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HYPERTENSION IS MORE AFFECTED BY FITNESS AND WAIST CIRCUMFERENCE THAN EXERCISE FREQUENCY AND BMI IN MIDDLE AGE

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ABSTRACT

Background and objective

Hypertension (HTN) is a representative cardiovascular disease worldwide. This study aimed to investigate the prevalence of HTN in middle age using cardiorespiratory fitness (CRF), exercise habits, and obesity.

Material and methods

A total of 4835 middle-aged individuals (2783 men and 2052 women; age range: 40–59 years) were analyzed. The diagnostic criterion for HTN was blood pressure ≥140/90 mmHg or current use of HTN medication. CRF was measured as VO_2max by gas analysis. The exercise frequency was indicated as participant days per week. Obesity was assessed using waist circumference and body mass index (BMI). The odds ratio (OR) was determined by logistic regression analysis. The groups were divided by quartile and median and classified by sex. The significance level was set at a p-value <0.05.

Results

The HTN OR in the highest CRF group decreased to 0.399 in men and 0.413 in women. The OR for exercise frequency decreased in the 5–7 days group by 0.428 in men and 0.488 in women than in the no-exercise group. The HTN OR in the normal BMI group decreased to 0.611 in men and 0.679 in women than in the obese group. The OR for waist circumference was 0.528 in men (≤89.9 cm) and 0.428 in women (≤84.9 cm). The OR of the high fitness-normal waist group was 0.244 in men and 0.191 in women. The OR of the low fitness-normal weight group was 0.872 in men and 0.766 in women (p<0.05), whereas that of the high fitness-overweight group was 0.561 in men and 0.582 in women (p<0.05).

Conclusion
The higher the exercise frequency and CRF and the lower the BMI and waist circumference, the lower the prevalence of HTN. The prevalence of HTN decreased significantly with higher CRF and lower waist circumference than with higher exercise frequency and lower BMI.

*Key Words***:** *hypertension; cardiorespiratory fitness; body mass index; waist circumference; odds ratio*

INTRODUCTION

Hypertension (HTN) causes stroke, coronary artery disease, heart failure, peripheral vascular disease, and kidney disease.[1,2] Additionally, the increase in mortality by HTN was steeper in middle age than in old age, and the mortality rate of cardiovascular disease (CVD) in middle-age patients with HTN was 2.95 times higher than those with normal blood pressure (BP).[3]

Factors that can prevent or improve HTN are lifestyle modifications, such as increased physical activity, weight loss, and decreased salt and alcohol intake. Lowering body mass index (BMI) and waist circumference is an important factor in controlling BP, and regular aerobic exercise results in a significant decrease in BP.[4–6]

In another study, all-cause mortality and CVD mortality were analyzed to determine the hazard ratio in men with HTN. The all-cause mortality hazard ratios were 0.58 and 0.43, and CVD hazard ratios were 0.48 and 0.30 in men with middle and high cardiorespiratory fitness (CRF), respectively.[7]

Although CRF, exercise frequency, and obesity all have significant effects, few studies have been conducted to elucidate which factors affected them more. Thus, this study aimed to analyze HTN prevalence based on large amount of data on CRF, exercise frequency, waist circumference, and BMI in middle-aged men and women.

METHODS

Subject

A total of 4835 individuals (2783 men and 2052 women) were analyzed. The participants were healthy and able to perform a maximum of fitness tests. Exercise, medical history, health-related habits (e.g., smoking and alcohol consumption), and medication use were investigated using a questionnaire. The initial subjects consisted of 6432 individuals. However, those who did not complete the test, did not meet the study criteria, or withdrew from the study by request were excluded. Individuals who used medications for CVD were also excluded. Testing was performed with consultation and monitoring by a physician to ensure safety.

Blood Pressure and Waist Circumference Measurement and Obesity Classification

The subjects were instructed to fast for 8 h, and BP was measured in sitting position in a stable state. BP in individuals with HTN in the first measurement was re-measured at least 1 h later. HTN was classified as a systolic BP>140 mmHg and diastolic BP>90 mmHg according to the Joint National Committee (JNC) 8th report.[8] BMI was calculated by dividing body weight by height squared. In the analysis, BMI ≤24.9 kg/m^2 was classified as normal, that within 25.0–29.9 kg/m^2 as overweight, and ≥30.0 kg/m^2 as obesity.[9] Waist circumference was measured with a tape measure horizontally at the belly line or the widest part of the abdomen while exhaling lightly in an upright position.[10] According to the Korean Society for the Study of Obesity, a waist circumference of 90.0 cm in men and 85.0 cm in women is indicated as abdominal obesity.[11]

Cardiorespiratory Fitness Test and Exercise Questionnaire

A CRF test was performed with cardiac stress test. Testing termination and evaluation followed the American College of Sports Medicine

(ACSM) guidelines.[12] Pretest evaluation was performed by a cardiologist to determine the progress of the test, and those who could not be tested for heart disease or musculoskeletal disease were excluded. VO_2max was measured using Vmax229 (SensorMedics Co., Yorba Linda, California, USA), and a treadmill test was performed following the Bruce protocol. A 12-lead real-time electrocardiogram (ECG) monitoring was performed, and BP, heart rate, rated perceived exertion (RPE), and chest pain scale scores were measured during the examination and recorded every 3 min. The indicators considered the maximum capacity were displayed or shown on examinee's request. The test was discontinued if there was suspicion of critical disease during the test. The values were recorded in mL/kg/min, and groups were divided by quartile for prevalence analysis. Groups G1, G2, G3, and G4 were classified as having the lowest, low, high, and highest CRF, respectively.

The exercise questionnaire asked how often did the participant exercise in a week. The analysis divided the participants into four groups, that is, G1, 0 day; G2, 1–2 days; G3, 3–4 days; and G4, 5–7 days. This classification was based on the recommended ACSM guidelines for at least 5 days of moderate intensity and at least 3 days of vigorous intensity exercise.[13]

Data Analysis

Data analysis was performed using SPSS Statistical Program 21.0 (IBM SPSS Inc., New York, USA). The independent *t*-test was performed to analyze the general characteristics and physical and hemodynamic variables of the HTN and normal groups. Logistic regression analysis was used to calculate the odds ratio (OR), and age, smoking, and alcohol consumption were adjusted. The statistical significance level was set at a p-value <0.05.

Next, all variables were divided into two upper and lower groups. The criteria were as follows. CRF is average (high, above average; low, below average), exercise frequency is 3 days a week (high, 3–7 days; low, 0–2 days), BMI is 25.0 kg/m^2 (overweight, ≥25.0 kg/m^2; normal weight, ≤24.9 kg/m^2), and waist circumference is 90.0 cm in men (over waist, ≥90.0 cm; normal waist, ≤89.9 cm) and 85.0 cm in women (over waist, ≥85.0 cm; normal waist, ≤84.9 cm).[11] Using the upper and lower values based on the median, four groups were obtained by combining CRF and BMI, CRF and waist circumference, exercise frequency and BMI, and exercise frequency and waist circumference. These four groups were used to compare which factors had more influence on the prevalence of HTN. We named the groups as follows: LF-OW, low fitness (frequency) + overweight (waist); HF-OW, high fitness (frequency) + overweight (waist); LF-NW, low fitness (frequency) + normal weight (waist); and HF-NW, high fitness (frequency) + normal weight (waist).

RESULTS

General Characteristics

The male HTN group was named MHTN, the male healthy control group was named MC, the female HTN group was named WHTN, and the female control group was named WC (Table 1). HTN rate was higher in men (28.3%) than in women (17.2%). Age, BMI, waist circumference, total cholesterol and triglyceride level, BP, and VO_2max were significantly different between the HTN and normal groups in both sexes (p<0.05). However, there were no significant differences in total cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol levels in men (Table 1).

Cardio Respiratory Fitness and Exercise Frequency and Odds Ratio

Table 2 shows adjusted ORs according to CRF, exercise frequency, and obesity. In men, ORs in the high (G3) and highest (G4) CRF groups were 0.657 and 0.399, respectively.

TABLE 1 General Characteristics of Subjects

Variables	Men		Women	
	MHTN (n=1282)	MC (n=3235)	WHTN (n=573)	WC (n=2758)
Age (years)	52.2±5.0	50.9±5.2*	52.6±5.2	49.2±4.5*
Height (cm)	169.4±5.6	170.0±5.6*	156.2±5.0	157.8±5.1*
Weight (kg)	73.4±9.0	70.7±8.8*	60.3±8.8	56.4±6.7*
BMI (kg/m^2)	25.6±2.6	24.5±2.5*	24.7±3.4	22.7±2.6*
Waist circumference (cm)	87.9±6.7	84.9±6.8*	79.5±8.3	74.5±6.7*
CVD risk factors				
TC (mg/dL)	193. ±36.0	193.2±32.5	204.8±35.0	194.0±34.5*
TG (mg/dL)	167. ±108.7	144.7 89.0*	128.6±71.9	100.7±54.6*
HDLC (mg/dL)	51.2±12.2	51.9 12.4	59.2±15.1	63.0±14.4*
LDLC (mg/dL)	125.1±30.6	126.5 28.8	132.7±31.9	121.8±30.8*
SBP (mmHg)	134.0±15.9	117.6±10.2*	135.0±17.9	110.6±11.5*
DBP (mmHg)	83.8±9.5	73.8±7.0*	83.5±9.9	70.1±7.7*
VO_2max (mL/kg/min)	30.0±5.6	31.4±5.9*	24.3±4.8	26.1±4.8*

**p<0.05.*
Values are mean±standard deviation.
MC = men control; MHTN = men hypertension; WC = women control; WHTN = women hypertension.
BMI = body mass index; CVD = cardiovascular disease; DBP = diastolic blood pressure; HDLC = high-density lipoprotein cholesterol; LDLC = low-density lipoprotein cholesterol; SBP = systolic blood pressure; TC = total cholesterol; TG = triglyceride.

TABLE 2 Odds Ratio according to Fitness, Exercise Frequency, BMI and Waist circumference

Variables	G1	G2	G3	G4
Men				
Fitness	Ref.	0.960 (0.682–2.170)	0.657 (0.251–0.859)*	0.399 (0.630–0.815)*
Exercise frequency	Ref.	0.918 (0.741–1.137)	0.854 (0.689–1.258)	0.428 (0.255–0.636)*
Fitness and Ex. freq.	Ref.	0.758 (0.339–0.611)*	0.795 (0.532–0.974)*	0.374 (0.215–0.884)*
BMI	Ref.	0.833 (0.640–0.930)*	0.611 (0.307–0.986)*	-
Waist circumference	Ref.	0.528 (0.278–0.828)*	-	-
Women				
Fitness	Ref.	0.921 (0.620–1.405)	0.805 (0.627–0.986) *	0.413 (0.227–0.848)*
Exercise frequency	Ref.	1.179 (0.858–1.620)	0.790 (0.575–0.994)*	0.488 (0.579–0.921)*
Fitness and Ex. freq.	Ref.	0.651 (0.491–0.822)*	0.624 (0.441–0.919)*	0.390 (0.285–0.517)*
BMI	Ref.	0.853 (0.307–0.986)*	0.679 (0.496–0.966)*	-
Waist circumference	Ref.	0.428 (0.220–0.878)*	-	-

**p<0.05; Ex. freq., Exercise frequency; Ref., reference values. Adjusted variables are age, smoking, and alcohol consumption.*
Fitness classification: G1, lowest; G2, low; G3, high; G4, highest exercise frequency; G1, 0 day; G2, 1–2 days; G3, 3–4 days; G4, 5–7 days.
Fitness and Ex. freq.: G1, low fitness + low frequency; G2, high fitness + low frequency; G3, low fitness + high frequency; G4, high fitness + high frequency.
BMI: G1, ≥30.0 kg/m^2; G2, 25.0–29.9 kg/m^2; G3, ≤24.9 kg/m^2.
Waist circumference: men's G1, ≥90.0 cm; G2, ≤89.9 cm.
Waist circumference: women's G1, ≥85.0 cm; G2, ≤84.9 cm.

According to exercise frequency, the 5–7 days group (G4) had an OR of 0.428, which was lower than that in the 0 day group (G1) ($p<0.05$). The OR in the BMI ≤24.9 group (G3) was 0.611, which was lower than that in the BMI ≥30.0 group, and the OR in the normal waist circumference group (G2) was 0.528 ($p<0.05$).

Regarding CRF in women, the ORs in the high (G3) and highest (G4) groups were decreased to 0.805 and 0.413, respectively, than in the lowest (G1) group. Regarding BMI and waist circumference, the OR in the normal BMI (OR, 0.679) and normal waist (OR, 0.428) decreased significantly than that in the obesity group ($p<0.05$).

The subjects were divided into four groups using the CRF (average) and exercise frequency criteria (3 days/week). The men and women in G2 (men, 0.758; women, 0.651), G3 (men, 0.795; women, 0.624), and G4 (men 0.374, women 0.390) had significantly lower HTN prevalence than those in G1 ($p<0.05$).

Fitness, Exercise Frequency, and Obesity and Odds Ratio

Table 3 presents four groups, combining the criteria of CRF average value, exercise frequency of 3 days/week, BMI of 25 kg/m^2, and waist circumference of 90.0 cm and 85.0 cm in men and women, respectively.

The results of the groups classified based on CRF + BMI are as follows. Prevalence of HF-NW had decreased to 0.271 in men and 0.239 in women compared to LF-OW. The CRF + waist analysis showed that prevalence decreased in men (OR, 0.244) and women (OR, 0.191) in the HF-NW. The OR in the HF-OW was lower than that in the LF-NW. These results indicate that, even with obesity, high CRF led to lower HTN prevalence.

In the analysis using exercise frequency + BMI, comparing the HF-NW and LF-OW, prevalence decreased to 0.342 in men and 0.338 in women. The frequency + waist analysis showed that prevalence decreased in men (OR, 0.315) and

TABLE 3 Fitness, Exercise Frequency, BMI, Waist Circumference, and Odds Ratio

Variables	LF-OW	HF-OW	LF-NW	HF-NW
Men				
Fitness and BMI	Ref.	0.561 (0.256–0.873)*	0.872 (0.583–0.986)*	0.271 (0.165–0.510)*
Fitness and waist	Ref.	0.428 (0.225–0.941)*	0.665 (0.446–0.894)*	0.244 (0.095–0.667)*
Frequency and BMI	Ref.	0.617 (0.301–0.903)*	0.742 (0.433–0.976)*	0.342 (0.162–0.709)*
Frequency and waist	Ref.	0.610 (0.480–0.985)*	0.698 (0.345–0.893)*	0.315 (0.092–0.745)*
Women				
Fitness and BMI	Ref.	0.582 (0.245–0.896)*	0.766 (0.378–0.954)*	0.239 (0.084–0.615)*
Fitness and waist	Ref.	0.345 (0.194–0.967)*	0.615 (0.204–0.941)*	0.191 (0.074–0.545)*
Frequency and BMI	Ref.	0.647 (0.203–0.993)*	0.717 (0.312–0.910)*	0.338 (0.185–0.845)*
Frequency and waist	Ref.	0.460 (0.234–0.798)*	0.684 (0.384–0.873)*	0.292 (0.114–0.363)*

*$p<0.05$.
Adjusted variables are age, smoking, and alcohol consumption.
Low fitness, below average versus high fitness, above average.
Low frequency, 0–2 days/week versus high frequency, 3–7 days/week.
Normal weight, ≤24.9 kg/m^2 versus overweight, ≥25.0 kg/m^2.
Normal waist, ≤89.9 cm in men (≤84.9 cm in women) versus Over waist, ≥90.0 cm in men (≥85.0 cm in women).
: HF-NW = high fitness (frequency) + normal weight (waist); HF-OW = high fitness (frequency) + overweight (waist); LF-NW = low fitness (frequency) + normal weight (waist); LF-OW = low fitness (frequency) + overweight (waist).

women (OR, 0.292) in the HF-NW. The OR in the HF-OW was lower than that in the LF-NW.

Therefore, even with obesity, high CRF and exercise frequency resulted in lower prevalence of HTN than with normal weight and low CRF and exercise frequency.

DISCUSSION

HTN is the leading cause of death worldwide, and its incidence is increasing. According to the World Health Organization Report, in 2000, 972 million individuals had HTN, but it is expected to increase by 60% (1.6 billion) by 2023.[14,15] The study aimed to raise awareness in individuals by studying the risk of HTN associated with low CRF, low exercise participation, and obesity. Therefore, the subjects were limited to individuals in their 40s and 50s and excluded elderly individuals who were relatively more vulnerable to disease due to aging.

To date, numerous studies have used similar themes and variables to study significant relationships among CRF, exercise participation, obesity, and HTN. Therefore, this study examined whether CRF or exercise participation, and BMI or waist circumference are more related to HTN prevalence. The subsequent analysis aimed to determine whether CRF or exercise participation and obesity were more related to HTN prevalence.

In this study, higher CRF and exercise frequency decreased the prevalence of HTN to 60.1% and 57.2%, respectively, in men and 58.7% and 51.2%, respectively, in women. These results were consistent with those of previous studies. Rankinen et al.[16] found that the group with the lowest CRF had a 2.7-fold increase in prevalence compared to the group with the highest CRF. Another study reported that the highest CRF group had decreased prevalence by 62% compared to the lowest CRF group.[17] Moreover, individuals with CRF <5 Mets (16.5 mL/kg/min) had approximately twofold increase in the relative risk of death due to HTN than those with CRF>8 Mets (28.0 mL/kg/min).[18] The ACSM guideline, which is related to exercise frequency in HTN, recommends 10 min of intermittent exercise several times a day, moderate intensity exercise >5 days a week, or vigorous intensity >3 days a week.[19]

Although several studies have reported that fitness and exercise are significant factors in preventing HTN, it remains unclear whether exercise frequency or CRF is more effective.

In this study, male CRF G4 had an OR of 0.399, and exercise frequency G4 had an OR of 0.428, while female CRF G4 had an OR of 0.413. The OR of CRF was lower than that of exercise frequency in both men and women. According to the principle of overload, it is necessary to exercise slightly higher than the current capacity to increase the CRF. Therefore, walking-level low-intensity exercise may be limited to increasing CRF. Evidently, low-intensity exercise has been effective in managing BP,[20] but vigorous exercise >6 Mets remains more effective than exercise <3 Mets.[21]

Obesity-related parameters include body fat, BMI, and waist circumference, of which abdominal obesity is considered more dangerous in CVD. Therefore, waist circumference is included as a diagnostic factor of metabolic syndrome.[22] This study also concurrently compared BMI and waist circumference. Compared with the obese group, the male normal BMI group had decreased prevalence of HTN by 38.9%, and those with normal waist circumference had decreased prevalence of HTN by 47.2%. In women, the normal BMI group had decreased prevalence by 32.1%, and the normal waist circumference group had decreased prevalence by 57.2%. The results show that waist circumference, that is, abdominal obesity, is more relevant in HTN than BMI.

Waist circumference measurement is a representative method of measuring abdominal obesity and predicts visceral fat. Accumulation of visceral fat interferes with insulin secretion and causes side effects that increase insulin resistance. Therefore, managing abdominal obesity is important in preventing CVD.[23–25]

In many debates, scholars were concerned regarding health, fitness, and fatness.[26,27] Both high CRF and low fat contribute to lower cardiovascular risk, but remains unclear which is more important. This study also attempted an analysis in this aspect (Table 3). We showed that the HF-OW group had lower OR than the LF-NW group. This may indicate that a high CRF is important, despite obesity. These results concur with previous findings. Regardless of the BMI, an unfit (low fitness) individual has a doubled all-cause mortality than the normal weight-fit individual. Moreover, the HF-OW group had mortality risks similar to those of HF-NW group.[26] However, all-cause mortality, not HTN, indicates that improving CRF is more effective than resolving obesity.[26] Fitness improvement should be emphasized, and weight loss can be achieved through physical activity and diet. These results indicate that the improvement of fitness, which is affected by exercise intensity, is more important.

The recommended exercise intensity for patients with HTN is moderate, but high-intensity exercise is known to improve CRF, endothelial function, markers of sympathetic activity, and arterial stiffness.[28] Therefore, a patient with HTN will be able to perform safe and effective exercise with the guidance of a professional.

In this study, HTN rates were 28.3% in men and 17.2% in women. However, the difference between ORs was small. Despite the relatively high incidence of alcohol consumption and smoking in Korean men, exercise and obesity, or a greater unknown risk factor, is more likely to affect HTN in women.[29,30] Further research may require sex-specific studies.

This study has some limitations. Due to the cross-sectional nature of the study, the relationship between variables and the before and after associations between independent and dependent variables are unclear. Further research is needed to address these issues through a longitudinal study. Additionally, age-sensitive HTN studies require more sophisticated designs for older individuals. Moreover, HTN and other obesity-related measures, such as waist-to-height ratios, need to be studied further.[31] This study has the feature of combining the advantage of BMI and waist circumference measurement by adding height while emphasizing on abdominal obesity. Furthermore, the exercise intensity and duration were not analyzed, and the 10-min several exercise per day was not considered. Furthermore, studies in relation to body fat and muscle ratio are warranted to validate this research.

CONCLUSIONS

This study investigated the prevalence of HTN using CRF, exercise frequency, BMI, and waist circumference. Higher CRF and exercise frequency resulted in decreased prevalence of HTN. Low BMI and waist circumference decreased the HTN prevalence, and prevalence was more affected by waist circumference than by BMI. CRF resulted in greater decrease in HTN prevalence than exercise frequency. The HF-OW group had a greater decrease in OR than the LF-NW group. Individuals with obesity with high CRF and exercise frequency had greater decrease in HTN prevalence than those with normal weight and low fitness and exercise frequency.

CONFLICT OF INTERESTS

The authors declare that there are no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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REFERENCES

1. Zucchetto A, Dal Maso L, Tavani A, et al. History of treated hypertension and diabetes mellitus and risk of renal cell cancer. Ann Oncol 2006;18: 596–600. https://doi.org/10.1093/annonc/mdl438
2. Sowers JR, Epstein M, Frohlich ED. Diabetes, hypertension, and cardiovascular disease: An update. Hypertension 2001;37:1053–9. https://doi.org/10.1161/01.HYP.37.4.1053
3. Hozawa A, Kuriyama S, Kakizaki M, et al. Attributable risk fraction of prehypertension on cardiovascular disease mortality in the Japanese population: the Ohsaki Study. Am J Hypertens 2009;22:267–72. https://doi.org/10.1038/ajh.2008.335
4. Svetkey LP, Harsha DW, Vollmer WM, et al. Premier: A clinical trial of comprehensive lifestyle modification for blood pressure control: Rationale, design and baseline characteristics. Ann Epidemiol 2003;13:462–71. https://doi.org/10.1016/S1047-2797(03)00006-1
5. Hayashi T, Tsumura K, Suematsu C, et al. Walking to work and the risk for hypertension in men: The Osaka Health Survey. Ann Intern Med 1999;131:21–6. https://doi.org/10.7326/0003-4819-131-1-199907060-00005
6. Zhao Y, Zhang M, Luo X, et al. Association of 6-year waist circumference gain and incident hypertension. Heart 2017;103:1347–52. https://doi.org/10.1136/heartjnl-2016-310760
7. McAuley PA, Sui X, Church TS, et al. The joint effects of cardiorespiratory fitness and adiposity on mortality risk in men with hypertension. Am J Hypertens 2009;22:1062–9. https://doi.org/10.1038/ajh.2009.122
8. Mancia G. Hypertension: Strengths and limitations of the JNC 8 hypertension guidelines. Nat Rev Cardiol 2014;11:189. https://doi.org/10.1038/nrcardio.2014.12
9. Arroyo-Johnson C, Mincey KD. Obesity epidemiology worldwide. Gastroenterol Clin 2016;45: 571–9. https://doi.org/10.1016/j.gtc.2016.07.012
10. Lee Y, Park H, Chun B, et al. Reliability of measurements of waist circumference at 3 different site. Korean J Obes 2002;11:123–30.
11. Park H, Park C, Oh S, et al. Prevalence of obesity and metabolic syndrome in Korean adults. Obes Rev 2008;9:104–7. https://doi.org/10.1111/j.1467-789X.2007.00421.x
12. ACSM. American college sports medicine, ACSM's guidelines for exercise testing and prescription 10th. Philadelphia, PA: Lippincott Williams & Wilkins; 2017.
13. ACSM. American college sports medicine, ACSM's guidelines for exercise testing and prescription 9th. Philadelphia, PA: Lippincott: Williams & Wilkins; 2013.
14. Kearney PM, Whelton M, Reynolds K, et al. Global burden of hypertension: Analysis of worldwide data. Lancet 2005;365:217–23. https://doi.org/10.1016/S0140-6736(05)17741-1
15. Mittal BV, Singh AK. Hypertension in the developing world: Challenges and opportunities. Am J Kidney Dis 2010;55:590–8. https://doi.org/10.1053/j.ajkd.2009.06.044
16. Rankinen T, Church TS, Rice T, et al. Cardiorespiratory fitness, BMI, and risk of hypertension: The HYPGENE study. Med Sci Sports Exerc 2007;39:1687. https://doi.org/10.1249/mss.0b013e31812e527f
17. Williams PT. Vigorous exercise, fitness and incident hypertension, high cholesterol, and diabetes. Med Sci Sports Exerc 2008;40:998. https://doi.org/10.1249/MSS.0b013e31816722a9
18. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: The evidence. CMAJ 2006;174:801–9. https://doi.org/10.1503/cmaj.051351
19. Pescatello LS, Franklin BA, Fagard R, et al. Exercise and hypertension. Med Sci Sports Exerc 2004;36:533–53. https://doi.org/10.1249/01.MSS.0000115224.88514.3A
20. Hua LP, Brown CA, Hains SJ, et al. Effects of low-intensity exercise conditioning on blood pressure, heart rate, and autonomic modulation of heart rate in men and women with hypertension. Biol Res Nurs 2009;11:129–43. https://doi.org/10.1177/1099800408324853
21. Swain DP, Franklin BA. Comparison of cardioprotective benefits of vigorous versus moderate

intensity aerobic exercise. Am J Cardiol 2006;97:141–7. https://doi.org/10.1016/j.amjcard.2005.07.130

22. Grundy SM. Metabolic syndrome update. Trends Cardiovasc Med 2016;26:364–73. https://doi.org/10.1016/j.tcm.2015.10.004
23. Sandeep S, Gokulakrishnan K, Velmurugan K, et al. Visceral & subcutaneous abdominal fat in relation to insulin resistance & metabolic syndrome in non-diabetic south Indians. Indian J Med Res 2010;131:629–35.
24. Smith U. Abdominal obesity: A marker of ectopic fat accumulation. J Clin Investig 2015;125:1790–2. https://doi.org/10.1172/JCI81507
25. Moon HU, Ha KH, Han SJ, et al. The association of adiponectin and visceral fat with insulin resistance and β-cell dysfunction. J Korean Med Sci 2019;34:e7. https://doi.org/10.3346/jkms.2019.34.e7
26. Barry VW, Baruth M, Beets MW, et al. Fitness vs. fatness on all-cause mortality: A meta-analysis. Prog Cardiovasc Dis 2014;56:382–90. https://doi.org/10.1016/j.pcad.2013.09.002
27. Lee D-c, Sui X, Church TS, et al. Changes in fitness and fatness on the development of cardiovascular disease risk factors: Hypertension, metabolic syndrome, and hypercholesterolemia. J Am Coll Cardiol 2012;59:665–72. https://doi.org/10.1016/j.jacc.2011.11.013
28. Ciolac EG. High-intensity interval training and hypertension: Maximizing the benefits of exercise? Am J Cardiovasc Dis 2012;2:102.
29. Jee SH, Samet JM, Ohrr H, et al. Smoking and cancer risk in Korean men and women. Cancer Causes & Control 2004;15:341–8. https://doi.org/10.1023/B:CACO.0000027481.48153.97
30. Kim W, Kim S. Women's alcohol use and alcoholism in Korea. Subst Use Misuse 2008;43:1078–87. https://doi.org/10.1080/10826080801914212
31. Savva S, Tornaritis M, Savva M, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes 2000;24:1453. https://doi.org/10.1038/sj.ijo.0801401