Gender Differences in Hypertension Control Among Older Korean Adults: Korean Social Life, Health, and Aging Project

Sang Hui Chu1, Ji Won Baek2, Eun Sook Kim3, Katherine M. Stefani4, Won Joon Lee5, Yeong-Ran Park6, Yoosik Youm2, Hyeon Chang Kim5

1Department of Clinical Nursing Science, Nursing Policy Research Institute, Yonsei University College of Nursing, Seoul; 2Department of Sociology, Yonsei University College of Social Sciences, Seoul; Departments of 3Nursing and 4Public Health, Yonsei University Graduate School, Seoul; 5Department of Preventive Medicine, Yonsei University College of Medicine, Seoul; 6Division of Silver Industry, Kangnam University, Yongin, Korea

Objectives: Controlling blood pressure is a key step in reducing cardiovascular mortality in older adults. Gender differences in patients’ attitudes after disease diagnosis and their management of the disease have been identified. However, it is unclear whether gender differences exist in hypertension management among older adults. We hypothesized that gender differences would exist among factors associated with hypertension diagnosis and control among community-dwelling, older adults.

Methods: This cross-sectional study analyzed data from 653 Koreans aged ≥60 years who participated in the Korean Social Life, Health, and Aging Project. Multiple logistic regression was used to compare several variables between undiagnosed and diagnosed hypertension, and between uncontrolled and controlled hypertension.

Results: Diabetes was more prevalent in men and women who had uncontrolled hypertension than those with controlled hypertension or undiagnosed hypertension. High body mass index was significantly associated with uncontrolled hypertension only in men. Multiple logistic regression analysis indicated that in women, awareness of one’s blood pressure level (odds ratio [OR], 2.86; p=0.003) and the number of blood pressure checkups over the previous year (OR, 1.06; p=0.011) might influence the likelihood of being diagnosed with hypertension. More highly educated women were more likely to have controlled hypertension than non-educated women (OR, 5.23; p=0.013).

Conclusions: This study suggests that gender differences exist among factors associated with hypertension diagnosis and control in the study population of community-dwelling, older adults. Education-based health promotion strategies for hypertension control might be more effective in elderly women than in elderly men. Gender-specific approaches may be required to effectively control hypertension among older adults.

Key words: Gender identity, Hypertension, Management, Older adults

INTRODUCTION

Hypertension is one of the most prevalent chronic diseases that acts as a modifiable risk factor for cardiovascular disease (CVD), stroke, and kidney disease [1]. Preventing CVD, a leading cause of death that accounts for up to 35% of all-cause mortality in Western countries and 30% of all global death [2], has been a global priority for health policy [3]. Currently, highly cost-effective antihypertensive medications are available, and taking antihypertensive medication is the most important factor associated with an improvement in blood pressure (BP)
control among adults with diagnosed hypertension [4]. Therefore, being aware of and understanding hypertension as well as adhering to antihypertensive treatments and lifelong healthy behaviors (e.g., not smoking, avoiding binge drinking, being more physically active, and eating a healthy diet) are critical for hypertension control.

Globally, undiagnosed and uncontrolled hypertension are highly prevalent, and a major barrier to the reduction of CVD [5]. According to data from the National Health and Nutritional Examination Surveys (2011-2012), the prevalence of hypertension is about 30% among adults in the USA, and approximately half of these cases of hypertension are uncontrolled [6]. As the prevalence of hypertension increases with aging, about two thirds of older adults become hypertensive [7]. A recent Korea National Health and Nutrition Examination Survey (KNHANES) also showed similar results, with 64.7% of Koreans aged 65 and older having hypertension but only 54.4% of them having controlled hypertension [6]. The asymptomatic nature of hypertension, together with the absence of distress or acute functional changes, may not motivate older adults to seek medical treatment. However, suboptimal management of hypertension in older adults can eventually result in CVD morbidity leading to frequent hospitalization [8], higher health care costs [9], and lower quality of life [10,11]. Considering the rapid increase in the proportion of older adults in the population and the high rate of suboptimal hypertension management in South Korea, controlling BP is a key step in attempts to reduce the CVD burden in older age.

Gender differences have been shown in the development and management of hypertension [4,12-14]. Women are more likely to develop a steep age-related increase in arterial stiffness after menopause [15] and are more likely to have uncontrolled hypertension than men [12,16,17]. Although the treatment benefit of antihypertensive agents does not differ between men and women [18], hypertensive women are less likely to achieve recommended BP goals even with a significantly higher use of antihypertensive drugs [12]. However, whether these gender discrepancies in controlling hypertension exist in older adults is not clear because health-related behaviors such as being screened by a healthcare professional, seeking advice, and attending educational sessions change with age as well as gender [19]. Moreover, limited evidence is available for gender differences in hypertension control among community-dwelling older adults.

We hypothesized that gender differences would exist among factors associated with hypertension diagnosis and control among community-dwelling, older adults. Exploration of gender differences in patients’ awareness of their BP level, attitudes to health screening, and clinical features could be an important step towards establishing gender-specific strategies to promote adherence to treatment and lifelong preventive health behaviors in this community.

**METHODS**

**Design and Subjects**

This study was conducted as a part of the Korean Social Life, Health, and Aging Project (KSHAP). The KSHAP aimed to recruit the entire population of adults aged 60 years or older, and their spouses, living in a single township on Gangwha Island, Korea. As of January 2013, the total population consisted of 1864 individuals in 871 families. With the aid of the township office and after performing a pilot study, a total of 860 people were identified as the target population of the KSHAP. Of these 860 adults, 814 people (94.7% response rate) completed face-to-face interviews from December 2011 to March 2012 [20]. All KSHAP participants were also invited to attend health examinations, and 698 people (85.7% of KSHAP participants, 81.1% of target population) received health examinations at a public health center (n=533) or at home (n=165) [21]. Individuals for whom data on BP checkup behaviors (n=15) or physical examination (n=30) was missing were excluded. Therefore, we included data from 653 older adults in the current study. Data from surveys and BP measurements were collected at the public health center or respondents’ homes by trained interviewers using a standardized questionnaire and protocol. The institutional review board of Yonsei University approved this study (YUIRB-2011-012-01), and each participant provided informed consent.

**Measurement of Hypertension**

Hypertension categories were derived from self-report and BP measurement at the health examination as suggested by Cornwell and Waite [22]. Physician-diagnosed hypertension or diabetes were identified by self-report by asking participants if their physician had ever told them that they had hypertension or diabetes. Resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured at least twice with the oscilloscopic method using an automatic sphygmomanometer (CareScape Dinamap V100; GE Healthcare, Milwaukee, WI, USA). Prior to each measurement, all participants rested for at least 5
minutes in a seated position, and the cuff size was adapted to their right upper arm. If the first and second measurements differed by \( \geq 10 \text{ mmHg} \) for either SBP or DBP, additional measurements were performed, and the average of the last two measurements were used for analysis. Elevated BP was defined as SBP \( \geq 140 \text{ mmHg} \) or DBP \( \geq 90 \text{ mmHg} \) for participants without diabetes, and as SBP \( \geq 130 \text{ mmHg} \) or DBP \( \geq 80 \text{ mmHg} \) for participants with a self-reported diabetes diagnosis. Self-reported hypertension diagnosis and BP measurements were used to categorize hypertensive participants as having undiagnosed hypertension (no physician diagnosis, but elevated measured BP), uncontrolled hypertension (physician-diagnosed hypertension with elevated measured BP), or controlled hypertension (physician-diagnosed hypertension without elevated measured BP).

### Covariates

Standing height and body weight were measured to the nearest 0.1 cm using a stadiometer and 0.1 kg using a digital scale, respectively. Body mass index (BMI) was calculated as kilograms per meters squared. Blood samples were collected from the antecubital vein of participants who had fasted at least 8 hours to measure total cholesterol and high-density lipoprotein cholesterol. In addition, data on socio-demographic information (age, education, occupation, co-resident partners, etc.), health behaviors (smoking status, alcohol intake, current use of antihypertensive agents, antihypertensive medication adherence, awareness of one’s own BP level, and frequency of BP checkups per year), and perceived health status were collected using the standardized questionnaire. The 10-year risk of coronary heart disease was calculated based on the Framingham point scores [23].

### Statistical Analysis

The differences in general characteristics between participants with and without hypertension were analyzed using independent t-tests for continuous variables and chi-square tests for categorical variables. All analyses for participants with hypertension were performed separately for men and women. For these gender-specific analyses, chi-square tests for categorical variables and t-tests or analyses of variance with a post-hoc analysis using Scheffe methods for continuous variables were performed. Multiple logistic regression models were used to identify factors which contribute to hypertension diagnosis among people with hypertension, and to identify factors which contribute to hypertension control among people with diagnosed hypertension. Independent variables in the logistic model included age, BMI, total cholesterol, high-density lipoprotein cholesterol, education, cigarette smoking, comorbid diabetes, BP level awareness, and the number of BP checkups per year. All analyses were performed using PASW Statistics version 18.0 (SPSS Inc., Chicago, IL, USA) and Stata 12.0 (StataCorp., College Station, TX, USA), and a two-sided p-value of less than 0.05 was considered to be statistically significant.

### RESULTS

Table 1 compares variables in people with hypertension and without hypertension. Among the 653 participants, 433 (66.3%) had hypertension. People with hypertension were more likely to be older, and less likely to be educated and live with a partner. There were no significant differences in health behaviors such as smoking and alcohol intake or in diabetes comorbidity between non-hypertensive and hypertensive participants. However, hypertensive participants were more likely to know their own BP level (71.8% vs. 58.6%, \( p = 0.001 \)), check their BP more often (19.0 times per year vs. 8.8 times per year, \( p < 0.001 \)), and perceive their health as bad (49.4% vs. 33.2%, \( p < 0.001 \)) compared to non-hypertensive participants. Table 2 shows the characteristics of hypertensive participants by gender. Hypertensive men were more likely to be educated, have a job, live with a partner, smoke cigarettes and drink alcohol, but less likely to have a worse perception of their health than hypertensive women. A total of 76.9% (72.2% in men and 79.9% in women) of hypertensive participants reported that they had been previously diagnosed with hypertension. The rate of controlled hypertension was 55.3% (57.4% in men and 53.6% in women) among those with diagnosed hypertension and 42.3% (41.4% in men and 42.8% in women) among all individuals with hypertension.

Table 3 compares undiagnosed, uncontrolled, and controlled hypertension separately for men and women. Diabetes was more prevalent among men with uncontrolled hypertension (42.3%) than it was among men with controlled (15.7%) or undiagnosed (8.5%) hypertension. Similarly, diabetes was more frequent in women with uncontrolled hypertension (31.6%) than in women with controlled (11.5%) or undiagnosed (9.4%) hypertension. Higher BMI was significantly associated with uncontrolled hypertension only among men with hypertension, whereas lower educational level was associated with uncontrolled hypertension among women with hypertension. The
Table 1. Characteristics of participants according to hypertension status (n=653)

| Variables                  | Non-hypertensive (n=220) | Hypertensive (n=433) | p-value |
|----------------------------|--------------------------|----------------------|---------|
| Age (y)                    | 70.6 ± 7.5               | 73.0 ± 7.6           | <0.001 |
| Body mass index (kg/m²)    | 23.4 ± 3.3               | 24.3 ± 3.4           | 0.003  |
| Systolic BP (mmHg)         | 120.8 ± 11.4             | 140.± 20.2           | <0.001 |
| Diastolic BP (mmHg)        | 68.5 ± 8.3               | 73.8 ± 10.5          | <0.001 |
| Gender                     |                          |                      |         |
| Woman                      | 118 (53.6)               | 264 (61.0)           | 0.07   |
| Man                        | 102 (46.4)               | 169 (39.0)           |         |
| Education                  |                          |                      |         |
| None                       | 57 (25.9)                | 141 (32.6)           | 0.005  |
| ≤ 6 y                      | 93 (42.3)                | 190 (43.9)           |         |
| > 6 y                      | 70 (31.8)                | 102 (23.6)           |         |
| Currently employed         |                          |                      |         |
| Yes                        | 153 (69.6)               | 293 (67.7)           | 0.63   |
| No                         | 67 (30.5)                | 140 (32.3)           |         |
| Co-resident partner        |                          |                      |         |
| Yes                        | 184 (83.6)               | 312 (72.1)           | 0.001  |
| No                         | 36 (16.4)                | 121 (27.9)           |         |
| Current smoker             |                          |                      |         |
| Yes                        | 35 (15.9)                | 47 (10.9)            | 0.06   |
| No                         | 185 (84.1)               | 386 (89.2)           |         |
| Alcohol intake             |                          |                      |         |
| None                       | 141 (64.1)               | 288 (66.5)           | 0.06   |
| < 1 drink per week         | 37 (16.8)                | 46 (10.6)            |         |
| ≥ 1 drink per week         | 42 (19.1)                | 99 (22.9)            |         |
| Known diabetes             |                          |                      |         |
| Yes                        | 35 (15.9)                | 86 (19.9)            | 0.22   |
| No                         | 185 (84.1)               | 347 (80.1)           |         |
| Perceived health status    |                          |                      |         |
| Good                       | 147 (66.8)               | 219 (50.6)           | <0.001 |
| Bad                        | 73 (33.2)                | 214 (49.4)           |         |
| Awareness of BP level      |                          |                      |         |
| Yes                        | 129 (58.6)               | 311 (71.8)           | 0.001  |
| No                         | 91 (41.4)                | 122 (28.2)           |         |
| BP checked at least once in a year |            |                      |         |
| Yes                        | 193 (87.7)               | 417 (96.3)           | <0.001 |
| No                         | 27 (12.3)                | 16 (3.7)             |         |
| No. of BP checkups Times per year |       | 8.8 ± 26.1          | 19.0 ± 40.8 | 0.001 |

Data are expressed as mean ± SD or frequency (%).
BP, blood pressure.

estimated 10-year coronary heart disease risk was significantly higher in participants with uncontrolled hypertension than in those with undiagnosed or controlled hypertension in both men and women. Self-reported health status, antihypertensive medication use, and antihypertensive medication adherence did not differ by hypertension status in either men or women. Awareness of BP level and the frequency of BP screening had different associations with hypertension status for men and women. Women with undiagnosed hypertension were less likely to know their BP level and check their BP level than women with uncontrolled or controlled hypertension. However, neither the awareness of BP level nor the number of BP checkups was associated with hypertension status in men.

Table 2. Gender comparison among participants with hypertension (n=433)

| Variables                  | Men (n=169) | Women (n=264) | p-value |
|----------------------------|-------------|---------------|---------|
| Age (y)                    | 73.2 ± 7.4  | 72.9 ± 7.8    | 0.66   |
| Body mass index (kg/m²)    | 140 ± 20.2  | 141.5 ± 20.3 | 0.46   |
| Systolic BP (mmHg)         | 75.1 ± 11.0 | 73.0 ± 10.2   | 0.04   |
| Diastolic BP (mmHg)        | 24.0 ± 3.3  | 24.4 ± 3.4    | 0.15   |
| Education                  |              |               |         |
| None                       | 24 (14.2)   | 117 (44.3)    | <0.001 |
| ≤ 6 y                      | 75 (44.4)   | 115 (43.6)    |         |
| > 6 y                      | 70 (41.4)   | 32 (12.1)     |         |
| Currently employed         |              |               |         |
| Yes                        | 125 (74.0)  | 168 (63.6)    | 0.02   |
| No                         | 44 (26.0)   | 96 (36.4)     |         |
| Co-resident partner        |              |               |         |
| Yes                        | 152 (89.9)  | 160 (60.6)    | <0.001 |
| No                         | 17 (10.1)   | 104 (39.4)    |         |
| Current smoker             |              |               |         |
| Yes                        | 42 (24.9)   | 5 (1.9)       | <0.001 |
| No                         | 127 (75.2)  | 259 (98.1)    |         |
| Alcohol intake             |              |               |         |
| None                       | 64 (37.9)   | 224 (84.9)    | <0.001 |
| < 1 drink per week         | 21 (12.4)   | 25 (9.5)      |         |
| ≥ 1 drink per week         | 84 (49.7)   | 15 (5.7)      |         |
| Known diabetes             |              |               |         |
| Yes                        | 37 (21.9)   | 49 (18.6)     | 0.40   |
| No                         | 132 (78.1)  | 215 (81.4)    |         |
| Perceived health status    |              |               |         |
| Good                       | 96 (56.8)   | 123 (46.6)    | 0.04   |
| Bad                        | 73 (43.2)   | 141 (53.4)    |         |
| Awareness of BP level      |              |               |         |
| Yes                        | 126 (74.6)  | 185 (70.1)    | 0.31   |
| No                         | 43 (25.4)   | 79 (29.9)     |         |
| BP checked at least once in a year |            |               |         |
| Yes                        | 162 (95.9)  | 255 (96.6)    | 0.69   |
| No                         | 7 (4.1)     | 9 (3.4)       |         |
| No. of BP checkups Times per year |         | 18.4 ± 37.0  | 19.5 ± 43.10 | 0.79 |
| Diagnosis among all participants with hypertension | | 122 (72.2) | 211 (79.9) | 0.06 |
| Yes                        | 47 (27.8)   | 53 (20.1)     |         |
| No                         | 70 (57.4)   | 113 (53.6)    | 0.50   |

Data are expressed as mean ± SD or frequency (%).
BP, blood pressure.
| Variables                  | Men with hypertension | Women with hypertension | Post-hoc test | p-value |
|---------------------------|-----------------------|-------------------------|---------------|---------|
|                           | Undiagnosed (a)       | Uncontrolled (b)        | Controlled (c) |         |
| Age (y)                   | 72.7±8.3              | 73.5±6.8                | 73.4±7.3      | 0.84    |
|                           | n=47 (27.8%)          | n=52 (30.8%)            | n=70 (41.4%)  |         |
| Body mass index (kg/m²)   | 23.6±3.0              | 25.1±3.6                | 23.4±3.2      | 0.01    |
| Systolic BP (mmHg)        | 155.5±17.4            | 150.0±11.2              | 122.2±11.8    | <0.001  |
|                           | a=b>c                 | 153.6±15.6              | 154.1±17.3    | 124.9±10.3 | <0.001  |
| Diastolic BP (mmHg)       | 80.5±11.7             | 77.9±8.9                | 69.2±8.9      | <0.001  |
|                           | a=b>c                 | 78.4±10.7               | 74.9±8.4      | 68.7±8.9 | <0.001  |
| Total cholesterol (mg/dL) | 178.6±39.2            | 163.8±39.9              | 173.3±33.3    | 0.13    |
| HDL cholesterol (mg/dL)   | 54.4±15.3             | 47.1±12.2               | 49.9±15.0     | 0.04    |
| 10-y CHD risk (%)         | 16.8±5.4              | 21.9±6.0                | 16.4±6.0      | <0.001  |
| Education                 | None                  | 5 (10.6)                | 21 (39.6)     | 43 (38.1) | 0.03    |
|                           | ≤6 y                  | 23 (48.9)               | 22 (41.5)     | 53 (46.9) |         |
|                           | >6 y                  | 19 (40.4)               | 10 (18.9)     | 17 (15.0) |         |
| Currently employed        | Yes                   | 39 (83.0)               | 33 (62.3)     | 70 (62.0) | 0.78    |
|                           | No                    | 8 (17.0)                | 20 (37.7)     | 43 (38.1) |         |
| Co-resident partner       | Yes                   | 40 (85.1)               | 34 (63.2)     | 64 (56.6) | 0.52    |
|                           | No                    | 7 (14.9)                | 19 (35.9)     | 49 (43.4) |         |
| Current smoker            | Yes                   | 14 (29.8)               | 1 (1.9)       | 1 (0.9)  | 0.51    |
|                           | No                    | 33 (70.2)               | 52 (88.1)     | 112 (99.1) |         |
| Alcohol intake            | None                  | 18 (38.3)               | 45 (84.9)     | 93 (82.3) | 0.11    |
|                           | ≤1 drink per week     | 6 (12.8)                | 2 (3.8)       | 15 (13.3) |         |
|                           | ≥1 drink per week     | 23 (48.9)               | 6 (11.3)      | 5 (4.4)  |         |
| Known diabetes            | Yes                   | 4 (8.5)                 | 5 (9.4)       | 13 (11.5) | <0.001  |
|                           | No                    | 43 (91.5)               | 48 (90.6)     | 100 (88.5) |         |
| Perceived health status   | Good                  | 32 (68.1)               | 30 (56.6)     | 53 (46.9) | 0.18    |
|                           | Bad                   | 15 (31.9)               | 23 (43.4)     | 60 (53.1) |         |
| Awareness of BP level     | Yes                   | 33 (70.2)               | 26 (49.1)     | 84 (74.3) | 0.001   |
|                           | No                    | 14 (29.8)               | 27 (50.9)     | 29 (25.7) |         |
| BP checked at least once  | Yes                   | 42 (89.4)               | 47 (88.7)     | 111 (98.2) | 0.002   |
| in a year                 | No                    | 5 (10.6)                | 6 (11.3)      | 2 (1.8)  |         |
| No. of BP checkups        | Times per year        | 12.5±25.8               | 8.2±12.0      | 25.7±59.2 | 0.05 c>a |
| Antihypertensive use      | Yes                   | 46 (88.5)               | 94 (95.8)     | 106 (93.8) | 0.49    |
|                           | No                    | 6 (11.5)                | 4 (4.1)       | 7 (6.2)  |         |
| Medication adherence      | Adherent              | 34 (73.9)               | 73 (77.7)     | 86 (81.1) | 0.54    |
|                           | Not adherent          | 12 (26.1)               | 21 (22.3)     | 20 (18.9) |         |

Data are expressed as mean±SD or frequency (%). BP, blood pressure; HDL, high-density lipoprotein; CHD, coronary heart disease.
The number of BP checkups was not significantly different between the three groups of hypertension status in men ($p = 0.085$). However, when we merged the undiagnosed and uncontrolled hypertension groups, men with controlled hypertension checked their BP more frequently than those with undiagnosed or uncontrolled hypertension (25.8 vs. 13.1 time/y, $p = 0.027$).

Table 4 shows the results of the multiple logistic regression analysis of socio-demographic and clinical factors as well as health behaviors. Higher BMI was not associated with hypertension diagnosis ($p = 0.735$) but was negatively associated with hypertension control (odds ratio [OR] 0.85 per 1 kg/m$^2$, $p = 0.020$) in men. However, in women, BMI was not associated with either diagnosis ($p = 0.727$) or control ($p = 0.856$) of hypertension. Higher education level (>6 years) was positively associated with hypertension control (OR, 5.23; $p = 0.013$) only in women. A known diagnosis of diabetes was positively associated with hypertension diagnosis in men (OR, 4.26; $p = 0.014$) but not in women (OR, 2.33; $p = 0.111$). In contrast, having been diagnosed with diabetes was negatively associated with hypertension control in both genders, but the negative association was stronger in women (OR, 0.23; $p < 0.001$) than in men (OR, 0.30; $p = 0.010$). In women, frequent BP checkups (OR 1.06 per 1 time/y, $p = 0.011$) and awareness of BP level (OR, 2.86; $p = 0.003$) were positively associated with hypertension diagnosis, although they were not significantly associated with hypertension control. In men, awareness of BP level and number of BP checkups were not associated with either diagnosis ($p = 0.295$ and $p = 0.192$, respectively) or control ($p = 0.527$ and $p = 0.187$, respectively) of hypertension.

**DISCUSSION**

We investigated factors associated with hypertension diagnosis and control among community-dwelling older men and women. The overall prevalence of hypertension in the current study was 66.3%, which is similar to that of the 2012 KNHANES (64.7%) studies [6]. In our study, a total of 76.9% of hypertensive participants knew that they had hypertension, and 42.3% kept their BP controlled. Among the elderly subgroup (aged 65 years or older) of the 2008-2012 KNHANES, the hypertension awareness rate was 82.7% and the hypertension control rate was 54.4% [6]. There are a few possible explanations for the lower hypertension awareness and control rates in our study population. First, it has been reported that hypertension awareness and control are poorer among older people living in rural areas than those living in urban areas [24]. This regional difference might be associated with socio-economic status, health behaviors, and accessibility to health care services. Second, the KNHANES report defined controlled BP as SBP <140 mmHg and DBP <90 mmHg regardless of the presence of diabetes, while we used a lower cutoff (SBP/DBP <130/80 mmHg) for those with diabetes.

Hypertension diagnosis and control rates were not significantly different between older men and women in our study. However, we identified gender-specific socio-behavioral and clinical factors that contributed to the diagnosis and control of hypertension. Consistent with previous studies [4,25], socio-

### Table 4. Factors associated with diagnosis and control of hypertension by gender

| Variables                                | Odds ratio (95% confidence interval) for hypertension diagnosis | Odds ratio (95% confidence interval) for hypertension control |
|-------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
|                                           | Men (n = 169)       | Women (n = 264)       | Men (n = 122)       | Women (n = 211)       |
| Age (per 1 year)                          | 1.02 (0.97, 1.09)   | 1.04 (0.99, 1.10)     | 0.96 (0.90, 1.02)   | 0.99 (0.94, 1.03)     |
| Body mass index (per 1 kg/m$^2$)          | 1.02 (0.90, 1.16)   | 0.98 (0.88, 1.09)     | 0.85 (0.74, 0.98)*  | 1.01 (0.92, 1.11)     |
| Total cholesterol (per 1 mg/dL)           | 1.00 (0.98, 1.01)   | 1.00 (0.99, 1.01)     | 1.01 (1.00, 1.02)   | 0.99 (0.98, 1.00)     |
| HDLC (per 1 mg/dL)                        | 0.98 (0.95, 1.00)   | 0.98 (0.95, 1.01)     | 1.00 (0.96, 1.03)   | 1.00 (0.97, 1.03)     |
| Education (reference: none)               |                   |                   |                   |                   |
| ≤6 y                                      | 0.60 (0.18, 2.00)   | 1.23 (0.56, 2.70)     | 0.64 (0.18, 2.35)   | 1.53 (0.78, 2.98)*    |
| >6 y                                      | 0.89 (0.23, 3.38)   | 0.84 (0.25, 2.79)     | 0.61 (0.15, 2.47)   | 5.23 (1.43, 19.20)*   |
| Current smoking (yes vs. no)              | 0.70 (0.30, 1.62)   | 0.81 (0.06, 10.02)    | 0.66 (0.24, 1.80)   | 0.16 (0.01, 2.02)     |
| Known diabetes (yes vs. no)               | 4.26 (1.34, 13.53)* | 2.33 (0.82, 6.60)     | 0.30 (0.12, 0.75)*  | 0.23 (0.11, 0.50)***  |
| Awareness of own BP level (yes vs. no)    | 1.56 (0.68, 3.58)   | 2.86 (1.44, 5.68)**   | 1.36 (0.52, 3.57)   | 0.77 (0.39, 1.55)      |
| No. of BP checkups (per 1/y)              | 1.01 (0.99, 1.04)   | 1.06 (1.01, 1.11)*    | 1.02 (0.99, 1.04)   | 1.01 (1.00, 1.02)     |

HDLC, high-density lipoprotein cholesterol; BP, blood pressure.

* $p<0.05$, ** $p<0.01$, *** $p<0.001$. 
behavioral factors were significantly associated with hypertension diagnosis and control in women. The first step in changing one’s behavior to prevent or manage chronic disease is to be aware of one’s individual risk. Increased knowledge of CVD risk factors among women has been proven to influence them to take action to prevent CVD [26]. In a previous study, hypertension was the most frequently cited cause of CVD in Korean middle-aged women, and 67% of them reported knowing their own BP level [27]. In the current study, undiagnosed hypertensive women were less likely to know their BP level and check their BP. Only 49% of undiagnosed hypertensive women knew their BP level, whereas the rate was 72% among all hypertensive participants. Moreover, these women checked their BP eight times during the previous year, whereas average hypertensive patients checked their BP 19 times during the same period. Given these results, efforts to increase awareness of one’s own BP level through regular BP checkups may aid the prevention and management of hypertension in older women. Considering the gap between awareness of one’s own BP level and awareness of a desirable BP level [27], healthcare providers should provide counseling to improve hypertension awareness, especially in older women.

Our results also indicated that women with a higher educational level were significantly more likely to have controlled BP than women with no education. Differences in socioeconomic status such as education, occupation, and income have been reported to be larger among women than among men [28]. These findings suggest that educational strategies can modify health behaviors more effectively among women. Recently, Cornwell and Waite [22] reported that interaction, information, emotional support, and social network resources may affect the risk of undiagnosed and uncontrolled hypertension. In our study population of older, community-dwelling Koreans, men and women are likely to have different roles and responsibilities in their families as well as in the community. Thus, older women have more limited social network resources, lower educational level, and higher caregiving responsibilities than men in the same community, which might lead to worse outcomes in the management of hypertension. Further studies are required to understand the relationship between hypertension control and community-based social networks to establish effective public health strategies to control hypertension among rapidly aging populations.

For BP control, clinical factors such as diabetes comorbidity, obesity, and blood cholesterol might have gender-specific relationships with hypertension diagnosis and control. Consistent with a previous study [4], diabetes was identified in this study as a common factor contributing to unfavorable BP control in both men and women. Diabetes and hypertension have a shared root in insulin resistance as well as a reciprocal relationship that leads to the vicious cycle between insulin resistance and endothelial dysfunction [29]. Insulin has a trivial net effect on BP regulation due to its multiple opposing hemodynamic actions of stimulating nitric oxide-dependent vasodilation and endothelin 1-induced vasoconstriction in healthy individuals [30]. However, insulin resistance caused by the hyperglycemic condition of diabetes breaks the balance between vasodilation and vasoconstriction by diminishing nitric oxide signaling in skeletal muscle arterioles, and this shift leads to a hypertensive response [31]. These pathophysiological links between hypertension and diabetes may create difficulties in maintaining optimal BP among hypertensive patients with diabetes. Animal models and observational studies in humans support the link between insulin resistance and endothelial dysfunction leading to CVD. Mice lacking insulin receptor substrate-1, which model type 2 diabetes, showed a hypertensive phenotype with impaired endothelium-dependent vascular relaxation [32]. Patients with both hypertension and type 2 diabetes have an approximately two-fold greater risk of CVD than non-diabetic patients with hypertension [33]. However, we cannot exclude the possibility that the lower control rate among hypertensive patients with diabetes in our analysis might be simply due to lower target BP levels for patients with diabetes (SBP < 130 mmHg and DBP < 80 mmHg). The Eighth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 8) questioned whether a lower BP goal should be applied to hypertensive patients with type 2 diabetes due to a lack of evidence from randomized clinical trials, and recommended the same cutoffs for those with diabetes [34].

We also found that other factors were associated with hypertension control in each gender. In a study by Davarian et al. [35] that included 2634 Japanese adults aged 68 or older, a higher BMI was significantly associated with a higher SBP and DBP, but no gender-specific analysis was performed. In our study, the link between a higher BMI and uncontrolled hypertension was observed only in men. On the contrary, increased total cholesterol tended to be associated with uncontrolled hypertensive women, although this was not statistically significant. A previous study also suggested that hypertensive women tended to
have more cardiovascular risk factors than men, such as central obesity, elevated total cholesterol, and low high-density lipoprotein [4], which might be caused by the physiological changes such as the abrupt drop of estrogen in postmenopausal women. Estrogen deficiency in postmenopausal women increases central adiposity and decreases muscle mass [36]. Although a strong relationship between hypertension and BMI exists, a well-known surrogate marker for general obesity has been established in the general population including older adults. In addition, a surrogate marker for central obesity such as waist circumference or waist to hip ratio, adjusted for BMI, should be considered in this population because BMI cannot completely capture the changes to body composition and fat distribution with aging, especially in older women.

The main strength of this study is that we used the KSHAP data, which included most of the population of older adults living in a rural community in South Korea. Resting BP was measured by a standard protocol throughout the study. These strengths might improve the ability of our study to represent community-dwelling older adults with hypertension, especially from a rural area of South Korea, and to add to our knowledge of hypertension control including the influence of behavioral and physical health factors. However, our study has several limitations. First, BP was measured at a single time point among all participants. Ambulatory BP monitoring and repeated measurements are recommended to assess diurnal and day-to-day BP variations and to exclude the influence of an observer bias and ‘white coat’ effect [37]. Thus, we cannot exclude the possibility of misclassification for the above reasons. Moreover, we were not able to collect detailed information on antihypertensive medication use, physical activity and diet, which also influence BP control. In future studies, more detailed data should be collected to comprehensively understand hypertension control among community-dwelling older adults.

Our study suggests that gender differences exist among factors associated with hypertension diagnosis and control in this population of community-dwelling, older adults. Hypertensive older adults with diabetes seem to be most susceptible to uncontrolled hypertension, regardless of gender. However, the impact of behavioral and cardiovascular risk factors on hypertension control might be different between men and women. Based on our results, gender-specific approaches are required to control hypertension effectively among older adults. Moreover, education-based health promotion strategies in hypertension control might be more effective in elderly women than in elderly men.

ACKNOWLEDGEMENTS

This study was supported by grants from the National Research Foundation of Korea (NRF-2011-330-B00137) and the Korean Health Technology R&D Project, Ministry of Health and Welfare, Republic of Korea (HI13C0715).

CONFLICT OF INTEREST

The authors have no conflicts of interest with the material presented in this paper.

REFERENCES

1. MacMahon S, Alderman MH, Lindholm LH, Liu L, Sanchez RA, Seedat YK. Blood-pressure-related disease is a global health priority. Lancet 2008;371(9623):1480-1482.
2. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB, et al. Heart disease and stroke statistics: 2012 update: a report from the American Heart Association. Circulation 2012;125(1):e2-e220.
3. Murray CJ, Lauer JA, Hutubessy RC, Niessen L, Tomijima N, Rodgers A, et al. Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular-disease risk. Lancet 2003;361(9359):717-725.
4. Ong KL, Tso AW, Lam KS, Cheung BM. Gender difference in blood pressure control and cardiovascular risk factors in Americans with diagnosed hypertension. Hypertension 2008;51(4):1142-1148.
5. Chow CK, Teo KK, Rangarajan S, Islam S, Gupta R, Avezum A, et al. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. JAMA 2013;310(9):959-968.
6. Korea Centers for Disease Control and Prevention. Korea health statistics 2012: Korea National Health and Nutritional Examination Survey (KNHANES V-3). Cheongju: Korea Centers for Disease Control and Prevention; 2013, p. 53-54, 623-624 (Korean).
7. Nwankwo T, Yoon SS, Burt V, Gu Q. Hypertension among adults in the United States: National Health and Nutrition Examination Survey, 2011-2012. NCHS Data Brief 2013;(133):1-8.
8. Liu L, An Y, Chen M, Liu Z, Hu X, Chou E, et al. Trends in the prevalence of hospitalization attributable to hypertensive diseases among United States adults aged 35 and older from 1980 to 2007. Am J Cardiol 2013;112(5):694-699.
9. Chi MJ, Lee CY, Wu SC. Multiple morbidity combinations impact on medical expenditures among older adults. Arch Gerontol Geriatr 2011;52(3):e210-e214.
10. Beckett NS, Peters R, Fletcher AE, Staessen JA, Liu L, Dumitras-cu D, et al. Treatment of hypertension in patients 80 years of age or older. N Engl J Med 2008;358(18):1887-1898.
11. Trevisol DJ, Moreira LB, Kerkhoff A, Fuchs SC, Fuchs FD. Health-related quality of life and hypertension: a systematic review and meta-analysis of observational studies. J Hypertens 2011;29(2):179-188.
12. Gu Q, Burt VL, Paulose-Ram R, Dillon CF. Gender differences in hypertension treatment, drug utilization patterns, and blood pressure control among US adults with hypertension: data from the National Health and Nutrition Examination Survey 1999-2004. Am J Hypertens 2008;21(7):789-798.
13. Yu HT, Kim KJ, Bang WD, Oh CM, Jang JY, Cho SS, et al. Gender-based differences in the management and prognosis of acute coronary syndrome in Korea. Yonsei Med J 2011;52(4):562-568.
14. Chou AF, Scholle SH, Weisman CS, Biernier AS, Correa-de-Araujo R, Mosca L. Gender disparities in the quality of cardiovascular disease care in private managed care plans. Womens Health Issues 2007;17(3):120-130.
15. Os I, Oparil S, Gerdts E, Hoieggan A. Essential hypertension in women. Blood Press 2004;13(5):272-278.
16. Gee ME, Biener A, McAlister FA, Robitaille C, Joffres M, Tremblay MS, et al. Factors associated with lack of awareness and uncontrolled high blood pressure among Canadian adults with hypertension. Can J Cardiol 2012;28(3):375-382.
17. Ostchega Y, Hughes JP, Wright JD, McDowell MA, Louis T. Are demographic characteristics, health care access and utilization, and comorbid conditions associated with hypertension among US adults? Am J Hypertens 2008;21(2):159-165.
18. Gueyffier F, Boutitie F, Boissel JP, Pocock S, Coope J, Cutler J, et al. Effect of antihypertensive drug treatment on cardiovascular outcomes in women and men: a meta-analysis of individual patient data from randomized, controlled trials: the INDANA Investigators. Ann Intern Med 1997;126(10):761-767.
19. Deeks A, Lombard C, Michelmore J, Teede H. The effects of gender and age on health related behaviors. BMC Public Health 2009;9:213.
20. Youm Y, Laumann EO, Ferraro KF, Waite LJ, Kim HC, Park YR, et al. Social network properties and self-rated health in later life: comparisons from the Korean social life, health, and aging project and the national social life, health and aging project. BMC Geriatr 2014;14:102.
21. Lee JM, Lee WJ, Kim HC, Choi W, Lee J, Sung K, et al. The Korean social life, health and aging project-health examination cohort. Epidemiol Health 2014;36:e2014003.
22. Cornwell EY, Waite LJ. Social network resources and management of hypertension. J Health Soc Behav 2012;53(2):215-231.
23. Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). JAMA 2001;285(19):2486-2497.
24. Prince MJ, Ebrahim S, Acosta D, Ferri CP, Guerra M, Huang Y, et al. Hypertension prevalence, awareness, treatment and control among older people in Latin America, India and China: a 10/66 cross-sectional population-based survey. J Hypertens 2012;30(1):177-187.
25. Han HR, Kim KB, Kang J, Jeong S, Kim EY, Kim MT. Knowledge, beliefs, and behaviors about hypertension control among middle-aged Korean Americans with hypertension. J Community Health 2007;32(5):324-342.
26. Mosca L, Mochari H, Christian A, Berra K, Taubert K, Mills T, et al. National study of women's awareness, preventive action, and barriers to cardiovascular health. Circulation 2006;113(4):525-534.
27. Choi EJ, Jekal Y, Kim S, Yoo JS, Kim HS, Oh EG, et al. Middle-aged women's awareness of cholesterol as a risk factor: results from a national survey of Korean Middle-aged Women's Health Awareness (KomWHA) study. Int J Nurs Stud 2010;47(4):452-460.
28. Kim HJ, Ruger JP. Socioeconomic disparities in behavioral risk factors and health outcomes by gender in the Republic of Korea. BMC Public Health 2010;10:195.
29. Kim JA, Montagnani M, Koh KK, Quon MJ. Reciprocal relationships between insulin resistance and endothelial dysfunction: molecular and pathophysiological mechanisms. Circulation 2006;113(15):1888-1904.
30. Cardillo C, Nambi SS, Kilcoyne CM, Choucair WK, Katz A, Quon MJ, et al. Insulin stimulates both endothelin and nitric oxide activity in the human forearm. Circulation 1999;100(8):820-825.
31. Lesniewski LA, Donato AJ, Behnke BJ, Woodman CR, Laughlin MH, Ray CA, et al. Decreased NO signaling leads to enhanced vasoconstrictor responsiveness in skeletal muscle arterioles of the ZDF rat prior to overt diabetes and hypertension. Am J Physiol Heart Circ Physiol 2008;294(4):H1840-H1850.
32. Abe H, Yamada N, Kamata K, Kuwaki T, Shimada M, Osuga J, et al. Hypertension, hypertriglyceridemia, and impaired endo-
thelium-dependent vascular relaxation in mice lacking insulin receptor substrate-1. J Clin Invest 1998;101(8):1784-1788.

33. Arauz-Pacheco C, Parrott MA, Raskin P; American Diabetes Association. Treatment of hypertension in adults with diabetes. Diabetes Care 2003;26 Suppl 1:S80-S82.

34. James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, et al. 2014 Evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). JAMA 2014;311(5):507-520.

35. Davarian S, Crimmins E, Takahashi A, Saito Y. Sociodemographic correlates of four indices of blood pressure and hypertension among older persons in Japan. Gerontology 2013;59(5):392-400.

36. Douchi T, Kosha S, Uto H, Oki T, Nakae M, Yoshimitsu N, et al. Precedence of bone loss over changes in body composition and body fat distribution within a few years after menopause. Maturitas 2003;46(2):133-138.

37. Banegas JR, Segura J, Sobrino J, Rodriguez-Artalejo F, de la Sierra A, de la Cruz JJ, et al. Effectiveness of blood pressure control outside the medical setting. Hypertension 2007;49(1):62-68.