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Determination and comparison of maximum aerobic capacity in terms of physical fitness index and maximum oxygen uptake between physically active and physically non-active male-female students of Tripura

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Abstract

Background: Obesity is one of the major self-regulating risk aspect along with cardio-respiratory fitness, that increases cardiovascular mortality. Physical Fitness Index is a basic measure of muscular strength and muscular endurance and a person can utilize maximum amount of oxygen during maximal exercise is called as VO_2 max. These parameters can be affected by different body composition and by body mass index. Aims and objectives: The foremost purpose of this study is to determine and differentiate the physical fitness index and maximum oxygen uptake (VO_2 max) between physically active and physically non-active students of male-female. Method: Eighty physically active students of male-female and eighty physically non-active male-female students were selected by random sampling. PFI and VO_2 max both were computed by Harvard Step Test and by indirect Queens College Step test (QCT). This is the easy method to determine cardio-respiratory strength in relation with maximum oxygen uptake for each group. Conclusion: In this study, it has been concluded that score of PFI and VO_2 max were significantly greater in physically active students than that of physically non-active male-female students. In addition, it has also been found that physically active males and females show higher PFI and VO_2 max than physically non-active male and female when compared individually. In addition, PFI score of physically active male-female showed a significant moderate and low positive correlation with VO_2 max of physically non-active male-female respectively by individual comparison.

Keywords: PFI, VO_2 max, Harvard Step Test, Queens College Step test.

INTRODUCTION

Physical fitness is one of the health-related components of cardiovascular fitness. It is also a condition of good health and well-being. Cardiovascular fitness measures the transport of oxygen to the muscles by heart, lung and blood vessels. Globally, Cardiovascular diseases are the foremost cause of death. Now-a-days, maximum people are adopted to sedentary lifestyle through which they become overweight and obese. Physical activity is essential for each and every person to overcome these health problems. There are three main aspects of Physical Fitness of a person, Those are dynamic fitness (ability to perform strenuous work), static fitness (absence of disease), and motor skills fitness [1,2]. Among these three, in athletes, the dynamic fitness is very important that can be measured by the Harvard Step Test. Physical Fitness Index is also known as Harvard Step Test. This is a cardiac stress test that measures fitness and recovery after exercise. The test involves step up and down from 16-inch platform for women or a 20-inch platform for men.

VO_2 max is the maximum volume of oxygen that can be applied throughout the maximal or forceful exercise by an individual. This measurement is generally used as a best indicator of aerobic fitness and cardiovascular fitness. The Queens College Step Test is used to evaluate cardio-respiratory fitness in young individuals [3,4]. VO_2 max is significantly related with the active muscle mass which is involved during exercise. High intensity interval training is considered the most effective way to increase VO_2 max and workout that are hard that reach the maximum aerobic limit. VO_2 max is also related with body mass. Individuals with high body mass index may have less VO_2 max and also reduced level of physical performance such as muscle strength, balance ability and mobility increases the risk of cardiovascular illness. Cardiac output is the primary limiting factor in one's VO_2 max. Exercise increases the cardiac output that results increase the body oxygen demands. The heart rate and stroke volume of heart increase linearly with exercise.

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Cardiovascular diseases can be increased by high triglyceride and cholesterol and deprived cardiovascular willingness also reduces life expectancy. Cardiovascular health is determined by VO_2 max. It is important in determining the mortality rate among cardiovascular patients and healthy people [5]. Good habits such as non-smoking, healthy diet and regular exercises are of key factors in anticipation and treating CVDs [6].

A higher PFI and VO_2 max are related to decreased risk factors for heart disease, diabetes and obesity. The Physical Fitness Index (PFI), Body Mass Index (BMI) and Maximum Oxygen Uptake (VO_2 max) are interconnected which collectively provides a comprehensive assessment of an individual's health and fitness. The effect of the exercise improves our circulatory system and it reflects the general capacity of body to deal with increased physical workload and ability to recover from it. The PFI and VO_2 max through targeted exercise programs can contribute to maintaining a healthy BMI and reducing the risk of obesity-related health issues.

Therefore, the current study conducted to determine and compare the Physical Fitness Index and VO_2 max between physically active male-female and physically non-active male-female students. And also this study aims to find the association of BMI with PFI and VO_2 max among both categories.

MATERIALS AND METHODS

Selection of the subject and their criteria

The students were selected within the campus of Tripura University and also from the Ram Thakur college and Ishwar Chandra Vidyasagar college in between the age group of 22-27 years old. The total samples size was 160. Among the total sample, 80 students were male-female of physically active category and remaining 80 were male-female of non- active category respectively and they were selected randomly. The students wore light clothes during experimentation.

Physically active male-female category belong to individuals involved in regular physical activities. Physically non-active male-female category were those individuals who were not involved in physical activities.

Measurement of physical parameters

Before the exercise starts, the subjects name, age and gender was recorded and then height, weight measured by stadiometer and weight machine and body mass index was calculated by using below formula:

$$\text{BMI} = \text{Weight in kilogram} / \text{Height in meter}^2$$

Determination of PFI

Modified Harvard step test can be used to determine PFI. In this test, pulse rate in resting condition was recorded before start of the exercise. Correct procedure of stepping was properly explained to each and every student. Then the students were asked to step up and down on the 16 inch platform or bench for 3 min or until fatigue at a frequency of 20 steps per min. Subjects were asked to take rest for 1min after successful completion of the exercise and then recovery pulse rate was counted. The first reading was counted from 1 min to 1 min 30 sec after the exercise, the second reading was from 2 min to 2 min 30 sec and the third reading from 3 min to 3 min 30 sec after the exercise [7]. Then the Physcal Fitness Index can be computed from the following formula:

- PR1–pulse rate counted from 1-1.5 min.
- PR2 – pulse rate counted 2-2.5 min
- PR3 – pulse rate counted from 3-3.5 min

$$\text{PFI} = \frac{\text{Duration exercise (in sec.)}}{2\,(\text{PR1} + \text{PR2} + \text{PR3})} \times 100$$

Measurement of maximum oxygen uptake (VO_2 max)

VO_2 max was measured by Queens College Step Test. In this test, selected students were permitted to performed a stepping up and down on a height of 16 inch stool for 3 minutes at the frequency of 24 cycles per minute. Cadence can be maintained by a metronome. The carotid pulse rate was measured for 15 seconds after the 5–20 sec recovery period of exercise. Then this 15 second pulse rate was converted into beats per minute. Following are the two equations used for the computation of VO_2 max[8].

In male, VO_2 Max = 111.33 – (0.42 × heart rate) (1)
In female, VO_2 Max = 65.81 – (0.1847 × heart rate) (2)

Statistical analysis

Student's unpaired 't' test was carried out among the physically active and physically non-active male–female students to determine the significant difference between the physical parameters of both the groups at 95% confidence interval and the chosen level of significance at $p<0.05$. Pearson's correlation coefficient is used to determine the association between BMI, VO_2 max and PFI. The scatter plot summarizes the results.

RESULTS

The study was conducted between 80 physically active male-female and 80 physically non-active male-female candidates. Total sample size was 160. VO_2 max and PFI were studied and calculated by using the standard equations. The physical fitness index, physical characteristics, VO_2 max of the subjects were represented in table 1.

PFI scores of each subject in this study were categorized in different ratings. Different grades of PFI of each group was shown as in Table 2.

In the above table, it was found that according to the PFI score, approx. 69% of physically non- active students were found as in 'poor' category of PFI score which was greater compared to that of physically active male-females. Not a single person of non-active students were found as in 'excellent' or 'good' category of PFI score. But where as in active category, approx. 24% were in 'good' category, approx. 13% were in 'excellent' category and only 3% of active students were found as in 'poor' category of PFI score.

Maximum Oxygen Consumption (VO_2 max) of each subject in the current study were categorized in different grades. Different ratings of VO_2 max of each group was shown as in Table 3.

Maximum oxygen uptake of 45% physically active candidates were found as in excellent category of VO_2 max which specifies that they have highest capacity for oxygen consumption compared to that of non-active category in which only approx 8% observed as in excellent category of VO_2 max.

The above table 4 shows the comparative study of PFI and maximum oxygen uptake between the physically active and non-active students of male – female category. From the statistical analysis, it was also detected that physically active male-female students have significantly higher PFI and VO_2 max than that of physically non-active male-female students ($p<0.05$).

In the above table 5, it was found that there is no any linear correlation between the parameters like BMI with PFI & VO_2 max of both active and non-active category respectively. But, a low positive correlation and negligible correlation was found between PFI and VO_2 max of

active and non-active male-female category respectively. And the results were significant at p<0.05.

Pie charts represents the BMI status of both groups which shows that 80% of non-active male-female students and 74% of active students were belong to a normal category of BMI score. Again, 20% of active male & females and 15% of non-active male & females were observed in 'Overweight' category. The 5% of both active & non-active students were as in 'Underweight' category. 1% of active group as observed in Obese category but none of the non-active students were in obese.

For the assessment of correlation between PFI and VO_2 max, Pearson correlation coefficient was computed in both active and non-active category of male and female students separately. It has been observed that active female students and active male students both were shown a moderate positive correlation whereas the non-active females and non-active males shown a low positive correlation when they were analyzed individually and the results were statistically significant (P<0.05). Scatter plot in figure 2 summarizes the results.

Table 1: VO_2 max, PFI and Physical characteristics of both physically active and physically non-active male-female students

Variables	Mean ± SD			
	Physically active male (n=40)	Physically non-active male (n=40)	Physically active female (n=40)	Physically non- active female (n=40)
Age (yr)	24.76 ± 0.73	22.45 ± 0.55	23.3 ± 1.20	22.35 ± 0.80
Height (cm)	166.85 ± 6.23	167.2 ± 4.28	153.18 ± 21.52	157.03 ± 2.68
Weight (kg)	63.63 ±8.61	61.35 ± 6.26	54.3 ± 6.44	58.28 ± 7.39
BMI (kg/m^2)	22.96 ± 2.64	21.92 ± 1.92	22.21 ± 2.64	23.48 ± 2.65
PFI	78.56 ± 15.68	51.37 ± 4.17	72.47 ± 12.81	51.61 ± 3.29
VO_2 max (ml/kg/min)	59.91 ± 6.25	45.02875 ± 6.17	42.98 ± 3.08	36.99 ± 2.53

Table 2: Categorization of PFI score of both physically active and non-active male-female students

PFI ratings	Physically active male-female (n=80)		Physically non-active male-female (n=80)	
	Frequency	Percentage	Frequency	Percentage
Excellent (90 & above)	10	12.5	0	0
Good (80-89)	19	23.75	0	0
Average (65-79)	48	60	25	31.25
Poor (below 55)	3	3.75	55	68.75

Table 3: Different grades of VO_2 max of both physically active and non-active male-female students

Maximum Oxygen Uptake (VO_2 max) (ml/kg/min)	Physically active male-female (n=80)		Physically non-active male-female (n=80)	
	Rate	Percentage	Rate	Percentage
Extremely poor (<35)	0	0	0	0
Poor (35 – 38.3)	10	12.5	25	31.25
Fair (38.4 – 45.1)	23	28.75	34	42.5
Good (45.2 – 50.9)	11	13.75	15	18.75
Excellent (>51)	36	45	6	7.5

Table 4: Comparative study of physical fitness index (PFI) and maximum aerobic capacity (VO2 max) among physically active and physically non-active students of male-female

Category of subjects	PFI	t score	p value	VO_2 max by QCT	t score	p value
Physically active male-female	75.52 ± 14.56	$0.625*10^{-16}$	P<0.05 (significant)	51.49 ± 3.73	$0.124*10^{6}$	P<0.05 (significant)
Physically non-active male-female	51.44 ± 9.82			41.01 ± 6.19		

Table 5: Association of BMI with PFI & VO_2 max in active & non-active category of male & female through correlation coefficient

Subject	Parameters	Correlation Coefficient (r)	Standard Error (SE)	t value	p-value (p <0.05)	Remarks
Active male & female	BMI & PFI	0.12	0.61	1.09	p > 0.05	NS
	BMI & VO_2 max	0.05	0.41	0.45	p > 0.05	NS
	PFI & VO_2 max	0.44	0.06	4.42	p < 0.05	S
Non-active male & female	BMI & PFI	-0.05	0.17	-0.45	p > 0.05	NS
	BMI & VO_2 max	-0.15	0.28	-1.34	p > 0.05	NS
	PFI & VO_2 max	0.22	0.18	2.01	p < 0.05	S

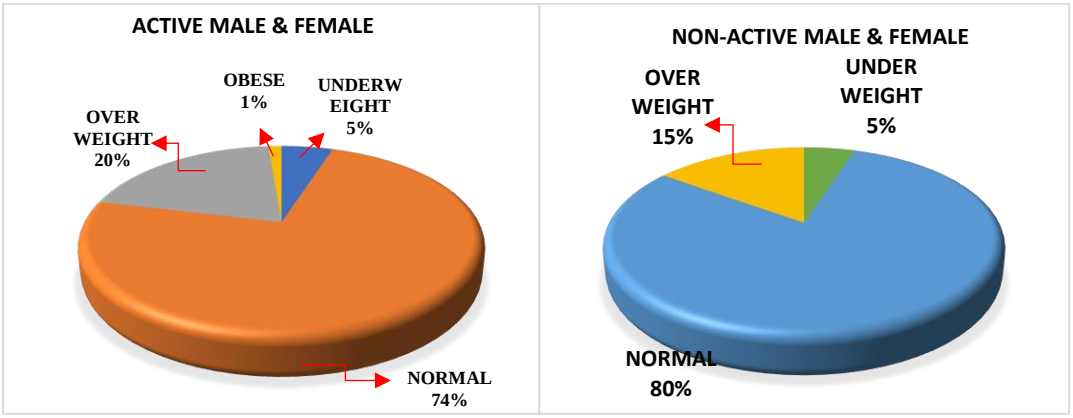

Figure 1: BMI status of A) active male & female students & B) Non-active male &female students

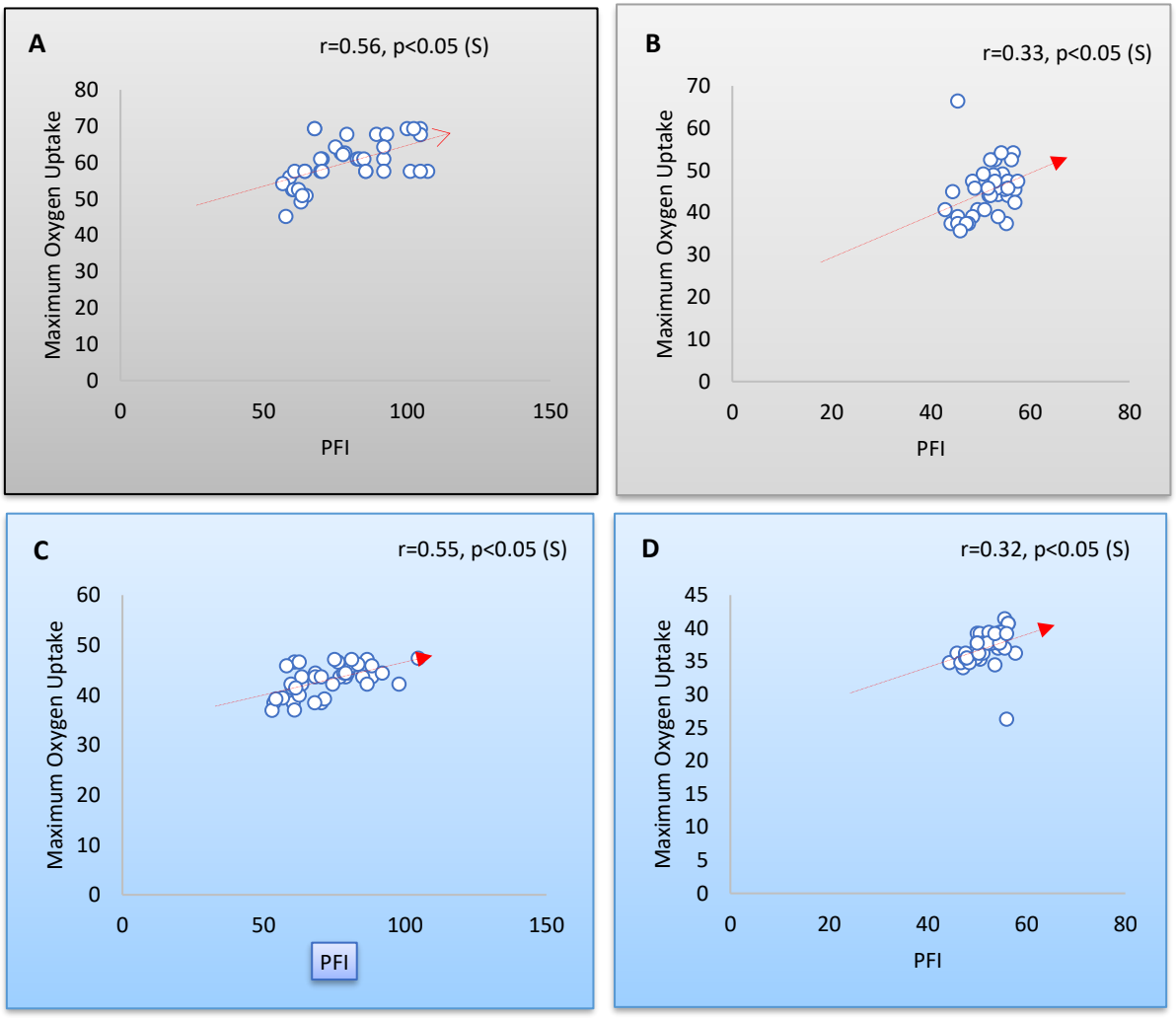

Figure 2: Representation of correlation between PFI and VO_2 max through Scatterplot **A.** Active male, **B.** Non-active male, **C.** Active female, **D.** Non-active female.

DISCUSSION

The present study conducted on male & female students of Tripura University and also from the Ram Thakur College and Ishwar Chandra Vidyasagar College within the range of age group 22-27 years old between physically active & non-active students. Size of total sample was 160 (active 80 & non-active 80).

In the present investigation, cardio-pulmonary parameters included are Physical Fitness Index and Maximum Oxygen Uptake (VO_2 max). In addition, BMI is a vital indicator to assess a person is overweight, obese, underweight or normal. The body becomes less sensitive, when a person turned out to be more obese, more restricting the scope of daily activities. This study has been shown that the physical parameters (age, height, weight, BMI) did not significantly differ between the physically active and non-active male-female students. It has been found that maximum percentage of active and non-active students were observed as an 'normal' category. 20% & 15% of active and non-active were in 'overweight' and only 5% of each active and non-active were observed as 'underweight' category of BMI status. Again 1% of active category were found as 'obese' but none of the non-active were obese.

The Harvard Step Test is used to be predict cardiovascular fitness (endurance) from the rise of heart rate during modest exercise as it is a submaximal fitness test. Aerobic capacity or maximum oxygen uptake capacity (VO_2 max) have been extensively measured to be reliable and effective measure of cardio-respiratory fitness [9]. Approx. 69% of non-active male-female candidates have PFI at 'poor' level. This poor or low category of physical fitness is due to lack of awareness of fitness level among non-active male-female students. But where as 60% of active male-female were as in 'average' category of PFI. Similarly, 45% of active male-female were in 'excellent' category of VO_2 max but only 7% of non-active were observed as 'excellent' category which was comparatively very low.

Between PFI and VO_2 max, there observed a significant difference between both the categories respectively. Statistically, it was found that Physically active male-female students have significantly higher PFI and VO_2 max than that of physically non-active male-female students and they were statistically significant at $p<0.05$. The increase in type II muscle fibers and decrease in type I muscle fibers in physically non-active students, which may have effect on reduced oxygen uptake. Due to altered sympathetic activity, the non-active students have higher resting heart rate and because of this, they are not able to recover the pulse rate quicker and the active students have greater PFI because they are capable to extend the duration of their physical activity while having a faster pulse rate recovery. Similar study was conducted by Arsha Krishnan et al., (2022), they observed that PFI was found to be higher in athletes than non-athletes and this was statistically significant ($P<0.05$) [10].

In this present study, Body Mass Index has no any significant association with PFI and VO_2 max of both the categories. But there was a significant low positive correlation and negligible correlation was found between PFI and VO_2 max of active and non-active category of male-female. In addition, there was a moderate positive correlation found in active male and active female when computed correlation coefficient individually and low positive correlation found between PFI and VO_2 max of non-active male and non-active female category respectively.

CONCLUSION

Daily physical activity leads to numerous cardio-pulmonary adaptations that can significantly increase the fitness levels of a person. The non-active students were not involved in daily physical activities, which can leads to unhealthy lifestyle. Regular physical exercise has a incredible influence on BMI, which in turn significantly affect the cardio-respiratory efficiency. In this study, it has been concluded that Physical Fitness Index (PFI) and Maximum Oxygen Uptake (VO_2 max) was significantly higher in active male-female students compared to that of non-active male-female. In addition, it has also been concluded that there was a moderate & low positive correlation found between PFI & VO_2 max of active & non-active category of male and female category individually but there was no any correlation found between BMI with PFI & VO_2 max of both active and non-active students by combination. This observation may be owing to the small sample size. Thus, it is necessary to investigate these parameters by increasing the sample size number in future investigation, so that we can find the association of BMI with PFI and VO_2 max between both categories of active and non-active male-female students.

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Conflict of interest

The authors reports no conflicts of interest.

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