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Research Article

Study of Blood Pressure and Heart Rate Responses to Exercise in Young Adults

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Abstract: The present study aims to examine and analyze the pattern of the blood pressure and the heart rate recovery after a sub-maximal exercise on the Bicycle ergo meter, in healthy young adults, both male and female. An attempt has been made to assess the gender differences on blood pressure and heart rate changes after exercise in non-athletic young adults. An increased understanding of this issue will have clinical implications, in addition to being important in prescribing exercise intensities. One hundred healthy medical students comprising of 50 men and 50 women within the age group of 18 to 21 served as subjects for this study. The pulse rate and blood pressure were measured before, during and after exercise. The exercise routine was scheduled in the morning hours at the laboratory after a light breakfast. Each subject was made to exercise on a bicycle ergo meter with a gradually increasing intensity every 3 minutes, starting from 50 then to 100 and then to 150 Watts, until they reach 70% of their maximal heart rate. The data was statistically evaluated to know the differences between the blood pressure and the heart rate recovery patterns of the male and female subjects. It was observed that there were significant differences ($p<0.05$) in the post-exercise systolic blood pressure and heart rate responses between males and females. The study revealed that the heart rate recovery of males was significantly higher than that of the females in the first 3 minutes (p value < 0.001). Recovery of systolic blood pressure of males was significantly higher than that of females in first 3 minutes (p value < 0.05). This study helps in arriving at a conclusion that gender difference does affect the systolic blood pressure and heart rate responses to exercise.
Keywords: Exercise, heart rate recovery, systolic blood pressure, stroke volume, bicycle ergo meter.

INTRODUCTION

Exercise is a bodily activity that enhances and maintains physical fitness and ensures overall health or wellness. It is performed due to various reasons that may include strengthening of muscles and the cardiovascular system, honing athletic skills, weight loss and maintenance, and perhaps for enjoyment as well. Frequent and regular physical exercise boosts the immune system and helps prevent the ‘diseases of affluence’ such as heart disease, cardiovascular disease, type-2 diabetes, and obesity. It also improves mental health, helps prevent depression, helps to promote or maintain positive self-esteem, and can even augment an individual’s body image.

Exercise regimens are designed to be of therapeutic value as well. There is evidence to demonstrate that exercise can lower arterial pressure and restore blood pressure to more normal values. This is of greater value in pre-hypertensive subjects where suitable exercise regimen can reverse or even retard the rate of progression from pre-hypertension to hypertension and thus prevent target organ injury. Regular physical activity increases the exercise capacity and it plays a role in both the primary and the secondary prevention of cardiovascular disease [1]. Exercise, a common physiological stress, can elicit cardio- vascular abnormalities that are not present at rest, and it can be used to determine the adequacy of cardiac function. Because exercise is only one of many stresses to which humans can be exposed, it is more appropriate to call an exercise test exactly that and not a ‘stress test’. This is particularly relevant considering the increased use of non exercise stress tests [2]. As exercise is initiated and its intensity increases, there is increasing oxygen demand from the body in general, but primarily from the working muscles. To meet these requirements, cardiac output is increased by an augmentation in stroke volume (mediated through the Frank-Starling mechanism) and heart rate as well as an increasing peripheral arteriovenous oxygen difference. However, at moderate to high-intensity exercise, the continued rise in cardiac output is primarily attributable to an increase in heart rate, as stroke volume typically reaches a plateau at 50% to 60% of maximal oxygen uptake except in elite athletes. Thus, maximal cardiac output during exercise is the product of augmentation of both stroke volume and heart rate. The immediate response of the cardiovascular system to exercise is an increase in heart rate that is attributable to a decrease in vagal tone, followed by an increase in sympathetic outflow. During dynamic exercise, heart rate in sinus rhythm increases linearly with workload and oxygen demand [2]. The expected value of heart rate can be predicted from one of several available equations, some of which are derived separately for men and women. The basic way to calculate maximum heart rate is to subtract age from 220 [3]. It is known that moderate exercise intensity results in 50-70% of maximum heart rate, and vigorous exercise results in 70-85% of maximum heart rate.

The pattern of cardiovascular responses to aerobic exercise is similar for both genders, although the magnitude of response may vary for some variables. Many of the differences in cardiovascular responses between the genders are related to differences in body size and structure. Females have a higher cardiac output and heart rate, but a lower stroke volume than males during sub-maximal exercise when work is performed at the same absolute work load [4- 6]. Higher heart rate more than compensates for the lower stroke volume in females, resulting in the higher cardiac output seen at the same absolute workload. Thus when a male and a female perform the same exercise, the female will be typically stressing the cardiovascular system to a greater extent. This relative disadvantage to women results from several factors. Firstly, females typically are smaller than males and they have smaller heart and less muscle mass. Secondly, they have lower oxygen carrying capacity than males. Finally they typically have lower aerobic capacity (VO_2 max).

The purpose of this study is to determine gender differences in normal systolic blood pressure and heart rate responses during and after a sub maximal-effort cycle ergo meter exercise test in healthy young adults.

MATERIAL AND METHODS

One hundred healthy medical students in age group of 18-21 years (50 Male sand 50 females) volunteered to participate in the study. Clearance from the Institutional Ethical Committee was obtained before undertaking the study. This study was conducted in the Physiology Laboratory of Andhra Medical College, Visakhapatnam during 2013. Participants were instructed not to consume beverages containing alcohol or coffee and not to eat a heavy meal immediately before the test. The study was conducted during morning hours after light breakfast, and commenced with the measurement and recording of the body weight, height and body mass index of the subjects. Height was measured in centimeters without footwear using a vertically movable scale. Weight was measured to the nearest 100 grams by using a digital scale. Body Mass Index was derived by Quetelet Index. Resting blood pressure (systolic and diastolic) was measured using a mercury sphygmomanometer, with the subject resting in a supine posture for 15 minutes. Measurement was done two times during two different visits to the laboratory. On the occasion of each visit, blood pressure was measured by the same experienced observer using a standard mercury sphygmomanometer, taking the first and the fifth phases of Korotkoff sounds as systolic and diastolic values, respectively. Subjects were excluded if the average of the last two values obtained during each visit for systolic and diastolic blood pressures was greater than 139 and 89 mmHg respectively. Subjects were excluded if they had a history of cardiovascular, peripheral vascular, respiratory disease and orthopedic or musculoskeletal lesions. Subjects selected were non-athletic but physically active, non-smokers, non-alcoholics, non-obese, non-diabetics, non-asthmatics, non-hypertensive, apparently healthy and free of cardiovascular diseases and not taking medications that could affect cardiovascular functions. Subjects were informed (written and oral) of the study protocol and their consent was obtained before participation. Each subject exercised on a bicycle ergo meter with a gradually increasing intensity every 3 minutes, starting from 50, 100, 150 and 300 watts, until they reach 70% of their maximal heart rate. Maximum heart rate can be calculated by subtracting age from 220. The average age of the subjects under study was 20 years, accordingly the maximum heart rate works out to 200 (220-20). Moderate exercise intensity was calculated as 50 to 70 percent of maximum heart rate i.e. 100 to 140 heart beats per minute. During the exercise, the heart rate was monitored by using the electronic display device which was inbuilt in the bicycle ergo meter, which showed the pulse rate of the exercising subjects. The exercise was stopped immediately when the heart rate crossed the predefined endpoint value. The end point heart rate was taken as 140 beats/minute for males and 130 beats/minute for females. Heart rate and blood pressure were measured at resting state after a lapse of 1 minute, 3 minutes and 5 minutes after the end of exercise (recovery heart rate). Systolic Blood Pressure was measured after a lapse of 1 minute, 3 minutes and 10 minutes after completion of exercise and the subject still sitting on the cycle without pedaling. Heart rate recovery is the rate at which the heart rate returns to baseline after a period of exercise. One easy way to measure heart rate recovery is to measure the change in heart rate during the first minute after sub-maximal exercise. A drop in heart rate of 15-20 beats per minute might be typical and a value less than 12 would be unfavorable [7]. All data were presented as a mean and standard deviation. Student t-test was used to compare the differences between values. The accepted level of significance for differences was equal to or less than

0.05 for all tests (P value< 0.05).

RESULTS

The mean values of physical characteristics of subjects are as shown in Table 1. The mean weight, height, were higher ($p<0.05$) in males than in females. Heart rate recovery is shown in Table 2.

Table 1: General Characteristics of Male and Female Subjects

Parameter	**Male (n=50)**	**Female (n=50)**	**p value**
Age in years	20±0.9	20±0.7	NS
Weight in Kgs	61.02±4.30	48.78±3.25	<0.05
Height in Cms	167.18±4.66	157.62±3.26	<0.05
BMI Kg/M^2	21.81±0.74	19.61±0.71	NS
Hemoglobin/dl	13.48±0.47	11.00±0.65	NS
Heart Rate	71.86±3.82	72.26±3.54	NS
BP at rest (mmHg):			
Systolic	120.6±3.06	111.4±4.20	NS
Diastolic	70.04±2.08	67.48±4.42	NS

Table 2: Heart rate recovery.

Heart rate recovery (BPM)	**Subjects**	**Mean ± SD**	**p value**
Heart rate recovery in 1 min	Males	25.9±3,67	< 0.001
	Females	15.45±3.06	
Heart rate recovery in 3 min	Males	56.5±2.87	<0.001
	Females	47.45±3.44	
Heart rate recovery in 5 min	Males	70.5±4.54	NS
	Females	60.34±6.76	

The data showed a difference in the heart rate recovery between males and females in the first 5 minutes. The results showed that the heart rate recovery of males was significantly higher than that of females in the first 3 minutes. Table 3 below shows the post exercise responses of Systolic blood pressure.

Table 3: Recovery of systolic blood pressure

Systolic BP (mmHg)	**Subjects**	**Mean±S.D**	**p value**
Systolic BP recovery in 1 min	Males (n= 50)	26.67±6.17	< 0.05
	Females (n=50)	25.45±4.45	
Systolic BP recovery in 3 min	Males (n= 50)	48.02±2.52	< 0.05
	Females (n=50)	42.24±2.91	
Systolic BP recovery in 5 min	Males (n= 50)	65.67±3.65	N.S
	Females (n=50)	60.05±4.65	

The results showed difference in the systolic blood pressure response after exercise between males and females. Recovery of systolic blood pressure of males was significantly higher than that of females in first 3 minutes. The diastolic pressure show not much change after exercise in both males and females.

DISCUSSION

Males and females display the same pattern of response for blood pressure. However, males tend to have a higher systolic blood pressure than females at the same relative workloads. Much of the difference in the magnitude of the blood pressure response is attributable to differences in resting systolic blood pressure. Diastolic blood pressure response to sub-maximal exercise is very similar for both sexes [8, 9, 10]. It is known in medical circles for nearly twenty years that heart rate recovery is a useful index of cardiovascular fitness. It is well established that heart rate recovery is a strong predictor of both cardiovascular-related and all-cause mortality in healthy adults. It was observed in the present study that the heart rate recovery of males was significantly higher than that of females in the first 3 minutes (p value < 0.001). In the fifth minute, the difference became non significant. The present study showed a faster recovery of systolic blood pressure at first 5 minutes in male students compared to their female counterparts. Recovery of systolic blood pressure of males was significantly higher than that of females in first 3 minutes (p value < 0.05). The diastolic pressure does not show much change after exercise. In a recent similar study on gender differences in systolic blood pressure and heart rate responses during and after exercise in non-athletic young adults differences were reported between males and females for SBP_3, HR_3, $\%SBP_{d3}$, $\%HR_{d3}$, and SBP_3 : Peak [11] The present study finds that exercising heart rate of male students is significantly higher than that of their female counterparts. This result could be explained by the fact that male students push themselves higher than female students because females are perhaps not familiar with bicycle ergo meter. In another study gender differences in some systolic blood pressure and heart rate responses, predictive of cardiovascular morbidity, of male and female healthy young adults disappear after adjustment for some covariates [12]. The present study is limited to a small bout of exercise and is conducted on healthy student volunteers. Further studies have to be conducted on similar lines to investigate gender differences with larger sample size. In the present study, body mass and percent body fat of men and women has not been taken into consideration. These deficiencies in the present study may account for the differences in the findings.

CONCLUSION

The present study indicates gender differences in recovery of heart rate after exercise in which there was a higher recovery of heart rate in males compared to females. Systolic blood pressure response to sub-maximal exercise also shows gender differences amongst healthy, young adolescents. The outcome of the present study is that every person should exercise regularly and should keep track of the recovery of the pulse rate within a reasonable amount of time after cessation of exercise.

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