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Original Article

Relationships between blood pressure and health and fitness-related variables in obese women

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Abstract. [Purpose] The present study aimed to separately compare systolic blood pressure and diastolic blood pressure with health and fitness-related variables among Asian obese and normal weight middle-aged women. [Subjects and Methods] The study included 1,201 women aged 30–59 years. The participants were classified into obese and normal weight groups. The blood pressure and health and fitness-related variables of all participants were assessed. [Results] Significant interaction effects were observed for most blood pressure and health and fitness-related variables between the groups. However, significant interaction effects were not observed for standard weight, basal metabolic rate, and heart rate. Blood pressure showed significant positive correlations with weight, body fat, fat weight, core fat, body mass index, and basal metabolic rate in both groups. Systolic blood pressure was significantly correlated with muscular endurance, power, and agility in the obese group and with VO2max and flexibility in the normal weight group. Diastolic blood pressure was significantly correlated with muscular endurance and power in the obese group and with VO2max in the normal weight group. [Conclusion] The relationships between systolic blood pressure and heart rate, muscle endurance, power, and agility are stronger than the relationships between diastolic blood pressure and these variables.

Key words: Blood pressure, Health, Obesity

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INTRODUCTION

Cardiovascular diseases are the leading cause of death worldwide[1)], and about two-thirds of the cerebrovascular disease burden and half of the ischemic heart disease burden can be attributed to non-optimal blood pressure[2)].

Hypertension burden and blood pressure staging are usually reported on the basis of both systolic blood pressure (SBP) and diastolic blood pressure (DBP)[3)] according to the Joint National Committee VI (JNC-VI) and International Society of Hypertension (WHO-ISH) guidelines[4, 5)]. However, different prevalences of systolic and diastolic hypertension have been reported[6, 7)]. Additionally, 2 recent studies have reported that SBP has a different impact than DBP on blood pressure staging[6, 8)]. To our knowledge, the impact of SBP and DBP on blood pressure staging has only been reported in the US[6, 8, 9)].

The impact of SBP and DBP on blood pressure staging, as well as the community burden of elevated SBP and DBP may vary across study populations and countries or between age groups and sexes within a population.

The beneficial effects of blood-pressure-lowering treatments on the risks of major cardiovascular events are well established[10–15)]; however, the influence of health and fitness-related variables remains unclear.

SBP is a more frequent cardiovascular risk factor than DBP, and has a greater impact on blood pressure staging, although this influence can vary with age, sex, and county[16)]. The present study aimed to separately compare SBP and DBP with health and fitness-related variables among Asian obese and normal weight middle-aged women in a community. The findings of

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this study will offer further evidence of the authenticity of the texts to human race and will provide valuable information on health in Asian middle-aged women.

SUBJECTS AND METHODS

The present study included 1,201 middle-aged women (age range, 30–59 years), who had not been previously diagnosed with abnormal glucose metabolism or other health problems and who did not exercise regularly. The participants were classified into an obese group (n=686) and a normal weight group (n=515), and all participants had body fat percentage greater than 30. The study protocols were approved by the Human Care and Use Committee for the Society of Sport Research Institute of Dongguk University and Gyeong-ju City Community Health Center in the Republic of Korea. All participants provided written informed consent.

All participants visited the Gyeong-ju City Community Health Center for evaluation of glucose metabolism or other health problems, and body composition and health and fitness-related variables were assessed.

The body composition measurements included height, weight, standard weight, percent fat, fat weight, core fat, body mass index (BMI), and basal metabolic rate (BMR). The health and fitness-related variables included cardiorespiratory endurance (maximal oxygen uptake [VO2max]), muscular strength (grip strength), muscular endurance (sit-ups), power (Sargent jump), agility (body reaction), flexibility (sit and reach), heart rate, and blood pressure (systolic and diastolic).

Blood pressure was measured using a mercury sphygmomanometer under standardized conditions, and the average of 3 readings was used in the analysis. Height, weight, standard weight, percent fat, fat weight, core fat, BMI, and BMR were measured using an 8-polar bioelectrical impedance instrument (InBody 720, Biospace, Seoul, Korea). The BMI values (kg/m^2) of the participants were calculated on the basis of their height and weight.

For the VO2max test, a computerized metabolic cart (Quinton, NJ) was used with the modified Bruce's protocol[17] in all participants. And measured stopping of RER≥1.10 or identity of VO2max and no longer difficult to perform themselves. For the grip-strength test (muscular strength), a grip strength-testing device (TKK 5401 Grip D, Takei, Tokyo, Japan) that had an inbuilt potentiometer control system was used. The control lever of the device was adjusted such that the second knuckles of the fingers were at the bottom of the grip bar. The participants flexed maximally over 3 trials, and the average strength (kg) was recorded. For the sit-up test (muscular endurance), the participants were instructed to lie on a sit-up board (NH 3000N, O2RUN, Korea), bend their knees to 90°, and raise their upper body and bend forward by using only their abdominal muscles. The number of sit-ups completed in 30 s was recorded. For the Sargent jump test (power), chalk powder was applied to the ends of the participants' fingertips. The participants were instructed to stand beside a wall, with both feet on the ground, reach up as high as possible with one hand, and mark the wall with the fingertips (M1). The participants were then instructed to jump as high as possible from a static position and mark the wall with the fingertips (M2). The distance (cm) from M1 to M2 was assessed. The highest distance among 2 trials was recorded. For the body-reaction test (agility), the participants were instructed to stand on a reaction measuring instrument with a lamp (NH 3000I, O2RUN, Korea) and move the foot when the lamp was turned on. The average time (1/1,000 s) among 5 trials was recorded. For the sit-and-reach test (flexibility), the participants were instructed to sit on a flexibility-measuring instrument (KJ092, Japan), position their heels approximately 5 cm apart, place their heels on the edge of the instrument, extend their knees, bend their backs forward, and naturally move the measuring instrument forward. The average distance (cm) among 3 trials was recorded[18].

All data are expressed as mean ± standard deviation. The independent t-test was performed to examine differences in blood pressure, body composition, and fitness-related variables between the 2 study groups. Additionally, Pearson's correlation analysis was performed to examine the relationships between blood pressure and other variables. The significance level was set at $p<0.05$, and all analyses were performed using SPSS version 21.0 (SPSS, Chicago, IL, USA).

RESULTS

The characteristics of the participants in the obese and normal weight groups are presented in Table 1. Comparisons of body composition and health and fitness-related variables between the groups are presented in Table 2. Significant interaction effects (independent t-test) were observed for weight ($t=18.759$, $p<0.001$), body fat ($t=44.909$, $p<0.001$), fat weight ($t=33.496$, $p<0.001$), core fat ($t=16.230$, $p<0.001$), BMI ($t=25.143$, $p<0.001$), SBP ($t=6.713$, $p<0.001$), DBP ($t=6.015$, $p<0.001$), VO2max ($t=-8.806$, $p<0.001$), muscular strength ($t=-3.364$, $p=0.001$), muscular endurance ($t=-6.652$, $p<0.001$), power ($t=-11.049$, $p<0.001$), agility ($t=5.509$, $p<0.001$), and flexibility ($t=-5.445$, $p<0.001$) were observed between the obese and normal weight groups. However, significant interaction effects were not observed for standard weight, BMR, and heart rate between the obese and normal weight groups (all $p>0.05$).

The correlations of blood pressure with body composition and health and fitness-related variables are presented in Table 3. Blood pressure showed significant positive correlations with weight, body fat, fat weight, core fat, BMI, and BMR in the obese and normal weight groups (all $p<0.05$).

In the obese group, SBP showed significant correlations with muscular endurance ($r=-0.124$, $p=0.001$), power ($r=-0.123$, $p=0.001$), and agility ($r=0.081$, $p=0.033$), while DBP showed significant correlations with muscular endurance ($r=-0.077$, $p=0.043$) and power ($r=-0.088$, $p=0.021$). In the normal weight group, SBP showed significant correlations with VO2max

Table 1. Characteristics of the subjects

Variables	OWG (n=686) M ± SD	NWG (n=515) M ± SD
Age (years)	44.7 ± 8.5	42.6 ± 7.7
Height (cm)	159.8 ± 54.4	161.9 ± 56.4
Weight (kg)	63.0 ± 8.6	54.6 ± 6.1
Body mass index (kg/m^2)	25.3 ± 2.9	21.4 ± 2.1
Body fat (%)	35.2 ± 3.9	25.3 ± 3.5

OWG: obese weight group, NWG: normal weight group

Table 2. Comparison of body composition, blood pressure and physical fitness levels between obese and normal middle-aged women

Variables	OWG M ± SD	NWG M ± SD
Weight (kg)	63.0 ± 8.6	54.6 ± 6.2
Standard weight (kg)	50.8 ± 46.2	52.6 ± 47.9
Body fat (%)	35.2 ± 3.9	25.3 ± 3.5
Fat weight (kg)	22.3 ± 5.1	13.9 ± 2.9
Core fat (waist/hip)	0.9 ± 0.1	0.9 ± 0.4
Body mass index (kg/m^2)	25.3 ± 2.9	21.4 ± 2.1
Basal metabolic rate (kcal)	1,245.3 ± 114.3	1,248.6 ± 88.3
SBP (mmHg)	119.1 ± 14.4	113.9 ± 12.2
DBP (mmHg)	71.5 ± 9.5	68.2 ± 9.2
Heart rate (bpm)	76.4 ± 8.4	77.1 ± 8.8
VO2max	25.9 ± 5.3	28.8 ± 6.2
Grip strength (kg)	23.4 ± 4.3	24.2 ± 4.2
Sit-up (time)	10.1 ± 4.9	11.9 ± 4.5
Sargent jump (cm)	19.6 ± 5.3	22.8 ± 4.5
Body reactions (1/1000 s)	338.0 ± 121.0	302.2 ± 97.5
Sit and reach (cm)	14.3 ± 7.3	16.6 ± 7.4

OWG: obese weight group, NWG: normal weight group
*p<0.05, **p<0.01, ***p<0.001

Table 3. Correlation between blood pressure, health and fitness related variable

Variables	Blood pressure			
	OWG		NWG	
	SDP	DBP	SDP	DBP
	r	r	r	r
Weight	0.249***	0.245***	0.236***	0.149**
Standard weight	−0.078*	−0.089*	−0.034	−0.019
Body fat	0.297***	0.266***	0.180***	0.114*
Fat weight	0.310***	0.289***	0.248***	0.158***
Core fat	0.282***	0.209***	0.301***	0.209***
Body mass index	0.323***	0.314***	0.274***	0.206***
Basal metabolic rate	0.216***	0.169***	0.171***	0.096*
Heart rate	0.201***	0.285***	0.007	0.017
Vo2max	−0.037	−0.001	−0.125*	−0.102*
Grip strength	0.037	0.078	0.029	0.051
Sit-up	−0.124**	−0.077*	−0.005	0.015
Sargent jump	−0.123**	−0.088*	−0.044	−0.022
Body reactions	0.081*	0.065	0.000	−0.024
Sit and reach	0.026	0.029	0.107*	0.073

*p<0.05, **p<0.01, ***p<0.001

(r=−0.125, p=0.004) and flexibility (r=0.107, p=0.015), while DBP showed significant correlations with VO2max (r=−0.102, p=0.020).

DISCUSSION

Obesity increases the insulin resistance in the body and results in metabolism abnormalities that cause dyslipidemia and arteriosclerosis, and it serves as one of the major factors that can elevate the risk of developing cardiovascular disorders and mortality[19]. In particular, abdominal obesity and weight gain are causative factors for high blood pressure and primary risk factors for various adult diseases[20], and have been reported to result from lack of exercise, stress, improper diet, etc.[21].

Lloyd et al.[22] performed a comparative analysis among 6,125 individuals under the age of 60 years by controlling age and sex in order to identify the hazard ratios of blood pressure and cardiovascular disorders based on the findings in the normal blood pressure group. The authors found that both phase 1 and phase 2 high blood pressure groups showed increases in the degree of hazards for cardiovascular disorders by 1.8 times and 3.1 times, respectively, when compared to the results in the normal blood pressure group. It has been reported that high blood pressure is a significant factor for cardiovascular disorders, coronary arterial heart disease, and congestive cardiac insufficiency and that obesity can cause diabetes, hyperlipidemia, and various cardiovascular disorders[20, 21].

Blair et al. and Williams reported that cardiovascular endurance is the most important predictable factor for determining the symptoms of cardiovascular disorders and has a high negative correlation with chronic diseases and mortality[23, 24]. In general, with higher blood pressure and a higher prevalence rate of high blood pressure, cardiovascular disorders are more likely to develop[25]. Additionally, Nakura reported that blood pressure is associated with age and obesity and has a positive correlation with BMI, and that the occurrence rate of high blood pressure is closely related with the extent of obesity[26].

The present study found that blood pressure has a positive correlation with body weight, standard weight, body fat, fat mass, abdominal fat, BMI, and BMR in obese and normal weight individuals, and these findings are consistent with those of previous studies, reaffirming a close relationship between blood pressure and obesity.

In addition, studies are being performed to identify the presence of relationships between obesity-related factors and cardiovascular endurance, and it has been reported that cardiovascular endurance affects a variety of obesity-related insulin resistance syndrome indexes[27].

Wong et al.[28] reported that superior cardiovascular endurance reduces body fat, intra-abdominal fat, and subcutaneous belly fat. Additionally, Ross and Katzmarzyk[29] reported that the amount of subcutaneous fat and the waistline were significantly lower in individuals with high cardiovascular endurance that in those with low cardiovascular endurance.

Aerobic exercises, walking, running, and body activities during leisure time have been reported to be effective for reducing the risk factors of high blood pressure and for lowering blood pressure[30]. Stewart et al. reported that male and female high blood pressure patients showed a significant decrease in DBP after aerobic exercises and resistive exercises performed for 6 months[31].

These previous studies indicate a possible correlation between cardiovascular endurance and obesity. The present study showed a negative correlation between VO2max and blood pressure among participants in the normal weight group, which supports a relation between VO2max and blood pressure that can be explained as an index of cardiovascular endurance in line with the relation between obesity and blood pressure reported previously. That is, a positive correlation between blood pressure and obesity demonstrated in previous studies and a negative correlation between VO2max and obesity are considered to be able to explain the negative correlation between VO2max and blood pressure noted in the present study.

Blair et al. performed an epidemiological survey and reported that blood pressure was lower in individuals with high physical strength than in those with low physical strength, indicating that exercise can improve cardiovascular activity and the cerebrovascular flow rate, and can expand the blood vessel owing to elastic factors in the arterial vessel wall[32]. Kelly et al. performed an analysis following long-term resistive exercise among 320 male and female adults and reported that gradual resistive exercise reduced both SBP and DBP by 3 mmHg[33].

The present study found a negative correlation between activities, such as sit-up and Sargent jump, and blood pressure among participants in the obese group, which supports a correlation between physical strength and blood pressure identified in previous studies.

As indicated by these results, deterioration in physical strength affects blood pressure, and an increase in blood pressure is one of the major factors that can increase the prevalence of obesity. With a higher extent of obesity, it is more likely that a patient will be exposed to risks involving various adult diseases.

In conclusion, the relationships between SBP and heart rate, muscle endurance, power, and agility are stronger than the relationships between DBP and these variables. Additionally, the values of health and fitness-related variables might be lower in obese individuals than in normal individuals. Moreover, blood pressure might show a strong relationship with health and fitness-related variables in obese patients.

Conflict of Interest

The authors declare that there is no conflict of interest.

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