Research Article

Correlation of body mass index and cardiovascular reactivity to exercise-induced stress in young adults

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Abstract

Background: Cardiovascular reactivity (CVR) is an increase in heart rate and blood pressure when exposed to stress. Increased CVR due to stress is an indicator of developing hypertension. In this study, we explored to know if exaggerated CVR and obesity are related to each other.

Objective: (1) To understand the correlation between body mass index (BMI) and CVR in normotensive young adults. (2) To compare the changes on the cardiovascular parameters, such as heart rate, blood pressure, stiffness index, reflection index, and pulse transit time, before and after exercise.

Materials and Methods: Institutional ethics committee (human studies) clearance was obtained and a convenient sampling of 32 males and 32 females was done based on their age (>18 to <25 years) and normotensive status. Baseline blood pressure, heart rate, and 5 min of finger photoplethysmography results were recorded. Pulse wave contour analysis gave the pulse transit time, stiffness index, and reflection index. With a pedometer hooked to the waistband, the subject was asked to walk around the department corridor with an average speed of 100 steps in 1 min to count 3,000 steps in 30 min. After 3,000 steps, heart rate, blood pressure, and finger photoplethysmography for 5 min were immediately measured in supine lying position. Pearson's correlation method and paired *t*-test were performed with statistical significance set at *p*-value of <0.05.

Result: A trend of positive correlation of statistically nil or less significance existed between BMI and various reactivity measures such as heart rate, systolic blood pressure, and diastolic blood pressure.

Conclusion: Autonomic nervous system is the most powerful energy-saving regulatory system in our body. Failure of this system will lead to deposition of fat in one's body causing obesity. Reduced autonomic activity in subjects with obesity is a suspected risk factor for cardiovascular morbidity.

KEY WORDS: Cardiovascular reactivity, heart rate variability, exercise

Introduction

The World Health Organization in 1997 declared obesity as a disease of pandemic significance both in developed and in developing countries.[1] Obesity is the major determinant of noncommunicable diseases such as diabetes mellitus, coronary heart disease, and stroke. India, standing second to China in population, contributes almost 16% to the world's death census.[2] National Family Health survey (NFHS) reports showed an increasing trend in obesity among ever married women from 11% in NFHS-2 (1999) to 15% in NFHS-3 (2006). Prevalence of hypertension and cardiovascular disease is rapidly increasing in India. A survey by the National Nutrition Monitoring Bureau reported the pooled estimate of prehypertension in rural men (42%) and women (39%) with prevalence being higher in younger age group and tended to decrease with increase in age.[3] Obesity is directly associated with hypertension as well as overall cardiovascular disease morbidity.[4] Stress is exhibited as a response toward the adverse interaction with the environment. The cause of stress may vary, such as fasting, exercise, exposure to heat/cold,

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or even emotional disturbances (mental). Stress affects the limbic system through the hypothalamic–pituitary–adrenal axis. Cardiovascular reactivity (CVR) is an increase in heart rate and blood pressure when exposed to stress. Increased CVR to stress is an indicator of developing hypertension.[5] Exaggerated CVR has become an additional risk for a range of cardiovascular outcomes, such as high blood pressure, carotid atherosclerosis, carotid intima thickness, and increased left ventricular mass.[4] This study was undertaken to find whether exaggerated CVR and obesity are associated or if they are independent risk factors for cardiovascular outcome. Moderate exercise was chosen to be the stressor, and the response was studied by the differences in heart rate, blood pressure, and vascular reactivity.

Objectives

This study aimed at the following:

1. To understand the correlation between body mass index (BMI) and CVR in normotensive young adults.
2. To compare the changes on the cardiovascular parameters such as heart rate, blood pressure, stiffness index, reflection index, and pulse transit time before and after exercise.

Materials and Methods

Before commencement of this study, clearance was obtained from institutional ethics committee (human studies). Volunteers aged between 18 and 25 years from the nearby villages of our medical college were recruited for this study. Convenient sampling of 32 women and 32 men was done based on their age, gender, tobacco use, alcoholism, habit of regular exercise, and those with normotensive blood pressure.

Imposed Intervention

The subject was asked to walk 3,000 steps in 30 min as moderate exercise using a pedometer.[6]

Data Collection Procedures and Instruments

Identified subjects reported to the Research Lab, Department of Physiology, Shri Sathya Sai Medical College & Research Institute, Tamil Nadu, India, between 8 and 9 am with no intake of any caffeinated or carbonated drinks for at least 3 h before the experiment. Complete procedures involved in the study were explained to them in the vernacular language and they were assured of data confidentiality. Written informed consent was obtained. After a brief introduction about the scope of our study, information on the habit of exercise, any illness/ medications, tobacco use, and alcoholism was collected. Anthropometric data of the subject, such as age, sex, height (to the nearest centimeter using a wall mount stadiometer, EasyCare, India), and body weight (to the nearest kilogram using a weighing machine, KRUPS, India), were recorded. BMI was calculated using Quetelet index. After supine resting for 10 min, baseline blood pressure and heart rate were measured using a semiautomatic digital sphygmomanometer (HEM 4021; Omron, India). Two readings were taken within an interval of 1 min and the average was considered for the study. Five minutes of finger photoplethysmography on right index finger was recorded using Digital Polyrite (RMS, India). Pulse wave contour analysis using Polyrite D software gave the pulse transit time, stiffness index, and reflection index. These parameters were in support of the vascular reactivity for the exercise stress that our subjects were exposed with. A pedometer of research grade, Digiwalker SW-200 (Yamax, Japan),[7] was hooked to the waistband of the subject and he/ she was asked to walk around the department corridor with an average speed of 100 steps in 1 min to count 3,000 steps in 30 min, which was considered to be a moderate exercise as recommended in their study published by Marshall et al.[6] Care was taken that the steps are taken continuously. The event was stopped immediately if any discomfort was noticed or reported by the subject and he/she was excluded from the study. After 3,000 steps, heart rate, blood pressure, and finger photoplethysmography for 5 min were immediately measured in supine lying position. Collected data were stored in MS-Excel 2007 and were analyzed for statistical significance later. Association between BMI and other CVR parameters such as the difference in heart rate (dHR), difference in systolic blood pressure (dSBP), difference in diastolic blood pressure (dDBP), difference in stiffness index (dStiffness index), difference in reflection index (dReflection index), difference in transit time (dTransit time) was determined using Pearson's correlation method by SPSS software, version 17.0. Paired sample *t*-test was performed in the variables before and after the exercise. Statistical significance was set at *p*-value of <0.05.

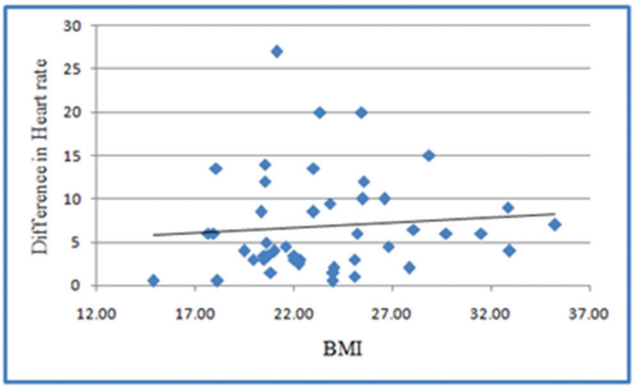

Figure 1: Correlation between body mass index and difference in heart rate before and after moderate exercise.

Results

Our findings in the study showed the existing positive correlation between the BMI and the various reactivity measures of the heart such as heart rate, systolic blood pressure, and diastolic blood pressure. Although statistically nonsignificant, a definite trend of positive correlation was noted as shown in Figure 1.

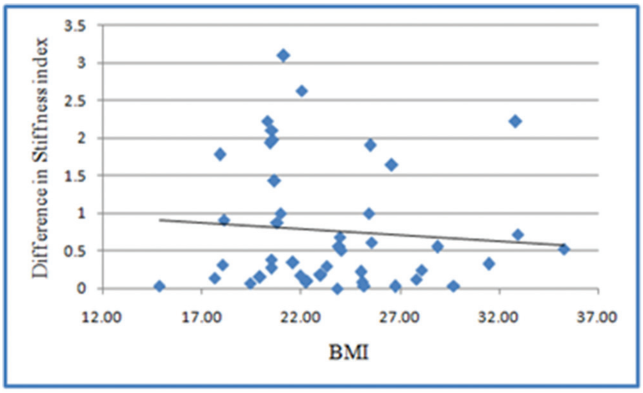

Figure 2: Correlation between body mass index and difference in stiffness index before and after moderate exercise.

Table 1: Anthropometric details of the subjects

Parameter	Mean ± SD
Age (years)	19.77 ± 0.95
Height (cm)	168.37 ± 8.10
Weight (kg)	67.24 ± 15.51
Step count (no.)	3171.97 ± 325.64

Table 2: Association between BMI and the various cardiovascular reactivity parameters

	Pearson's correlation coefficient	*p*-Value
BMI × dHR	0.089	0.559
BMI × dSBP	0.128	0.403
BMI × dDBP	0.165	0.279
BMI × dStiffness index	−0.097	0.525
BMI × dReflection index	−0.282	0.060
BMI × dTransit time	−0.162	0.287

We observed a negative correlation with those parameters of large artery stiffness (stiffness index), small artery stiffness (reflection index), transit time, and the increasing BMI. Results were statistically nonsignificant; however, the trend was seen to have negative correlation as shown in Figure 2.

The paired *t*-test of the collected data in Table 3 shows the statistically significant differences in the variable assuring the changes before and after moderate exercise that have come up with the intervention of the exercise in these subjects. The changes in heart rate and systolic blood pressure were very vivid with no change in diastolic blood pressure, indicating the moderate level of exercise induced. Also, the reflection index from the pulse plethysmography data shows the significant decrease indicating the possibility of slight vasoconstriction of the smaller arteries.

Discussion

Our study describes the CVR to moderate exercise in young adults with differing BMI [Table 1]. Cardiovascular adjustments are much required to cope up with both physical and psychological stress. Studies conducted earlier have found CVR to acute psychological stress as a subclinical risk for coronary vascular disease in young adults.[8,9] Majority of the studies have been conducted with psychological stress as a tool to assess the CVR. Here in this study we have used moderate exercise as the stressor. Similar CVR was observed in maximal exercise and acute psychological stress.[10] However, fewer studies have examined the role of CVR in coronary vascular disease during psychological stress. The association between the heart rate and BMI clearly showed a positive correlation. Reduced sympathetic and parasympathetic activities in children with obesity have been correlated to the increased body fat, which is considered to be an etiological factor for childhood obesity.[11] Here in our study the autonomic adjustment for an increased heart rate from the baseline was found to be higher in individuals with obesity than that in normal individuals or those with low BMI. The extent to which autonomic nervous system (ANS) of an individual with obesity is agitated by a moderate stress was clearly seen. And, this change was measured by the difference in the pre and post exercise heart rate, which was clearly found to have a greater value in case of individuals with obesity than in the normal subjects. Changes in blood pressure were correlated with BMI and were found to be again having a positive correlation [Table 2]. This was again in line with the findings of other studies that have reported individuals with obesity to have a reduced autonomic activity. Sympathetic nervous system (SNS) is reported to be the most important regulatory system for energy balance and hence altered SNS activity may affect the amount of fat mass in

Table 3: Differences in the different variables before and after the moderate exercise

Parameter	Pre-exercise (mean ± SD)	Post-exercise (mean ± SD)	*p*-Value
Heart rate (bpm)	77.48 ± 12.30	81.65 ± 13.95	0.001*
Systolic blood pressure (mmHg)	115.04 ± 11.44	117.94 ± 11.61	0.014*
Diastolic blood pressure (mmHg)	63.58 ± 7.28	63.60 ± 6.85	0.990
Stiffness index (m/s)	5.22 ± 1.40	6.23 ± 6.47	0.297
Reflection index (%)	55.51 ± 27.08	47.40 ± 19.22	0.014*
Transit time (s)	0.355 ± 0.14	0.344 ± 0.08	0.670

*Statistically significant $p < 0.05$

humans.[12–15] Reduced or blunted sympathetic activity in adults with obesity has been reported in certain physiological conditions.[16] Here in our study these subjects are of young adult age group and our findings are also similar to those of the other two. Hence, we believe that obesity at all age has the same effect on ANS. The association between BMI and the parameters that measure the stiffness arteries, such as the stiffness index measuring the large artery stiffness and the reflection index measuring the small artery stiffness, was opposite to that of the observations made with blood pressure and the heart rate. As there is always an inverse relationship between the above two, our observations were in the same line with the stiffness index and reflection index showing negative correlation with that of the BMI. The extent of dilatation and constriction depends on the property of the arterial wall elasticity. In atherosclerosis and arteriosclerosis this happens to be lost, and hence when a pre- and post-exercise difference in the elasticity achieved in an artery will be lesser to that in normal person with no earlier-mentioned changes in the artery. Therefore, the difference in the arterial elasticity nature decreases with the increase in BMI and obesity. It holds the same for the transit time of pulse, which depends on the velocity of blood flow that is directly dependent on the diameter of the blood vessel. As in these cases, the smaller the diameter of the blood vessel, the greater the velocity of blood flowing through, therefore the lesser will be the transit time. The statistically significant changes in the heart rate and blood pressure were well appreciated by the moderate exercise executed by all the subjects. Although the correlation exhibited by all the studied parameters showed a trend of either positive or negative correlation, they were statistically nonsignificant. Considering the previous studies, findings of our study are in line with them concluding that there is reduced autonomic activity or blunted sympathetic activity in the subjects with obesity.

Conclusion

ANS is the most powerful energy-saving regulatory system in our body. Failure of this system will lead to deposition of fat in one's body causing obesity. This unwanted deposition brings about a failure of the autonomic system in turn leading to a number of cardiovascular diseases and thereby increasing mortality and morbidity. Further studies in the line of improving the ANS with modalities such as yoga and exercise in individuals with obesity can be conducted to understand which could give better changes in reverting the damaged ANS in them to normal.

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