

## Age and Gender Differences in White Coat Phenomenon of Blood Pressure

Zhang TING Li

Third Department of Internal Medicine, Nagasaki University School of Medicine

Home blood pressure has recently become a widely used measurement in the diagnosis and management of hypertension. Home blood pressure readings often differ from blood pressure readings taken during patient clinic visits due to what is referred to as the “white coat” phenomenon. In other words, blood pressure readings taken by a medical professional in a medical setting tend to be elevated in comparison to blood pressure readings taken by the patients themselves at home, a fact that is generally taken into consideration when a patient’s condition is being reviewed. However, the effects of patient age and gender on white coat phenomenon have not been well studied. To investigate the relationship of these factors to white coat phenomenon, we studied 288 residents (119 men and 169 women, all over 40 years of age) of a rural community in southern Japan. White coat phenomenon was evaluated in each subject by subtracting mean morning home blood pressures, both systolic and diastolic, from regular-checkup blood pressure. The difference in systolic blood pressures in men over 65 years of age was significantly greater than that in men under age 65. No age-related differences were observed in systolic pressures among the women in our study. While the difference between home systolic blood pressure and regular-checkup systolic blood pressure in women under 65 years of age was significantly greater than that in men of the same age group, no gender-related differences were observed in subjects over 65. In contrast to the results for systolic blood pressure, there were no age- or gender-related differences in diastolic blood pressures. Age- and gender-related differences seen in the systolic blood pressures were not mimicked in other parameters such as serum total cholesterol levels, serum triglycerides levels, or fasting blood sugar levels. These results support the importance of considering white coat phenomenon as a factor in the out-patient clinical setting, which should be taken into account in the treatment of hypertension, especially in women and older men.

---

**Key words :** home blood pressure, regular-checkup blood pressure, white coat phenomenon

### Introduction

It has been well documented that elderly hypertensive subjects have highly variable blood pressure readings<sup>1)</sup>. Home blood pressure (HBP) as recently become a widely

used measurement in patients all over the world. White coat phenomenon (WCP), a difference between HBP and regular-checkup blood pressure (RCBP), is commonly found in the out-patient clinical setting when HBP is being recorded. Although the factors influencing WCP have not been clarified, we considered stress to be a possible contributor to this effect and hypothesized that gender- and age-related differences in WCP might occur. To test this hypothesis, this study was carried out to comparing WCP in elderly vs. middle aged residents of both genders in a rural community in southern Japan.

### Materials and Methods

#### *Subjects*

We studied 288 persons age 40 and over from 1300 orange farmers and their families who live in Tarami, 15 miles from Nagasaki City, and who participated in regular checkups in regional halls. Informed consent was obtained from all participants. Persons receiving anti-hypertensive drugs were excluded from this study. One hundred nineteen men were divided into two groups, those under age 65,  $52 \pm 7$ ,  $n = 64$ , and those age 65 or older,  $71 \pm 4$ ,  $n = 55$ . One hundred sixty-nine women were also divided into two groups, those under age 65,  $52 \pm 7$ ,  $n = 118$ , and those age 65 or older,  $71 \pm 4$ ,  $n = 51$ . Hypertension was defined as a systolic pressure of more than 160 mmHg or a diastolic pressure of more than 95 mmHg recorded during a regular-checkup. Based upon this criteria, 56 participants were hypertensive. We included both normotensive and hypertensive subjects in the study.

#### *Measurements of HBP*

After training all subjects to properly measure blood pressure, HBP devices (HEM-403C, Omron, Japan) were loaned to each subjects for one month. The HBP devices were semiautomatic blood pressure measurement units based on the cuff-oscillometric principle. HBP was measured by individual subjects each morning before breakfast.

A precise time was not designated for measurement since lifestyles and schedules vary from person to person. Only persons who recorded their HBP more than 20 times during the month were included in this study. Mean morning HBP was calculated for each subject.

### *RCBP*

Height, body weight, serum total cholesterol levels, serum triglycerides levels, and fasting blood sugar levels were measured in the morning under fasting conditions in the regional hall where regular yearly checkups were performed. Body mass index (BMI) was calculated by the formula of body weight (kg)/height<sup>2</sup> (m). It is considered that hyperlipidemia, diabetes mellitus, and obesity are risk factors of arteriosclerosis. Serum total cholesterol levels, serum triglyceride levels, blood sugar levels, and BMI were evaluated to find the effects of atherogenic factors on age and gender differences in WCP. Serum total cholesterol levels and triglyceride levels were measured using the enzymatic methods reported by Roeschlau et al<sup>2)</sup> and Wahlefeld et al<sup>3)</sup>; ascorbic acid oxydase and cholesterol esterase were used for the measurement of serum total cholesterol levels and glycerol kinase was used for the measurement of serum triglyceride levels. Blood pressure was also measured in the morning with sphygmomanometers by 3 nurses wearing white coats. During these regular-checkups, blood pressure was measured 3 times, and the average of the 2<sup>nd</sup> and 3<sup>rd</sup> measurement was defined as the RCBP. The nurses who measured blood pressure were well trained by physicians specializing in hypertension.

### *WCP*

The mean morning HBP was calculated for each subject and taken as the individual HBP measurement. For the purpose of this study WCP was defined as the difference between HBP and RCBP. Values were expressed as the difference between HBP and RCBP (mmHg).

### *Statistics*

Clinical variables were expressed mean value  $\pm$  SD. The data from each of the 4 groups were compared using a two-way repeated measures analysis of variance (ANOVA). Intergroup differences were compared by unpaired t test;  $p < 0.05$  was considered statistically significant.

## **Results**

### *RCBP*

Regular-checkup systolic blood pressure (RCSBP) levels

in men and women aged 65 or older ( $147 \pm 22$  mmHg and  $148 \pm 20$  mmHg, respectively) were significantly higher than those in men and women younger than age 65 ( $131 \pm 18$  mmHg and  $133 \pm 21$  mmHg, respectively) (Figure 1). There were no statistically significant gender-related differences in RCSBP. Regular-checkup diastolic blood pressure (RCDBP) levels in men and women 65 or older ( $82 \pm 12$  mmHg and  $78 \pm 9$  mmHg, respectively) were not different from those in subjects in men and women younger than age 65 ( $80 \pm 12$  mmHg and  $78 \pm 11$  mmHg, respectively). There were no significant age- or gender-related differences observed in RCDBP levels (Figure 2).

### *Home blood pressure (HBP)*

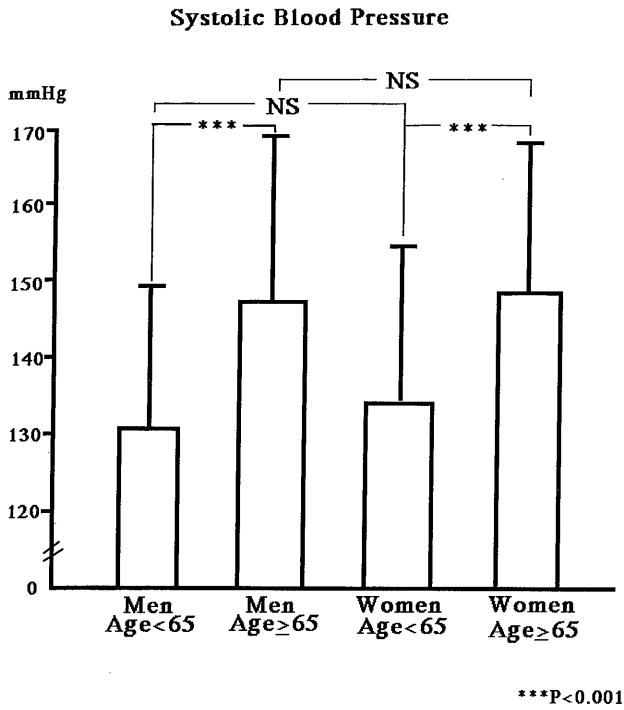
As summarized in Figure 3, systolic HBP in men and women 65 or older ( $134 \pm 18$  mmHg and  $137 \pm 17$  mmHg, respectively) was significantly greater than that in subjects of the same gender but younger than age 65 ( $127 \pm 13$  mmHg and  $118 \pm 17$  mmHg, respectively). No gender-related differences in systolic HBP were observed. Diastolic HBP in men and women 65 or older ( $81 \pm 13$  mmHg and  $79 \pm 9$  mmHg, respectively) was not different from that in subjects of the same gender but younger than age 65 ( $83 \pm 10$  mmHg and  $78 \pm 16$  mmHg, respectively). No gender-related differences in diastolic HBP were observed (Figure 4).

### *WCP*

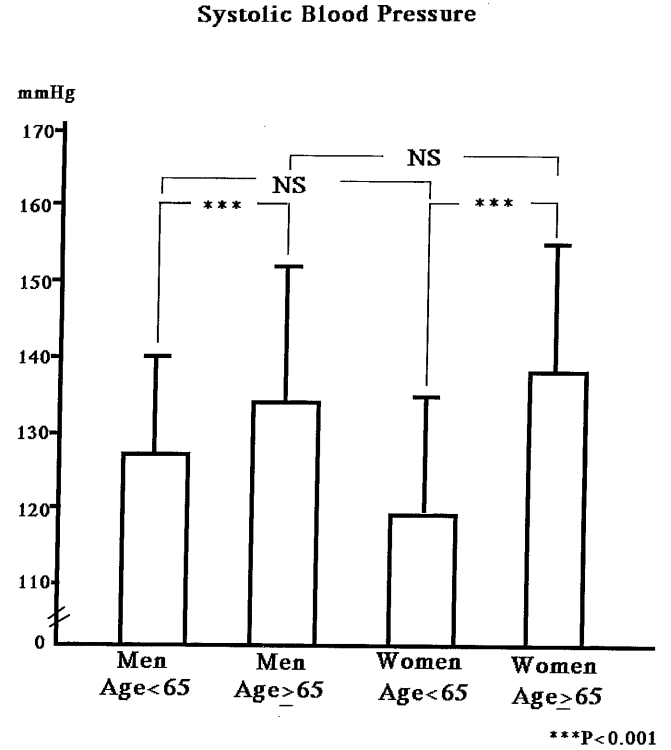
Although WCP of systolic blood pressure was significantly greater in men aged 65 or older ( $12 \pm 14$  mmHg) than in younger men ( $4 \pm 14$  mmHg) (Figure 5), no significant difference was observed between the two age groups among women. Furthermore, WCP of systolic blood pressure was significantly greater in women younger than age 65 ( $11 \pm 16$  mmHg) than those in men younger than age 65 ( $4 \pm 14$  mmHg), but no similar difference was noted between the older women ( $11 \pm 17$  mmHg) and the older men ( $12 \pm 14$  mmHg). No statistically significant age- or gender-related differences were observed between WCP of diastolic blood pressure (Figure 6).

### *Serum total cholesterol levels, serum triglyceride levels, fasting blood sugar levels and BMI*

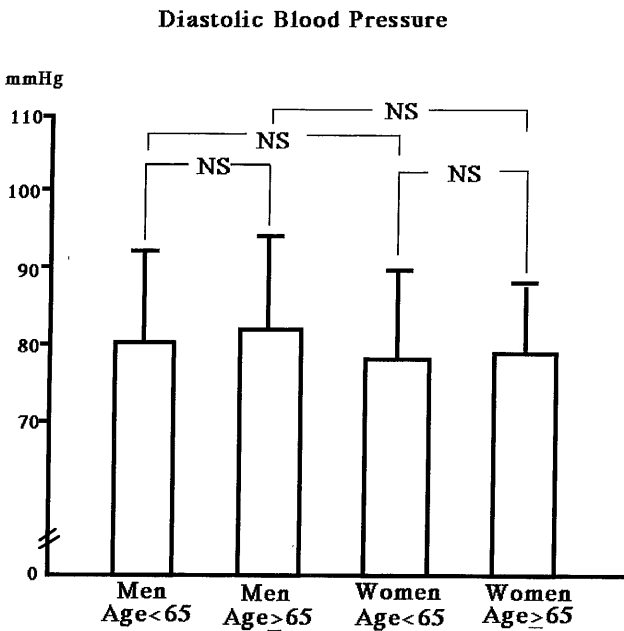
Although serum total cholesterol levels in men aged 65 or older were not significantly different from those in men under 65 ( $198 \pm 41$  mg/dl and  $190 \pm 33$  mg/dl, respectively) serum total cholesterol levels of women aged 65 or older ( $218 \pm 32$  mg/dl) were significantly higher than those of women under 65 ( $198 \pm 41$  mg/dl) (Figure 7). Women aged 65 or older had significantly higher total cholesterol levels ( $218 \pm 32$  mg/dl) than men of the same age group ( $198 \pm 41$  mg/dl); however, no gender differences were observed in



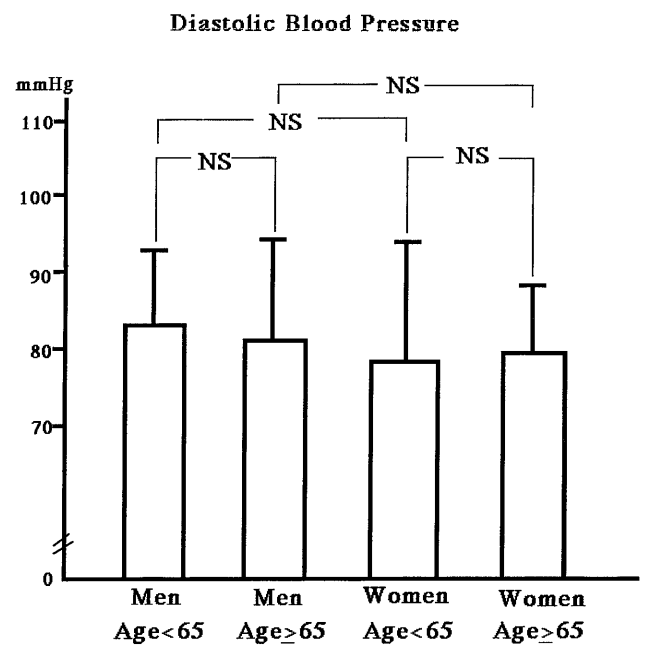
**Figure 1** RCSBP. Values are mean±SD. Systolic blood pressure in men and women over age 65 was significantly higher than that of subjects of the same gender under 65 years. There were no gender-related differences.



**Figure 3** Systolic HBP. Values are mean±SD. Systolic blood pressure in men and women age 65 or older was significantly higher than that of subjects of the same gender under 65 years old. There were no gender-related differences.



**Figure 2** RCDBP. Values are mean±SD. There were no age- or gender-related differences.



**Figure 4** Diastolic HBP. Values are mean±SD. There were no age- or gender-related differences.

**WCP of Systolic Blood Pressure**

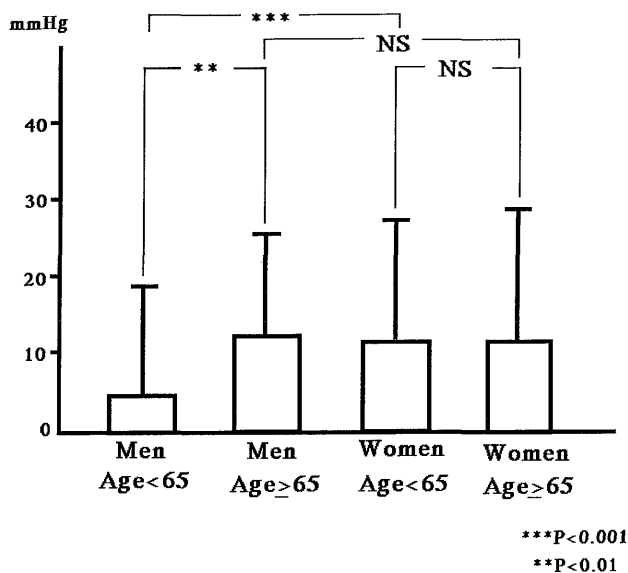


Figure 5 WCP of systolic blood pressure. Values are mean±SD.

WCP of systolic blood pressure of men age 65 or older was significantly higher than in younger men. WCP of systolic blood pressures of women in both age groups were not different.

Women less than 65 years old had a significantly greater WCP of systolic blood pressure than men of the same age group; however, no gender differences were observed in subjects age 65 or older.

**WCP of Diastolic Blood Pressure**

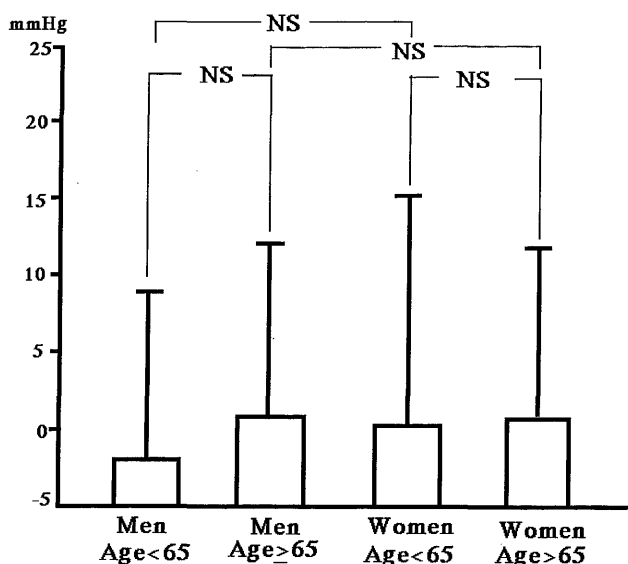


Figure 6 WCP of diastolic blood pressure. Values are mean±SD.

There were no gender- or age-related differences.

**Serum Total Cholesterol Levels**

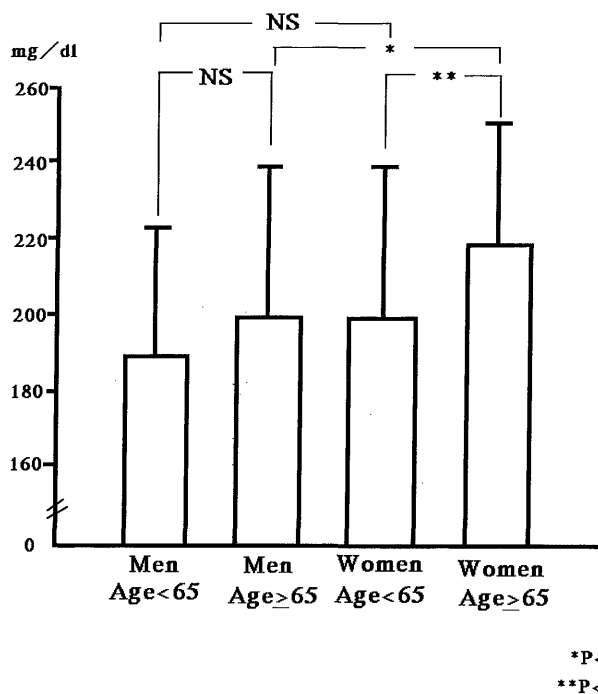


Figure 7 Serum total cholesterol levels. Values are mean±SD.

Serum total cholesterol levels in men age 65 or older was not different from that of men under 65 years old. Serum total cholesterol levels in women aged more than 65 years was significantly higher than that of women less than 65 years. Women age 65 or older had significantly higher serum total cholesterol levels than men in the same age group; however, no gender differences were observed in subjects less than 65 years old.

subjects less than 65 years old. No significant age-related differences in serum triglyceride levels were noted for either gender. Serum triglyceride levels in men aged 65 or older ( $102 \pm 48$  mg/dl) were not significantly different from those of men under 65 ( $99 \pm 74$  mg/dl), serum triglyceride levels in women aged 65 or older ( $108 \pm 70$  mg/dl) were not different from those of women under 65 ( $90 \pm 64$  mg/dl). Fasting blood sugar levels in men aged 65 or older ( $98 \pm 53$  mg/dl) were not significantly different from those of men under 65 ( $92 \pm 25$  mg/dl), and fasting blood sugar levels in women aged 65 or older ( $111 \pm 65$  mg/dl) were not different from those of women under 65 ( $91 \pm 68$  mg/dl). No gender-related differences in fasting blood sugar levels were observed. BMI in men aged 65 or older ( $22.4 \pm 2.1$  kg/m<sup>2</sup>) were not significantly different from those of men under 65 ( $22.8 \pm 2.5$  kg/m<sup>2</sup>), and BMI in women aged 65 or older ( $23.3 \pm 3.1$  kg/m<sup>2</sup>) were not different from those of women under 65 ( $23.1 \pm 3.0$  kg/m<sup>2</sup>). No gender-related differences in BMI were observed.

## Discussion

The measurement of HBP has become a widely accepted practice and has provided much clinically useful information on blood pressure in hypertensive subjects<sup>4,11</sup>. However, a WCP has been noted in the comparison between home- and clinic-derived blood pressure measurements<sup>4,5,10</sup>. Since blood pressure in the clinical setting can be influenced by stress-related tension, HBP measurement is necessary for a more accurate evaluation of blood pressure levels. Pickering et al<sup>4</sup> reported that 31% of 292 patients with borderline hypertension in the out-patient clinic had white coat hypertension. Recently, Julius et al<sup>5,9</sup> investigated the measurement of HBP in rural areas. In the Tecumseh Blood Pressure Study, where 937 adults measured their own blood pressure at home (14 readings in 7 days), 829 subjects were reported to have normal blood pressure, 47 subjects were diagnosed with sustained hypertension, and 50 subjects were reported to have white coat hypertension<sup>9</sup>. Imai et al also performed a cross-sectional survey of HBPs in a rural community in northern Japan<sup>6</sup>; we studied HBP in a rural area in southern Japan. Our study clearly demonstrated that WCP is more prominent in women than in men in subjects under 65 years of age. However, in subjects aged 65 or older men and women experienced WCP almost identically. To our knowledge no other data has indicated such an age and gender-related difference in WCP. Furthermore, the prevalence of WCP was significantly greater in men aged 65 or older than younger men. The factors contributing to WCP have not been well studied. However, Saito et al reported that their clinic vs home differences in blood pressure measurements could not be explained by sympathetic nerve activity<sup>12</sup>. Siegel et al reported that physiological, psychological, and behavioral factors were not different between patients with persistent hypertension and those with white coat hypertension<sup>13</sup>. We did not elucidate the precise origins of WCP in the present study. However, our results may provide an important clue for interpreting blood pressure measurements in the out-patient clinic. Men under 65 years of age demonstrated WCP to a lesser degree than older men and women of both age group. Although serum total cholesterol levels, serum triglyceride levels, fasting blood sugar levels, and BMI were also measured and age and gender differences were evaluated, age and gender difference in WCP were not explained by these parameters. It is reported that HBP monitoring is helpful for the evaluation of treatment-resistant hypertension<sup>14</sup>. The recording of HBP by patients themselves is not only important clinically for the detection of WCP by the physicians, it is also an important factor in the motivation needed by patients for their cooperation in long-term treatment<sup>15</sup>. Self measurement of home blood pressure may stimulate patient compliance in the treatment of hypertension<sup>16,17</sup>,

particularly in treatment by non-pharmacological methods. Although there have been no established norms with respect to white coat phenomenon, our data suggest that age and gender should be considered in the assessment of the impact of white coat phenomenon in normotensive and hypertensive patients. White coat phenomenon can be routinely evaluated by subtracting the average of home blood pressure or ambulatory blood pressure measurements from the average of blood pressure measurements taken by physicians in out-patient clinics. Our data was obtained from regular-checkup blood pressure measurements taken only once (3 readings) by nurses wearing white coats, and the variables of regular-checkup blood pressures were not evaluated. It is possible that white coat phenomenon is more pronounced with physician-determined blood pressure than with that determined by nurses. However, this remains to be investigated. In conclusion, our data suggest that age and gender may indeed influence white coat phenomenon, and that the strongest influence is seen among women and older men.

## Acknowledgements

The author wishes to thank Prof. Katsusuke Yano and Dr Shin Suzuki for their direction and review of this study.

## References

- 1) Floras JS, Hassan O, Jones JV, Osikowska BA, Sever P: Sleight P. Factors influencing blood pressure and heart rate variability in hypertensive humans. *Hypertension* 11 : 273-281, 1988
- 2) Roeschlau P, Bernt E, Gruber W: Enzymatic determination of total cholesterol in serum. *J. Clin. Chem. Clin. Biochem* 12 : 226-227, 1974
- 3) Wahlefeld AW: Triglyceride determination after enzymatic hydrolysis. In: Bergmeyer HU, ed. *Methods of Enzymatic Analysis*. New York: Academic Press, 1831-1835, 1976
- 4) Pickering TG, James GD, Boddie C, Harshfield GA, Blank S, Laragh JH: How common is white coat hypertension? *JAMA* 259 : 225-228, 1988
- 5) Julius S, Mejia A, Jones K, et al.: "White coat" versus "sustained" borderline hypertension in Tecumseh, Michigan. *Hypertension* 16 : 617-623, 1990
- 6) Imai Y, Nakatsuka H, Ikeda M, et al.: A cross-sectional survey of home blood pressure in a rural community in northern Japan. *Clin. & Exper. Hyper.-Theory & Practice* A12 : 1095-1106, 1990
- 7) Kleinert HD, Harshfield GA, Pickering TG, et al.: What is the value of home blood pressure measurement in patients with mild hypertension? *Hypertension* 6 : 574-578, 1984
- 8) Bobrie G, Day M, Tugay A, Chatellier G, Menard J: Self blood pressure measurement at home. *Clin. & Exper. Hypertension* 15 : 1109-1119, 1993
- 9) Julius S, Jamerson K, Gudbrandsson T, Schork N: White coat hypertension: A follow up. *Clin. & Exper. Hyper. -Theory & Practice* A14 : 45-53, 1992
- 10) Gosse P, Promax H, Durand P, Clementy J: 'White coat' hypertension No harm for the heart. *Hypertension* 22 : 766-770, 1993
- 11) Julius S: Home blood pressure monitoring: advantages and limitations. *J Hyperten* 9 (suppl 3) : s41-s46, 1991
- 12) Saito I, Takeshita E, Hayashi S, et al.: Comparison of clinic and home blood pressure levels and role of the sympathetic nervous system in clinic-home differences. *Am J Hypertens* 3 : 219-224, 1990

- 13) Siegel WC, Blumenthal JA, Divine GW : Physiological, psychological, and behavioral factors and white coat hypertension. *Hypertension* 16 : 140-146, 1990
- 14) Mejia AD, Egan BM, Schork NJZ, Zweifler AJ : Artifacts in measurement of blood pressure and back of target organ involvement in the assessment of patients with treatment-resistant hypertension. *Ann Inter Med* 112 : 270-277, 1990
- 15) Edmonds D, Foerster E, Groth H, Greminger P, Siegenthaler W, Vetter W : Does self-measurement of blood pressure improve patient compliance in hypertension? *J Hypertens* 3 : 31-34, 1985
- 16) Meyers MG, Reeves R : White coat phenomenon in patients receiving antihypertensive therapy. *Am J Hypertens* 4 : 844-849, 1991
- 17) Mengden T, Binswanger B, Weisser B, Vetter W : An evaluation of self-measured blood pressure in a study with a calcium-channel antagonist versus a  $\beta$ -blocker. *Am J Hypertens* 5 : 154-160, 1992