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RESEARCH ARTICLE

A study on oxygen dependent fitness (aerobic capacity) in pre-collegiate boys of North Karnataka region

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ABSTRACT

Background: Aerobic capacity (VO_2 max) measures the higher limit of energy content in the muscles. In general, genetics of an individual decides the higher limit of the muscle, but physical training can improve it by up to 20% as compared to non-trained individuals. **Aims and Objectives:** To evaluate oxygen dependent fitness (aerobic capacity) in pre-collegiate boys (age group of 16-18 years) of North Karnataka region. **Materials and Methods:** A total of 87 young adolescent healthy pre-collegiate boys volunteered for this study. Physical anthropometric parameters such as body surface area (BSA), body mass index (BMI), and body fat percentage (BF%); physiological parameters such as systolic and diastolic blood pressure; fitness tests such as physical fitness index (PFI) and aerobic capacity (VO_2 max) were measured. Correlation analysis and *Z*-test was used to obtain the data. **Results:** Physical anthropometric parameters of the subjects were found within normal range. Statistically significant exercise-induced rise in blood pressure was observed in Harvard step test. PFI correlated with aerobic capacity. Aerobic capacity correlated with BSA and did not correlate with BF% and BMI. **Conclusion:** The PFI was in good category, normal physiological response to exercise, and PFI correlated with aerobic capacity (VO_2 max). Aerobic capacity was found within the normal range in pre-collegiate boys of age 16-18 years in the study area. Ideal BMI may not be possible in this age group.

KEY WORDS: Body Mass Index; Aerobic Capacity; Physical Fitness; Blood Pressure

INTRODUCTION

Oxygen-dependent, i.e. aerobic fitness is the ability to exercise continuously for an extended period without being tired.[1] The factors determining aerobic fitness include genetic factors, age, sex, muscle mass, and physical training.[2] Aerobic fitness is the most useful in potential dangerous situation such as earthquakes and floods and in other intense difficulty.[3] The competition is the best example of performance capability, and therefore, the best indication of training success. Concert in any sport event is the result of a multitude of factors such as the performance in training, motivational level, nutritional status, and weather.[4,5]

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Aerobic capacity is the reliable and widely acceptable measure of cardio-respiratory fitness. Aerobic capacity determination is an indicator of the running endurance. The distance runner who acquires a high VO_2 max will obviously be at an advantage. The VO_2 max improves with training though reaches a maximal at a certain time.[6] VO_2 max reflects the amount of oxygen utilized by working muscles during maximal exercise.

Aerobic fitness is the ultimate factor in growth and development during childhood and adolescence. It is also a very important indicator in aging process. A better status of aerobic fitness during the growing years reflects the development of the muscles, bones, and cardio-respiratory system. The direct measurement of VO_2 max needs well-established laboratory setup with skilled personnel and medical supervision to avoid risk factors involved in exhausted works. Extrapolated VO_2 max as an alternative technique using ergometry such as treadmill, bicycle, step-up tests such as Margaria's test.[7] It is cost effective, easy to perform for both subjects and operators. Hence, this study was undertaken to evaluate oxygen dependent fitness (aerobic capacity) in pre-collegiate boys (age group of 16-18 years) of North Karnataka region.

MATERIALS AND METHODS

A randomized controlled study was done in 6 months from July to December 2015 involving 87 pre-collegiate boys of age group of 16-18 years from SECAB P.U. (Composite) College for Boys of Vijayapur (Karnataka). The selected subjects were called in the morning hours of the school with breakfast. Al Ameen Medical College, Vijayapur Institutional Ethical Committee approved the study. Permission was sought from college authorities to conduct the study. Eligible pre-collegiate boys (age group of 16-18 years) were given consent forms to be signed by their parents/legal guardians. Anthropometric parameters such as body surface area (BSA), body mass index (BMI), and body fat percentage (BF%); physiological parameters such as systolic blood pressure (SBP) and diastolic blood pressure (DBP); fitness tests such as Harvard step test and Margaria's step test were recorded.

Sample Size

A total of 156 healthy pre-collegiate students were studying during the study period. All the students were asked to participate in the study. The purpose of the study was explained to the students, and oral and written consents were taken. The obtained response rate was 55.77% and a total of 87 students comprised the subjects of the study. The subjects were allowed to fill the questionnaire, and only 87 of them were eligible for the study.

Inclusion Criteria

Young adolescent healthy pre-collegiate boys of age group of 16-18 years were selected for the study. At the onset, the study protocol was briefed and those who came forward voluntarily to participate were enrolled.

Exclusion Criteria

Subjects with presence of any cardio-respiratory disorders, diabetes, and other disorders, which could affect while performing oxygen dependent (aerobic) fitness tests were excluded from the study.

Anthropometric Parameters

BSA

BSA in square meters (m^2) was calculated by DuBio's nomogram.[8]

BMI

BMI was calculated using Quetelet's index[9] formula: Body weight (kg)/height (m^2).

BF%

BF% was calculated using the Deurenberg's equation:[10]

$$BF\% = 1.2 \times BMI + 0.23 \times Age - 10.8 \times Sex - 5.4 \text{ (male = 1 and female = 0)}.$$

Physiological Parameters

Pre-exercise blood pressure

The pre-exercise blood pressure or resting blood pressure, both SBP and DBP, was recorded using a sphygmomanometer by auscultatory method in mmHg in supine position after 3 min rest.

Post-exercise blood pressure

The post-exercise SBP and DBP were recorded in supine position after 2 min of exercise without changing the position of arm cuff, and the same instrument was used for all the subjects.

Fitness Tests

Physical fitness index (PFI)

The physical fitness was assessed in all the subjects by Harvard step test.[11] Each subject was asked to complete up and down task (20 steps/min) on a 16″ bench for 5 min duration. Immediately after 1 min of exercise, pulse rate was recorded for 30 s. The values were fed in the given formula to get the PFI scores.

$$PFI = [\text{Duration of exercise (sec)} \times 100]/[5.5 \times (\text{Pulse rate from } 1 - 11/2 \text{ min})]$$

The subjects were categorized into poor, fair, good, and excellent as per the PFI scores of <91, 91-102, 103-115, and >115, respectively.[11]

Oxygen dependent fitness (aerobic capacity)

The aerobic capacity VO_2 max of all the subjects was determined by Margaria's step test[6] using following equation:

$$VO_2 \text{ max} = \{[23.5 - 19 \times (200 - HR2)]/(HR2 - HR1)\} + 23.5$$

The step test consisted of two-step test studies each for 5 min work, i.e., 15 steps/min and 20 steps/min work, separated by 5 min rest. Each subject was asked to complete up and down task (15 steps/min) on a 13" or 33 cm bench for 5 min duration, then 5 min rest was given. Again the same protocol was followed for 20 steps/min. During the exercise, heart rate (HR1) was obtained with the time taken for 0-5 beats using electronic stopwatch immediately at the end of the first 5 min step test work, and the second heart rate (HR2) was taken in a similar manner with the next; and later, it was determined into beats per minute.

Statistical Analysis

The Window 2007 MS Excel Software was used to analyze the mean, standard deviation (SD), standard error of mean (SEM), and correlation analysis. *Z*-test was applied for the analysis of pre-exercise and post-exercise blood pressure (systolic and diastolic) changes in all the subjects. $Z > 3$ was considered as statistically significant.

RESULTS

The mean, SD, and SEM of BSA, BMI, and BF% of individuals are shown in Table 1, and the values of "*t*", "*P*", "*r*" and the relation between BSA versus VO_2 max, BMI versus VO_2 max, and BF% versus VO_2 max are shown in Table 2. The BSA (m^2), BMI (kg/m^2), and BF% (%) of the subjects in this study were 1.66 ± 0.20, 19.90 ± 3.74, and 11.63 ± 4.61, respectively. The BSA positively correlated with VO_2 max ($r = 0.297$, $P < 0.01$) of the individuals. However, the BMI ($r = 0.118$, $P > 0.05$) did not correlate with VO_2 max of the individuals.

The mean, SD, and SEM of pre-exercise SBP (mmHg) and DBP (mmHg) of individuals are shown in Table 1, and the values of "*t*", "*P*", and "*r*" are shown in Table 2. The mean pre-exercise SBP (mmHg) and DBP (mmHg) of the subjects in this study were 109.95 ± 0.994 and 69.36 ± 0.680, respectively. The pre-exercise SBP ($r = -0.071$, $P > 0.05$) and DBP ($r = -0.009$, $P > 0.05$) did not correlate with VO_2 max of the individuals.

The mean, SD, and SEM of post-exercise SBP (mmHg) and DBP (mmHg) of individuals are shown in Table 1, and the values of "*t*", "*P*", and "*r*" are shown in Table 2. The mean post-exercise SBP and DBP of the subjects in this study were 123.79 ± 1.35 mmHg and 74.37 ± 0.677 mmHg, respectively. The pre-exercise SBP ($r = 0.053$, $P > 0.05$) and DBP ($r = 0.069$, $P > 0.05$) did not correlate with VO_2 max of the individuals.

The raised post-exercise SBP was statistically significant when compared with pre-exercise SBP ($Z = 10.40$, $P \leq 0.001$) (Table 2). The raised post-exercise DBP was statistically significant when compared with pre-exercise DBP ($Z = 5.23$, $P \leq 0.001$) (Table 2).

PFI

The mean, SD, and SEM of PFI (score) of individuals are shown in Table 1, and the values of "*t*", "*P*", and "*r*" are shown in Table 2. The mean PFI score of the subjects in this study was 103.25 ± 1.81. Figure 1 shows category wise distribution of the subjects as per PFI scores by pie chart. Subjects were found to fall in the flowing categories: Excellent = 24%, good = 22%, fair = 26%, and poor 28% as per PFI Scores. The PFI correlated with VO_2 max ($r = 0.238$, $P < 0.02$).

VO_2 max/aerobic capacity/oxygen dependent fitness: The mean, SD, and SEM of VO_2 max (mL/kg/min) of individuals are shown in Table 1, and the values of "*t*", "*P*", and "*r*" are shown in Table 2. The mean VO_2 max of the subjects in this study was 30.79 ± 0.629. The VO_2 max correlated BSA ($r = 0.297$, $P < 0.01$) and PFI ($r = 0.238$, $P < 0.02$). The relation between VO_2 max versus BSA and VO_2 max versus PFI are shown in Figures 2 and 3, respectively. The VO_2 max did not correlate with BMI ($r = 0.118$, $P > 0.05$), BF% ($r = 0.136$, $P > 0.05$), pre-exercise SBP ($r = 0.071$, $P > 0.05$), pre-exercise

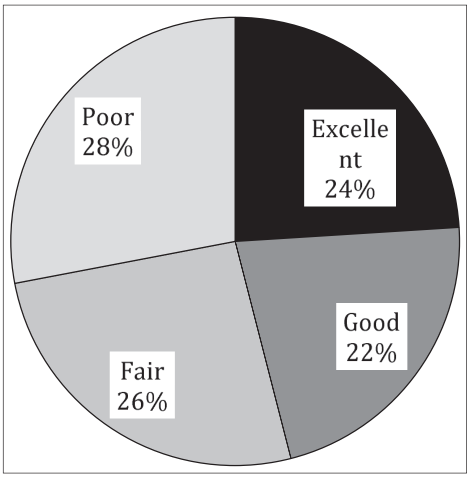

Figure 1: Distribution of the subjects as per physical fitness index scores ($n = 87$)

Table 1: Anthropometric parameters, physiological parameters, and fitness tests on the subjects (*n*=87)

Statistical Parameters	Anthropometric parameters			Physiological parameters				Fitness tests	
	BSA (m^2)	BMI (kg/m^2)	BF% (%)	Pre-exercise (mmHg)		Post-exercise (mmHg)		PFI (score)	VO_2 max (mL/kg/min)
				SBP	DBP	SBP	DBP		
Mean	1.66	19.90	11.63	109.95	69.36	123.79	74.37	103.25	30.79
SD	0.20	3.74	4.61	9.24	6.32	12.62	6.29	16.83	5.85
SEM	0.021	0.402	0.495	0.994	0.680	1.357	0.677	1.810	0.629

BSA: Body surface area, BMI: Body mass index, BF%: Body fat percentage, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PFI: Physical fitness index, VO_2 max, aerobic capacity, SD: Standard deviation, SEM: Standard error of mean

Table 2: *z*, *r*, *t*, and *P* of correlation of the subjects (*n*=87)

Parameter	*z*	*r*	*t*	*P*
VO_2 max versus BSA		0.297	2.863	<0.01
VO_2 max versus BMI		0.118	1.094	>0.05
VO_2 max versus BF%		0.136	1.262	>0.05
VO_2 max versus pre-exercise SBP		0.071	0.658	>0.05
VO_2 max versus pre-exercise DBP		−0.009	−0.084	>0.05
VO_2 max versus pre-exercise SBP		0.053	0.485	>0.05
VO_2 max versus pre-exercise DBP		0.069	0.636	>0.05
VO_2 max versus PFI		0.238	2.258	<0.02
Pre-exercise SBP versus post-exercise SBP	10.40	-	-	<0.001
Pre-exercise DBP versus post-exercise DBP	5.235	-	-	<0.001

BSA: Body surface area, BMI: Body mass index, BF%: Body fat percentage, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PFI: Physical fitness index

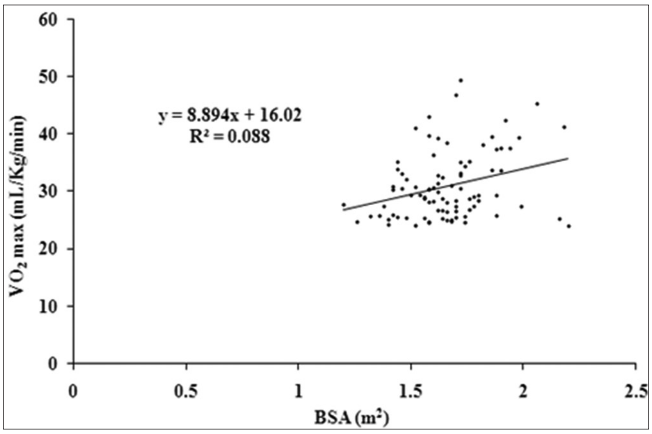

Figure 2: Relation between VO_2 max versus body surface area in the subjects (*n* = 87)

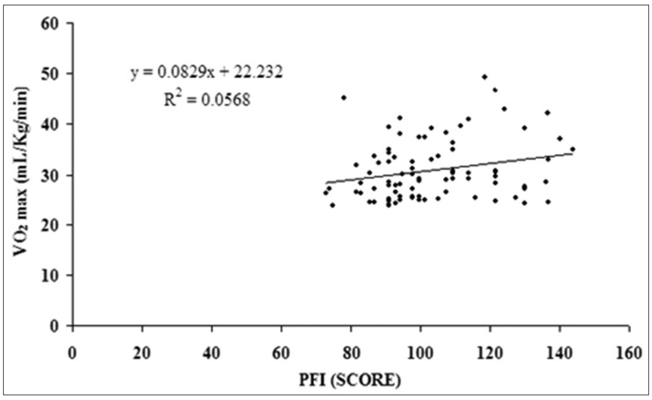

Figure 3: Relation between VO_2 max versus physical fitness index in the subjects (*n* = 87)

DBP ($r = -0.009$, $P > 0.05$), post-exercise SBP ($r = 0.053$, $P > 0.05$), and post-exercise DBP ($r = 0.069$, $P > 0.05$).

DISCUSSION

Aerobic capacity is the maximum volume of oxygen consumed by the body each minute during exercise. The measurement of oxygen consumption is nothing but the measure of aerobic fitness. The physical limitation restricts the rate of aerobic energy which can be dependent on the chemical nature of muscle tissue to use oxygen in breaking down fuels, cardiovascular and pulmonary system to transport oxygen.[12] The aerobic fitness evaluation is a preventive measure in early stage non-communicable diseases that occur due to bad lifestyle.[13] The habit of regular exercise in any form can bring healthy lifestyle. Aerobic fitness reflects individual's capacity to strenuous work. Therefore, it can be an indirect tool to find out the person's lifestyle.

Das and Dhundasi[6] in a study observed that VO_2 max was found to be 34.31 ± 2.44 mL/kg/min by Margaria's step test of 33 cm height in age group of 12-16 years in 2001. The observed values were found to be decreased when compared to their Caucasian (people from Europe, North Africa, Western, middle and central Asia) counterparts but closely similar when compared with their Indian counterparts.[6]

Higher VO_2 max was observed in athletes than non-athletes by graded exercise of running at 11 Km/hr on a treadmill in 22-33 years athletes. It may be due to increased stroke volume and arterio-venous oxygen difference.[14,15]

Study of Das and Bhattacharya[16] on age group of 18-22 years among non-athletes, mean VO_2 max of 42.36 mL/kg/min (range 32-58 mL/kg/min) and among distance runners of same age group mean VO_2 max of 50.09 mL/kg/min (range 36-70 mL/kg/min) were found by Queen's College test method. Analysis of VO_2 max scores done by various aerobic fitness test methods (i.e., Cooper test, Blake test, Multistage fitness test, Rockport walking test, etc.) report the followings: Endurance runners and cyclists VO_2 max was of >75 mL/kg/min, Squash = 65 mL/kg/min, Football (male) = 60-65 mL/kg/min, Rugby = 55 mL/kg/min, and Baseball (male) = 50 mL/kg/min (h 42). In our study, the mean VO_2 max of the subjects was found to be 30.79 ± 0.629. It was also observed that the average value of VO_2 max was within the referred range of variations, i.e. 20-90 mL/kg/min (h 32) with most of the above studies with different methods. The muscle cells should contract at peak rate to produce the energy. There must be a mechanism to bring oxygen to the excited muscle cells and aerobic respiration.[17] The use of this oxygen is first restricted by the number of mitochondria available in the muscle cells to produce aerobic energy.

VO_2 max significantly correlates with PFI in school going children of 12-16 years.[6] As the subjects in this study were of 16-18 years, non-obese, had PFI in good category, and not suffering from any cardio-respiratory disorders, the VO_2 max correlated with BSA and PFI. The VO_2 max did not correlate with BF%, pre-exercise (SBP and DBP), post-exercise (SBP and DBP), and BMI. No correlation with BF% and BP may be due to the fact that VO_2 max reflects the amount of oxygen utilized by working muscles during maximal exercise, whereas fat mass reflects unwanted burden on heart function and oxygen uptake by excited muscle cells. Age group of 16-18 years is not ideal to have perfect weight/height ratio as up to 18 years weight is considered age-matched rather than height matched hence ideal BMI may not be possible in this age group which may be responsible for BMI not correlating with VO_2 max in our study. Hence, this study showed that BMI and BF% should not be taken into consideration for evaluating VO_2 max of the subjects up to the age of 18 years.

Our study was restricted to a small number of adolescent boys and all the boys belonging to a relative narrow age group, i.e., 16-18 years. The population studied was pre-collegiate students, which may not be a representative population. Our future research scope would be involving a number of factors including subjects of all the age groups of male and female, which will give the correct prediction for North Karnataka region. This study may contribute to the research being done by the national and international physical fitness scientists to develop reference data representative of populations. This reference data should be updated regularly to reduce the effect of changing lifestyle and environment.

CONCLUSION

The aerobic capacity (VO_2 max) determination clearly reflects the concept of the capacity, control of oxygen transport, and importance in the assessment of physical fitness. In this study, VO_2 max correlated with BSA and PFI. Increased post-exercise SBP and DBP in Harvard step test shows normal physiological response to exercise. The VO_2 max did not correlate with BF% and BMI as it reflects the amount of oxygen utilized by working muscles during maximal exercise. The VO_2 max did not correlate with BMI because up to 18 years weight is considered as age-matched rather than height matched. Hence, ideal BMI may not be possible in this age group.

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