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Original Article

Comparison of Mean VO_2 max in normal Weight, Overweight and Obese Students of a Local Medical College Using Analysis of Variance

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Abstract

Background: VO_2 max is considered as a marker for evaluation of cardiovascular fitness and is measured by exercise tests such as treadmill or cycle ergometer. Body mass index has a major influence on the maximal oxygen capacity of an individual as estimated by VO_2 max.
Objective: To compare the mean VO_2 max in normal weight, overweight and obese students selected from a local medical college.
Study design, settings and duration: This cross-sectional study was conducted in the Department of Physiology of a local medical college in the suburbs of Karachi from 25th November 2016 to 31st July 2017.
Subjects and Methods: A total of one hundred and two, both male and female medical students were selected. Body mass index was calculated after measuring the height and weight of each individual. Bruce Protocol treadmill test was used to measure the VO_2 max. Descriptive statistics applied for continuous variables depicted mean age as 20±1.23 years. According to the BMI classification for Asian population, study subjects were divided into three groups.
Results: Mean BMI for normal, overweight and obese individuals was reported as 21.05±1.01 kg/m2 and 24.10±1.06 kg/m2 and 28.43±0.06 respectively. Mean VO_2 max for individuals with normal weight was found to be 55.29±9.27ml/kg/min. In overweight and obese students, mean VO_2 max was reported as 49.35± 5.24ml/kg/min and 46.24±6.34ml/kg/min respectively. Comparison of means for VO_2 max and body mass index was found to be significantly lower (p <0.05) among all the three groups. Gender differences of VO_2 max showed remarkable difference with increased maximal oxygen consumption reported in males compared to females.
Conclusion: In conclusion, VO_2 max was significantly lower in normal weight, overweight and obese students. Therefore, improvement in aerobic fitness can be attained by reduction in body mass index.
Key words: VO_2 max, body mass index, bruce protocol, exercise.

Introduction

Cardiovascular disease burden is on the rise and a leading cause of mortality worldwide. Increase in the body mass index i.e; overweight and obesity pose a major risk for developing cardiorespiratory illness.[1]

According to recent studies, morbid illness in both healthy and non-healthy persons can be predicted by the maximal oxygen consumption that determines the cardiorespiratory endurance.[2] Related to the various functional mechanisms of the body, cardiorespiratory refers to the uptake and transport of oxygen, while the musculoskeletal system is involved in the maximum utilization of oxygen. Therefore, physical exercise by treadmill or ergometry is an indirect measure of VO_2 max.[3,4]

While performing an exercise, oxygen deficit limits its performance and it is the VO_2 max that measures the aerobic endurance of an individual to offset that limitation. Multiple factors influencing the VO_2 max include the physical activity, gender, cardiorespiratory and skeletal muscle functions.[5] Due to increased amount of fat

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mass, there is less uptake of oxygen by the musculoskeletal system during incremental exercise. However, with the reduction of weight, improvement in VO_2 max was found. This is due to the fact that, in obesity there are reduced numbers of type I muscle fibers compared to type II muscle fibers leading to less uptake of oxygen in these individuals.[6-8] It has been reported that physiologically, males have 20-25% greater VO_2 max compared to females due to their increased lean body mass and reduced total fat mass.[9]

In this study, VO_2 max is measured following the Bruce Protocol in which the individual performs the exercise test on the treadmill and both its speed and incline is made to increase after every three minutes. The length of time on the treadmill is the test score and can be used to estimate the VO_2 max value.[10] The main aim of this study was to compare the means of VO_2 max among normal weight, overweight and obese individuals.

Subjects and Methods

A total of one hundred and two medical students were included in this cross-sectional study by purposive sampling. The study was conducted in the department of Physiology of a local medical college in Karachi from 25th November 2016 to 31st July 2017 after research committee approval of Liaquat National Hospital & Medical College.

Total sample size was estimated as 180 using the open epi sample size calculator with prevalence rate of obesity reported in Pakistan as 25% [11] and CI=95%. Written informed consent was taken from each participant prior to the start of the study.

Inclusion criteria: Both healthy male and female undergraduate medical students, between 19-23 years.

Exclusion criteria: Past history of cardiorespiratory illness such as congenital heart disease, known asthmatics and females on any hormonal medications.

The World Health Organisation (WHO) defines weight status according to body mass index (BMI), the ratio of weight (in kilograms) divided by height (in meters square).[12]

Weight and height of each student was measured using the standard stadiometer. The body mass index was calculated, from an individual's weight in kg divided by the square of the height in meters [5] using the following formula:

Body mass Index (BMI) = weight (Kg)/ Height (m^2).

According to WHO BMI classification for Asian population,[12] students were divided into normal (18.5-22.9 kg/m^2), overweight (23-24.9 kg/m^2) and obese (≥25 kg/m^2) groups.

The selected students were instructed to prevent from any exertion 24 hours prior to the treadmill test. They were also asked to refrain from coffee intake four hours before the Bruce test.

To assess $\dot{V}O_2$ max, the participants completed a continuous incremental exercise test to voluntary exhaustion on a calibrated treadmill. The participants started exercising on a calibrated treadmill (Ranker Model; RT-18400) at a speed of 2.7 km/h and an incline of 10% gradient for 3 minutes according to Bruce Protocol. Speed and inclination were subsequently increased after every three minutes until voluntary exhaustion was reached.[10,13]

The Bruce Protocol Formula for estimating VO_2 max:

Males

Men: VO_2 max (ml/kg/min) = 2.94 x T + 7.65

Females

Women: VO_2 max (ml/kg/min) = 2.94 x T + 3.74

T = Total time on the treadmill measured as a fraction of a minute (ie: A test time of 9 minutes 30 seconds would be written as T=9.5).[13]

Statistical analysis of the data was done on SPSS version 21 software. Continuous data were expressed as means and standard deviation. Mean values for age, body mass index and VO_2 max were calculated through descriptive statistics. One way analysis of variance (ANOVA) was done to compare the means of VO_2 max in normal, overweight and obese groups. Post-hoc analysis by Tukey's test was done to evaluate the significant difference between the three groups. *p*-value at less than 0.05 was considered as statistically significant.

Results

A total of 102 gender and age matched, undergraduate medical students were recruited to participate in the study for VO_2 max estimation using the Bruce test. Mean age depicted was 20±1.23 years and mean BMI of normal, overweight and obese individual was reported as 21.05±1.01 kg/m^2 and 24.10±1.06 kg/m^2 and 28.43±0.06 respectively. Mean VO_2 max for individuals with normal weight was found to be 55.29±9.27 ml/kg/min., overweight and obese groups had mean values of 49.35±5.24 ml/kg/min and 46.24±6.34 ml/ kg/min respectively.

Table 1: Descriptive statistics of continuous variables.

Variables	*Mean± SD*		
	Normal Weight (n=40)	*Overweight (n=32)*	*Obese (n=30)*
BMI(kg/m^2)	21.05±2.01	24.10±1.06	28.43±0.06
VO_2 max (ml/kg/min)	55.29±9.27	49.35± 5.24	46.24±6.34

* BMI: Body mass index, VO_2 max: Maximal oxygen consumption, SD: standard deviation

ANOVA and Post-hoc analysis showed significant mean differences of VO_2 max with the body mass index in all the three groups (p <0.05) as in Table-2. Gender differences of VO_2 max showed remarkable difference with increased maximal oxygen consumption reported in males compared to females as shown in Table-3.

Table 2: Comparison of means of VO_2 max and BMI groups using ANOVA.

BMI Groups	*N=102*	*VO_2 max Mean ±SD (ml/kg/min)*	*S.E*	*p-value*
Normal weight (18.5-22.9 kg/m^2)	40	55.29±9.27	4.20	
Overweight (23-24.9 kg/m^2)	32	49.35± 5.24	3.83	0.0001
Obese (≥25 kg/m^2)	30	46.24±6.34	3.21	

Table 3: Gender differences of mean VO_2 max.

Groups N=102	Mean ±SD (VO_2 max) ml/kg/min	*p*-value
Male (52)	57.25±6.30	0.0001
Female(50)	42.24±2.22	

Discussion

In the present study, mean VO_2 max was estimated and compared with the body mass index in normal weight, overweight and obese students. Lack of regular physical activity and sedentary behavior leads to increased risk of cardiovascular ailments, obesity, diabetes mellitus, cancer, and early death. Recent studies have predicted a lethal association of prolonged total sedentary time with multiple chronic diseases and mortality outcomes.[14,15] Lee et al has reported that among the various factors that pose a major risk for cardiovascular co-morbidities, VO_2 max has been established as one of the independent risk factor leading to cardiovascular mortality.[16]

In the present study, mean VO_2 max was compared in normal weight, overweight and obese individuals. Students with increased fat mass or body mass index (overweight and obese), were reported to have decreased VO_2 max leading to reduced levels of physical fitness compared to normal weight participants. This was in agreement with the study conducted by Bandyopadhyay et al in which females with body mass index ≥25 kg/m^2 had reduced VO_2 max.[8] According to the researcher, decreased cardiorespiratory fitness was reported due to the fact that exceess deposition of fat had imposed a hindering effect in obese girls.[8]

Furthermore, a study conducted by Mondal et al, was also consistent with our study stating that an increase in BMI and body fat percentage has led to diminished levels of VO_2 max in young adults.[17]

The present study showed significant mean differences of VO_2 max between male and female participants. This was in agreement with the Perez-Gomez, Rodriguez et al. study who found that muscle consumes the greatest amount of oxygen during an endurance activity and since males have greater muscle mass compared to females, increased VO_2 max has been reported in them. According to a study by Nindl et al, the percentage of total fat in women is higher and the percentage of total lean tissue in men is greater. All these factors contribute to the inherent decreased muscle mass in females compared to males and thus the VO_2 max.[18,19]

Several limitations regarding this study were lack of measurement of clinical cardiorespiratory correlates such as heart rate, blood pressure, respiratory rate, etc and their association with VO_2 max. More large scale studies are needed to elucidate the effect of aerobic endurance on VO_2 max and create awareness about the importance of physical exercise among the young population.

In conclusion, results from this study indicate that body weight has a great impact on VO_2 max of an individual. Thus, reduction in body weight can lead to marked improvement in aerobic endurance of overweight and obese students.

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Conflict of interest: None declared.

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