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Original Article

Prevalence and Risk Factors Associated with Prehypertension by Gender and Age in a Korean Population in the KNHANES 2010–2012

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Abstract

Background: Prehypertension frequently progresses into hypertension and is related to an increased risk of cardiovascular disease. We studied the prevalence of prehypertension and their determinants by gender and age.

Methods: The study used nationally representative data from 11,754 participants aged 20–91 years collected between 2010–2012 Korea National Health and Nutrition Examination Surveys (KNHANES).

Results: Prehypertension was more prevalent in men than women (aOR = 2.48, CI = 2.11–2.92). Aging was positively associated with prehypertension (40-59 vs. 20-39, aOR = 1.79, CI = 1.55–2.05; 60+ vs. 20-39, aOR = 2.89, CI = 2.35–3.56). In women aged ≥60, prehypertension was associated with WC (aOR = 1.04, CI = 1.00–1.07), whereas in both men and women aged 20–39, it was associated with BMI (men, aOR = 1.14, CI = 1.04–1.24; women, aOR = 1.08, CI = 1.01–1.16). In subjects aged 40–59, age (men, aOR = 1.03, CI = 1.01–1.06; women, aOR = 1.05, CI = 1.02–1.07) was the significant factor increasing the risk of prehypertension, whereas smoking (men, aOR = 0.55, CI = 0.38–0.80; women, aOR = 0.43, CI = 0.24–0.76) showed an inverse association with prehypertension. Alcohol intake showed a positive association with prehypertension in only men aged 40-59.

Conclusion: Our findings suggest that different gender/age groups may have different patterns of risk factors associated with prehypertension. Thus, healthcare providers should consider both gender and age when designing community-based interventions for controlling BP and reducing prehypertension.

Keywords: Prehypertension, Risk factor, Gender, Age, Korea

Introduction

Prehypertension is a latent global but growing public health concern (1, 2). It is a modifiable precursor of hypertension (2), which is often associated with cardiovascular risk factors, including obesity, metabolic syndrome, and diabetes mellitus (3) and an increased risk of stroke or cardiovascular disease morbidity and mortality (1).

In previous epidemiologic studies, the prevalence of prehypertension (31.0–48.9%) was shown to be higher than the prevalence of hypertension (18.1–28.7%) (4-7), and it is rising steadily in the general adult population (6, 8). Other study has indicated that preventative approaches are effective and valuable for delaying or reducing the progression from prehypertension to hypertension (2). To develop strategies to control prehypertension, it is important to explore risk factors associated with prehypertension.

Growing evidence has shown that risk factors of elevated blood pressure (BP) may differ depending on the sex or age of the individual. One study reported that hypertension had a positive association with age and was more common in women than in men among Iranian population aged 15–64 years (9). Another literature indicated that alcohol consumption was positively associated with elevated BP in men but not in women (6). Other literature reported that a positive association of hypertension with alcohol drinking was statistically significant in middle aged men but not in young men (10). Understanding factors associated with prehypertension by sex and age group is essential for developing tailored blood pressure control programs that meet the specific needs of individuals of different ages and genders. Most previous studies have been limited to certain subject groups (8, 11), studying solely age or gender but not both. Although several large-scale population studies have analyzed hypertension by gender (6, 7), very few studies have carried out in-depth analyses of differences in both sex and age risk factors associated with prehypertension.

Thus, in this study, we examined risk factors associated with prehypertension by gender and age grouping using a representative sample of the Korean population.

Materials and Methods

Subjects and sampling

Data were obtained from the fifth Korean National Health and Nutrition Examination Survey (KNHANES V, 2010-2012) performed by the Korean Ministry of Health and Welfare. KNHANES V consisted of a health interview survey, a nutrition survey, and a health examination study. The variables used in this study were derived from the health interview and the health examination. The health interview was conducted by trained interviewers using a structured questionnaire following a standardized procedure. The health examination, including anthropometric measurements and BP measurement, was performed by trained nurses. This survey applied a stratified multi-stage clustered probability sampling design of household registries based on geographic regions, sex, and age group to obtain a nationally representative sample of community-dwelling Koreans. In the first stage, 576 national districts were systematically chosen from 201,677 census survey districts based on geographic regions, administration district, and habitation sites (multi- or single-family housing). In the second stage, 20 households were randomly selected in each district, composed of 60 households. All study subjects were household members older than 1 year. Finally, from 11,400 households, 25,534 family members participated in the KNHANES V. The response rate was 80.0%. Of the data from the baseline survey, subjects who were younger than 20 years of age (n = 6140), had missing values for blood pressure (n = 1770), and had been diagnosed or taken antihypertensive medication (n = 5870) were excluded; data from the remaining 11,754 subjects 20 years of age and older (4668 men and 7084 women) were used for these analyses. To produce results that represented the entire Korean population, weights were assigned to each participant in the study's final sample analyses. The sample weights in the KNHANES V were computed reflecting the multi-stage sampling design and non-response bias adjustments. Detailed information of the survey design and sampling methods has been described elsewhere (11). The survey was approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention (KCDCP). Before data collection, all participants provided written informed consent.

Measures

BP measurement

Three consecutive measurements of systolic and diastolic BP were obtained by well-trained nurses using the appropriately sized cuff and the bell of a standard stethoscope, with at least 30 seconds between measurements after the participant had rested for 5 min in a sitting position. The averages of the second and third measures were used for analysis (6). The participants were classified into normotension, prehypertension, and hypertension according to JNC7 (the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure) (12).

Normotension was defined as BP values <120/80 mm Hg in people who were not taking antihypertensive medication. Prehypertension was defined as systolic BP (SBP) ≥120 and <140 mm Hg and/or diastolic BP (DBP) ≥80 and <90 mm Hg in people who were not taking antihypertensive medication. Hypertension was defined as SBP ≥140 mm Hg and/or DBP ≥ 90 mm Hg and/or current use of antihypertensive medication.

Sociodemographic and health variables

The independent variables used in this study were sociodemographic and health variables. The sociodemographic variables were: age, sex, marital status, educational level, monthly household income, residential area, and occupation. Monthly household income was calculated as total household income divided by the square root of the number of household members. These scores were then divided into quartiles. Health variables included smoking status, alcohol intake, moderate-intensity physical activity, level of psychological stress, body mass index (BMI), waist circumference (WC), diabetes, and family history of hypertension. Alcohol intake was assessed using the question "how often did you drink alcoholic beverage during the previous year?" and was classified into 3 groups (never/once or less in a month/twice a month or more) according to the frequency of alcohol drinking. Moderate-intensity physical activity was assessed using the International Physical Activity Questionnaire and was categorized as 'yes' and 'no'. Moderate-intensity physical activity was defined as participating in any combination of swimming, badminton, table tennis, or any other activity that causes a slight increase in heart rate or breathing for at least 30 minutes per day, 5 days per week (13). BMI was computed from measured weight and height as weight in kilograms divided by height in meters squared, and participants were categorized into normal, overweight, and obese, following the WHO (World Health Organization) definitions. WC was measured using a tape measure (to the nearest 0.1 cm) at the narrowest point between the lowest rib and the top of the iliac crest. Having diabetes was assessed based on self-reports; participants were asked whether they had ever been diagnosed with diabetes by a physician.

Statistical analysis

To assure nationally representative reporting of the findings, the SPSS complex-samples procedure using stratification variables and sampling weights proposed by the KCDCP (Korea Centers for Disease Control and Prevention) based on the population structure for each survey year was applied for all statistical analyses. Sampling weights were adjusted for population distribution and non-response after the surveys were completed. Characteristics of subjects were summarized using descriptive statistics (frequency and weighted proportions) by sex. Chi-square (χ^2) and t-tests were conducted to compare the distributions of sociodemographics and health characteristics between normotension and prehypertension by sex. Multivariate logistic regression analyses were conducted separately by sex and age groups to identify risk factors associated with prehypertension by sex and age. Age was classified into three groups, 20–39, 40–59, and 60+ years. Statistical analyses were performed using SPSS for Windows (version 21.0). All analyses reported were two-tailed, with $P < 0.05$ used as the significance level.

Results

Among the 11,754 participants, 7084 (60%) were women. Ages ranged from 20 to 91 years, with a mean age at 45.6 years. The overall prevalence of prehypertension was 36.8%. The prevalence rate of prehypertension was higher in men than in women ($P < 0.001$) (Table 1).

Table 2 shows the unadjusted and adjusted ORs for prehypertension in the total sample. After controlling for related variables, including age and sex, significant factors increasing the risk of prehypertension were being male, aged 40-59, aged ≥60, having an elementary school education or less education, alcohol consumption, BMI, and WC. We conducted multivariate logistic regression analyses by sex and age groups to identify risk factors associated with prehypertension by sex and age.

Table 1: Sociodemographic features of the study population (n = 11754)

Variable	Total (n = 11754) *n*	Men (n = 4668) *n* (%)	Women (n = 7084) *n* (%)	X^2 (*P*) or t (*P*)
Age groups (years), (mean±SD)	45.63 ± 15.13	46.93 ± 15.80	44.77 ± 14.62	7.481 (.000)
20-29	1783	681 (49.9)	1102 (50.1)	
30-39	2979	1099 (47.1)	1880 (52.9)	
40-49	2489	950 (45.3)	1539 (54.7)	
50-59	2149	820 (45.4)	1329 (54.6)	
60 +	2354	1118 (48.5)	1236 (51.5)	
Marital status				24.720 (.000)
Married	8714	3554 (45.6)	5160 (54.4)	
Single or without spouse	3037	1113 (50.5)	1924 (49.5)	
Education				87.262 (.000)
≤ Elementary school	1963	643 (35.7)	1320 (64.3)	
Middle school	1101	467 (46.4)	634 (53.6)	
High school	4272	1686 (48.8)	2586 (51.2)	
College or above	4403	1869 (49.3)	2534 (50.7)	
Household income				5.776 (.182)
1 quartile (lowest)	1616	672 (45.9)	944 (54.1)	
2 quartile (medium-lowest)	2976	1167 (45.9)	1809 (54.1)	
3 quartile (medium-highest)	3474	1396 (48.5)	2078 (51.5)	
4 quartile (highest)	3575	1395 (47.8)	2180 (52.2)	
Residential area				7.602 (.028)
Rural	2175	947 (49.9)	1228 (50.1)	
Urban	9579	3721 (46.6)	5858 (53.4)	
Occupational category				1139.235 (.000)
Manager & profession	1819	886 (55.5)	933 (44.5)	
White-collar job	2689	1102 (46.9)	1587 (53.1)	
Blue-collar job	2824	1700 (67.7)	1124 (32.3)	
Unemployed	4406	974 (27.8)	3432 (72.2)	
Smoking status				4752.407 (.000)
Never	7180	940 (18.7)	6240 (81.3)	
Ex-smoker	2068	1642 (78.6)	426 (21.4)	
Current smoker	2506	2086 (84.9)	420 (15.1)	
Alcohol intake				1377.908 (.000)
Never	2917	726 (29.1)	2191 (70.9)	
Once or less in a month	3804	996 (32.3)	2808 (67.7)	
Twice a month or more	4950	2918 (65.3)	2032 (34.7)	
Moderate physical activity				35.715 (.000)
Yes	1008	461 (55.9)	547 (44.1)	
No	10709	4195 (46.3)	6514 (53.7)	
Stress				68.678 (.000)
None	510	164 (36.4)	346 (63.6)	
Low	2687	980 (42.7)	1707 (57.3)	
Moderate	6999	2825 (48.9)	4174 (51.1)	
Extreme	1529	691 (52.2)	838 (47.8)	
Body mass index (mean±SD)	23.09 ± 3.24	23.54 ± 3.03	22.80 ± 3.34	12.487 (.000)
Normal (≤24.9 kg/m^2)	8745	3289 (44.5)	5456 (55.5)	
Overweight (25.0–29.9 kg/m^2)	2625	1249 (56.3)	1376 (43.7)	
Obese (30 or more kg/m^2)	327	110 (43.9)	217 (56.1)	
Waist circumference (mean±SD)	79.11 ± 9.58	82.98 ± 8.53	76.56 ± 9.38	38.273 (.000)
Having diabetes				29.054 (.000)
Yes	520	300 (60.3)	220 (39.7)	
No	11234	4368 (46.7)	6866 (53.3)	
Family history of hypertension				20.533 (.000)
Yes	2967	1021 (43.5)	1946 (56.5)	
No	7599	3133 (48.3)	4466 (51.7)	
Prehypertension				452.585 (.000)
Yes	4330	2264 (52.3)	2066 (47.7)	
No	7424	2404 (32.4)	5020 (67.6)	

%: Percent of the weighted population

Table 2: Odds ratios for prehypertension comparing to normotension (n = 11754)

Variables	OR (95% CI)	*P* value	AOR (95% CI)	*P* value
Sex				
Male	2.43(2.20-2.68)	.000	2.48(2.11-2.92)	.000
Female	1		1	
Age groups				
20-39	1		1	
40-59	1.89(1.70-2.11)	.000	1.79(1.55-2.05)	.000
60+	3.32(2.92-3.77)	.000	2.89(2.35-3.56)	.000
Marital status				
Married	1		1	
Single or without spouse	0.79(0.70-0.88)	.000	1.07(0.93-1.23)	.321
Education				
≤ Elementary school	2.32(2.04-2.65)	.000	1.48(1.18-1.85)	.001
Middle school	1.74(1.47-2.07)	.000	1.20(0.96-1.50)	.117
High school	1.09(0.98-1.21)	.108	1.05(0.91-1.21)	.501
College or above	1		1	
Household income				
1 quartile (lowest)	1.43(1.23-1.66)	.000	1.07(0.87-1.32)	.512
2 quartile (medium-lowest)	1.05(0.92-1.20)	.473	1.01(0.87-1.18)	.883
3 quartile (medium-highest)	1.00(0.89-1.13)	1.000	1.04(0.91-1.18)	.611
4 quartile (highest)	1		1	
Residential area				
Rural	1		1	
Urban	0.75(0.66-0.86)	.000	0.93(0.80-1.09)	.358
Occupational category				
Manager & profession	1		1	
White-collar job	1.08(0.92-1.27)	.332	1.02(0.84-1.23)	.885
Blue-collar job	1.60(1.37-1.88)	.000	1.02(0.83-1.26)	.830
Unemployed	0.98(0.85-1.13)	.806	1.08(0.90-1.30)	.425
Smoking status				
Never	1		1	
Ex-smoker	1.82(1.61-2.06)	.000	0.85(0.71-1.02)	.083
Current smoker	1.52(1.35-1.70)	.000	0.78(0.65-0.93)	.007
Alcohol intake				
Never	1		1	
Once or less in a month	0.76(0.67-0.87)	.000	1.00(0.86-1.16)	.994
Twice a month or more	1.20(1.06-1.35)	.004	1.23(1.06-1.43)	.006
Moderate physical activity				
Yes	1		1	
No	1.04(0.87-1.24)	.666	1.16(0.96-1.40)	.127
Stress				
None	1		1	
Low	1.34(1.03-1.74)	.027	1.34(0.99-1.81)	.057
Moderate	1.39(1.08-1.79)	.011	1.25(0.93-1.68)	.134
Extreme	1.79(1.37-2.33)	.000	1.27(0.92-1.74)	.142
Body mass index	1.15(1.13-1.17)	.000	1.08(1.04-1.12)	.000
Waist circumference	1.06(1.05-1.07)	.000	1.02(1.01-1.03)	.002
Having diabetes				
Yes	1		1	
No	0.53(0.42-0.66)	.000	0.95(0.73-1.24)	.726
Family history of hypertension				
Yes	1		1	
No	0.95(0.85-1.07)	.421	0.79(0.70-0.90)	.000

* OR: unadjusted odds ratio/ ** AOR: adjusted odds ratio.

We observed that the influence of risk factors on prehypertension may differ depending on gender and age. Among both men and women aged 20–39, BMI (men, aOR = 1.14, CI = 1.04–1.24; women, aOR = 1.08, CI = 1.01–1.16) was the significant factor increasing the risk of prehypertension. However, in the women aged ≥60, WC (aOR = 1.04, CI = 1.00–1.07) were positively associated with prehypertension. Among both men and women aged 40–59, age (men, aOR = 1.03, CI = 1.01–1.06; women, aOR = 1.05, CI = 1.02–1.07) was the significant factor increasing the risk of prehypertension, whereas, interestingly, smoking (men, aOR = 0.55, CI = 0.38–0.80; women, aOR = 0.43, CI = 0.24–0.76) showed significant inverse associations with prehypertension. Alcohol intake showed a positive association with prehypertension in only men aged 40-59.

Discussion

The overall goal of this study was to assess the prevalence of prehypertension and explore risk factors associated with prehypertension by sex and age in a Korean population. Here, using KNHANES data from 2010 to 2012, we observed a 36.8% prevalence of prehypertension, which was comparable with the findings of earlier studies conducted in the Ethiopia (37.2%) (4), and the Asia-Pacific Region (38.0%) (5) and lower than those of studies in Vietnam (41.8%) (6), and China (40.5%) (7). Our data analysis determined a prehypertension rate that was even higher than the 22.9% reported using KNHANES data from 2001 (14), which showed an increase in prehypertension prevalence among the Korean population. An increase in prehypertension has also been reported in other Asian countries including China and Vietnam (6 8). Because prehypertension frequently progresses to hypertension and increases risks for cardiovascular disease (2, 3), it is a crucial public health problem that demands more attention.

We analyzed the sample separately by gender and age groups since we expected differences in risk factors. In this study, we found that prehypertension was more prevalent in men than in women, which is in agreement with other study (6). We found that the influence of risk factors on prehypertension may differ depending on the gender/age of the individual. Among men, frequent alcohol consumption was associated with an increased probability of prehypertension, whereas among women there was no significant relationship between alcohol consumption and prehypertension. These results are in line with other studies (3, 6). However, when further analyzed with stratification by age groups in men, alcohol consumption was positively associated with prehypertension among only middle aged men (40–59 years). Previous studies have reported conflicting results on the association between alcohol intake and blood pressure in different age categories. Some studies showed that the elevating effect on blood pressure of drinking alcohol was statistically significant in men aged 40-69 but not in men aged 20-39 (10). Other studies have reported stronger associations between alcohol consumption and blood pressure in younger subjects (15).

An interesting finding of this study was that the risk of prehypertension was significantly decreased in current smokers than in ex-smokers and non-smokers, inconsistent with the results of previous finding that smoking is a major risk factor of hypertension and prehypertension (6). A possible explanation of this may be due to the negative correlation of smoking and BMI (16), which in turn leads to lower BP. It is possible that at first, a vasoconstriction mediated by nicotine could lead to acute increase in systolic BP. Subsequently, the chronic depressant effects by nicotine may lead to lower the BP, as has been suggested previously (17). An inverse association of smoking and prehypertension has also been observed in the results of existing study in other populations (8), but the reason for this association is still unclear and controversial. More research is needed.

We observed gender and age differences in the association between BMI, WC, and prehypertension. This finding was line with other study reporting that among younger Chinese men aged 18-44 years, BMI had a stronger association with elevated BP than WC, whereas in elderly men, the correlation is the reverse (7). The associations between BP, BMI, and WC have been reported to be different. In some literature, WC had a stronger association with BP than did BMI (18). In other literature, BMI was a more superior predictor of elevated BP than WC (19). Our study showed that WC may be a better index than BMI for predicting prehypertension in Korean women aged ≥ 60, whereas for young Korean men and women, it is the reverse. Physical activity was inversely related to prehypertension in women aged ≥ 60 only but not in men and women of other age groups. This finding is similar to a study among adults aged 60-78 reporting that physical activity was significantly associated with lower blood pressure in women but not in men (20). Most studies indicate that regular physical activity improves cardiovascular function and can help lower blood pressure (6, 21). However, only a few studies have focused on how physical activity at various ages is associated with blood pressure by gender. One study among the oldest old age ≥ 85 population reported no significant association between physical activity and cardiac function in men and women (22). Another study on the long term effect of physical activity among 6,410 men reported that physical activity in middle age decreased metabolic syndrome including hypertension in old age (23). More research is needed to determine whether the effect of physical activity on blood pressure differs by gender and age.

This study has several limitations. First, our study was based on a cross-sectional survey, and any causal inference from the identified associations cannot be allowed. Second, the diabetes and household income were measured by self-report. The use of a self-report measures rather than medical confirmation of diagnoses for diabetes may lead to measurement error. Self-reporting of household income may be incomplete and raise reliability concerns because survey respondents are often unwilling to reply to a direct question about income (24).

Finally, our data on prehypertension were obtained from 3 consecutive measurements during 1 visit, whereas ≥ 2 visits after an initial screening are recommended according to the guidelines set by the World Health Organization. Nevertheless, other large population-based studies have also used single visits (6-8), and for that reason, our findings are suitable for comparison with other data. Despite these limitations, this study has several strengths including its large size and the nationally representative sample of men and women.

Conclusion

In this study of 11,754 Korean adults aged 20–91 years, we observed that that 36.8% of individuals who do not have a diagnosis of hypertension have prehypertension. To our knowledge, this is the first report to examine risk factors associated with prehypertension and to illustrate how these associations are differentially modified by sex and age in a Korean adult population using nationally representative data. In this study, we showed that different sex/age groups may have different patterns of risk factors associated with prehypertension. Therefore, it is important to consider sex and age differences when designing interventions for controlling BP and reducing prehypertension in community-based individuals. More research is recommended to investigate the mechanisms explaining sex and age differences and their association with risk factors of prehypertension and to confirm and extend the findings of this study among racially and ethnically diverse populations.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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