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Original Research Article

A study on oxygen independent fitness (anaerobic capacity) in pre-collegiate boys of Vijayapur, North Karnataka, India

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ABSTRACT

Background: The anaerobic capacity is a useful concept, its application during exercise testing should considerably increase the information gained regarding cardiovascular function in health and disease. The objective was to evaluate oxygen independent fitness (anaerobic capacity) in pre-collegiate boys (age group of 16-18 years) of Vijayapur, North Karnataka, India.
Methods: Eighty seven young adolescent healthy pre-collegiate boys volunteered for this study. The following parameters were recorded: Physical anthropometric parameters: body surface area, body mass index, body fat percentage, Physiological parameters: Blood pressure, physical fitness index test and anaerobic fitness step test. Correlation analysis and Z tests were used to analyze the obtained data.
Results: Physical anthropometric parameters of the subjects were found within normal range. Statistically significant exercise induced rise in blood pressure were observed in physical fitness step test. Anaerobic capacity was correlated with body surface area, body mass index, body fat percentage and pre and post exercise blood pressure. Physical fitness index was not correlated with anaerobic capacity.
Conclusions: The physical fitness index was in good category, normal physiological response to exercise but physical fitness index not correlated with anaerobic capacity. Anaerobic capacity was found within normal range in pre-collegiate boys of age 16-18 years in study area. Ideal body mass index may not be possible in this age group.

Keywords: Anaerobic capacity, Anaerobic step test, Body mass index, Karnataka

INTRODUCTION

Oxygen independent i.e. anaerobic fitness usually refers to activities, which require large bursts of energy, over short periods of time. Anaerobic state will usually come into play within first 30 second of high intensity exercise. As fatigue sets in, exercise intensity will decrease and the aerobic system takes over until aerobic capacity is reached.[1] Anaerobic threshold may be defined as the workload just below which steady-state exercise can continue for a prolong time.[2] Anaerobic power is defined as peak power output attained in a test of short duration, usually lasting less than / equal to 30 second.[3] Anaerobic capacity is defined as maximal work performed over period of 30 second to 2 minutes.[4] Age and sex, size of the muscle, type of muscle fibers and type of exercise determine the anaerobic capacity. Direct methods for quantification of anaerobic energy yield are presently not available; some sort of indirect methods such as vertical jump test, sprint test, wingate anaerobic test, anaerobic tread mill test, Margaria's step test, anaerobic step test, etc have to be applied when studying the kinetics, power and capacity of these processes.[5] More sophisticated tests are expensive and usually able to detect changes from untrained to moderately trained states but are not sensitive to changes in higher level of fitness.[6] The strength of anaerobic step test is that many people may be tested at one time and is very inexpensive.[7] It is easy to perform for both subjects and operators. India is home to a diverse population playing many different sports across the country.

Cricket is the most popular sport. Football is a popular sport in some of the Indian states. Field hockey is another popular game in India. We designed this study to promote physical activity among pre-colligiate boys (age group of 16-18 years) of Vijayapura (north Karnataka, India) and to evaluate their oxygen independent fitness (anaerobic capacity) with cost effective measures.

METHODS

A randomized controlled study was done in 6 months from July to December 2016 involving 87 pre-collegiate boys of age group of 16-18 years from SECAB P.U. (Composite) College for Boys of Vijayapur (Karnataka, India). The selected subjects were called in the morning hours of the school with a 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 like body surface area (BSA), body mass index (BMI) and body fat percentage (BF%), physiological parameters like systolic blood pressure (SBP), diastolic blood pressure (DBP), physical fitness index test (PFI) and anaerobic fitness 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 independant (anaerobic) fitness test were excluded from the study.

Anthropometric parameters

Body surface area

Body surface area (BSA) in square meters (m^2) was calculated by DuBois nomogram.[8]

Body mass index

Body mass index (BMI) was calculated by using Quetelet's Index formula: Body Weight (Kg)/Height (m^2).[9]

Body fat percentage

Body fat percentage (BF%) was calculated by using the Deurenberg's equation[10] BF% = 1.2 x BMI + 0.23 x Age – 10.8 x Sex – 5.4 (male = 1 and female = 0).

Physiological parameters

Pre exercise blood pressure

The pre exercise blood pressure or resting blood pressure, both systolic (SBP) and diastolic (DBP), was recorded using sphygmomanometer by auscultatory method in mmHg in supine position after three minutes rest.

Post exercise blood pressure

The post exercise systolic (SBP) and diastolic blood pressure (DBP) was recorded in supine position after two minutes of exercise without changing the position of arm cuff and same instrument was used for all the subjects.

Physical fitness index (PFI) test

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 per minute) on a 16 " bench for five minutes duration. Immediately after one minute of exercise pulse rate was recorded for 30 second. Values were fed in given formula to get the PFI scores.

$$PFI = \frac{\text{Duration of exercise (second) x 100}}{\text{5.5 x (Pulse rate from 1-11/2 min)}}$$

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]

Anaerobic fitness step test

This test is performed to evaluate anaerobic power and capacity. It is a good indicator of long anaerobic fitness, because it lasts 60 second.[12] This test is classified as an anaerobic endurance test because its duration is 60 second, exactly where the oxidative metabolism begins to predominate.[13] This test is primarily dependent on the glycolytic pathway for energy and is reliable as it takes into account a straight forward 60 second interval, which can be performed many times at precise level. Strength of this test is that many people may be tested at one time and is very inexpensive. One limitation of this test is that there may not be a correct step height in the vicinity of testing and this may throw off the results.[14]

Step test protocol

Each subject was asked to complete up and down task on a 40cm bench with the dominant leg only as many times as possible in one minute duration (60 second). A step counted each time the subject's support leg was straightened and then returned to the starting position. The numbers of steps were recorded at the end of one minute.

Anaerobic capacity/power (P) was calculated by multiplying subject's weight by the distance covered i.e. height of the step N number of steps and dividing by time (60 second). The anaerobic power was expressed in watts by using the conversion factor 1Kg / sec = 9.81 watts.

$$P\ (\text{watts}) = \frac{F \times N \times D \times 1.33}{t}$$

Where P = Power in watts, F = Force, the weight of the subject (Kg), D = Distance covered i.e. number of steps N step height and t = Time in second, 1.33 (constant) = Factor to convert $^{+}$W (Positive work) to total work.[15]

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 value greater than 3 was considered as statistically significant.

RESULTS

The mean, SD and SEM of BSA, BMI and BF% of individuals are shown in Table 1.

The values of "t", "p", "r" and the relation between BSA vs anaerobic capacity, BMI vs anaerobic capacity and BF% vs anaerobic capacity 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, BMI and BF% are positively correlated with anaerobic capacity (r = 0.709, p<0.001), r = 0.557, p<0.001 and r = 0.549, p<0.001), of the individuals.

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

	Anthropometric parameters			Physiological parameters				Fitness tests	
	BSA (m^2)	BMI (kg/m^2)	BF % (%)	Pre exercise (mmHg)		Post exercise (mmHg)		PFI (Score)	Anaerobic capacity (Watts)
				SBP	DBP	SBP	DBP		
Mean	1.66	19.90	11.63	109.95	69.36	123.79	74.37	103.25	186.25
SD	0.20	3.74	4.61	9.24	6.32	12.62	6.29	16.83	40.74
SEM	0.021	0.402	0.495	0.994	0.680	1.357	0.677	1.810	4.38

BSA, body surface area; BMI, body mass index; BF%, body fat percentage; SBP, systolic blood pressure; DBP, diastolic blood pressure; PFI, physical fitness index; SD, standard deviation; SEM, standard error of mean.

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

Parameters	z	r	t	p
Anaerobic capacity verses BSA		0.709	9.247	<0.001
Anaerobic capacity verses BMI		0.557	6.164	<0.001
Anaerobic capacity verses BF%		0.549	6.038	<0.001
Anaerobic capacity verses pre exercise SBP		0.310	3.001	<0.001
Anaerobic capacity verses pre exercise DBP		0.273	2.606	<0.001
Anaerobic capacity verses post exercise SBP		0.253	2.402	<0.01
Anaerobic capacity verses post exercise DBP		0.198	1.857	<0.05
Anaerobic capacity verses PFI		-0.001	-0.010	>0.05
Pre exercise SBP verses post exercise SBP	10.40	-	-	<0.001
Pre exercise DBP verses 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.

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 was 109.95±0.994 and 69.36±0.680 respectively. The pre exercise SBP (r = 0.310, p<0.001) and DBP (r = 0.273, p<0.001) were correlated with anaerobic capacity 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 was 123.79±1.35mmHg and 74.37±0.677mmHg respectively. The pre exercise SBP (r = 0.253, p<0.01) and DBP (r = 0.198, p<0.05) also correlated with anaerobic capacity of the individuals.

The raised post exercise SBP was statistically significant when compared with pre exercise SBP (z = 10.40, p≤0.001) (Table 2). The raised post exercise DBP was statistically significant when compared with pre exercise DBP (z = 5.23, p≤0.001) (Table 2).

Physical Fitness Index (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 did not correlate with anaerobic capacity (r = -0.001, p>0.05) (Figure 1).

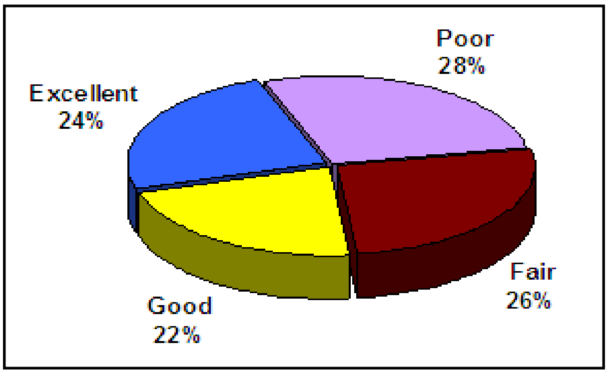
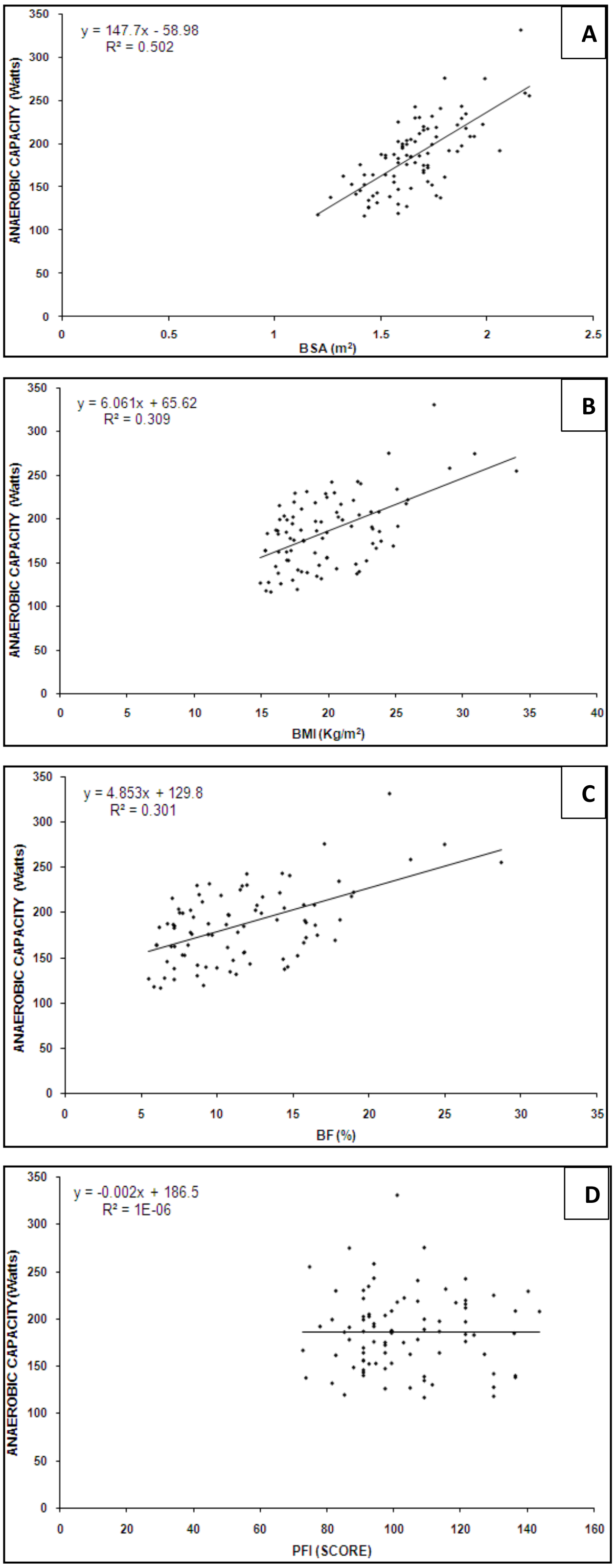


Figure 1: Distribution of the subjects as per PFI scores (n=87).

Anaerobic Capacity / Oxygen independent fitness: The mean, SD and SEM of anaerobic capacity of individuals are shown in Table 1 and the values of “t”, “p” and “r” are shown in Table 2. The mean anaerobic capacity of the subjects in this study was 186.25±40.74. Figure 2 represents the statistical relation between study parameters and anaerobic capacity as follows: The anaerobic capacity correlated with BSA (r = 0.709, p <0.001), BMI (r = 0.557, p < 0.001), BF% (r = 0.549, p <0.001), Pre exercise SBP (r = 0.310, p<0.001), Pre exercise DBP (r = 0.273, p<0.001), Post exercise SBP (r = 0.253, p < 0.001) and Post exercise DBP (r = 0.198, p<0.001). The anaerobic capacity did not correlate with PFI (r = -0.001, p>0.05).



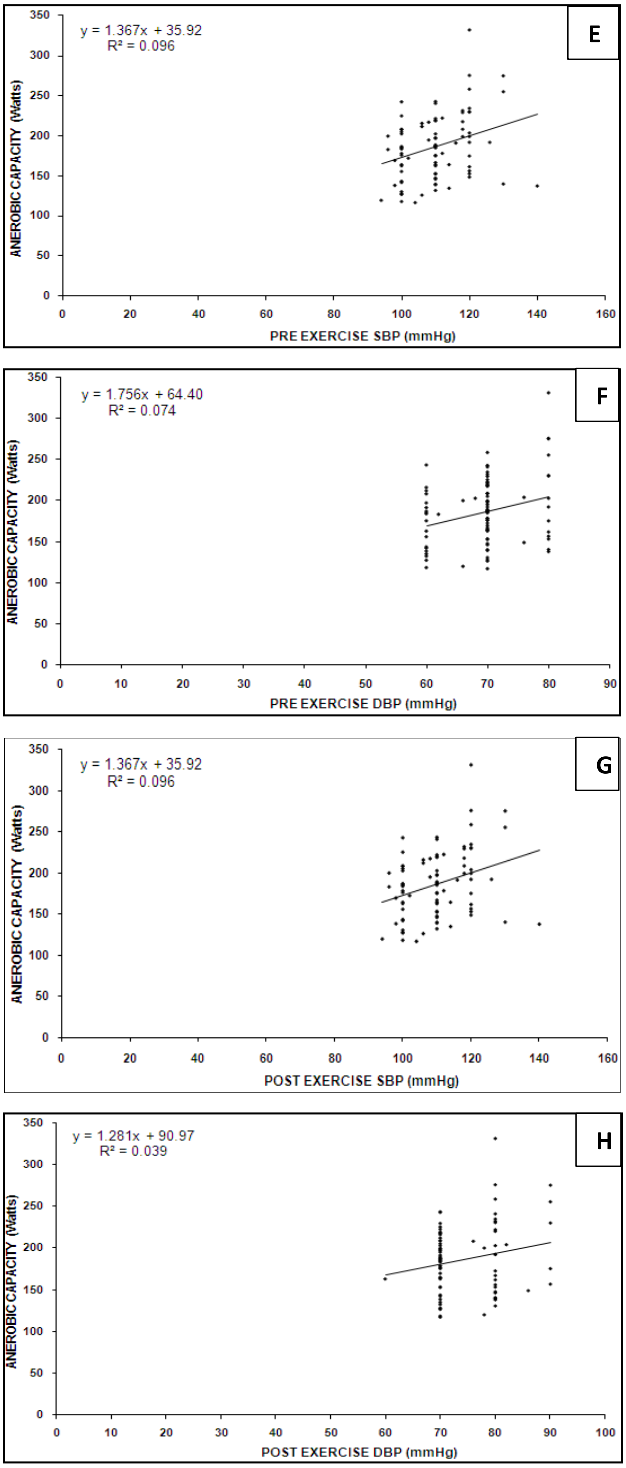


Figure 2: Statistical relation between body surface area (A), body mass index (B), body fat percentage (C), physical fitness index (D), Pre and Post exercise blood pressure (E-H) and anaerobic capacity in the subjects (n=87).

DISCUSSION

Anaerobic capacity is the maximal work performed over a period of 30 seconds to 2 minutes. Anaerobic capacity is characterized by the ability to generate ATP (adenosine triphosphate) through anaerobic (non-mitochondrial) methods. Since anaerobic exercise typically has a short duration of less than 5 minutes and often much shorter, the energy sources used are mainly the Creatine-phospate system (for the first 20 seconds) and the glycolytic pathway (predominates for the first 2 minutes). The creatine-phosphate system relies on the small amount of available stored creatine phosphate to generate ATP stores for immediate use, but since only a small amount is stored, it tends to be depleted quickly, in approximately 20 seconds. The glycolytic pathway kicks in right away and peak near 45 seconds of intense anaerobic exercise.[16] Anaerobic, energy yielding metabolic process play an increasingly greater role if the severity of exercise increases. The aerobic power during exercise can be followed quite accurately by measuring the oxygen uptake. Since we lack a similar tool for direct measurement of anaerobic power, some sort of indirect method have to be applied when studying the kinetics, power and capacity of these processes.[5]

There are protocols proposed with the aim of measuring anaerobic capacity the subject is made to exercise with the highest possible power during 30-60 seconds. On a cycle ergometer and the total work done as well as power developed during the defined time periods are calculated. Certainly anaerobic processes dominate the energy yield, and it can be assumed that a 30-60 seconds work output correlates with the absolute anaerobic capacity. In maximal exercise of short duration the rate of glycogen breakdown is higher. In his review, a researcher presents the maximal power for the lactic mechanism for an average individual.[17] The oxygen equivalent is 75mL/Kg/min with a body weight of 75 Kg the total will be 5.6 L/min and the power as high as 1950 watts. A degradation of one mol glucosyl of the glycogen unit yields energy which can resynthesize 3 ATP. The equivalent amount of glucose only covers the formation of 2 ATP and therefore it is not likely that the glucose is an important substrate during very intense anaerobic exercise. A second advantage with glycogen is that it is stored in the muscle fibers. During short term exercise, there would not be time to transport substrate from the liver and fatty tissues, the muscle must be able to function on their own resources. It is emphasized that there are no methods available for an accurate measurement of the anaerobic power or capacity. Therefore it is possible to evaluate objectively whether or not a specific anaerobic training program is effective or not.[18]

A significant increase in aerobic power and a significant decrease in anaerobic power was observed in previous studies on same setup (i.e. our subject's age, inclusion and exclusion criteria in this study).[19,20]

In other study, in 1993 observed a significant increase in cardiovascular endurance (by Harvard step test) and anaerobic power (by Sargent jump test) as a result of yogic training in forty male high school students aged 12 – 15 years.[21]

A study in 1969, a significant increase in anaerobic energy output in 20 years old boys and girls as compared to 8 years by using Margaria's Staircase sprint. This may be due to an improved technique with age, including greater ability to make use of the elastic properties of the muscles.[22]

Margaria and his group have developed a method by which one can estimate the maximal anaerobic power output.[23] The subjects climb a normal height of stairs and maximal speed taking 2-3 steps at a time. The peak speed is attained within 2-3 second and can be maintained up to the 6th second from then on it declines. From speed, vertical distance climbed and body weight the power output can be calculated. By this method they have obtained values which were about 25% of the peak "external" power reported by Davis and Rennie. The variation were explained by the difference in the two types of exercise, in high jump, it was a matter of one muscular contraction of legs simultaneously, in stair climbing, the values obtain represent an average involving a series of contraction using one leg at a time.

In our study the mean anaerobic power was found 186.25±4.38 watts by anaerobic step test. This value differs from the above workers as they have evaluated the anaerobic power with different techniques, methods and timings. The observed value may serve as control value for this age and in this part of the state (north Karnataka, India). The anaerobic capacity correlated with BSA, BMI, BF%, Pre exercise SBP and DBP and Post exercise SBP and DBP.

A peak is usually reached at the age of 20 for men and a few years earlier for women. According to a researcher[17] the average man is 15-30% superior to average woman in maximal lactic anaerobic power .The correlation of anaerobic capacity with the parameters determining body composition in our study is suggestive of body composition of the subjects within normal range and anaerobic capacity is in the process of reaching towards its peak.

In this study it was also observed that there was no correlation between anaerobic capacity and PFI. The PFI assessed by Harvard's step test. The ground methods for quantification of anaerobic energy yield are presently not available. Although, it is the availability of oxygen in the cell that determines the extent to which the metabolic processes can proceed aerobically or anaerobically.[24]

CONCLUSION

The anaerobic capacity correlated with BSA, BMI and BF%. This may be due to the body composition of these subjects being within normal range. The anaerobic capacity is in the process of reaching towards its peak. The PFI did not correlate with anaerobic capacity may suggest that an individual with higher PFI score need not have higher anaerobic capacity and vice versa. The observed values of anaerobic capacity by using anaerobic step test may serve as control value for this age and in this part of the Indian state.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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