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Relationship between body mass index and cardiorespiratory fitness to interpret health risks among sedentary university students from Northern India: A correlation study

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ABSTRACT

Background: Obesity has been linked to a higher risk of developing cardiovascular diseases (CVD). The risk of CVD outcomes appears to be stratified by cardiorespiratory fitness (CRF). The study's goal was to determine the relationship between university students' Body Mass Index (BMI) and CRF.

Methods: BMI and anthropometric measurements of sedentary male (n = 25) and female (n = 18) voluntary physiotherapy students, aged 18–25 years were taken. Pre- and post one minute (post1) and post 5 minutes (post2) six-minute walk test measurements of CRF—including respiration rate (breath per minute), oxygen saturation (in percentage), pulse rate (beat per minute), and blood pressure (mm Hg) were taken. The total distance (in meters) travelled in six minute (6MWDm) was recorded and entered into the formula: Vo2max = −9.824 + (0.072 x 6MWDm).

Results: Males and females had median (IQR) values of BMI (20.75 and 22.15 kg/m^2) and Vo2max (27.07 and 24.84 ml/kg/min) respectively. The data was divided into four groups based on body mass index categorization in relation to Vo2max, with negative coefficients of correlation in underweight (−0.18), overweight (−0.26), and obese (−0.33), and positive coefficients of correlation in normal (0.24) individuals. Wilcoxon signed rank test revealed post1 and post2 readings of respiration rate, oxygen saturation, pulse rate and systolic blood pressure were significantly higher than pre readings ($p < 0.05$).

Conclusion: High obesity rate, weak cardio respiratory fitness and negative relationship between BMI and VO2Max indicate necessity of regular aerobic activities to improve health status among University students.

1. Introduction

Body Mass Index (BMI) is divided into four categories according to Asian classification: Underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23–24.9 kg/m^2), and obese 1 (≥25–29.9 kg/m^2).[1,2] BMI classification of obesity in individuals younger than 50 years of age has been strongly linked with multi-morbidities in later stages of life. Obesity tends to compromise disease-free survival.[3] Certain environmental influences such as lesser physical activity, consumption of trans fats, co-morbidities, diabetes, hypertension, heart and endocrine disorders, malignancies, and so on, adversely impact body weight and increases body mass index.[4] The BMI of an individual is crucial in determining probable future health difficulties, and the maintenance of a normal range is an amenable target for a healthy living.[4] Transition to higher education has often seen an unfavourable shift towards unhealthy behaviours and increased weight gain,[5] with college and university students particularly susceptible to sedentary behaviour. Young adults may generally be motivated to be in good health, with educational institutions and student welfare organisations encouraging them to participate in a variety of physical activities. University students, according to a study, are both sedentary and active.[6] Quarantine during coronavirus pandemic has encouraged people to stay at home and work smarter, rather than going outside or to the gym. Due to the restriction on daily purchasing, quarantine may be

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Table 1
Demographic statistics of Age, Height, Weight, BMI, Vo2max and Distance covered in 6 min walk test of participants (n = 43).

Demographic Data	Median (IQR 25 to 75 percentile)
Age(years)	22.00(21.00–23.00)
Height(cm)	167.00(160.00–176.00)
Weight(kg)	58.00(55.00–71.00)
BMI (kg/m^2)	21.64(19.39–24.16)
Vo2max(ml/kg/min)	25.81(23.94–28.91)
Distance (m)	492.00(469.00–526.00)

Abbreviation -BMI: Body mass index, IQR: Interquartile Ranges, cm: centimeter, m: meter, Kg: kilogram.

linked to an unhealthy diet, deficient in fresh foods such as fruits and vegetables and high in processed goods. Obesity and sleep disruption are known to be linked to a poor diet, typified by excessive fat and low fiber intake.[7] Cardiorespiratory fitness (CRF) is the ability to deliver oxygen to the mitochondria of the skeletal muscle for the synthesis of energy required during physical activity. Peak alveolar oxygen uptake (Vo2max) is widely used in experiments to determine maximum aerobic power during incremental exercise until volitional exhaustion.[8] The characterization of maximum aerobic power or Vo2max may be used to examine cardiorespiratory fitness of an individual. Vo2max is affected by genetics, physical activity, gender, age, and body composition.[9] The present study aims to evaluate the body mass index, cardiorespiratory fitness as well as subsequent correlation between these two variables among sedentary physiotherapy students in a regional university of Haryana, India. Early analysis of the situation will help to raise awareness among young individuals to create a healthier lifestyle amending predisposing factors of obesity. It may also help in the creation of evidence-based strategies to alleviate the difficulties associated with obesity, particularly in young adults.

2. Methods

2.1. Study design and participants

A strobe based cross sectional survey was conducted between October 2021 and April 2022. The observational study measuredVo2max (ml/kg/min) and BMI (Kg/m^2) of physiotherapy students aged 18–25 years of a university in Haryana, India. The study was accepted and approved by the student project committee of Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be) University, Mullana, Haryana, India (2021/1818023). Participants suffering from musculoskeletal disorders, cardiovascular illness, systolic blood pressure >140 mmHg, or diastolic blood pressure <60 mmHg, respiratory disease, or those unable to fully follow the instructions were excluded from the study. The participants with self reported sedentary lifestyle were included. Due to the COVID-19 lockdown situations, the physical presence of physiotherapy students was restricted. Hence from an initial survey of potential 65 participants, 43 participants who volunteered for this study were included and an informed consent was obtained.

2.2. Testing protocol

All participants were assessed and tested by a professional physiotherapist. The testing was carried out on a 100 ft (30 m) indoor track with hard ground that was marked at regular intervals. The 6-min walk test was used to evaluate the Vo2max (ml/kg/min) of the subjects. The total distance (in metres) travelled in 6 min was recorded and placed into the formula: Vo2max = −9.824 + (0.072 6MWDm),[10] and height and weight of the subjects for this study were acquired and entered into the body mass index formula: the BMI is calculated as weight (in kg)/height (in m) squared.

2.3. Measurements

Participants were encouraged to dress comfortably and wear walking shoes. Prior to testing, all participant baseline data was collected, including age (in years), height (in cm), weight (in kg), pulse rate (beats per minute), respiratory rate (breaths per minute), blood pressure (mm Hg), and oxygen saturation (in percentage) measured. Readings of the same variables were taken at 1 min (denoted by post1) and 5 min (denoted by post2) post completion of test.[10]

2.4. Statistical analysis

The baseline characteristics were presented using SPSS software, and the normality of all data was confirmed using the Shapiro-Wilk test. The Spearman's test was used to get the correlation coefficient "ρ" between BMI categories and Vo2max values. The Wilcoxon signed rank test was used to compare Respiratory Rate, Pulse Rate, Oxygen Saturation, Systolic Blood Pressure, and Diastolic Blood Pressure between pre reading and post reading (1) and post reading (2).

3. Results

3.1. Demographic details of participants

The students recruited for the study were all from the same institute, hence the sample was homogeneous. The demographic data of the students has been described in Table 1. The data was not normally distributed as determined by the Shapiro-Wilk test (p value below 0.05).[11]

Table 3
Spearman correlation test between BMI and VO2Max in Male and Female Participants.

Participants	Variable	Median (IQR)	ρ value	P value
Male = 25 (58.1%)	BMI	20.75(18.82–24.01)	−0.33	0.81
	VO2max	27.07(24.74–33.93)		
Female = 18 (41.9%)	BMI	22.15(19.65–24.27)	−0.29	0.21
	VO2max	24.84(23.65–27.27)		

P < 0.05 show as significant.
ABBREVIATION –IQR: Interquartile ranges.

Table 2
Spearman correlation test between BMI values and VO2Max of participants.

Category	Asian classification of BMI	No. of student	Median (IQR) of BMI (kg/m^2)	Median (IQR) of Vo2max	ρ value	P value
Group one	<18.5	4	18.01(17.36–18.29)	29.52(25.81–35.49)	−0.18	0.20
Group two	18.5–22.9	21	19.78(18.89–21.43)	25.09(23.07–27.43)	0.24	0.29
Group three	23–24.9	5	23.38(23.20–23.47)	34.38(25.23–39.97)	−0.26	0.55
Group four	25–29.9	13	25.82(24.36–29.56)	25.45(24.04–29.09)	−0.33	0.44

*Spearman test, p < 0.05 as significant.
Abbreviation – IQR: Interquartile Ranges, ρ: correlation of coefficient.

Table 4
Comparison of pre reading and post reading (1) variables among male and female participant.

Sno.	Participants	Variables	Median (IQR 25,75) 95% C.I.	Skewness	Kurtosis	Z value	PValue
1	Male	RR pre reading	17.00(17.00–18.00)	0.573	−0.40	−4.39	<0.01*
		RR post reading (1)	24.00(22.50–24.50)	−0.29	−0.78		
2	Female	RR pre reading	17.00(16.00–18.00)	1.245	1.95	−3.74	<0.01*
		RR post reading (1)	23.00(22.00–24.25)	−0.23	−0.58		
3	Male	PR pre reading	85.00(73.50–88.50)	0.00	−0.78	−4.37	<0.01*
		PR post reading (1)	97.00(85.00–106.00)	0.02	−1.39		
4	Female	PR pre reading	88.00(85.00–92.00)	−0.44	0.01	−3.72	<0.01*
		PR post reading (1)	103.00(99.00–110.50)	−0.27	−0.28		
5	Male	OS pre reading	98.00(97.50–98.50)	0.24	0.52	−3.57	<0.01*
		OS post reading (1)	99.00(98.00–100.00)	−0.66	−0.55		
6	Female	OS pre reading	98.00(98.00–99.00)	−0.49	0.74	−3.34	<0.01*
		OS post reading (1)	99.00(99.00–100.00)	−0.52	−0.93		
7	Male	BP pre reading SBP	122.00(116.00–129.00)	−0.54	−0.65	−4.26	<0.01*
		BP Post reading (1) SBP	133.00(126.00–139.00)	−0.06	0.94		
8	Female	BP pre reading SBP	114.50(110.00–118.75)	0.23	−1.05	−3.72	<0.01*
		BP Post reading (1) SBP	125.00(120.00–129.25)	−0.07	−0.90		
9	Male	BP pre reading DBP	79.00(75.00–82.50)	0.55	−0.20	−3.31	<0.01*
		BP post reading (1) DBP	84.00(78.50–89.00)	0.553	−0.70		
10	Female	BP pre reading DBP	74.00(69.50–78.75)	−0.10	−0.56	−3.72	<0.01*
		BP post reading (1) DBP	84.00(79.25–86.75)	−0.07	−0.51		

*WILCOXON SIGNED RANK TEST, P < 0.05 as significant, **ABBERVATION:** CI- Confidence Interval, IQR: Interquartile Range, RR: Respiratory Rate, PR: Pulse Rate, OS: Oxygen Saturation, BP: blood pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure.

Table 5
Comparison of pre reading and post reading (2) variables among male and female participant.

Sno.	Participants	Variables	Median (IQR 25,75)95% C.I.	Skewness	Kurtosis	Z value	P Value
1	Male	RR pre reading	17.00(17.00–18.00)	0.573	−0.40	−3.71	<0.001
		RR post reading (2)	20.00(18.00–20.50)	0.04	−0.90		
2	Female	RR pre reading	17.00(16.00–18.00)	1.245	1.95	−3.16	0.002
		RR post reading (2)	18.50(18.00–19.25)	0.30	0.45		
3	Male	PR pre reading	85.00(73.50–88.50)	0.00	−0.78	−2.62	0.009
		PR post reading (2)	88.00(76.00–92.00)	−0.10	−1.25		
4	Female	PR pre reading	88.00(85.00–92.00)	−0.44	0.01	−3.16	0.002
		PR post reading (2)	92.00(88.75–96.25)	0.45	0.56		
5	Male	OS pre reading	98.00(97.50–98.50)	0.24	0.52	−3.30	0.001
		OS post reading (2)	99.00(98.50–99.00)	−0.78	0.28		
6	Female	OS pre reading	98.00(98.00–99.00)	−0.49	0.74	−2.35	0.018
		OS post reading (2)	99.00(98.00–99.00)	0.38	−0.90		
7	Male	BP pre reading SBP	122.00(116.00–129.00)	−0.54	−0.65	−2.22	0.026
		BP Post reading (2) SBP	127.00(121.00–130.50)	−0.39	1.34		
8	Female	BP pre reading SBP	114.50(110.00–118.75)	0.23	−1.05	−2.35	0.019
		BP Post reading (2) SBP	118.50(111.50–121.25)	0.09	−1.00		
9	Male	BP pre reading DBP	79.00(75.00–82.50)	0.55	−0.20	−0.80	0.422
		BP post reading (2) DBP	78.00(74.50–86.50)	0.53	−0.57		
10	Female	BP pre reading DBP	74.00(69.50–78.75)	−0.10	−0.56	−1.63	0.102
		BP post reading (2) DBP	77.00(73.50–80.25)	−0.44	1.18		

*WILCOXON SIGNED RANK TEST, P < 0.05 as significant, **ABBERVATION:** CI- Confidence Interval, IQR: Interquartile Range, RR: Respiratory Rate, PR: Pulse Rate, OS: Oxygen Saturation, BP: blood pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure.

3.2. Reading of variables

Table 2 describes the Spearman's correlation test between the classification of BMI and Vo2max. The value of p was greater than 0.05 in four groups, indicating that there was no significant correlation; the value of ρ in group two showed a positive coefficient of correlation (0.24). The relationship between BMI and Vo2max in male and female participants showed inverse relationship using Spearman's correlation test. However the value of p was greater than 0.05, indicating that no significance exists between the variables (Table 3).

In Tables 4 and 5 Wilcoxon signed rank was utilised to compare variable readings among male and female participants from pre-readings to post-readings (1) and pre-readings to post-readings (2) in RR, PR OS, SBP, and DBP. The p value in RR, PR, OS, and SBP was less than 0.05, indicating that post-readings (1) and post-readings (2) were significantly higher as compared to pre-reading values separately; however DBP had a p value more than 0.05, indicating no significant difference between pre- and post-values.

4. Discussion

In the present study the convenience sampling technique[12] was used to recruit the physiotherapy students to evaluate correlation between their BMI and cardio-respiratory fitness. The results of the study showed higher obesity rate, weak cardio respiratory fitness anda negative relationship between BMI and Vo2max among University students. Health consequences of obesity or overweight remain challenging to maintain. Health related physical fitness, including body composition, and cardio-respiratory fitness of otherwise healthy looking adults should be regularly monitored for necessary early interventions. Demographic characteristics of 43 participants were analysed using descriptive statistics (Table 1).

4.1. Correlation between BMI and Vo2max

All subjects were divided into four groups based on BMI classification. Twenty one (48% of total participants) individuals were found to be within normal BMI range while 13(30%) were categorized as obese according to the Asian classification of BMI. Rest 4 (10%) and 5 (12%) were underweight and overweight respectively. Young adults are at a particular risk of transitioning to an overweight or obese BMI category.[13] An association was established between BMI and Vo2 max within each of the four categories. Weak negative coefficients of correlation in group 3 and group 4indicatedthat as BMI values increased in the category of overweight and obese, capacity of O_2 uptake was relatively low[14,15]; while positive coefficients of correlation in group 2 indicating that BMI raise within normal ranges has positive influence on O_2 uptake (Table 2). A relatively higher number of individuals belonging to overweight and obese category raises concern as Asian population differs from western populations in terms of mean body mass and increased risk of developing co-morbidities at the same body weight. Hence a lower cut off for overweight and obese category compared to World Health Organization BMI classification is set.[16]

4.2. Gender specific relationship between BMI and VO2Max

The Spearman's correlation test between BMI and Vo2max values in males ($\rho = -0.33$) and females ($\rho = -0.29$), with $p > 0.05$ indicated statistically non significant data (Table 3). The overall Vo2 max values in present study indicated poor cardiorespiratory fitness among both male and female participants. A prior study conducted in 2015 used the Queen's College step test to assess cardio-respiratory fitness among medicos (18–24 years old), with females found to be more physically fit than their male counterparts. The majority of females (36.6%) were in the excellent and good categories, as compared to males (36.4%) in the fair group. Physical fitness was discovered to be inversely associated to BMI. Heart rate was also found to be inversely related to cardiorespiratory fitness.[17]

4.3. Difference between pre and post reading of variables

In both male and female participants, the variables that showed a significant difference from pre-readings to post-readings (1) (Table 4) and pre-readings to post-readings (2) (Table 5) were respiratory rate, oxygen saturation, pulse rate and systolic blood pressure. Wilcoxon sign rank test was used to examine the data and the p value less than 0.05 indicated that even post 5 min of 6MWT the vital signs were not able to return to resting levels, indicating poor cardiorespiratory fitness among individuals. Researches indicate that prolonged time ($\geq$3 min) taken to return of heart rate to resting levels post 6MWT is an independent predictor of cardiac events among heart failure patients.[18]

The strength of the current study is that researchers have used digital methods to analyse the readings and the procedure is convenient and carried out in very a less amount of time. There are a few limitations in the study as the sample size is less due toCOVID-19 restrictions, so the researchers were unable to collect more samples. The study only focused on the age group of 18–25 years among physiotherapy students but it is suggested to discover more in each age group and in normal population as well.

5. Conclusion

The current investigation reported an inverse association between BMI and Vo2max among male and female individuals. Breathing and cardiac output have an impact on Vo2max, which measures total body oxygen consumption. Sedentary lifestyle lowers the lungs' ability to improve ventilation, affecting Vo2max.[19] Present study revealed students at the college of physiotherapy had a high frequency of obesity and overweight and lower cardiorespiratory fitness. This makes it even more important to promote a healthy lifestyle, nutritious eating habits, and physical activity to prevent consequences from obesity.[20]

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Declaration of competing interest

None.

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