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Differences in the cardiovascular change in normal and obese according to treadmill exercise

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트레드밀 운동에 따른 정상인과 비만인의 심혈관계 변화 차이

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Abstract The purpose of this study is to examine the difference in cardiovascular changes between obese people and the general public using a treadmill. This study was conducted by recruiting 32 adult males who had no experience in hospital visits or treatment due to cardiovascular disease. The subjects were divided into an obese group and a general group based on BMI 25 and performed treadmill exercise for 12 minutes. SBP, DBP, HR, MAP, and PP before and after the treadmill were measured to see the difference in cardiovascular system changes. Data analysis was evaluated using an independent t-test. In the case of SBP, MAP, and PP, there were significant differences between groups ($P<0.05$). For DBP and HR, no significant difference was found between the two groups ($P>0.05$). The subjects of this study consisted only of healthy adult males in their 20s, and there is a limitation in that it was performed in a short time.

Key Words : Cardiovascular system, Obesity, Systolic blood pressure, Diastolic blood pressure, Heart rate, Arterial pressure, Pulse pressure

요 약 : 본 연구의 목적은 트레드밀을 이용하는 동안의 비만인과 일반인의 심혈관계 변화 차이를 알아보는 것이었다. 본 연구는 심혈관계 질환으로 병원 방문 및 치료 경험이 없는 성인 남성 32명을 대상으로 진행되었다. 대상자들은 BMI (body mass index) 25를 기준으로 비만군과 일반군으로 나누어 트레드밀 운동을 12분간 실시하였다. 심혈관계 변화의 차이를 알아보기 위해 트레드밀 전후의 SBP, DBP, HR, MAP, PP를 측정하였다. 두 그룹의 비교는 독립 t-검정을 사용하여 분석되었다. SBP, MAP, PP의 경우 군간 유의한 차이가 발견되었다($P<0.05$). 그러나 DBP와 HR의 경우 두 그룹 간에 유의한 차이가 발견되지 않았다($P>0.05$). 본 연구의 대상자는 건강한 20대 성인 남성으로만 구성되어 있어 짧은 시간에 수행되었다는 제한점이 있었다.

주제어 : 심혈관계, 수축기 혈압, 이완기 혈압, 심박수, 대동맥압

1. Introduction

The number of obesity in modern society is rapidly increasing. Many factors in the stressful environment of busy modern society promote weight gain, and the deterioration of sleep quality accompanied by obstructive sleep apnea, competition, and leisure greatly influence appetite control. In addition to the external environment, human eating habits have changes

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dramatically over the past few decades driven by changes in fiber intake and increase consumption of pasteurized and processed foods [1]. According to WHO data, 39% of the world`s population over the age of 18 are overweight, of which 13% are obese. Numerous studies have demonstrated the relationship between obesity and cardiovascular disease, which contributes to the increased prevalence of hypertension, myocardial infarction, angina pectoris, arteriosclerosis, and stroke [2]. The association between obesity and hypertension, diabetes, dyslipidemia and sleep apnea syndrome also increases the incidence of cardiovascular disease. In addition, it is closely related to an increase in the risk of chronic diseases, secondary symptoms due to obesity, and a decrease in quality of life. Considering the increased cardiovascular risk, regular cardiology check-ups and control of asymptomatic obese patients are important for early diagnosis and treatment. [3].

Fitness is the ability to perform physical activities without undue fatigue. The related factors consist of factors such as strength, muscular endurance, flexibility, coordination, and cardiorespiratory endurance. Among them, cardiorespiratory endurance refers to the ability of the circulatory and respiratory systems to supply oxygen and nutrients to the exercising muscles during continuous physical activity. It is known as an index that can evaluate the overall state of physical fitness. Cardiorespiratory endurance is measured after measuring heart rate and oxygen intake during exercise. Although this method has advantages and limitations, the most appropriate method is measurement by a clinical expert [4].

Although physical activity and exercise are often used interchangeably, the two words do not mean the same thing. Physical activity is any physical activity produced by the contraction of skeletal muscles that results in a significant increase in the caloric requirement compared to the energy used at rest. However, exercise is a physical activity consisting of planned, structured, repetitive body movements performed to maintain or improve one or more elements of physical health [4]. Among them, aerobic exercise is an exercise that can be performed without using high-intensity power, and it has the effect of improving cardiorespiratory function by supplying oxygen to the body. In other words, it is a full-body exercise that converts fat and carbohydrates into energy. [5]. Aerobic exercise is effective in reducing body fat when you continuously exercise using fat and helps prevent or treat adult diseases by maintaining the normal range of blood cholesterol levels, high blood pressure, ischemic heart disease, hyperlipidemia, arteriosclerosis. It can prevent diabetes and delay aging [6]. Also, according to Nassis et al (2005), regular aerobic exercise reduces hepatic lipids in the obese state even if no weight loss occurs. It is said that weight loss and fatty liver management can be achieved by promoting physical activity through aerobic exercise [7]. Johnson et al. (2014) reported that several weeks of aerobic exercise improved insulin sensitivity in overweight and obese patients without changes in inflammatory markers. This suggests that aerobic exercise can improve metabolic abnormalities related to obesity. [8]. Zanesco et al. (2007), exercise promotes beneficial health effects by preventing or reducing the harmful effects of pathological diseases such as arterial hypertension, coronary artery disease, arteriosclerosis, diabetes, osteoporosis, Parkinson's disease, and Alzheimer's disease. In general, exercise training decreases sympathetic nervous system activity and increases

parasympathetic activity in humans and laboratory animals. Changes in the autonomic nervous system are associated with decreased heart rate and decreased blood pressure [9].

Ha et al. (1997), the index of abdominal obesity tends to increase with increasing age, and among the risk factors for cardiovascular disease, total cholesterol in the blood, fasting blood glucose, and diastolic blood pressure all increased [10]. See also Choi et al. (2009) show that obese people increase total blood volume, cardiac output, and heart load [11]. Patients with obesity showed relatively higher cardiac output and lower peripheral resistance than the general population with the same blood pressure level. The increase in stroke volume and activation of the sympathetic nervous system show the increase in cardiac output and heart rate seen in obese patients. High blood pressure is more likely in the general population, and weight gain causes an increase in blood pressure, and dilatation of the left ventricle occurs frequently due to an increase in filling pressure and blood volume. In obese patients, the left ventricle and left atrium dilate as blood pressure and age increase, and the dilatation of the left atrium causes an increase in heart failure and various complications such as atrial fibrillation [11].

Therefore, Pacy et al. (2012) suggest that weight loss should be combined with calorie reduction [12]. It should be remembered that exercise tolerance in severe obesity (BMI 〉 40) is very low. In people who are physically active, the incidence of ischemic heart disease may be reduced. This is likely related to the direct effect of exercise on known cardiovascular risk factors. Increased physical activity should be encouraged as the training involved in performing these activities on a regular basis may be more conducive to weight loss, health and general lifestyle changes for a better life. In the long run, additional benefits may be gained by reducing responsibility for ischemic heart disease [12]. Also, regular physical exercise increases the efficiency of diet by increasing the saturation efficiency of a fixed meal and is useful for maintaining diet-induced weight loss [13].

Ko et al. (2009), the expansion of exercise that neglects the individual's physical strength may have side effects such as physical injury or death during exercise rather than health promotion. Although a reliable estimation interval was presented even with a relatively low exercise load, a study on various groups is needed. [14]. In this study, heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and pulse pressure (PP) were measured among adult males and obese adults using a treadmill. Based on this, we aim to see the difference in cardiovascular changes between obese people and the general public.

2. Methods

2.1 Participants and design

This study recruited 32 adult males between the ages of 20 and 30 who were enrolled at S University in Asan City and had no experience in hospital visits or treatment due to cardiovascular disease Table 1. The sample number result was obtained by inputting the values of the mean and standard error measured in the study using the sample number calculation program 'G POWER 3.1.9.7'. Means difference between two independent means (two group) statistical results in the T test showed that 32 people in 2 groups were assigned to 16 people in the obese group and 16 people in the general population.

Table 1. Subject general characteristics

	Normal group (N=16)	Obesity group (N=16)
Age (years)	20.18±1.75	20.68±1.85
Height (cm)	176.57±4.10	174.06±3.06
Weight (kg)	69.61±6.69	80.51±5.62
Body mass index (kg/cm^2)	22.55±2.37	26.58±1.76

2.2 Measurement

This experiment was carried out using the exercise load test. Cardiac stress test (Mortara, Instrument INC, USA) and Metabolic test system (Parvo Medics, USA) were used for exercise stress test. The exercise stress test is a test that comprehensively evaluates changes in the cardiovascular system during exercise load. Preheat the exercise load tester (Quinton Q-Stress Cardiac Stress System, CardioCare, USA) for 30 minutes to 1 hour before the experiment, and set the temperature, humidity, and air pressure in the flow meter calibration according to the device manual for more accurate experiments. Using a 3L syringe pump, set the air inside the machine to an error of ± 3 %.

In gas calibration, open the gas and measure while sampling the air in the room. Recognize the current environment and proceed if the error is ±4%. A blood pressure measurement device (HS-2000, Hans Rudolph, USA) is worn on the inside of the arm through which the blood vessels pass. The electrocardiogram (Quinton Q-Stress Cardiac Stress System, CardioCare, USA) is placed on the left and right lower clavicle, left and right lower rib cage, left and right sides of the trunk of the sternum, and the 4th to 6th ribs of the left chest to check whether there is a problem with the patient's heart. Start the experiment when the green and yellow indicators appear on the screen and reconnect when the red and white indicators appear. Afterwards, the subjects of the study rest for 5 minutes in a position with their backs on a chair and their arms bent at a 90° angle, and after measuring each variable, these values are considered to be stable. The protocol used in this study can set the gradual exercise load by changing the inclination and speed of the treadmill (Quinton Q-Stress Cardiac Stress System, CardioCare, USA). The protocol was applied starting at 0% slope and speed of 1.7 mph and increasing every 3 minutes at 10% slope and speed of 1.5 mph. The detailed values of speed and slope for each step are shown in Table 2.

Table 2. treadmill in speed and slope

stage	speed (mph)	slope (%)	time (min)	Cumulative time (min)
1	1.7	0	3	3
2	1.7	5	3	6
3	1.7	10	3	9
4	2.5	12	3	12

2.3 Experimental procedures

In order to prevent accidents in advance, the subjects received sufficient training on safety and equipment. The day before the experiment, cigarettes that could affect the exercise stress test were prohibited. Stretching was done before and after the experiment. During the test, check the rating of perceived exertion (RPE) every minute and check the condition of the subject from time to time. When the exercise load does not rise anymore, or inability to maintain exercise intensity. Exceeding 90% of the maximum heart rate estimated by age. A systolic blood pressure greater than 260 mmHg or a diastolic blood pressure greater than 115 mmHg. If an abnormal ECG waveform is measured and the RPE is 19 or higher, it is judged that the subject is exhausted, and the test is terminated. Prepare drinks for fatigue or hydration.

All the general public and obese people participating in the study were assigned to the obese group and the general group according to the BMI measurement. Obesity is based on BMI (Weight/Height × Height), and the average age is in the early to mid-20s, and the number of people with a result value of 25 kg/m2 or more according to world health standards is designated as obese. (World Health Organization, Asia-Pacific region and the Korean Society of Obesity standards BMI 〉25 kg/m2 or more) For more accurate experiments, the general public and obese people are tested under the same conditions. The experimenter sits in a chair while wearing the equipment, rests for 5 minutes, and measures systolic blood pressure, diastolic blood pressure, heart rate, mean arterial pressure, and pulse pressure. After the measurement, the experimenters proceeded with the treadmill exercise according to Table 2 up to 4 steps. Each stage lasts for 3 minutes, and the condition of the subjects is measured before and after exercise.

At the end of the experiment, the experimenters are asked to sit down and rest. This study confirms the difference in cardiovascular changes between the general public and obese people on the treadmill by calculating and comparing the average of the changes in the measured values before and after exercise between the general public and the obese.

2.4 Statistical analysis

In this study, descriptive statistics were used to analyze the mean and standard deviation (SD) of each variable. SPSS was used for all statistical analyses. Means difference between the two independent means was used to compare the differences in cardiovascular changes between obese people and the general population, and the statistical significance level was set to α = 0.05.

3. Results

The treadmill exercise according to Table 2 was applied to both groups for 12 minutes, and systolic blood pressure, diastolic blood pressure, heart rate, pulse pressure, and mean arterial pressure were measured before and after. Table 3 shows the rate of increase from 0 to 12 minutes in each item by comparing them with an independent t-test. Table 3 shows the average value of the increase rate of each item.

In the increase rate of systolic blood pressure, t=-3.771, P=0.001, which was statistically significant based on the significance level of 0.05 (P〈0.05). Therefore, it can be said that there is a difference in the rate of increase in systolic blood pressure between the general population and obese people. The average increase in systolic blood pressure of obese people was measured as an average of 0.4125 for the general public and 0.6926 for obese people, which was relatively higher than that of the general population.

In the increase rate of diastolic blood pressure, t=-0.890, P=0.385, which was not statistically significant based on the significance level of 0.05. (P〉0.05). Therefore, there was no difference in the rate of increase in diastolic blood pressure between the general population and obese people. The average increase rate of systolic blood pressure of obese people was measured as -0.1360 for the general public and -0.0699 for obese people on average, but it was not a statistically significant difference.

In the heart rate increase rate, t=-0.155, P=0.878, which was not statistically significant based on the significance level of 0.05. (P〉0.05). Therefore, there was no difference in the rate of increase in heart rate between the general public and the obese. The average of the general public was -0.6000 and the obese -0.6121, which

was measured as a relatively high average heart rate increase rate of the obese than the general public, but the difference was not statistically significant.

In the increase rate of mean arterial pressure, t=-3.279, P=0.003, which was statistically significant based on the significance level of 0.05 (P<0.05). Therefore, it can be said that there is a difference in the average arterial pressure increase rate between the general public and obese people. The average of the general public was 1.2494 and that of the obese was 2.4505.

In the increase rate of pulse pressure, t=-2.696, P=0.014, which was statistically significant based on the significance level of 0.05 (P<0.05). Therefore, it can be said that there is a difference in the increase rate of pulse pressure between the general public and obese people. The average of the general population was 0.1181 and that of the obese was 0.2551.

Table 3. Comparison of SBP, DBP, HR, MAP, PP growth rate between obesity and normal

	Normal	Obesity	P
SBP growth rate	0.41 (0.18)	0.69 (0.24)	0.001
DBP growth rate	-0.14 (0.09)	-0.07 (0.28)	0.385
HR growth rate	0.60 (0.16)	0.61 (0.27)	0.878
MAP growth rate	0.12 (0.08)	0.26 (0.19)	0.014
PP growth rate	1.25 (0.79)	2.45 (1.23)	0.003

Mean (SD), Growth rate: pre value/post value, DBP: diastolic blood pressure, SBP: systolic blood pressure, HR: heart rate, MAP: mean arterial pressure, PP: pulse pressure

4. Discussion

This study was conducted to determine the difference in cardiovascular changes by dividing 16 out of 32 adult males into the general population and 16 obese groups. Exercise was performed on a treadmill for 12 minutes to determine the difference in cardiovascular changes between the general population and obese people. This study was able to identify differences in systolic blood pressure, mean arterial pressure, and pulse pressure between the obese group and the general group. On the other hand, there was no difference in diastolic blood pressure and heart rate on the treadmill between the general population and the obese group.

According to Kim (2011), there was a significant positive correlation between BMI and systolic blood pressure, and there was a significant difference in systolic blood pressure in the general population and obese people [15]. However, there was no significant difference in blood pressure according to BMI in diastolic blood pressure. Therefore, it was confirmed that BMI was the most relevant index for blood pressure in male adults in their 20s among BMI, body fat percentage, and HR [15]. Lee et al. (1996) found that the average blood pressure of middle school students increased as the BMI increased, and in the case of students, the hypertension rate also increased, especially when they were obese [16]. As a result, it was suggested that the systolic and diastolic blood pressure of all male and female middle school students differed according to the degree of obesity according to body weight and BMI [16]. In addition, according to Choi et al (2009), it was proved that SBP and DBP MAP were statistically and significantly increased in obese middle-aged women compared to general middle-aged women [11].

In previous studies on PP and BMI, Yoon et al. (2018) reported that abdominal obesity and obesity were not significant variables influencing PP in men, and Giovanni et al. (2012), in a study conducted on adult males and females, there was no significant difference in PP according to BMI [18,19]. However, Yoon et al. (2013) confirmed that an increase in pulse pressure was correlated with BMI in a study on adult males and females. [20]. In this regard, Vera et al.

According to (2012), the inconsistency in the results of previous studies is that there is a difference according to gender and race in the criteria for determining abdominal obesity and obesity, and that the use of a correction variable without dividing the sex may be one reason suggested [21].

In this study, as a result of comparing cardiovascular changes in the treadmill of the general public and obese people, significant differences were found in systolic blood pressure, mean arterial pressure, and pulse pressure, but no significant differences were found in diastolic blood pressure and heart rate. As a result, some cardiovascular changes and BMI were significantly correlated in healthy men in their 20s. This can be seen as adding a great burden to the body when performing exercise that requires cardiovascular ability in obese people according to BMI. According to a study by Jekal et al (2010), the BMI and physical fitness of adolescents with an average age of 17 have a significant effect on metabolic disease risk factors in adults in their 40s. [22]. In addition, according to Kim et al (2012), it is very important to prevent obesity in adolescence and twenties before the 30s and 50s, when metabolic diseases occur, and to improve physical strength through exercise is very important for the prevention of metabolic diseases after the age of 40 [23]. In this regard, it was suggested that combining exercise and weight control is the most effective way to prevent or reduce metabolic syndrome and cardiovascular disease that may occur in the future [23]. However, if a person with a normal BMI of 25 or more is set to the same exercise as a person with a normal body weight, it is highly likely to put a great strain on cardiovascular function. Therefore, it suggests that delicate management is necessary when prescribing exercise for overweight people.

This study has several limitations. First, since it was performed in a short time, further studies in a long time are needed. Second, the BMI distribution of the subjects is uneven, and the age and gender are also limited to adult males in their 20s. Third, since only one experiment was performed, there is a possibility that the condition of the subjects affected the result value, and it is necessary to supplement this limitation in future studies.

5. Conclusion

This study was carried out to compare the differences in systolic blood pressure, diastolic blood pressure, heart rate, arterial pressure, and pulse pressure on a treadmill between the general population and obese people. As a result of the study, there was a difference in the rate of increase in systolic blood pressure, mean arterial pressure, and pulse pressure in the general population and obese people. On the other hand, there was no difference in the rate of increase in diastolic blood pressure and heart rate between the general population and the obsess.

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