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ORIGINAL ARTICLE

A STUDY ON CARDIOPULMONARY CHANGES WITH EXERCISE IN ADOLESCENT BOYS AND GIRLS

P. V. V. Lakshmi[1], Kilim Srinivas Reddy[2]

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ABSTRACT: INTRODUCTION: Exercise is an important part of keeping adolescents healthy. The prevalence of obesity-related hypertension, in children and adolescents is on the rise. Exercise regimen can reverse or retard the rate of progression from prehypertension to hypertension in adolescents. The incidence of lung diseases including bronchial asthma is high in adolescent age group. There are gender differences in cardiopulmonary changes with exercise. The pulmonary function testing during exercise is often used for further assessment and determining the degree of airway impairment and response to treatment. The present study was performed to study the effect of various intensity of exercise on cardiopulmonary variables and to evaluate quantitative relationship between the variables. **MATERIALS AND METHODS:** The present study is carried out in a group of 100 healthy First year medical students of both sexes, who were not regular athletes. The subjects being medical students presented an added advantage of belonging to matching age groups of between 18-21 years of comparable physical standards and also medically screened at the time of admission. Before undertaking the exercise regimen blood hemoglobin concentration, RMV, MVV, FVC, FEV1, PEFR, RR, HR and Blood Pressure (BP) were determined in all the subjects. Then the subject exercised on a bicycle ergometer with incremental loads. The Pulse Rate of the subject is noted and mentioned as the heart rate per minute. During the exercise the pulse was monitored by a pulse Oximeter. Blood Pressure was manually measured using standard mercury sphygmomanometer. The recordings before exercise, during exercise and 30 minutes after end of exercise of FVC, FEV-1 and PEFR were measured using a digital spirometer. **RESULTS:** All the observations recorded in Group-A (Boys) subjects and of Group-B (Girls) subjects were noted. The arithmetical mean, standard deviation and standard error were calculated for each parameter. Paired't' Test was done and the degree of relationship between the variables was assessed by finding the coefficient of correlation. The results of study demonstrated that high intensity exercise produced significant changes in heart rate and systolic blood pressure. The rise in heart rate in Group-A subjects was 120% ($P<0.001$) and in Group-B subjects was 116% ($P<0.001$). Study demonstrated an increase of systolic blood pressure in Group-A subjects by 26. 64% ($P<0.001$) during exercise and in Group-B subjects the increase was 27.24% ($P<0.001$). The diastolic blood pressure in our study showed a minimal decrease. In Group-A subjects the decrease of diastolic blood pressure was 2. 99% ($P<0.001$) and in Group-B subjects the decrease was 2.96% ($P<0.001$). Exercise induced bronchospasm in asthmatics cause airway obstruction leading to fall in PEFR values with exercise. However in normal subjects there is no airway obstruction seen in mild and moderate exercise **SUMMARY AND CONCLUSION:** cardiovascular variables of Heart Rate and Systolic and the diastolic pressure varied depending on the severity of exercise. Moderate exercise regimen may reduce diastolic pressure and the rate of progression from prehypertension to hypertension in adolescents. Measurement of pulmonary function subsequent to exercise could provide useful information about

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the function reserve capacity of lung and control of breathing both in healthy person and in patients with pulmonary disorders. There were no significant changes in values of pulmonary variables like FVC. However FEV-1 increased in both Groups. Pulmonary function testing is often used for assessment and determining the degree of airway impairment.

KEYWORDS: exercise, cardiopulmonary, prehypertension, adolescents, gender.

INTRODUCTION: Exercise is accomplished by alteration in the body response to the physical stress. Many important details concerning the physiological changes which follow exercise have only recently been described. The Cardiovascular and Pulmonary changes that occur during acute exercise and the mechanisms that underlie these changes help us to appreciate the different effects of dynamic exercise on these parameters. The metabolism at the cellular level is also modulated to accommodate the demands of exercise.

Regular physical activities in adolescence improve cognitive skills and attitudes, academic behaviors, control weight, reduce anxiety and stress. The prevalence of obesity-related hypertension and insulin resistance, in children and adolescents has increased substantially over the past several years. This has led to worsening of cardiovascular health in children and adolescents, which may result in a serious public health crisis. Exercise regimen can reverse or retard the rate of progression from prehypertension to hypertension in adolescents, and prevent target-organ injury in the future. The incidence of lung diseases including bronchial asthma is high in adolescent age group. The Ventilatory responses to exercise provide valuable information in identifying various obstructive or restrictive lung diseases. There are gender differences in cardiopulmonary changes with exercise. Females exhibit smaller lung volumes and reduced inspiratory and expiratory flow rates.

Our aim was to study the effect of exercise on FVC, FEV-1 and PEFR, to evaluate association between anthropometric measurements and most variables of cardiopulmonary assessment in adolescent age group and to compare the cardiopulmonary responses between boys and girls of adolescent age group.

MATERIALS AND METHODS: The present study is carried out in a group of 100 healthy First year medical students of both sexes, who were not regular athletes. The subjects being medical students presented an added advantage of belonging to matching age groups of between 18-21 years of comparable physical standards and also medically screened at the time of admission. Nevertheless brief medical histories of all the subjects were recorded including previous health, smoking daily routine, physical activity and exercise habits if any. None of the students in this present study engaged in regular exercise or strenuous physical activities. The subjects had no history of any major diseases and the examination revealed the same. They were not under any medications. The subjects were informed about the experimental purpose and protocol. Oral consent obtained from all subjects. Height and weight of all the subjects were recorded by height measuring stand and a weighing machine respectively. The data was compiled separately for both sexes and designated as Group-A for males and Group-B for females. Each group comprising 50 students. BMI was calculated to assess whether they are obese, underweight or normal.

The experimental protocol implemented is as follows. Before undertaking the exercise regimen blood hemoglobin concentration, Respiratory Minute Volume (RMV), Maximum Voluntary Ventilation (MVV), Forced Vital Capacity (FVC), Forced Expiratory Volume (FEV1), Peak Expiratory Flow Rate (PEFR), Respiratory Rate (RR), Heart Rate (HR) and Blood Pressure (BP) were determined in all the subjects as detailed below. Then each subject exercised on a bicycle ergometer with incremental loads, until the maximum is reached at exhaustion.

Cardio respiratory responses to exercise on a bicycle ergometry have been extensively studied in the past few decades. Ergometers were developed to register the amounts of mechanical work per unit time. Balkeb and Ware R. W. [1] employed treadmill for exercise physiology studies. This technique suffers from the disadvantage that external physical work of the subject walking or running cannot be measured. In comparison with the other laboratory work loading mechanism- Bicycle Ergometer provides more nearly identical working conditions and standard rate of work and fulfills the requirement of good test. Mechanical Bicycle Ergometer was designed by Van Dobelin[2] and was manufactured by Monark Crescent. AB, Varberg, Sweden.

Work output attained is calculated from a record of the number of revolutions and loads employed. Details of the above experimental procedures were presented below.

The Pulse Rate of the subject is noted and mentioned as the heart rate per minute. During the exercise the pulse was monitored by a pulse Oximeter. Blood Pressure was manually measured using a standard mercury sphygmomanometer taking the I and V phases of Korotkoffs sounds as systolic and diastolic sounds respectively. This procedure was performed during rest, during exercise and 30 minutes after end of exercise. Before undertaking the exercise regimen, Respiratory Minute Volume (RMV) and maximum voluntary Ventilation (MVV) were determined with a wet spirometer. The recordings before exercise, exercise and 30 minutes after end of exercise of Forced Vital Capacity (FVC), Forced Expiratory Volume in first second (FEV-1) and Peak Expiratory Flow Rate (PEFR) were measured using a digital spirometer.

The Parameters of FVC, FEV-1, and PEFR were recorded with a digital spirometer. In order to ensure properly standardized conditions and familiarize the subjects, ergometer and test procedure, all the subjects were allowed a 4 minute unloaded pedaling at least on two occasions. Then they participated in progressive incremental, ergometric testing. The load was increased stepwise every succeeding minute until the maximum exercise tolerance was reached and physical exhaustion was reported apparent. Although the exercise is carried to an essentially symptom limited maximal power output, objective criteria were also laid down to stop the exercise test by the observer.

RESULTS: All the observations recorded in Group-A (Boys) subjects and of Group-B (Girls) subjects were noted. The arithmetical mean, standard deviation and standard error were calculated for each parameter. Paried 't' Test was done and the degree of relationship between the variables was assessed by finding the coefficient of correlation.

PARAMETER	GROUP - A Rise or Fall		GROUP - B Rise or Fall		p' Value
	Mean	S. D.	Mean	S. D.	
Heart Rate(beats/min)	83.58	4.6	82.56	5.11	NS
Systolic Blood Pressure(mm of Hg)	35.2	5.02	30.4	4.25	< 0.01
Diastolic Blood Pressure(mm of Hg)	2.48	2.16	2	0.98	NS
Respiratory Rate(/min)	21.16	2.82	22.02	2.8	NS
FVC(L/min)	0.18	0.11	0.27	0.01	< 0.01
FEV-1(L/min)	0.69	0.16	0.54	0.18	< 0.01

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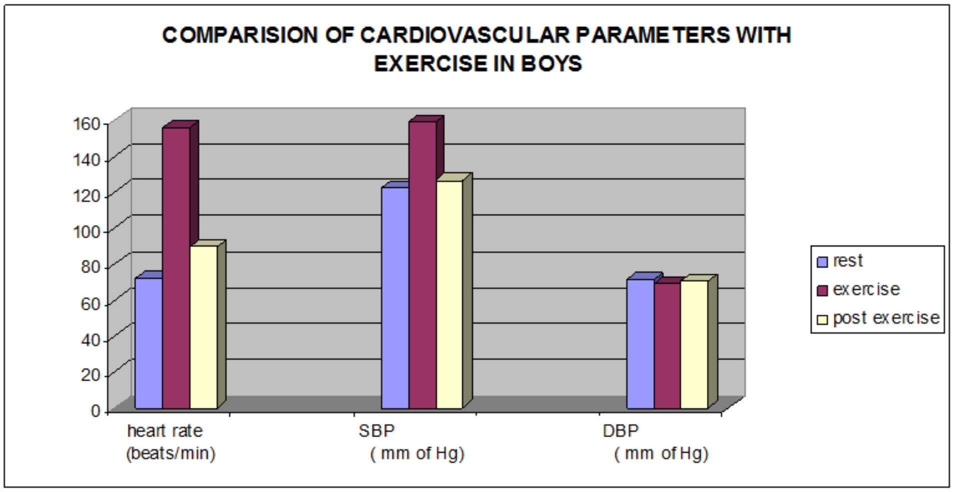
PEFR(L/min)	20.9	13.51	24.48	9.88	NS

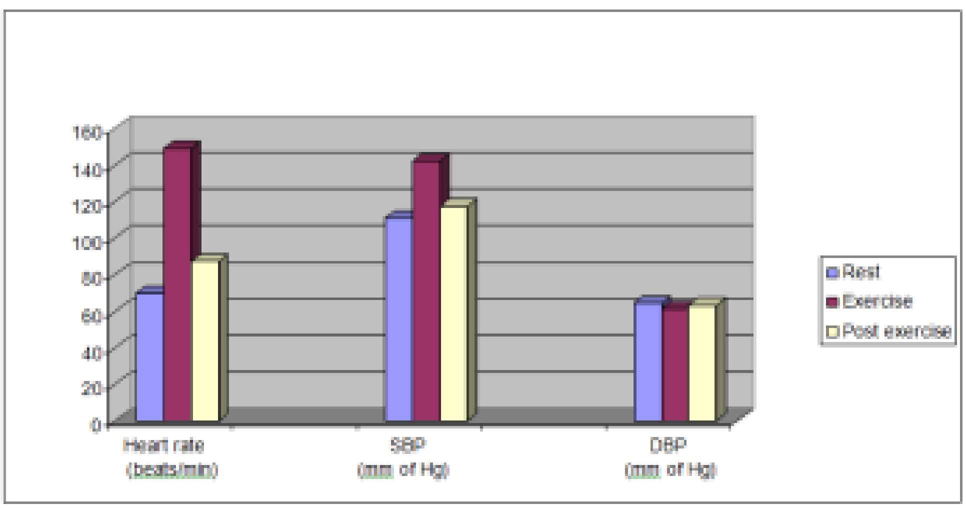
Table 1: Comparison of Cardio respiratory Responses to Exercise between GROUP-A and GROUP-B Subjects

Graph 1: COMPARISION OF CARDIOVASCULAR PARAMETERS WITH EXERCISE IN BOYS.



Graph 1

Graph 2: COMPARISION OF CARDIOVASCULAR PARAMETERS WITH EXERCISE IN GIRLS.



Graph 2

DISCUSSION: The increased metabolic demands with exercise determine a range of integrated cardio-respiratory adjustments to maintain the homeostasis of internal milieu (Whipp B. J. 1994).[3] It imposes enhanced energy demands which are met by increased activity of normal energy delivery systems, principally cardiovascular and respiratory systems. There are extensive studies in physiology dealing with both the short term responses to a single bout of occasional exercise (acute

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exercise) and long term adaptation to regular exercise (Chronic exercise). Individuals differ in their exertional abilities which are determined by large number of variables such as age, nutritional status, hemodynamic and respiratory capacities, muscular strength, environmental factors, training, skills, motivation etc. The choice of medical students as test subjects offers advantage of having a group matched in height, weight, nutritional status etc. They were within age group of 18-20 years. As is shown in the statistical data in Table-I of Group-A subjects had a mean height of 166.3±0.7 cm and mean weight of 61.6±4. 7kgs. The mean height for Group-B subjects was 157.4±3.3 cm and mean weight was 48.78±3. 2kgs. Stress is not laid on the anthropometric data which obviously is closely matched. Haemoglobin in the blood constitutes an important delivery system in Oxygen releasing to tissues. Exercising muscles plays greater demand for Oxygen through increased metabolism. From the statistical data derived from the data Table I and IV, Group-A and Group-B subjects in the present study had a mean concentration of haemoglobin 11.68±1 gm/dl and 11.44±1 gm/dL. In our study the statistical data points to no relationship between haemoglobin concentration and work output. However it has been described that in long standing aneamias in otherwise healthy individuals exertional dypnoea observed when the haemoglobin concentration falls to 7. 4 gm/dL.

Using Ergometers and methods of quantification of work output the influence of multiple variables on exercise capacity and physiological responses in exercise were investigated in several studies. RYT Sung[4] in the study of cardiopulmonary responses to exercise on a treadmill test in adolescent subjects found a high correlation of height, weight and skin fold thickness with few variables. The taller and adolescent boys have high blood pressure and better lung function while the body weight was associated with FEV-1. One of the earliest and perhaps obvious observations about the cardiovascular system is that heart rate and blood pressure rise during exercise (Krogh & Lindhard).[5]

M. Herold Laughlin[6] in his review of cardiovascular responses to exercises described that heart rate, cardiac output and Oxygen consumption all increase linearly with exercise intensity up to maximal levels. Mean and systolic blood pressure increase with increasing exercise intensity. While during dynamic exercise at maximal levels the total peripheral resistance was less than its value at rest. The decrease in total peripheral resistance is the result of decreased vascular resistance in skeletal muscle vascular beds, leading to increased blood flow. There is relaxation of vascular smooth muscles in resistant arteries and arterioles feeding the active skeletal muscles.

M. Humayun Ikram et al[7] evaluated Pre and Post exercise pulmonary function tests in Medical students, of FVC, FEV-1, PEFR in males and females. This study revealed significant improvement in FEV-1 after exercise in both males and females. Cordian L et al[8] studied various parameters of lung function prior to exercise and 5 minutes, 15, 30 min. post exercise. They found an increase in residual volume, and slightly elevated FEV-1. They suggested that decrease in expiratory muscle strength due to fatigue may in part be responsible for increase in residual volume. The bronchi and larger bronchioles account for 50% of the airway resistance; the caliber of these airways is another major determinant of PEFR. The test is used to monitor degrees of bronchoconstriction in patients with asthma. However being effort dependent, it may be reduced if the respiratory muscles are weak.

The main idea for many years was that at the onset of exercise there is “mass sympathetic discharge” causes heart rate and blood pressure to rise, and also evokes vasoconstriction in the periphery. Local metabolic vasodilatation in the active muscles then overcomes this vasoconstriction, and this permits a high fraction of (the increased) cardiac output blood to be directed towards the

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active muscles. At rest, heart rate is controlled predominantly by parasympathetic nerves travelling in the Vagus and there is high baseline vagal tone. Under these circumstances baroreflex mediated changes in heart rate are almost brought about by changes in vagal nerve traffic. During exercise in humans, heart rate increases initially by withdrawal of vagal tone, and as heart rate reaches about 100 beats min" there is increasing activation of cardiac sympathetic accelerator fibres. There is also evidence to demonstrate that exercise (As a therapeutic treatment for hypertension) can lower arterial pressure and restore or partially restore baroreflex control of heart rate and blood pressure to more normal values (Timmers et al).[9]

The results of study demonstrated that high intensity exercise produced significant changes in heart rate and systolic blood pressure. The rise in heart rate in Group-A subjects was 120% (P<0. 001) and in Group-B subjects was 116% (P<0. 001). Heart rate is often used in evaluation of cardiac response to exercise. Since the age range of the subject material is 18 - 20, it is not surprising that age dependent response to exercise heart rate are lacking. It is well known that men with 50-70 years old will evidence a higher heart rate for work capacity than younger men (Noris et al)[10] and that maximal heart rates decrease with advancing age(Blackman et al).[11] The drop in heart rate after cessation of exercise during various time intervals is the Recovery Heart rate. The time it takes for the heart rate to return to the baseline value improves with training. Recovery Heart rate is often used as an indicator of improved training status. In our study the mean values of Heart Rate 7 minutes after exercise was 87. 78 in Group-A and 91. 3 in Group-B subjects which is 24% (P<0. 001) and 28% (P<0. 001) above the resting heart rate respectively.

The result of this study demonstrated an increase of systolic blood pressure in Group-A subjects by 26. 64% (P<0.001) during exercise and in Group-B subjects the increase was 27. 24% (P<0.001). The diastolic blood pressure in our study showed a minimal decrease. In Group-A subjects the decrease of diastolic blood pressure was 2. 99% (P<0.001) and in Group-B subjects the decrease was 2. 96% (P<0.001). 7 minutes after exercise the systolic blood pressure in Group-A subjects was 3. 98% (P<0.001) higher than that before exercise, and in Group-B subjects 4. 83% (P<0.001) higher than before exercise levels. The diastolic blood pressure in both Group-A and Group-B subjects was 1% (P>0. 5 nonsignificant) below the resting levels.

Exercise induced bronchospasm in asthmatics cause airway obstruction leading to fall in PEFR values with exercise. However in normal subjects there is no airway obstruction seen in mild and moderate exercise. Mild airway obstruction may be noted only after sternuous exercise. As all the subjects of our study were non-asthmatics we did not note any decrease in PEFR values in contrast Group-A subjects showed a marginal increase of 4%(P<0.001) and Group-B subjects showed an increase by 5. 6% (P<0.001) with exercise. In this study FVC increased by 6% (P<0.001) and 8. 5% (P<0. 001) in Group-A and Group-B subjects respectively. In Group-A subjects FEV1% increased from 82-97%. In Group-B subjects FEV1% increased from 83-94% with exercise. The difference between MVV and RMV is the Breathing Reserve (BR).

The mean values of MVV and RMV at rest in Group-A subjects are 76.7±4.94 and 5.29±0.24 respectively. These figures in Group-B subjects are 54.72±2.87 and 3.19±0.32 respectively. The termination of exercise at perception of dyspnoea and use of percentage of BR as an objective index for dyspnoea justifying relatively to exercise capacity. Exercise stress can be used in diagnosis of cardiorespiratory disease because of the tight relationship between exercise intensity, heart rate, cardiac output, and cardiovascular function. Moderate and high-fit prehypertensive individuals

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exhibit significantly lower ambulatory BP, exercise BP and heart rate at submaximal and absolute workloads when compared with unfit (Peter Kokkinos et al,).[12]

The rise in heart rate during exercise is considered to be due to the combination of parasympathetic withdrawal and sympathetic activation. The fall in heart rate immediately after exercise is considered to be a function of the reactivation of the parasympathetic nervous system. Technical advancements, especially the incorporation of computer in diagnostic equipment have simplified approach to exercise testing. Use of this important tool in evaluation of the cardiopulmonary function should be a routine practice in clinical assessment. In contrast to young subjects, coronary artery disease (CAD) is the most frequent pathological finding among older individuals who die during exertion. The cause for this is increased stress by increased heart rate, increased blood pressure and spasm of the coronary artery in diseased segments.

SUMMARY AND CONCLUSION: Dynamic exercise produces the most striking burden on cardio respiratory systems of any of the various stresses encountered in normal life. The study of cardio respiratory responses with exercise provide an excellent method to improve understanding of how the circulatory and Respiratory System respond and interact during exercise. Exercise stress is also used clinically to evaluate and quantity the severity of cardiovascular and/or respiratory disease.

In this study the cardiovascular variables of Heart Rate and Systolic Blood Pressure significantly increased with exercise, while the diastolic pressure decreased very minimally. The increase in Heart rate resulting in an increased Cardiac output provides the increased blood flow to the active skeletal muscles. Indeed the blood flow is also redistributed from the visceral tissues to active skeletal muscle. The other important cause of increased blood flow to the active skeletal muscle is decrease in vascular resistance the arteries and arterioles feeding the active skeletal muscle. This is demonstrated with the decrease of diastolic pressure. The value of heart rate and systolic blood pressure recovery measured at a specified time after cessation of exercise, were still above the resting levels. Abnormal values of heart rate recovery are considered an independent predictor of mortality.

Measurement of pulmonary function subsequent to exercise could provide useful information about the function reserve capacity of lung and control of breathing both in healthy person and in patients with pulmonary disorders. In this study the respiratory rate increased in both Groups with exercise. Several physiological mechanisms modulate the pattern and timing components of exercise Hyperpnoea. There were no significant changes in values of pulmonary variables like FVC. However FEV-1 increased in both Groups. Pulmonary function testing is often used for assessment and determining the degree of airway impairment. FEV-1 and PEFR are the most acceptable measures in assessment of airway impairment. This study results showed that there was no airway impairment with moderate exercise in both Groups. This finding could be partly explained by the fact that all the subjects were non-asthmatics and because the age group of subjects was of adolescent age.

Future research needs to be done in areas of cardiovascular response to exercise at different intensities; resistance exercise, exercise training and life style modifications. Physical activity should be recommended to everyone and should be seen as a necessary element in the pattern of daily living at all ages including children and adolescents.

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AUTHORS:

1. P.V.V. Lakshmi
2. Kilim Srinivas Reddy

PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Physiology, Rangaraya Medical College, Kakinada, Andhra Pradesh, India.
2. Associate Professor, Department of Physiology, Rangaraya Medical College, Kakinada, Andhra Pradesh.

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NAME ADDRESS EMAIL ID OF THE CORRESPONDING AUTHOR:

Dr. P. V. V. Lakshmi,
1-15-2, Sriram Nagar,
Near Bhanugudi Junction,
Kakinada-533003,
Andhra Pradesh.
E-mail: drlakshmi.pothula@yahoo.in

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