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Original Article

Effect of body mass index on cardiorespiratory parameters among medical students: a cross-sectional study

Helly Shah[1], Snehalata Mali[2], Surbhi Ranga[3], Charushila Jadhav[4], Atul Rukadikar[5], Amit Kant Singh[6], Geeta Shamnani[7]

[1]ZMCH, Dahod, Gujarat, India; [2]Department of Physiology, MIMSR Medical College, Latur, Maharashtra, India; [3]Department of Physiology College of Dental Science & Research Centre, Ahmedabad, Gujarat, India; [4]Department of Physiology, AIIMS, Gorakhpur, Uttar Pradesh, India; [5]Department of Microbiology, AIIMS, Gorakhpur, Uttar Pradesh, India; [6]Department of Physiology, Uttar Pradesh University of Medical Sciences, Saifai, Etawah Uttar Pradesh, India; [7]Department of Physiology, Atal Bihari Vajpayee Government Medical College, Vidisha, India

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Abstract: Background: Obesity is a global crisis due to its significant contribution to mortality and morbidity. This study discovered an association between body mass index (BMI) with pulmonary function tests (PFTs) and aerobic capacity (VO_2 max) in medical students of Zydus Medical College and Hospital, Dahod, Gujarat. Aim: The study aimed to determine the effect of obesity on cardiopulmonary health of medical students. Objectives: The study objectives were as follows: 1. To compare PFT parameters and VO_2 max between obese and non-obese students. 2. To study the correlation of BMI with PFTs and VO_2 max. Material and methods: BMI was calculated with the formula BMI = weight/height^2. PFTs were assessed with computerized spirometry. Aerobic capacity was calculated with Astrand 6-minute Cycle Test. Statistical analysis was done with unpaired t-test. Results: This study found a significant difference in forced vital capacity (FVC), forced expiratory volume in 1 minute (FEV_1), slow vital capacity (SVC), maximum ventilatory volume (MVV), and VO_2 max between obese and non-obese students ($P<0.05$). There was a positive correlation between BMI and forced mid-expiratory flow (FEF_{25-75}), peak expiratory flow rate (PEFR), MVV, SVC, expiratory reserve volume (ERV), and MVV and negative correlation with FVC, FEV_1, lung age, and VO_2 max in non-obese students. There was also a positive correlation between BMI and PEFR, SVC, FVC, FEV_1, lung age, MVV, ERV, and a negative correlation with FEF_{25-75} and VO_2 max in obese students. Conclusion: As BMI is inversely related to cardiopulmonary function, students having high BMI can be motivated toward a healthy lifestyle.

Keywords: BMI, cardiopulmonary function, PFT, VO_2 max

Introduction

Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health [1]. Obesity, typically quantified in terms of Body Mass Index (BMI) exceeding threshold values, is considered a leading cause of premature death worldwide [2]. It can be derived from the formula BMI = Weight (kg)/Height (m)^2. According to WHO, BMI is used to classify nutritional states, as BMI<18.5 is an indication of being underweight, 18.5-24.9 of being normally nourished, and BMI>30 of being obese [3].

Earlier studies have revealed that obese people are often exhausted by regular work even if they do not have any pulmonary diseases [4]. A pulmonary function test (PFT) is one of the basic and essential tests for the assessment of pulmonary status. Some researchers have reported a substantial reduction in the forced vital capacity (FVC), forced expiratory volume in 1 minute (FEV_1), and peak expiratory flow rate (PEFR) in adolescent boys with high BMI status. Jones and Nzekwu analyzed 373 patients and found that BMI had a significant negative effect on lung volume or expiratory reserve volume (ERV) [5]. Fung et al. show that BMI had a posi-

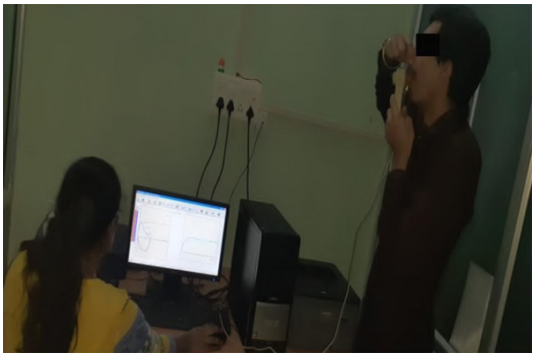

Figure 1. Performing spirometry test.

tive correlation with respiratory function in girls among 1586 healthy children [6].

Physical fitness is considered to be a degree to be able to execute a physical task under various ambient conditions. Aerobic capacity, muscular endurance, flexibility, and body composition are important components of physical fitness [7]. VO_2 max is the maximum volume of oxygen consumed in one minute during maximal exercise. The measurement of VO_2 max is useful to analyze the fitness status of a person considering cardiovascular risk. Subjects can be educated by knowing the VO_2 max status [8]. A study among healthy subjects of 18-22 years of age showed a negative association between VO_2 max and the BMI documented [9].

We conducted this study and found a correlation of BMI and PFT parameters and VO_2 max in obese and non-obese medical students of Zydus Medical College, Gujarat. Medical students face the burden of study pressure and new environment, so they do not pay much attention to their health, which leads to affected cardiopulmonary health.

Material and methods

The present study is a descriptive cross-sectional study carried out in the clinical laboratory of the department of Physiology after being approved by the Institution Ethical Committee (ZMCH/IEC/ICMR/STS-004/2019, Dated 26/04/2019) in April 2019-October 2019.

We selected healthy medical students, between 18 and 21 years of age, with informed consent, and subjects who were free from cardiopulmonary disease. We excluded subjects having a history of smoking, tobacco chewing, and alcohol consumption, those with a major

Figure 2. Performing spirometry test.

respiratory or cardiovascular illness, and those who were on regular medication affecting the cardiopulmonary system. Sample size was calculated with the Open Epi software. Prevalence of obesity in medical students taken from previous study was 11.5%, and allowable error was 5% [10]. We found a minimum sample size of N=78. A total of 167 medical students (more than the minimum sample size) was selected. These students were divided into two groups according to BMI (obese: BMI>30 and non-obese: BMI<24.9). We used the t-test for the comparison, the Pearson correlation coefficient for correlation, and SPSS Version 16.0 for statistical calculations.

The anthropometric assessment was done as per Anthropometry Procedures Manual Guidelines [11]. BMI was calculated through the formula BMI = weight/height^2.

VO_2 max was calculated with the Astrand 6-minute Cycle Test (**Figure 3**). Subjects were instructed for warm-ups for 10 minutes after the demonstration. We did the setting of cycle work rate as 125, 115, and 85 for male students with weights below 35 kg, 35-55 kg, and over 55 kg, respectively. The cycle work rate was set as 115, 85, and 60 for female students with

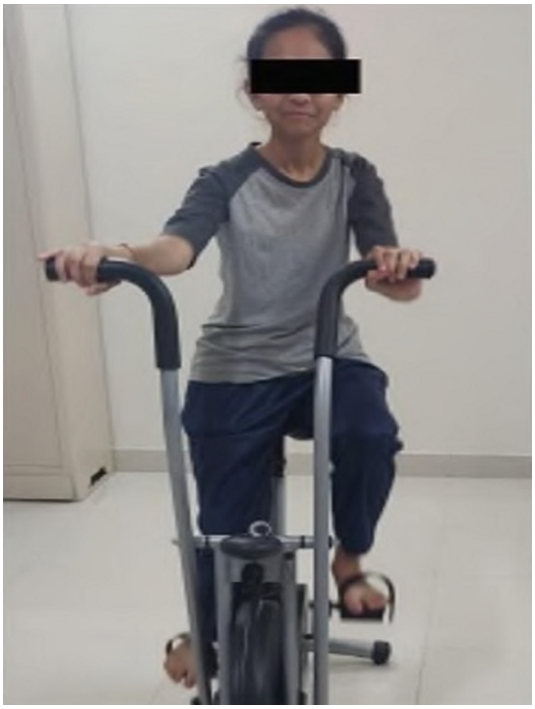

Figure 3. Performing bicycle ergometry test.

weights below 35 kg, 35-55 kg, and over 55 kg, respectively. This setting raised the subject's heart rate to 130-160 bpm after 2 minutes of cycling at 60 rpm. With the command "GO", we started the stopwatch. We instructed the subject to pedal at 60 rpm for 6 minutes and recorded the subject's heart rate each minute. If the target heart-rate range of 130-160 bpm was not achieved after 2 minutes, we adjusted work rate wattage. We stopped the test after 6 minutes and recorded the final work rate wattage. Then we calculated VO_2 max with the Astrand-Rhyming nomogram [12].

We used computerized spirometry for measuring PFT (**Figures 1**, **2**) and informed the subject about the procedure. We closed their nostrils with a nose clip to allow air to flow only through the mouth. Then we performed the PFT maneuver as per the standard guidelines. We instructed the subject to first breathe in deeply to measure the FVC. Then the subject was asked to expel air quickly through the transducer and breathe in quickly. We instructed the subject to breathe regularly through the mouthpiece to measure the SVC. After each deep inhalation and exhalation, they were asked to take a few gentle, normal breaths. We also instructed them to breathe deeply and quickly through the mouthpiece for 15 seconds constantly to measure the MVV.

Results

1. There was a significant difference in FVC, FEV_1, SVC, MVV, and VO_2 max between non-obese and obese students, and no significant difference was observed in forced mid-expiratory flow (FEF_{25-75}), PEFR, and ERV.

2. There were positive correlations between BMI and FEF_{25-75}, PEFR, MVV SVC, ERV, and MVV and a negative correlation between BMI and FVC, FEV_1, lung age, and VO_2 max among non-obese students.

3. We found a significant positive correlation between BMI and PEFR, SVC, FVC, FEV_1, lung age, MVV, ERV, and MVV and a negative correlation between BMI and FEF_{25-75} and VO_2 max among obese students.

Discussion

Obesity leads to various clinical complications such as diabetes, vascular diseases, and osteoarthritis. Yet, limited attention has been given to the effect of obesity on the respiratory system [13]. In this study, we attempted to determine the effect of obesity on cardiorespiratory function.

We found statistically significant differences in FVC, FEV_1, SVC, and MVV between non-obese and obese medical students (**Table 1**). Statistically, there was no significant difference observed in FEF_{25-75}, PEFR, and ERV between non-obese and obese medical students. This may be because of fat accumulation around the ribs, abdomen, and diaphragm, which causes restricted movement of ribs, reducing lung volume and decreasing respiratory compliance [14]. Increased adiposity has been associated with increased levels of cytokines, such as interleukin 6 and tumor necrosis alpha, and decreased levels of adiponectin, thereby increasing the level of systemic inflammation, which in turn negatively affects lung function [14]. In healthy subjects, the primary factors that affect PEFR are the strength of the expiratory muscles generating the force of contraction, the elastic recoil pressure of the lungs, and the airway size [15]. In case of obesity, the function of respiratory muscles is impaired from the increased resistance they must over-

Table 1. Comparative study of PFT and VO_2 max in obese and non-obese medical students

Parameters	Non-obese	Obese	t value	*P* value
	Mean ± S.D	Mean ± S.D		
FVC	2.30±0.53	2.66±0.77	-3.47	0.001**
FEV_1	2.30±0.53	2.65±0.75	-3.42	0.001**
FEF_{25-75}	4.43±1.17	4.61±1.15	-0.98	0.328
PEFR	5.56±1.40	5.16±1.56	1.7	0.087
SVC	2.83±0.66	3.27±0.84	-3.7	0*
ERV	0.77±0.57	0.80±0.76	-0.3	0.762
MVV	86.6±26.64	94.26±21.23	-2.01	0.046*
VO_2 Max	43.8±8.68	19.15±10.18	16.8	0*

*Statistically significant (P<0.05). **Statistically highly significant (P<0.01).

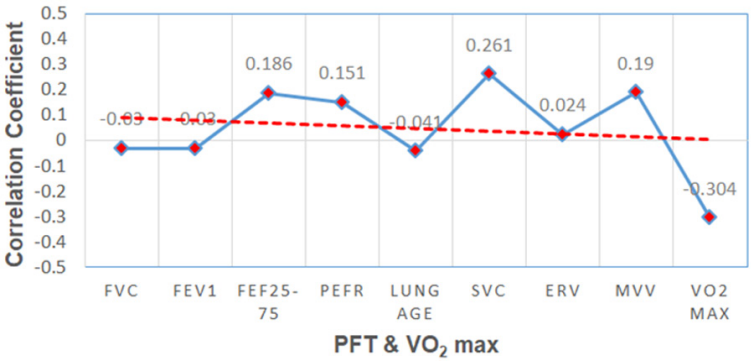

Figure 4. Correlation between BMI with PFT and VO_2 max in non-obese medical students.

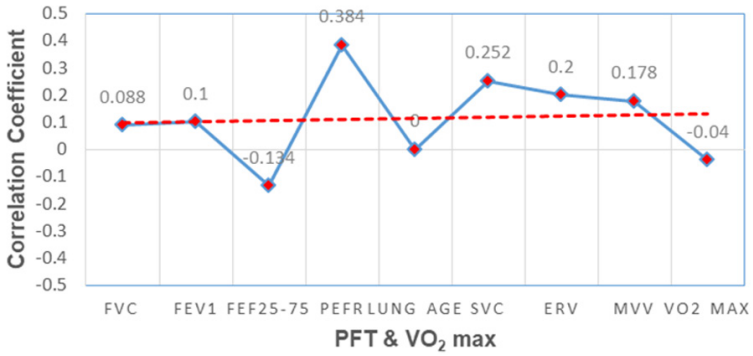

Figure 5. Correlation between BMI with PFT and VO_2 max in obese medical students.

come and from the reduced capacity of these muscles [16]. Similar results have been found by earlier studies [17-22]. Another study found that VO_2 max was reduced in obese compared to non-obese students [23]. In conclusion, we found that increased BMI harms cardiorespiratory function.

There was a positive correlation between BMI and FEF_{25-75}, PEFR, SVC, ERV, and MVV and a negative correlation with FVC, FEV_1, lung age, and VO_2 max (**Figure 4**) among the non-obese medical students. There was also a positive correlation between BMI and FVC, FEV_1, PEFR, SVC, Lung age, ERV, and MVV and a negative correlation with FEF_{25-75} and VO_2 max (**Figure 5**) among the obese medical students.

As shown in **Table 2**, earlier studies showed a positive correlation between BMI and FVC and FEV_1, FEF_{25-75}, MVV, and PEFR [24] and negative correlation of BMI with FVC, FEV_1, and PEFR [25, 26]. Some studies also showed a negative correlation of BMI with VO_2 max [27, 28]. In obese individuals, there was an increase in Type II muscle fibers and a decrease in Type I muscle fibers, which may affect reduced oxygen uptake. Furthermore, there may be changes in the cardiovascular functions in severely overweight individuals. This showed that the greater the BMI, the more severe will be functional impairment. During exhaustive exercise, the excessive hyperactive body musculature fails to uptake a sufficient amount of oxygen due to the deposition of a proportionately high amount of fat mass [28].

Conclusion

Medical students often face severe stress due to the new environment and new curriculum. To cope with studying, they pay less attention to physical activity, which leads to being overweight as well as obesity and affects their cardiopulmonary function. Awareness programs should be planned for the affected population to prevent further complications. As per the new compe-

Table 2. Previous publications related to association of BMI, PFT and VO_2 max

Author	Study	Reference
Kharodi C (2019) Kohli PG (2017)	PFT parameters like FVC, FEV_1, $FEF_{25-75\%}$, PEFR, MVV were increased in obese than non-obese	[17, 18]
Chandrashekhar N (2018) Sgariboldi D (2016) Santana H (2001)	Decrease in FVC, FEV_1, PEFR, MVV was found to be significantly lower in obese compared to non-obese	[19-21]
Pandit R (2017) Ghosh A (2017)	VO_2 Max was reduced in obese than non-obese	[22, 23]
Kharodi C (2019) Nowreen N (2018)	Positive correlation of BMI with FVC & FEV_1, FEF_{25-75}, MVV, PEFR	[17]
Santana H (2001) Yaqub BI (2015) J Banerjee (2014)	Negative correlation of BMI with FVC, FEV_1, PEFR	[21, 25]
Laxmi CC (2014) Pandit R (2017) Ghosh A (2017) Dhara S (2005) Chatterjee S (2005)	Negative correlation of BMI with VO_2 Max	[22, 23, 27-29]

tency-based medical education, sports hours are allotted for medical students. This will be helpful for the improvement of their cardiopulmonary status. However, more initiatives should be taken at school, college, village, district, state, and national levels. Only then will the purpose of "Prevention is better than cure" be served.

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Disclosure of conflict of interest

None.

Address correspondence to: Charushila Jadhav, Department of Physiology, AIIMS, Gorakhpur, Uttar Pradesh, India. Tel: +91-9689865748; E-mail: charuruks11@gmail.com

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