of participants	128	127	129	128	376
Age (years)	74.2 (73.5–75.0)	75.4 (74.6–76.2)	76.3 (75.5–77.1)	76.4 (75.6–77.2)	75.9 (75.5–76.4)
Sex (female)	43.8	63.0	55.8	58.6	56.9
BMI	22.3 (21.8–22.9)	23.3 (22.8–23.9)	23.8 (23.2–24.3)	24.6 (24.0–25.2)	24.4 (24.1–24.8)
Total number of physical illness					
≥4	12.5	15.0	17.1	21.9	39.1
2–3	42.2	43.3	46.5	38.3	43.4
Lack of perceived social support (total score=0)	18.8	22.8	20.2	19.5	18.7
Cognitive ability					
Normal (28≤MMSE≤30)	63.3	63.8	55.0	60.9	59.3
Slightly impaired (24≤MMSE≤27)	31.3	32.3	39.5	33.6	33.8
Smoking status					
Current smoker	14.8	11.8	16.3	11.7	10.9
Ex-smoker	31.3	23.6	24.0	33.6	32.5
Driking status					
Current drinker	38.3	38.6	45.0	37.5	41.2
Ex-drinker	16.4	11.8	7.8	7.8	13.0
PA (≥ level 4)	39.8	33.1	30.2	28.1	31.9
Educational level (≤12 years)	33.6	45.7	45.0	39.1	44.4
Pain	26.6	15.0	24.0	20.3	23.9
Impaired IADL	17.2	18.9	20.2	13.3	20.5

	Subjects non-taking antihypertensive drugs (quartile)				Subjects taking antihypertensive drugs
	DBP				DBP
	49.6–69.0 mmHg	69.3–74.9 mmHg	75.0–82.1 mmHg	82.1–105.4 mmHg	49.3–123.8 mmHg
No. of participants	128	128	128	128	376
Age (years)	75.8 (75.0–76.6)	75.8 (75.0–76.6)	75.4 (74.6–76.2)	75.3 (74.5–76.1)	75.9 (75.5–76.4)
Sex (female)	54.7	53.9	57.8	54.7	56.9
BMI	22.4 (21.8–22.9)	23.7 (23.1–24.2)	23.8 (23.2–24.3)	24.2 (23.6–24.8)	24.4 (24.1–24.8)
Total number of physical illness					
≥4	14.1	17.2	15.6	19.5	39.1
2–3	49.2	41.4	42.2	37.5	43.4
Lack of perceived social support (total score=0)	22.7	23.4	20.3	14.8	22.3
Cognitive ability					
Normal (28≤MMSE≤30)	63.3	56.3	57.8	65.6	59.3
Slightly impaired (24≤MMSE≤27)	30.5	38.3	37.5	30.5	33.8
Smoking status					
Current smoker	14.8	10.2	14.8	14.8	10.9
Ex-smoker	25.0	31.3	25.0	31.3	32.5
Driking status					
Current drinker	36.7	35.2	43.0	44.5	41.2
Ex-drinker	14.8	14.1	7.8	7.0	13.0
PA (≥ level 4)	41.4	35.2	28.9	25.8	31.9
Educational level (≤12 years)	39.1	46.1	43.0	35.2	44.4
Pain	22.7	21.1	24.2	18.0	23.9
Impaired IADL	20.3	20.3	17.2	11.7	20.5

Variables are presented as mean (95% CI) or %. CI, confidence interval; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; MMSE, Mini Mental State Examination; PA, physical activity; IADL, instrumental activities of daily living.

Educational level was assessed by determining age at completion of schooling and was divided into two categories: ≤12 or >12 years. Perceived social support (PSS) was evaluated on the basis of responses (yes or no) to five questions: "Do you have someone to talk to when you are in trouble?" (PSS 1); "Do you have someone to talk to when you're not feeling well?" (PSS 2); "Do you have someone who can help you with daily housework?" (PSS 3); "Do you have someone who can take you to the hospital when you don't feel well?" (PSS 4); and "Do you have someone who can take care of you when you are ill in bed?" (PSS 5). These questions were extracted from a previous study regarding social support and elderly depression in a rural community (*33*). A strong association between negative answers to these items and depression has been confirmed in two Japanese community studies of elderly populations (*33*, *34*). A single summed score was calculated based on the PSS 1–5. No PSS was defined as a score of 0.

Health-related variables assessed included history of physical illness, pain, cognitive function, instrumental activities of daily living (IADL), and current use of medication. History of physical illness was evaluated on the basis of responses (yes or no) to questions concerning history of a stroke, ischemic heart disease, diabetes mellitus, hyperuricemia, hyperlipidemia, renal disease, liver disease, cholelithiasis or cholecystitis, a gastric or duodenal ulcer, tuberculosis, pneumonia, asthma, a hearing disturbance, cataracts, glaucoma, arthritis, and osteoporosis. Subjects were classified into three categories according to the total number of these conditions in the subject's history: 0–1, 2–3, or ≥4. Pain within the previous 4 weeks was assessed by the question, "Have you had any pain recently? If so, how intensely do you feel such pain?" Possible answers were "no pain," "very mild pain," "mild pain," "moderate pain," and "severe pain." A subject who reported mild to severe pain was considered to have pain. Cognitive function was assessed on the basis of the MMSE and was classified into three categories: 18–23, 24–27, and 28–30. IADLs were assessed using the Rouken-Shiki scale (*35*), and a cutoff point of 10/11 was used to determine impairment in IADL. Information about antihypertensive drugs was confirmed by a well-trained pharmacist.

Information on smoking status and drinking status was obtained from the questionnaire survey. Physical activity (PA) was assessed first by a self-reported single-item question on whether or not the participant obtained any PA in the past year. If yes, questions were asked about the frequency and duration of walking, brisk walking, and sports. PA was then classified into three categories, based on frequency and duration in the participant: 1) High: at least 3–4 times per week for at least 30 min each time; 2) Low: reporting some activity in the past year, but not enough to meet high levels; and 3) None: no PA. Furthermore, PA was classified into six levels based on these three categories and each PA such as walking, brisk walking, and sports: 1) Level 1: no walking, no brisk walking, no sports; 2) Level 2: low walking, no brisk walking, no sports; 3) Level 3: high walking, no brisk walking, no sports; 4) Level 4: any walking, low brisk walking, no sports; 5) Level 5: any walking, high brisk walking, no sports; 6) Level 6: any walking, any brisk walking, low or high sports. Detailed information was provided in previous reports (*36*). Finally, subjects were divided into two categories: ≤level 3 or >level 3.

Statistical Analysis

Descriptive data are presented as means (95% confidence interval [CI]) or percentages. Depressive symptoms (GDS scores ≥11) were used as the dependent variables and the HBP level as the independent variable. Multiple logistic regression analysis was used to examine the relationship between HBP and depressive symptoms after adjustment for age, sex, BMI, self-reported medical conditions, lack of PSS, smoking and drinking habits/history, educational level, impaired physical functioning, cognitive status, pain, PA, and the number of HBP measurements. p values for linear trends were calculated using the median (mmHg) of HBP groups. The odds ratios (ORs) and 95% CI of depressive symptoms for increasing HBP levels, with the lowest level as the reference, were also calculated using multiple logistic regression analysis. A significant difference was defined as $p<0.05$. All statistical analyses were performed using the Statistical Analysis System 9.1 edition for Windows (SAS Institute, Cary, USA).

Results

In this study, 34.8% (407/1,169) of the subjects were classified as having depressive symptoms. Among the 888 subjects who were available for analysis, 285 (32.1%) were classified as having depressive symptoms.

Baseline characteristics according to BP status are presented in Table 1.

Table 2 shows the adjusted association between the HBP quartile of subjects not taking antihypertensive drugs, subjects taking antihypertensive drugs, and depressive symptoms. Although not statistically significant, ORs adjusted for potentially confounding factors for depressive symptoms were lowest in the highest tertiles of subjects not taking antihypertensive drugs (OR: 0.59; 95% CI: 0.32–1.08) in SBP. Similarly, we observed lower ORs of having depression in participants taking antihypertensive medication compared with the lowest SBP quartile of participants not taking antihypertensive medication. In contrast, there was no apparent association between DBP and depressive symptoms.

Table 3 shows separately the adjusted association between HBP quartiles and depressive symptoms in subjects not taking antihypertensive drugs and those taking antihypertensive drugs. In subjects not taking antihypertensive drugs, the ORs of depressive symptoms decreased across the levels of SBP. The age- and sex-adjusted ORs for depressive symptoms

Table 2. Adjusted Relationships of Blood Pressure to Depressive Symptoms

	Subjects non-taking antihypertensive drugs (quartile)				Subjects taking antihypertensive drugs
	SBP				SBP
	81.4–123.6 mmHg	123.7–134.7 mmHg	134.9–147.0 mmHg	147.2–203.3 mmHg	105.7–224.7 mmHg
No. of participants	128	127	129	128	376
No. of depressive symptoms	43	44	43	32	123
Odds ratio (95% CI)					
Age- and sex-adjusted	1.00	0.92 (0.54–1.56)	0.87 (0.51–1.47)	0.57 (0.32–0.98)	0.85 (0.55–1.32)
Multiple adjusted*	1.00	0.97 (0.55–1.69)	0.88 (0.50–1.55)	0.59 (0.32–1.08)	0.70 (0.43–1.15)

	Subjects non-taking antihypertensive drugs (quartile)				Subjects taking antihypertensive drugs
	DBP				DBP
	49.6–69.0 mmHg	69.3–74.9 mmHg	75.0–82.1 mmHg	82.1–105.4 mmHg	49.3–123.8 mmHg
No. of participants	128	128	128	128	376
No. of depressive symptoms	38	49	42	33	123
Odds ratio (95% CI)					
Age- and sex-adjusted	1.00	1.48 (0.88–2.52)	1.16 (0.68–1.98)	0.83 (0.48–1.45)	1.14 (0.74–1.78)
Multiple adjusted*	1.00	1.51 (0.87–2.64)	1.20 (0.68–2.12)	0.94 (0.52–1.69)	0.96 (0.59–1.57)

*Adjusted for age, sex, BMI, self-reported medical conditions, lack of perceived social support, respectively, smoking and drinking habits/history, educational level, cognitive status, pain, physical activity, impaired instrumental activities of daily living and the number of HBP measurements. CI, confidence interval; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; HBP, home blood pressure.

across SBP were 1.00, 0.86, 0.82, and 0.53 (p for trend=0.03), and ORs across DBP were 1.00, 1.50, 1.16, and 0.83 (p for trend=0.31), respectively. These results were unchanged when adjusted for multiple confounding factors. In contrast, no apparent association was observed in subjects taking antihypertensive drugs.

Discussion

In this cross-sectional study, we examined the relationship between HBP and depressive symptoms in a community-dwelling elderly population aged 70 years and over. Our results suggested that lower SBP, but not lower DBP, was related to depressive symptoms independently of potential confounding factors in subjects not taking antihypertensive drugs.

Several studies used office BP to investigate the relationship between BP and depressive symptoms, but the results were inconsistent. Four cross-sectional (*12–15*) studies and a prospective study (*16*) showed inverse associations between BP and depressive symptoms. Another prospective study found no association (*17*). In contrast, three cross-sectional studies found a positive association between hypertension and depression (*18–20*). Only one previous study (*37*) using HBP reported no significant relationship between BP levels, and psychological dysfunction/fatigue was demonstrated among younger subjects (mean age±SD: 48.7±16 years). However, they did not assess the depressive symptoms. Because some studies reported that the white-coat phenomenon was frequently observed in depressive symptoms (*21*, *22*), it might be interesting to investigate the relationship between BP measured in nonmedical settings and depressive symptoms. Therefore, HBP was used to assess the relationships between BP and depressive symptoms in this study. The present results suggested that SBP, but not DBP, is inversely related to depressive symptoms among an elderly population not taking hypertensive drugs.

An important finding in the current study was the inverse relationship between HBP and depressive symptoms in subjects who were not taking antihypertensive drugs. Moreover, the ORs of having depression were lower, although not significantly, in subjects taking antihypertensive drugs than among the lowest SBP quartile of subjects not taking antihypertensive drugs. This result can be interpreted in several ways. First, because antihypertensive medication lowered BP, weaken BP's influence on depressive symptoms. Second, one

Table 3. Adjusted Relationships of Blood Pressure (Quartile) to Depressive Symptoms

a. Subjects non-taking antihypertensive drugs ($n=512$)

	Systolic blood pressure (mmHg)				*p* for trend
	81.4–123.6	123.7–134.7	134.9–147.0	147.2–203.3	
No. of participants	128	127	129	128	—
No. of depressive symptoms	43	44	43	32	—
Odds ratio (95% CI)					
Age- and sex-adjusted	1.00	0.86 (0.50–1.47)	0.82 (0.48–1.40)	0.53 (0.30–0.92)	0.03
Multiple adjusted*	1.00	0.81 (0.46–1.47)	0.72 (0.39–1.33)	0.46 (0.23–0.88)	0.02
	Diastolic blood pressure (mmHg)				*p* for trend
	49.6–69.0	69.3–74.9	75.0–82.1	82.1–105.4	
No. of participants	128	128	128	128	—
No. of depressive symptoms	38	49	42	33	—
Odds ratio (95% CI)					
Age- and sex-adjusted	1.00	1.50 (0.88–2.55)	1.16 (0.67–1.98)	0.83 (0.48–1.45)	0.31
Multiple adjusted*	1.00	1.47 (0.82–2.64)	1.15 (0.64–2.09)	0.90 (0.48–1.69)	0.52

b. Subjects taking antihypertensive drugs ($n=376$)

	Systolic blood pressure (mmHg)				*p* for trend
	105.7–134.3	134.5–144.3	144.7–156.4	156.5–224.7	
No. of participants	94	94	94	94	—
No. of depressive symptoms	33	29	30	31	—
Odds ratio (95% CI)					
Age- and sex-adjusted	1.00	0.82 (0.44–1.51)	0.86 (0.46–1.58)	0.84 (0.45–1.57)	0.64
Multiple adjusted*	1.00	0.84 (0.44–1.62)	1.03 (0.53–1.99)	0.80 (0.41–1.59)	0.64
	Diastolic blood pressure (mmHg)				*p* for trend
	49.3–72.0	72.0–77.9	77.9–84.0	84.0–123.8	
No. of participants	94	94	94	94	—
No. of depressive symptoms	32	38	23	30	—
Odds ratio (95% CI)					
Age- and sex-adjusted	1.00	1.34 (0.74–2.43)	0.64 (0.34–1.21)	0.93 (0.51–1.72)	0.39
Multiple adjusted*	1.00	1.70 (0.89–3.29)	0.85 (0.43–1.70)	0.95 (0.49–1.84)	0.43

*Adjusted for age, sex, BMI, self-reported medical conditions, lack of perceived social support, respectively, smoking and drinking habits/history, educational level, cognitive status, pain, physical activity and impaired instrumental activities of daily living and the number of HBP measurements. CI, confidence interval; BMI, body mass index; HBP, home blood pressure.

more possibility that might explain the inverse relationship between SBP and depressive symptoms was the issue of measurement timing. HBP was measured in the early morning, and a question on the GDS (Question 27: "Do you enjoy getting up in the morning?") was in harmony with symptoms of hypotension in the morning. Therefore, participants with morning hypotension tended to score higher on the GDS scale. This also makes it possible to explain the inverse association of BP with depression symptoms. To understand the causal relation of BP in nonmedical settings with depressive symptoms, prospective studies using ambulatory BP measurements that can assess not only morning BP but also daytime BP are required.

The biological mechanisms involved in the relationship between HBP and depression are not well known. Recent findings have indicated that many neuropeptides play a major role in mediating the response to stress-related diseases, including depression and anxiety disorders (*38*). The overexpression of endogenous neuropeptide Y in transgenic rats has been associated with lower BP at baseline and during stress (*39*). Thus, these findings suggested that neuropeptide Y may be a possible link between low BP and depressive symptoms. Further study is required to clarify the biological mechanism underlying the association between lower BP and depressive symptoms.

A previous study reported that chronic hypotensives have a female preponderance (*40*). In contrast, the current results show that the proportion of males was higher in the lowest SBP group than in the other SBP groups (Table 1). Differences in participant population may partly explain the incon-

sistencies. Further study is required for clarification.

This study had several limitations. First, the participants were sufficiently active and healthy to participate in the survey; therefore, it is possible that our results do not apply to subjects at higher risk. Second, because this study was cross-sectional, we could not conclude that lower HBP increases the occurrence of depressive symptoms or that depressive symptoms lead to the decline of HBP among subjects aged 70 years and over. Therefore, a prospective study or trial should be undertaken to confirm the relationship between HBP and depressive symptoms. Third, since screening BP was not measured, we could not infer the influence of screening BP on depressive symptoms in this study population. Finally, the GDS scale was designed for measuring the intensity of depressive symptoms and not for making a clinical diagnosis of depressive episodes. Therefore, a larger sample population using a standardized comprehensive structured diagnostic interview should be undertaken to confirm the relation between HBP and depressive episodes.

In conclusion, home SBP, but not home DBP, was independently related to a lower prevalence of depressive symptoms in a community-dwelling elderly population not taking antihypertensive drugs. A prospective study or randomized trials are required to clarify the causality in this relationship.

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References

1. Wada T, Ishine M, Sakagami T, *et al*: Depression in Japanese community-dwelling elderly—prevalence and association with ADL and QOL. *Arch Gerontol Geriatr* 2004; **39**: 15–23.
2. Shimamoto K, Kita T, Mabuchi H, *et al*: Effects of hypertension and type 2 diabetes mellitus on the risk of total cardiovascular events in Japanese patients with hypercholesterolemia: implications from the Japan Lipid Intervention Trial (J-LIT). *Hypertens Res* 2007; **30**: 119–123.
3. Ishiguro K, Sasamura H, Sakamaki Y, Itoh H, Saruta T: Developmental activity of the renin-angiotensin system during the "critical period" modulates later L-NAME–induced hypertension and renal injury. *Hypertens Res* 2007; **30**: 63–75.
4. Nakamura K, Okamura T, Kanda H, *et al*: Impact of hypertension on medical economics: a 10-year follow-up study of national health insurance in Shiga, Japan. *Hypertens Res* 2005; **28**: 859–864.
5. Owens PE, Lyons SP, O'Brien ET: Arterial hypotension: prevalence of low blood pressure in the general population using ambulatory blood pressure monitoring. *J Hum Hypertens* 2000; **14**: 243–247.
6. Lucas KE, Rowe PC, Coresh J, Klag MJ, Meoni LA, Ford DE: Prospective association between hypotension and idiopathic chronic fatigue. *J Hypertens* 2004; **22**: 691–695.
7. Wessely S, Nickson J, Cox B: Symptoms of low blood pressure: a population study. *BMJ* 1990; **301**: 362–365.
8. Pilgrim JA, Stansfeld S, Marmot M: Low blood pressure, low mood? *BMJ* 1992; **304**: 75–78.
9. Pemberton J: Does constitutional hypotension exist? *BMJ* 1989; **298**: 660–662.
10. Duschek S, Meinhardt J, Schandry R: Reduced cortical activity due to chronic low blood pressure: an EEG study. *Biol Psychol* 2006; **72**: 241–250.
11. Duschek S, Schandry R: Cognitive performance and cerebral blood flow in essential hypotension. *Psychophysiology* 2004; **41**: 905–913.
12. Barrett-Connor E, Palinkas LA: Low blood pressure and depression in older men: a population based study. *BMJ* 1994; **308**: 446–449.
13. Stroup-Benham CA, Markides KS, Black SA, Goodwin JS: Relationship between low blood pressure and depressive symptomatology in older people. *J Am Geriatr Soc* 2000; **48**: 250–255.
14. Hildrum B, Mykletun A, Stordal E, Bjelland I, Dahl AA, Holmen J: Association of low blood pressure with anxiety and depression: the Nord-Trondelag Health Study. *J Epidemiol Community Health* 2007; **61**: 53–58.
15. Jorm AF: Association of hypotension with positive and negative affect and depressive symptoms in the elderly. *Br J Psychiatry* 2001; **178**: 553–555.
16. Paterniti S, Verdier-Taillefer MH, Geneste C, Bisserbe JC, Alperovitch A: Low blood pressure and risk of depression in the elderly. A prospective community-based study. *Br J Psychiatry* 2000; **176**: 464–467.
17. Gilmore C, Green BH, Copeland JR, *et al*: Blood pressure as a risk factor for depression in elderly people: a prospective study. *Acta Psychiatr Scand* 1995; **91**: 126–129.
18. Kabir AA, Whelton PK, Khan MM, Gustat J, Chen W: Association of symptoms of depression and obesity with hypertension: the Bogalusa Heart Study. *Am J Hypertens* 2006; **19**: 639–645.
19. Artinian NT, Washington OG, Flack JM, Hockman EM, Jen KL: Depression, stress, and blood pressure in urban African-American women. *Prog Cardiovasc Nurs* 2006; **21**: 68–75.
20. Chen R, Wei L, Hu Z, Qin X, Copeland JR, Hemingway H: Depression in older people in rural China. *Arch Intern Med* 2005; **165**: 2019–2025.
21. Shkarin VV, Shkarina IN, Malygin VL: Psychological aspects of systemic approach to intra-nosological diagnosis in arterial hypertension. *Ter Arkh* 2000; **72**: 43–46.
22. MacDonald MB, Laing GP, Wilson MP, Wilson TW: Prevalence and predictors of white-coat response in patients with treated hypertension. *CMAJ* 1999; **161**: 265–269.
23. Imai Y, Okubo T, Asayama K, *et al*: Epidemiology of hypertension based on ambulatory blood pressure monitoring and self-measurement of blood pressure at home. *J Health Sci* 2004; **50**: 113–119.
24. O'Brien E, Asmar R, Beilin L, *et al*: European Society of Hypertension recommendations for conventional, ambulatory and home blood pressure measurement. *J Hypertens* 2003; **21**: 821–848.
25. Hozawa A, Ohkubo T, Kikuya M, *et al*: Blood pressure control assessed by home, ambulatory and conventional

blood pressure measurements in the Japanese general population: the Ohasama study. *Hypertens Res* 2002; **25**: 57–63.
26. Brink T, Yesavage J, Lum O, Heersema P, Adey M, Rose T: Screening tests for geriatric depression. *Clin Gerontol* 1982; **1**: 37–44.
27. Hozawa A, Ebihara S, Ohmori K, *et al*: Increased plasma 8-isoprostane levels in hypertensive subjects: the Tsurugaya Project. *Hypertens Res* 2004; **27**: 557–561.
28. Imai Y, Satoh H, Nagai K, *et al*: Characteristics of a community-based distribution of home blood pressure in Ohasama in northern Japan. *J Hypertens* 1993; **11**: 1441–1449.
29. Williams S, Dale J: The effectiveness of treatment for depression/depressive symptoms in adults with cancer: a systematic review. *Br J Cancer* 2006; **94**: 372–390.
30. Folstein MF, Folstein SE, McHugh PR: "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975; **12**: 189–198.
31. Niino N, Imaizumi T, Kawakami N: A Japanese translation of the Geriatric Depression Scale. *Clin Gerontol* 1991; **10**: 85–87.
32. Chonan K, Kikuya M, Araki T, *et al*: Device for the self-measurement of blood pressure that can monitor blood pressure during sleep. *Blood Press Monit* 2001; **6**: 203–205.
33. Muraoka Y, Oiji A, Ihara K: The physical and psychological and social background factor of elderly depression in the community. *Jpn J Geriatr Psychiatry* 1996; **7**: 397–407 (in Japanese).
34. Koizumi Y, Awata S, Seki T: Association between social support and depression in the elderly Japanese population. *Jpn J Geriatr Psychiatry* 2004; **41**: 426–433 (in Japanese).
35. Koyano W, Shibata H, Haga H, Suyama Y, Nakazato K: Measurement of competence in the elderly living at home: development of an index of competence. *Nippon Koshueiseigaku Zasshi* 1987; **34**: 109–114 (in Japanese).
36. Niu K, Hozawa A, Fujita K, *et al*: Influence of leisure-time physical activity on the relationship between C-reactive protein and hypertension in a community-based elderly population of Japan: the Tsurugaya project. *Hypertens Res* 2005; **28**: 747–754.
37. Donner-Banzhoff N, Chan Y, Szalai JP, Hilditch JR: Low blood pressure associated with low mood: a red herring? *J Clin Epidemiol* 1997; **50**: 1175–1181.
38. Holmes A, Heilig M, Rupniak NM, Steckler T, Griebel G: Neuropeptide systems as novel therapeutic targets for depression and anxiety disorders. *Trends Pharmacol Sci* 2003; **24**: 580–588.
39. Fuxe K, Aguirre JA, Agnati LF, *et al*: Neuropeptide Y and central cardiovascular regulation. Focus on its role as a cotransmitter in cardiovascular adrenergic neurons. *Ann N Y Acad Sci* 1990; **611**: 111–132.
40. Akahoshi M, Hida A, Imaizumi M, *et al*: Basic characteristics of chronic hypotension cases: a longitudinal follow-up study from 1958 through 1999. *Hypertens Res* 2006; **29**: 1–7.