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RESEARCH ARTICLE

Effect of acute isotonic exercise on cardiovascular functional status among adolescents with different body mass indices

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ABSTRACT

Background: Although within the physiological range, overweight and obese adolescents, who are otherwise normal, have blood pressures at the higher side, whereas underweight adolescents have lower blood pressures when compared with the normal weight individuals. **Aims and Objectives:** (1) To assess the functional status of the cardiovascular system by measuring the heart rate (HR) and blood pressure in adolescents with different body mass indices (BMI) at rest. (2) To illustrate the response of the cardiovascular system to acute isotonic exercise by recording the HR and blood pressure in normal weight, underweight, and overweight adolescents. **Materials and Methods:** A total of 44 adolescents, aged between 17 and 19 years with different BMI, are the study group. Subjects are categorized into underweight, normal weight, and overweight/obese group based on their BMI. HR and blood pressure were recorded before and immediately after the acute bicycle ergometer exercise test, with three finger test and sphygmomanometer, respectively. **Results:** Increase in HR, systolic blood pressure (SBP), and pulse pressure (PP) in diastolic blood pressure (DBP) were observed immediately after the exercise (P = 0.000) among all the subjects. Before the exercise, SBP, DBP, and mean arterial blood pressure (P = 0.002, 0.008, and 0.003) and after the exercise, SBP and PP (P = 0.007 and 0.037) are significant among underweight, normal weight, and overweight subjects. **Conclusion:** Overweight/obese adolescents are having higher blood pressure at rest. SBP and PP were increased more in overweight/obese adolescents after the exercise than the normal weight subjects.

KEY WORDS: Isotonic Exercise; Bicycle Ergometer; Body Mass Index; Adolescents

INTRODUCTION

There is increased epidemic of obesity among the athletic adolescents, resulting in improper functioning of the cardiovascular system.[1] Not only in adolescents but also in adult males and females, hypertension in overweight and hypotension in underweight persons, are serious health concerns.[2] There is increased magnitude of association between the blood pressure and cardiovascular diseases with increased body mass index (BMI).[3] BMI, age, systolic blood pressures (SBP) and diastolic blood pressures (DBP) are positively correlated, though the extent of relation is different. Sedentary life style, poor food habits, improper sleep, and mental stress are the common predisposing factors for both obesity and hypertension. Change in socioeconomic status intensifies the BMI and blood pressure levels.[4] BMI is directly associated with blood pressure at rest.[5] In general, blood pressure indices will be high in overweight and low in underweight adolescents, though there is a gender difference. SBP and DBP are more in overweight and less in underweight male adolescents, but in females only DBP is significant.[6] At rest parasympathetic activity is more in female adolescents

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than in males,[7] and hence, their heart rate (HR) is lower than the males. There are ethnic variations in blood pressure among the adolescents; Indian origin adolescents have higher blood pressure values than their counterpart African origin people in Suriname.[8] Hypothesis of the study is, overweight/obese adolescents, who are otherwise normal, have blood pressures at the higher side, before and after the exercise when compared with the normal weight individuals and underweight adolescents have lower blood pressures.

Objectives

1. To assess the functional status of the cardiovascular system by measuring the HR and blood pressure in adolescents with different BMI at rest.
2. To illustrate the response of the cardiovascular system to acute isotonic exercise by recording the HR and blood pressure immediately after the exercise in normal weight, underweight, and overweight adolescents.

MATERIALS AND METHODS

It is a simple, randomized experimental study. The present study is permitted by the institutional ethical committee. Written informed consent was obtained from all the subjects after making them to understand the methods and objectives of the study.

Forty four adolescents of both the gender, aged between 17 and 19 years, were included in the study randomly. Adolescents who are not willing to participate in the study, h/o recent surgeries, h/o cardiovascular diseases were excluded from the study.

Methods

The study was conducted in the research laboratory of the department of physiology; duration of the study is 1 month. After removing the footwear with minimal cloths on, height and weight were measured to the nearest points with a stadiometer and weighing machine, respectively. Subjects are categorized into underweight, normal weight, and overweight/obese group based on their BMI. BMI was calculated using the formula; BMI = Weight (in kg)/height (in m^2). Subjects with BMI ≤18.4 are categorized as underweight, 18.5-24.99 normal weight, 25-29.9 overweight, and ≥30 are obese subjects; we kept the overweight and obese subjects under one group as overweight/obese groups.[9]

Blood pressure was recorded with the sphygmomanometer, and HR was measured with three finger test. After allowing complete rest for 5 min, blood pressure was recorded on left hand in sitting posture with appropriate cuff sizes by a qualified physician; three readings were taken at an interval of 1 min. Average of the three readings was considered as the final figure. All the participants are subjected to bicycle ergometer and requested to peddle the ergometer as fast as they can for 5 min. They are advised to stop the exercise immediately if they attain muscular fatigue. HR and blood pressure were recorded before and immediately after the bicycle ergometer exercise test. Management of blood pressure is followed as per the guidelines.[10]

Statistical Analysis

Sample size was calculated based on the below-mentioned formula for HR as outcome variable; probability of Type I error or level of significance (α) was 0.05 (5%), the power of the test (1−β) was 0.80 (80%), the effect size (E) was 1.475, the SD of the change in the outcome (S (Δ)) was 3.475. $N = [(1.00)(Z_\alpha+Z_\beta)^2]/[(E/S(\Delta))^2] = 43.56 = 44$.[11] Data were analyzed with GraphPad Prism 6.01 Version Software. For normal continuous data, paired "*t*" test was administered before and after the exercise. Comparison of normal continuous data between underweight, normal weight, and overweight groups was carried out with one-way "ANOVA" test. For continuous non-normal data, Kruskal-Wallis test is performed followed by Bonferroni's/Dunn's multiple comparisons test.[12,13] $P < 0.05$ are considered as significant.

RESULTS

Findings of this study are depicted in Tables 1-3.

DISCUSSION

Table 1 shows the HR, SBP, DBP, pulse pressure (PP), and mean arterial blood pressure (MABP) in all the adolescents before and after the exercise. In the present study, HR, SBP, and PP were increased significantly after the exercise, whereas DBP is decreased. In isotonic moderate or severe

Table 1: In all the subjects, HR in beats per minute, SBP, DBP, PP, MABP in millimeters of mercury (before and after the exercise)

Parameter	Exercise	*N*	Mean±SD	*P* value
HR	Before	44	72.4±8.8	0.000
	After	44	102.0±20.1	
SBP	Before	44	109.0±9.4	0.000
	After	44	127.0±23.2	
DBP	Before	44	75.5±11.0	0.000
	After	44	62.6±8.6	
PP	Before	44	32.8±7.7	0.000
	After	44	67.5±15.2	
MABP	Before	44	86.3±9.9	0.217
	After	44	85.0±9.1	

Paired *t*-test, $P<0.05$ is significant. SD: Standard deviation, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PP: Pulse pressure, MABP: Mean arterial blood pressure, HR: Heart rate

Table 2: Comparison of HR in beats per minute, SBP, DBP, PP, MABP in millimeters of mercury in all the three groups (before the exercise)

Parameter	Groups	*N*	Mean±SD	*P* value
HR	Underweight	12	72.6±7.6	0.652
	Normal Weight	25	73.1±10.0	
	Overweight	7	69.6±6.2	
SBP	Underweight	12	105.0±4.7	0.002
	Normal Weight	25	108.0±8.9	
	Overweight	7	119.0±10.6	
DBP	Underweight	12	74.0±7.2	0.008
	Normal Weight	25	73.0±9.8	
	Overweight	7	86.9±14.5	
PP	Underweight	12	29.7±7.8	0.185
	Normal Weight	25	34.6±7.2	
	Overweight	7	32.0±8.3	
MABP	Underweight	12	83.9±5.3	0.003
	Normal Weight	25	84.4±8.8	
	Overweight	7	97.5±12.7	

One-way analysis of variance test (Kruskal-Wallis test), $P<0.05$ is significant. SD: Standard deviation, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PP: Pulse pressure, MABP: Mean arterial blood pressure, HR: Heart rate

Table 3: Comparison of HR in beats per minute, SBP, DBP, PP, MABP in millimeters of mercury in all the three groups (after the exercise)

Parameter	Groups	*N*	Mean±SD	*P* value
HR	Underweight	12	100.2±17.8	0.924
	Normal Weight	25	102.6±22.5	
	Overweight	7	100.0±16.8	
SBP	Underweight	12	116.3±30.8	0.007
	Normal Weight	25	126.3±16.7	
	Overweight	7	148.0±16.7	
DBP	Underweight	12	61.0±7.0	0.360
	Normal Weight	25	61.8±6.8	
	Overweight	7	68.3±14.6	
PP	Underweight	12	63.7±10.2	0.037
	Normal Weight	25	65.8±17.3	
	Overweight	7	79.7±6.7	
MABP	Underweight	12	82.03.7	0.201
	Normal Weight	25	83.8±7.2	
	Overweight	7	94.8±15.0	

One-way analysis of variance test (Kruskal-Wallis test), $P<0.05$ is significant. SD: Standard deviation, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PP: Pulse pressure, MABP: Mean arterial blood pressure, HR: Heart rate

exercise, the SBP is directly proportional to HR, and as the HR is increased SBP also increases. DBP is directly proportional to peripheral resistance, in moderate isotonic exercise DBP may increase, decrease, or remain same. However, in severe isotonic exercise, peripheral resistance will decrease and hence DBP also decreases. As there is increased SBP and decreased DBP, PP also increases because it is the difference of these two pressures. Although DBP is decreased, MABP is not changed because of increased PP. Tables 2 and 3 shows the comparison of HR, SBP, DBP, PP, and MABP among underweight, normal weight, overweight adolescents before and after the exercise, respectively. At rest SBP, DBP, and MABP and immediately after the exercise SBP and PP were significant when compared among the three adolescent groups. There is a positive correlation between the BMI and the MABP among the adolescents, and our results are in line with the earlier research reported.[14] Higher levels of blood pressure and BMI in midlife prelude the risk of cardiovascular diseases in late life.[15] BMI is significantly associated with cardiopulmonary fitness exercise tests in heart failure patients.[16] BMI and waist circumference are positively correlated with blood pressure.[17] Among the adult population of Africa and Asia, blood pressure is strongly associated with BMI.[18] BMI can be a predictor of hypertension among the adult women who are normotensive initially.[19] Even in pregnant women who are either normotensive or chronic hypertensive, the MABP is positively correlated with BMI.[20] Higher free triiodothyronine levels may be one of the cause for high PP in overweight and obese adult individuals.[21] There are some contradicting results also reported, during long-term follow-up, alteration in BMI is not accompanied by changes in PP,[22] this could be attributed to age. Multiple comparisons of HR, SBP, DBP, and MABP among the three groups were carried out before and after the exercise. Before the exercise, SBP, DBP, and MABP between normal weight versus overweight and also between underweight versus overweight adolescents were significant. After the exercise, SBP and PP between underweight versus overweight, and SBP between normal weight versus overweight adolescents were significant. Weight control along with the regular physical activity can obtain the normal blood pressure.[23] Regular long-term exercise will stabilize the cardiovascular functional status by maintaining the normal BMI in underweight and overweight adult individuals.[24] By keeping the ideal BMI, one can restrict or delay the occurrence of the cardiovascular diseases.

Limitations of the Study

Advanced investigating tests such as ECG and 2D Echo have an advantage over the methods used in the present study.

CONCLUSION

Overweight adolescents are having higher blood pressures and underweight adolescents are having lower blood pressures before and after the exercise when compared with the normal weight individuals.

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