ORIGINAL ARTICLE

Changes in body fat distribution through menopause increase blood pressure independently of total body fat in middle-aged women: the Korean National Health and Nutrition Examination Survey 2007–2010

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Blood pressure in women increases sharply in middle age, especially after menopause. As the menopausal transition is known to induce changes in body fat distribution, the aim of this study was to investigate the effect of body fat distribution as compared with the effect of total body fat on blood pressure through the menopausal transition. We analyzed 1422 subjects aged 45–55 years using the database from the Korean National Health and Nutrition Examination Survey 2007–2010. The waist circumference (WC) of post-menopausal women was larger than that of pre-menopausal women (80.44 cm, 95% confidence interval (CI) 79.36–81.52 vs. 78.94 cm, 95% CI 78.27–79.61, $P=0.013$), but there was no statistically significant difference in body mass index (BMI). Systolic and diastolic blood pressure (SBP and DBP) were significantly higher in post-menopausal women than in pre-menopausal women: SBP was 118.33 mm Hg, 95% CI 116.52–120.15 vs. 115.22 mm Hg, 95% CI 114.17–116.28 ($P=0.003$) and DBP was 76.94 mm Hg, 95% CI 75.88–77.99 vs. 75.25 mm Hg, 95% CI 74.57–75.93 ($P=0.009$). BMI and WC were positively correlated with BP. After adjustment for BMI, the correlation of WC with SBP remained significant ($\beta=0.250$, 95% CI 0.024–0.476, $P=0.030$). In a stratified analysis, WC correlated with SBP in women with BMI < 25 kg m⁻² ($\beta=0.358$, 95% CI 0.138–0.579, $P=0.001$), but not in women with BMI ≥ 25 kg m⁻². We conclude that the changes in body fat distribution through the menopausal transition are associated with SBP, independent of total body fat. This finding indicates that alterations in the localization of body fat are another cause of menopause-related changes in BP.

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INTRODUCTION

The age-related increase in blood pressure accelerates through the menopausal transition,^{1–3} and the prevalence of hypertension appears to be higher in menopausal women than in age-matched men.^{1,4,5} The hormonal changes that occur after menopause have been thought to be contributing factors.^{6,7} However, hypotheses implicating other physiological changes have been suggested as a result of clinical and animal studies;^{8,9} these include aging,^{10–12} obesity¹³ and physical activity.¹⁴ Among these, total body fat, weight and body mass index (BMI) have been shown to be strongly correlated with blood pressure.^{15–18} Central obesity also has an effect on blood pressure,^{19,20} and changes in body composition and fat distribution are known to occur after menopause.^{21–25} Therefore, it is reasonable to suppose that the menopause-related changes in blood pressure are partly due to changes in fat distribution in middle-aged women.

According to several reviews,^{26–29} the relationships between age, menopause, body fat distribution and blood pressure are rather unclear and have not been evaluated in population-based studies. In this study, we investigated the association between the menopause-related effects on body fat distribution and blood pressure in middle-aged women in the population using data from the Korean National Health and Nutrition Examination Survey (KNHANES) 2007–2010.

METHODS

2007–2010 KNHANES

This study was based on data obtained from the KNHANES 2007 to 2010, representing the KNHANES IV (2007–2009) and the first year of the KNHANES V (2010), which used a rolling sampling design that involved a complex, stratified, multistage, probability-clustered survey of a representative sample of the non-institutionalized civilian population of South Korea. The

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survey consisted of three components, the Health Interview Survey on general health conditions and health-related lifestyle, the Nutrition Survey for dietary assessment and the Health Examination Study on prevalent chronic diseases. The field survey in the KNHANES was conducted throughout the year by specially trained interviewers at mobile centers and in the participants' households. The health interviews and health examination surveys were performed in specially designed and equipped mobile centers, which traveled to locations throughout the country. The interviewer was not given any information about specific participants before performing the interviews and all of the participants provided written consent to participate in the study. Details of the surveys can be found by consulting items in the reference section.^{30,31}

Analyzed participants

In the 2007–2010 KHNANES database, the mean age of natural menopause was 49.08 years (95% confidence intervals (CIs) 48.93–49.23). Therefore, we analyzed 2554 middle-aged women ranging from 45 to 55 years of age whose history of menopause and blood pressure were available. We excluded post-menopausal women who had undergone surgical menopause or hysterectomy (280 women) and women who were taking an oral contraceptive or hormone replacement agent (594 women). We also excluded 258 women who had recently (past year or less) developed menopause. This left us with 1422 women (1029 pre-menopausal and 393 post-menopausal women) suitable for this study.

Anthropometry

Height, body weight and waist circumference (WC) measurements were conducted by trained examiners. Height was measured to the nearest 1 mm with a portable stadiometer (Seriter, Bismarck, ND, USA) with the subject standing barefoot. Body weight was measured to the nearest 0.1 kg with a calibrated balanced-beam scale (Giant-150N; Hana, Seoul, Korea) with the subject in a light-weight gown or underwear. WC was measured to the nearest 0.1 cm in a horizontal plane at the level of the midpoint between the iliac crest and the costal margin after a normal expiration. BMI was calculated as body weight (kg) divided by height squared (m^2).

Menopause status

Menopause status was categorized into pre- and post-menopausal. Menopause was determined based on self-report. We asked whether the participant was menstruating currently and obtained the age of natural menopause if she had experienced menopause. Women were categorized as pre-menopausal if a participant answered 'yes' to the question: 'do you currently menstruate?' If a woman answered 'no', we considered her to be post-menopausal except if she was pregnant or breastfeeding.

Blood pressure measurements and laboratory data

Blood pressure was measured three times by trained nurses with a mercury sphygmomanometer (Baumanometer; Baum, Copiague, NY, USA) in a seated position after a 5-min rest. The final blood pressure value was obtained by averaging the values of the second and third blood pressure measurements.

Blood samples were obtained by venipuncture during the physical examination after a minimum 8-h overnight fast. Serum glucose, total cholesterol, high-density lipoprotein cholesterol, triglycerides and creatinine were measured enzymatically using a Hitachi automatic analyzer 7600 (Tokyo, Japan).

Other variables

Age (years), cigarette smoking history (current smoker, ex-smoker or non-smoker) and physical activity level (walk, moderate or strenuous activity) were obtained using a self-administered questionnaire and were assessed by the interviewers. Total energy intake and the intake from carbohydrates, proteins and fats were assessed using a 24-h dietary recall. We categorized a participant as having hypertension if any of the following criteria were met: current use of antihypertensive medication (self-report), systolic blood pressure (SBP) of 140 mm Hg or higher or diastolic blood pressure (DBP) of 90 mm Hg or higher. We categorized a participant as having diabetes if any of the following

criteria were met: current use of an oral hypoglycemic agent or insulin, or serum fasting glucose level of 126 mg dl^{-1} or higher. A participant was categorized as having hyperlipidemia if any of the following criteria were met: current use of lipid-lowering medication, serum total cholesterol level of 240 mg dl^{-1} or higher, or serum triglyceride level of 200 mg dl^{-1} or higher.

Statistical analysis

Statistical analyses were performed using SPSS (version 18.0; SPSS, Chicago, IL, USA). We incorporated sample weights, and adjusted the analyses for the complex sample design of the survey. Survey sample weights were used in all of the analyses to produce estimates that were representative of the non-institutionalized civilian Korean population. All measured values are described as mean values with 95% CIs for continuous variables after analysis of variance, and as frequencies and percentages for categorical variables. To assess differences in characteristics, lifestyle and blood pressure between pre- and post-menopausal women, Student's *t*-test was used for means with 95% CI, and the χ^2 test to analyze categorical variables. Categories of BMI were defined according to the standard World Health Organization classification. We used a multiple linear regression model to assess correlations between anthropometric measures and blood pressure. In the first step, correlation models were adjusted for age, menopausal status and lifestyle factors; in the second, we adjusted the BMI model for weight, WC or both, and the WC model for weight, BMI or both. In addition, we assessed correlations between WC and blood pressure across two categories of BMI: $<25 \text{ kg m}^{-2}$ and $\geq 25 \text{ kg m}^{-2}$. A two-tailed *P*-value of <0.05 was considered statistically significant.

RESULTS

Demographic characteristics and anthropometry of pre- and post-menopausal women

Table 1 summarizes the descriptive characteristics of the participants by menopausal status. Mean ages were 47.99 (95% CI 47.82–48.17) and 52.54 (95% CI 52.28–52.79) years for pre- and post-menopausal women, respectively ($P < 0.001$). The pre-menopausal women tended to be heavier and taller than the post-menopausal women, but there was no statistically significant difference in BMI between the two groups (23.80 kg m^{-2} , 95% CI 23.57–24.03 vs. 23.90 kg m^{-2} , 95% CI 23.53–24.27, $P = 0.617$). However, the WC of the post-menopausal women was significantly greater than that of the pre-menopausal women (80.44 cm, 95% CI 79.36–81.52 vs. 78.94 cm, 95% CI 78.27–79.61, $P = 0.013$). Rates of hypertension and hyperlipidemia were significantly higher in the post-menopausal women (hypertension: 23.1% vs. 17.2%, $P = 0.031$; hypercholesterolemia: 21.8% vs. 8.4%, $P < 0.001$; hypertriglyceridemia: 17.1% vs. 8.2%, $P = 0.003$), but there was no difference in the prevalence of diabetes mellitus (8.4% vs. 6.3%, $P = 0.297$). The post-menopausal group was more likely to take medications for hypertension and hyperlipidemia (15.7% vs. 10.1%, $P = 0.015$ and 5.1% vs. 2.0%, $P = 0.002$, respectively) but not for diabetes mellitus (3.7% vs. 3.1%, $P = 0.685$).

Comparison of lifestyles in the pre- and post-menopausal women

As shown in Table 2, smoking habits and physical activity were not different in the two groups. Although the daily intake of carbohydrates was greater in the post-menopausal women ($306.67 \text{ g day}^{-1}$, 95% CI 291.13–322.21 vs. $284.38 \text{ g day}^{-1}$, 95% CI 276.68–292.08, $P = 0.011$), total energy and sodium intake were not different ($P = 0.416$ and $P = 0.429$, respectively).

Comparison of blood pressure and laboratory data between the pre- and post-menopausal women

Table 3 shows that SBP and DBP were significantly higher in the post-menopausal women than in the pre-menopausal women (118.33 mm Hg, 95% CI 116.52–120.15 vs. 115.22 mm Hg, 95% CI 114.17–116.28,

Table 1 Descriptive characteristics of pre- and post-menopausal women aged 45–55 years participating in the KNHANES 2007–2010

Characteristics	Pre-menopausal women (n = 1029)	Post-menopausal women (n = 393)	P-value
Age, years	47.99 (47.82–48.17)	52.54 (52.28–52.79)	<0.001
Height, cm	157.31 (156.94–157.69)	155.28 (154.65–155.91)	<0.001
Weight, kg	58.87 (58.31–59.43)	57.61 (56.69–58.53)	0.019
Waist circumference, cm	78.94 (78.27–79.61)	80.44 (79.36–81.52)	0.013
BMI, kg m ⁻²	23.80 (23.57–24.03)	23.90 (23.53–24.27)	0.617
< 18.5	21 (2.3%)	10 (3.1%)	0.714
18.5–24.9	688 (66.1%)	253 (65.2%)	
≥ 25	317 (31.6%)	130 (31.7%)	
<i>Chronic disease, n (%)</i>			
Diabetes mellitus	54 (6.3%)	29 (8.4%)	0.297
Hypertension	189 (17.2%)	100 (23.1%)	0.031
Hyperlipidemia			
Hypercholesterolemia	97 (8.4%)	79 (21.8%)	<0.001
Hypertriglyceridemia	70 (8.2%)	45 (17.1%)	0.003
<i>Medication use (%)</i>			
Antidiabetes drug (including insulin)	28 (3.1%)	12 (3.7%)	0.685
Antihypertensive drug	110 (10.1%)	65 (15.7%)	0.015
Lipid-lowering drug	25 (2.0%)	20 (5.1%)	0.002

Abbreviations: BMI, body mass index; CI, confidence interval.

Continuous variables are presented as mean (95% CI) and dichotomous variables presented as n (%), unless otherwise specified.

Table 2 Lifestyles of pre- and post-menopausal women aged 45–55 years participating in the KNHANES 2007–2010

Variables	Pre-menopausal women (n = 1029)	Post-menopausal women (n = 393)	P-value
<i>Cigarette smoking status, n (%)</i>			
Current smoker	30 (2.9%)	17 (4.9%)	0.085
Ex-smoker	18 (1.8%)	11 (3.4%)	
Non-smoker	979 (95.2%)	363 (91.7%)	
<i>Physical activity</i>			
Walk, n (%)	426 (41.4%)	168 (43.4%)	0.569
Moderate, n (%)	158 (14.7%)	65 (17.4%)	0.273
Strenuous, n (%)	169 (16.3%)	50 (13.9%)	0.337
<i>Diet</i>			
Total intake, kcal day ⁻¹	1650.93 (1607.74–1694.13)	1689.44 (1604.49–1774.39)	0.416
Carbohydrate, g day ⁻¹	284.38 (276.68–292.08)	306.67 (291.13–322.21)	0.011
Protein, g day ⁻¹	61.03 (58.93–63.13)	57.54 (53.80–61.27)	0.100
Fat, g day ⁻¹	30.86 (29.31–32.41)	28.25 (25.05–31.45)	0.129
Na intake, mg day ⁻¹	4507.47 (4253.36–4664.25)	4650.04 (4215.52–5084.56)	0.429

Continuous variables are presented as mean (95% confidence interval (CI)) and dichotomous variables presented as n (%), unless otherwise specified. physical activity level was categorized by the type of walk, moderate and strenuous activity (>30 min and more than five times a week).

$P=0.003$ and 76.94 mm Hg, 95% CI 75.88–77.99 vs. 75.25 mm Hg, 95% CI 74.57–75.93, $P=0.009$, respectively). Pulse pressure was higher in the post-menopausal women (41.40 mm Hg, 95% CI 40.33–42.46 vs. 39.97 mm Hg, 95% CI 39.29–40.66, $P=0.021$), but heart rate was not significantly different. Higher serum total cholesterol ($P<0.001$) and triglycerides ($P=0.001$) were noted in the post-menopausal women, but serum creatinine, fasting glucose and high-density lipoprotein cholesterol were similar ($P=0.079$, 0.370 and 0.785, respectively).

Correlation between two anthropometric measures of obesity and blood pressure

There was a significant relationship between WC and BMI ($R^2=0.731$, $\beta=0.307$, 95% CI 0.293–0.322, $P<0.001$). A stratified analysis revealed that the relationship between WC and BMI in lean women (BMI < 25 kg m⁻²) and overweight women (BMI ≥ 25 kg m⁻²) was also significant ($R^2=0.481$, $\beta=0.209$, 95% CI 0.191–0.228, $P<0.001$; $R^2=0.513$, $\beta=0.226$, 95% CI 0.186–0.266, $P<0.001$, respectively).

Table 3 Blood pressure and laboratory data among pre- and post-menopausal women aged 45–55 years participating in the third KNHANES 2007–2010

Variables	Pre-menopausal women (n = 1029)	Post-menopausal women (n = 393)	P-value
<i>Blood pressure, mm Hg</i>			
Systolic	115.22 (114.17–116.28)	118.33 (116.52–120.15)	0.003
Diastolic	75.25 (74.57–75.93)	76.94 (75.88–77.99)	0.009
Pulse pressure, mm Hg	39.97 (39.29–40.66)	41.40 (40.33–42.46)	0.021
Heart rate, beats min ⁻¹	69.17 (68.50–69.84)	69.02 (67.89–70.14)	0.813
Creatinine, mg dl ⁻¹	0.73 (0.72–0.74)	0.76 (0.73–0.79)	0.079
Fasting glucose, mg dl ⁻¹	96.28 (94.85–97.71)	97.45 (95.27–99.63)	0.370
<i>Cholesterol, mg dl⁻¹</i>			
TC	189.39 (187.31–191.46)	210.06 (205.62–214.51)	<0.001
TG	111.91 (106.06–117.75)	137.20 (124.06–150.35)	0.001
HDL-C	50.76 (50.01–51.51)	50.55 (49.22–51.88)	0.785

Abbreviations: CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; TC, total cholesterol, TG, triglyceride. Continuous variables are presented as mean (95% CI), unless otherwise specified.

Table 4 Relationship between anthropometric measure and blood pressure

	Systolic blood pressure		Diastolic blood pressure	
	Regression coefficient (95% CI)	P-value	Regression coefficient (95% CI)	P-value
<i>BMI</i>				
No adjustment	1.417 (1.149 to 1.685)	<0.001	0.794 (0.630 to 0.958)	<0.001
Basic adjustment ^a	1.339 (1.073 to 1.604)	<0.001	0.761 (0.600 to 0.923)	<0.001
Basic adjustment + weight	1.185 (0.590 to 1.781)	<0.001	0.393 (0.027 to 0.760)	0.035
Basic adjustment + waist circumference	0.754 (0.214 to 1.294)	0.006	0.682 (0.341 to 1.022)	<0.001
Basic adjustment + weight and waist circumference	0.771 (0.101 to 1.441)	0.024	0.407 (–0.024 to 0.838)	0.064
<i>Waist circumference</i>				
No adjustment	0.503 (0.399 to 0.607)	<0.001	0.254 (0.193 to 0.315)	<0.001
Basic adjustment ^a	0.480 (0.375 to 0.585)	<0.001	0.245 (0.184 to 0.306)	<0.001
Basic adjustment + weight	0.364 (0.162 to 0.566)	<0.001	0.058 (–0.053 to 0.169)	0.305
Basic adjustment + BMI	0.248 (0.035 to 0.460)	0.022	0.035 (–0.092 to 0.163)	0.588
Basic adjustment + weight and BMI	0.250 (0.024 to 0.476)	0.030	–0.002 (–0.132 to 0.128)	0.972

Abbreviations: BMI, body mass index; CI, confidence interval.

^aAdjusted for age, menopausal status, cigarette smoking status, physical activity level and amount of carbohydrate and sodium.

Table 4 shows the correlation between BMI or WC and blood pressure with or without additional adjustment for other anthropometric variables. In the BMI model, the correlation coefficients for SBP decreased after adjustment for body weight or WC but were still significant ($\beta = 0.771$, 95% CI 0.101–1.441, $P = 0.024$). However, the relationship between DBP and BMI was not significant after additional adjustment for weight and WC ($\beta = 0.407$, 95% CI –0.024 to 0.838, $P = 0.064$). In the WC model, although the relationship with SBP was weak after additional adjustment, it remained significant after accounting for weight and BMI ($\beta = 0.250$, 95% CI 0.024–0.476, $P = 0.030$). However, the relationship with DBP was not significant after adjusting for weight ($\beta = 0.058$, 95% CI –0.053 to 0.169, $P = 0.305$).

Correlation between fat distribution and blood pressure in lean and overweight or obese women

A stratified analysis revealed that in lean women (BMI <25 kg m⁻²), WC was significantly and positively correlated with SBP ($\beta = 0.358$,

95% CI 0.138 to 0.579, $P = 0.001$) but not with DBP ($\beta = 0.049$, 95% CI –0.084 to 0.181, $P = 0.470$; Table 5). In overweight women (BMI ≥ 25 kg m⁻²), WC was not correlated with SBP and DBP.

DISCUSSION

In this cross-sectional study of 1422 middle-aged women, WC was significantly associated with SBP before and after adjusting for age and BMI. In the stratified analysis, these associations were significant in non-obese women (BMI <25 kg m⁻²) but not in obese women (BMI ≥ 25 kg m⁻²).

The increase in blood pressure after menopause is a complex, multifaceted problem, and the specific mechanism responsible for post-menopausal hypertension has not been elucidated.³² Age, menopause and obesity are known to have major roles in the blood pressure increase.^{10–13} However, they are related to each other.²⁸ Age is a confounding factor when studying the influence of menopause on blood pressure because menopause coincides with aging. There has been a long standing debate over the link between age and the

Table 5 Relationship between waist circumference and blood pressure stratified by BMI category

	Systolic blood pressure		Diastolic blood pressure	
	Regression coefficient (95% CI)	P-value	Regression coefficient (95% CI)	P-value
<i>Waist circumference</i>				
BMI < 25 kg m ⁻² (n = 972)	0.358 (0.138 to 0.579)	0.001	0.049 (−0.084 to 0.181)	0.470
BMI ≥ 25 kg m ⁻² (n = 447)	0.158 (−0.212 to 0.528)	0.402	−0.031 (−0.226 to 0.163)	0.753

Abbreviations: BMI, body mass index; CI, confidence interval.

Adjusted for age, menopausal status, weight, cigarette smoking status, physical activity level, and amount of carbohydrate and sodium.

post-menopausal increase in blood pressure.^{10,12} Therefore, we analyzed women in a narrow age range (from 45 to 55) to minimize the influence of age and concentrated on the relationship of obesity with blood pressure after adjusting for both age and menopausal status.

Obesity is known to be closely related with blood pressure and hypertension. Among measures of obesity, body weight, BMI and WC are frequently used in clinical practice or research. Although BMI is often used at the population level, it has limitations for discrimination at the individual level, and numerous types of metabolic abnormality, including hypertension, have been noted in individuals with similar BMIs.²⁰ In this study, both lower height and weight in post-menopausal women resulted in no difference in BMI. Body weight generally increases after menopause, and yet this study showed the opposite result. The weight loss first seems to be related to the decrease in height. When adjusting for the difference in the height of women before and after menopause, the finding was not significant (58.33 vs. 58.62 kg, $P = 0.568$). Second, in this study, a high, but not significant, proportion of post-menopausal women were smokers ($P = 0.085$). Also, the effect of smoking on the paradox of high waist-to-hip ratio and low BMI was previously reported in the Korean population.³³ This suggests that further study needs to be done to determine whether smoking induces the decrease in the height. WC has been suggested to be a simple, inexpensive, easy and effective indicator of body fat distribution,³⁴ and is well correlated with the results of abdominal imaging.³⁵ We found that the WCs of the pre- and post-menopausal groups were significantly different, but that their BMIs were not. WC was also correlated with blood pressure like BMI was. This finding suggests that body shape is changed by the altered body fat distribution, which may be as important an influence on the blood pressure increase as the increase in total body fat. However, WC alone may be an inadequate read-out for body fat distribution because previous studies have failed to verify a significant effect of menopause on body fat distribution after adjusting for age, with WC as a surrogate for central obesity.^{36–38} This failure may be related to variability in measurement location³⁹ or to WC itself being an insufficient indicator of central obesity.

In this study, there was no significant relationship between WC and blood pressure in overweight and obese women (BMI ≥ 25 kg m⁻²). It can be suggested that abdominal fat may no longer have an additional effect on blood pressure, which may be due to an already high amount of total body fat. This finding is similar to the relationship between WC and sex hormones in a previous study, which showed that WC was associated with levels of sex hormones and sex hormone-binding globulins in non-obese women but not in obese women.⁴⁰ Estrogen levels and sex hormone-binding globulins are known to decline and free testosterone levels are known

to increase after menopause, and this is thought to induce central obesity.⁴¹ Dramatic alterations in the dynamics of estrogen production have been suggested to be responsible for changes in body fat distribution.⁴²

In addition to sex hormones, body fat distribution could be related to the effect of aging^{43,44} or physiological and/or behavioral changes.^{45,46} However, studies using computed tomography, a highly reliable method for measuring body fat distribution, found an effect of the menopausal transition on body fat distribution that was significant after adjusting for BMI and age.⁴⁷ The changes in body composition and fat distribution occurred even in non-obese menopausal women.⁴⁸ In a study by Kotani *et al.*,⁴⁹ a steeper regression line for the association between abdominal obesity and age was found in post-menopausal women, suggesting that menopause accelerates the selective deposition of intra-abdominal fat.

The mechanisms linking central obesity to blood pressure are not clearly understood. The deposition of adipose tissue in the visceral area has been associated with insulin resistance, which contributes to the development of hyperinsulinemia. This may lead to increased sympathetic nervous system stimulation, enhanced sodium resorption and stimulation of the renin–angiotensin–aldosterone system, which could elevate blood pressure.^{50,51} Therefore, an effect of the accelerated change in body fat distribution on blood pressure at menopause may be another cause of the increased blood pressure and high prevalence of hypertension in post-menopausal women.

Several limitations of this study are worth noting. The study was cross-sectional and there may been a selection bias because we excluded women for whom did not have complete data. As the KNHNES does not fully cover menstrual cycle frequency and regularity, we could not divide subjects into pre-, peri- and post-menopausal categories. Although we excluded women who had recently entered menopause, some peri-menopausal women may have been included in the two groups. It is known that the agreement between self-reported menopausal status and gynecologists' medical records is relatively high,⁵² but the reliability of self-reported menstruation status may be a limitation of this study. Finally, it may not be possible to generalize these findings to all Korean women. Nevertheless, the strength of this study lies in having clinically measured anthropometry outcomes and blood pressure measurements in a large nationally representative sample.

In summary, we analyzed women ranging from 45 to 55 years of age from the 2007 to 2010 KNHANES, a large population-based survey. Our findings suggest that the changes in body fat distribution through the transition into menopause are associated with SBP independent of total body fat in middle-aged women. Therefore, it can be suggested that the change in body fat composition may be another cause of menopause-related changes in blood pressure.

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