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Sex Differences in Blood Pressure and Body Composition after Short-Term High-Intensity Interval Training

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Abstract

Regular exercise is recommended for adults experiencing hypertension with low and moderate cardiovascular risks. High intensity interval training (HIIT) is an efficient training method and has a better cardiometabolic protective effect. The purpose of this study was to determine sex differences in blood pressure and body composition after high intensity interval trainings. Twenty-two adults with hypertension and central obesity (male n = 16, aged 35.56 ± 4.56 years, waist circumference 98.85 ± 6.85 cm, systolic blood pressure 134.22 ± 2.86 mmHg, diastolic blood pressure 85.03 ± 6.58 mmHg) - (female n = 6, aged 37.83 ± 5.46 years, waist circumference 95.09 ± 7.49 cm, systolic blood pressure 133.50 ± 6.47 mmHg, diastolic blood pressure 89.80 ± 5.94 mmHg) participated in a high intensity interval training (HIIT). The HIIT consisted of 3x4 minutes training at 77– 95% of maximum heart rate interspersed by 3 minutes of active rest at 64-76% of maximum heart rate. The training was conducted three sessions per week for 10 weeks. Systolic blood pressure and diastolic blood pressure were significantly reduced in men. There was an improvement in body composition parameters, including a decrease in waist-to-hip ratio, visceral fat, and body fat mass in men ($p < 0.05$). Waist circumference decreased in both men and women ($p < 0.05$). It concludes that there are sex differences in cardiometabolic adaptation after the HIIT program.

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INTRODUCTION

Cardiovascular disease is the leading cause of death in the world. Hypertension is the major risk factor of cardiovascular disease. The management of hypertension does not only include drug therapy, but also requires lifestyle changes. According to the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) in 2013, the increase of blood pressure is defined as the increase of systolic blood pressure ≥ 130 mmHg and diastolic blood pressure ≥ 85 mmHg (Mancia et al., 2014).

In Indonesia, the prevalence of hypertension has increased from 31.7% to 34.1%, while the incidence of hypertension in people aged 35-45 years is 31.6%. Central obesity in people aged ≥ 15 years has increased from 26.6% to 31% (Badan Litbang Kesehatan, 2018). At the age of > 30 years, 20 mmHg increase in systolic blood pressure and 10 mmHg increase in diastolic blood pressure will increase the risk of death from heart disease (Rapsomaniki et al., 2014). The incidence of hypertension in adults with central obesity tends to increase due to an inactive lifestyle (Li W et al., 2017), thus an exercise intervention is necessary to reduce the cardiovascular risk. Hypertension complications cause approximately 9.4 million deaths worldwide every year (World Health Organization, 2015). The most common complications are heart disease (45%) and stroke (51%) (Lim SS et al, 2012). Based on gender, women (36.9%) outnumber men (31.3%) in the incidence of hypertension (Badan Litbang Kesehatan, 2018). The risk of cardiovascular complications in men and women is about the same.

Exercise will improve cardiometabolic function. Aerobic exercise can reduce blood pressure by 5-8 mmHg, while weight training reduces blood pressure for about 4-5 mmHg (Whelton et al., 2018). In general, the recommended exercise program for hypertension is a combination of moderate intensity aerobic exercise for 30 minutes / session and weight training, 2-3 times / week, to achieve 150 minutes/week minimum time (Pescatello et al, 2015). Exercise is influenced by frequency, intensity, and duration. The higher the intensity of aerobic exercise, the more significant the decrease in blood pressure (Pescatello LS et al, 2015). High-intensity interval training (HIIT) does not only reduce blood pressure in hypertension with central obesity (Haram et al, 2009; Sosner et al, 2016), but also improves cardiorespiratory fitness and metabolic syndrome (Gremeaux et al, 2012; Landaeta-Díaz et al, 2013). Heart rate improvement is also better in high-intensity training than in moderate-intensity training (Alansare et al, 2018). High-intensity interval training has the potential to provide better cardiovascular protective effects than other exercise methods (Sharman et al, 2014).

A number of studies had compared aerobic exercise, weight training, or combination training methods to reduce cardiovascular risk in hypertension. Previous research had shown that HIIT is one of exercises that has the potential for hypertension treatment. However, there are still limited data regarding the effect of the HIIT training method on hypertension patients with central obesity based on gender. For that reason, this study was aimed to investigate sex differences in blood pressure and body composition after a high intensity interval training program.

METHODS

Participants

The participants of this study were 22 inactive adults with hypertension and central obesity. All participants had met the following inclusion criteria: aged 30-45 years; had central obesity (waist circumference: male> 90 cm, female> 80 cm); had hypertension stage I (systolic blood pressure 130-139 mmHg or diastolic blood pressure 80-89 mmHg); did not have history of metabolic, orthopedic, or cardiovascular disease; and did not consume anti-hypertension drugs. The exclusion criteria were smoking, following an exercise program 3 months prior to the study, and the presence of health problems. All participants gave their consent before participating in this study. The mean of age for men was 35.56 ± 4.56 years, while for women was 37.83 ± 5.46 years. The Research Ethics Committee of The Ministry of Health - National Health Research

Sampling Procedures

Before joining this study, all participants took pre-participation screening (PPE), health evaluation, and resting heart record (ECG) measurement as the contra-indication screening for this study. After qualifying for participating in the study, the participants were involved in three HIIT training sessions per week for 10

weeks. In each training session, blood pressure measurements were taken 10 minutes before and after training. All data collection processes were carried out 3 days before the training session started and 3 days after the last training session. During the study, all participants were advised to take their usual daily intake.

Procedures

All participants were advised not to consume caffeine and get enough sleep before the test. Resting blood pressure was measured by a digital tensimeter (Omron Tensimeter, model HEM-7130) while sitting. Measurements were taken at 08.00-10.00 A.M. after the participants had rested for 15 minutes. The hands of the participants were at the heart level, while the soles of the feet were resting on the floor. The size of the cuff was adjusted to the arm of each participant. During the measurement, participants were prohibited from speaking to avoid errors in measurement. The test was carried out three times with three-minute interval between tests. Results were taken from the average scores of the last two tests.

Figure 1. High intensity interval training and blood pressure measurement

Total body composition, including body weight, waist-to-hip ratio, skeletal muscle mass, fat-free mass, fat mass, body fat percentage, and visceral fat level were measured by Bioelectric Impedance (InBody 270). Participants wore special clothes. During measurement, participants placed their feet parallel to the foot electrodes. The measurement of waist circumference was carried out in the mid-horizontal plane between the lowest ribs and the iliac crest at the end of a normal expiration using a measuring tape.

Participants did high-intensity interval training by running on a treadmill, three times a week for 10 weeks. Heart rate was measured and recorded every minute during the training session using a heart rate monitor (Polar FT1). After 10 minutes of warm-up at <64% of DNM, participants performed a 3x4 minute high intensity training at 77-95% DNM interspersed by 3 minutes of active rest at 64-76% DNM. After that, the participants did a cool down for 5 minutes. The total training time was 33 minutes per session.

Data Analysis

The data normality test was determined by the Kolmogorov-Smirnov test with p> 0.05. Parametric test or non-parametric test was decided based on the distribution of the data. If the data were not normally distributed, the analysis used the Wilcoxon signed ranks test. If the data were normally distributed, the dependent sample t-test was used. A p-value <0.05 was considered significant. The displayed data were presented in mean and standard deviation.

RESULT

The difference of anthropometric characteristics between men and women was only seen in the body fat percentage. Women had a higher percentage of body fat than men (Table 1). Based on sex differences, there were significant decreases in systolic blood pressure and diastolic blood pressure after high-intensity interval training in men (Table 2).

Table 1. Anthropometric Characteristics

Anthropometric	Men n=16	Women n=6	p value
Age (Mean±SD) Year	35.56 ± 4.56	37.83 ± 5.46	
Weight (Mean±SD) Kg	80.97 ± 10.67	72.63 ± 14.49	0.161
BMI (Mean±SD) Kg/m^2	29.58 ± 2.54	29.32 ± 4.55	0.899
Waist size (Mean±SD) Cm	98.85 ± 6.85	95.92 ± 10.86	0.455
Body Fat Percentage (Mean±SD) %	32.81 ± 4.27	39.33 ± 4.15	0.004*

*Significance Difference between Men and Women before Intervention (p <0.05)

There were significant differences in body composition parameters between before and after HIIT program in men and women (Table 3). Regarding gender, high intensity interval training (HIIT) reduced waist circumference (p = 0.001), waist-to-hip ratio (p = 0.000), visceral fat (p = 0.009), and body fat mass (p = 0.032) in men. Meanwhile, in women, there was only a

decrease in waist circumference (p = 0.029). However, there were also increases in skeletal muscle mass (p = 0.027) and fat-free mass (p = 0.026) in women.

Table 2. Blood Pressure Differences Before and After Training between Men and Women

Blood Pressure	Men (n=16)		Women (n=6)	
	Pre	Post	Pre	Post
SBP (Mean±SD) mmHg	134.22 ± 2.86	125.34 ± 9.45*	133.50 ± 6.47	124.33 ± 7.20
DBP (Mean±SD) mmHg	85.03± 6.58	80.47± 6.00*	89.80± 5.94	85.50± 3.74

Table 3. Body Composition Differences Before and After Training in Men and Women

Body Composition	Men (n=16)		Women (n=6)	
	Pre	Post	Pre	Post
Weight (Mean±SD) Kg	80.97 ± 10.67	80.18 ± 10.50	72.63 ± 14.49	73.38 ± 14.97
Waist Circumference (Mean±SD) Cm	98.85 ± 6.85	95.92 ± 10.86*	95.09 ± 7.49	92.08 ± 10.79*
Waist-to-hip Ratio (Mean±SD)	0.95 ± 0.05	0.91 ± 0.06*	0.91 ± 0.08	0.89 ± 0.06
Skeletal Muscle Mass (Mean±SD) Kg	30.54 ± 4.27	30.4 ± 4.29	23.85± 4.23	24.27 ± 4.36*
Fat Mass (Mean±SD) Kg	26.70 ± 5.80	26.0± 6.04*	28.92± 8.25	28.95 ± 8.17
Fat-free Mass (Mean±SD) Kg	54.27 ± 7.08	54.1± 7.13	43.72 ± 6.83	44.43 ± 7.09*
Body Fat Percentage (Mean±SD) %	32.81 ± 4.27	32.31± 4.77	39.33± 4.15	38.97 ± 3.57
Visceral Fat (Mean±SD)	0.91 ± 0.13	0.89± 0.05*	0..87 ± 0.21	0.94 ± 0.64

* Significance Difference between Pre and Post HIIT (p <0.05)

DISCUSSION

Aerobic exercise reduces blood pressure in hypertension people with central obesity due to the decrease of plasma aldosterone and pulse wave velocity that causes vasodilation (Collier et al., 2015). High intensity interval training (HIIT) induces an improvement in blood pressure through the dilatation process of blood vessels, thereby the blood flow to muscles increases along with the increase of exercise intensity and the regulation of the nervous system and hormones in form of decreased norepinephrine levels at rest (Ciolac et al., 2010; Ciolac et al., 2011; Ramos et al., 2015). High intensity interval training has a better effect on blood pressure and body composition on overweight people than on normal weight people (Maillard et al., 2018).

The results of this study are in line with previous studies (Álvarez et al., 2018; Gunjal et al., 2013; Molmen-Hansen et al., 2012; Sosner et al., 2016; Tjønna et al., 2013) that high intensity interval training has a positive effect on blood pressure. The increase of exercise intensity corresponds to the reduce of blood pressure effect (Molmen-Hansen et al., 2012).

Based on gender, there was a decrease in systolic pressure and diastolic blood pressure in both men and women after doing high-intensity interval training. However, the reduce of blood pressure effect was more significant in men than in women. After the exercise, blood vessels in heart, diaphragm, and skeletal muscles experience a peripheral resistance decrease which reduces the blood pressure. This change was more visible in men than in women (Amaral et al., 2011). Different results were presented in previous studies, where women experienced a higher decrease in blood pressure than men (Morita & Okita ,2013). However, several studies showed that there was no difference on the decrease of

blood pressure in men and women after performing aerobic exercise (Collier et al., 2011; Maillard et al., 2018; Pescatello et al., 2004). Although there is a controversy over the effect of gender on the reduce of blood pressure after exercising, the risk of cardiovascular complications in men and women is the same. Aerobic exercise interventions, such as high-intensity interval training, can recover blood pressure, hence this exercise becomes a potential alternative exercise, especially for people with hypertension stage I and central obesity.

High-intensity interval training improves body composition through post-workout energy expenditure and the greater use of fatty acid oxidation (Bagley et al., 2016). This study showed a significant reduction of waist circumference, waist-to-hip ratio, fat mass, and visceral fat content in men. These results are relevant with the previous study of (Bagley et al., 2016). However, the results of other studies stated that there was no effect of gender on body composition after participating in HIIT (Maillard et al., 2018). The effect of gender on fat loss might be due to differences in muscle mass (Bijlsma et al., 2013), muscle contractility and energy metabolism during exercise (Mcphee et al., 2014), and a higher energy expenditure during exercise in men (Bagley et al., 2016).

The increase of skeletal muscle mass and fat-free mass occured only in women. It might be due to the higher levels of daily physical activity of women compared to men. However, in this study, there was no analysis of daily physical activity outside the exercise program. The refinement in body fat percentage was not significant, it was possibly influenced by the duration of the study. A short-term high-intensity interval training significantly reduces waist circumference, whereas long-term exercise could also reduce body fat percentage in obese people (Batacan et al., 2017). Cardiometabolic improvements appeared better in a long-term (> 12 weeks) exercise duration in obese person than in a short-term one (Batacan et al., 2017; Campbell et al., 2019; Jelleyman et al., 2015; Kessler et al., 2012).

The limitation of this study is the relatively short duration of the study (<12 weeks). We suggest that further studies provide a longer duration of study (> 12 weeks) to obtain more consistent results regarding the improvement of cardiometabolic function in hypertension patients with central obesity.

CONCLUSION

The results of this study indicate that high-intensity interval training can be an effective non-pharmacological alternative therapy in reducing cardiovascular risk. Men tend to experience better cardiometabolic improvements than women.

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