Effect of body mass index on cardiorespiratory fitness in young healthy males

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Background: Low cardiorespiratory fitness in young adults has emerged as an important factor for developing cardiovascular comorbidities later in middle age. Increased body fatness as predicted by body mass index is an additional factor for developing cardiovascular diseases.

Objective: The objective of this study was to determine the cardiorespiratory fitness in terms of VO_2 max in young healthy males and to study the relation between body mass index and cardiorespiratory fitness.

Methodology: One hundred young healthy male subjects in the age group of 18 to 22 years were included in this study group. Body mass index was measured as weight (in kilograms) divided by height (in meters) squared. Cardiorespiratory fitness in terms of VO_2 max was assessed by following the protocol of Queen's College Step Test (QCT).

Results: There was a significant negative correlation between body mass index (BMI) and VO_2max (ml/kg/min) ($r = -0.48$, $p<0.01$).

Conclusion: The results suggest the striking effect of body fat on cardiorespiratory functions. Excessive amount of body fat exerts an unfavorable burden on cardiac function and oxygen uptake by working muscles. Low cardiorespiratory fitness in young adults with increased body fat could be a factor for developing cardiovascular comorbidities later in middle age.

Index Terms: VO_2max, QCT, body mass index, cardiorespiratory fitness

I. INTRODUCTION

Cardiovascular diseases are a leading cause of mortality and morbidity worldwide. The prevalence of cardiovascular disease (CVD) has increased substantially over the past few decades in younger population. Unfavorable cardiovascular risk profiles are found in youth with low levels of cardiovascular fitness and high percentage of body fat. Numerous clinical studies have established a strong association between low cardio respiratory fitness and mortality (1, 2, 3). Numerous risk factors for CVD including hypertension, diabetes and hypercholesterolemia are suspected to be influenced by fitness (4, 5) and these factors may mediate the association between low cardiorespiratory fitness and mortality. Cardiovascular diseases account for a large proportion of mortality in adults older than 45 yrs (6). Maximal oxygen uptake (VO_2max) is the highest rate of oxygen consumption attained during maximal or exhaustive exercise. VO_2max is internationally accepted parameter to evaluate cardio respiratory fitness (7).The use of direct method to measure VO_2max is restricted because of its exhausting and difficult experimental protocol and absence of well-equipped laboratory. Earlier studies have established the use of Queen's College Step Test to predict VO_2max indirectly (8).Obesity is an independent risk factor for cardiovascular disease. Energy dense cheap foods, labor-saving devices, motorised transport and sedentary work in the present time has led to obesity. Obesity can be assessed in several ways. Measurements of body weight (anthropometry) are used to reflect body fat in clinical settings as these measurements provide rapid and cheap way to estimate body fat (9). Earlier studies have demonstrated the importance of low cardio respiratory fitness in young adulthood as a factor for developing cardio respiratory comorbidities later in middle age (10). This study is designed to evaluate cardio respiratory fitness in terms of VO_2max and its relation with body mass index in young healthy male subjects.

II. MATERIAL AND METHODS

The study group comprised of 100 young healthy males in the age group of 18 to 22 yrs.

1. **Inclusion criteria**
   a. Males
   b. Age between 18-22 yrs
   c. Otherwise healthy
2. **Exclusion criteria**
   a. Male subjects below 18 and above 22yrs
   b. History of cardiac disease
   c. History of lung disease
   d. Smoking
   e. Not on regular medications affecting cardiovascular and respiratory system
   f. Not undergoing any physical conditioning programme.

100 apparently healthy male subjects in the age group of 18-22 yrs from Kolar town were selected for the study. They were asked to fill a questionnaire to assess their physical activity status (11). The experimental protocol was fully explained to the participants to allay apprehension. They refrained from any energetic physical activity for 2 to 3 hours before the test.

Informed consent was taken from all the subjects. The study was approved by institutional Ethical Committee.

Experimental Design

Data was collected by calculating body mass index and assessing VO_2max indirectly by Queen's college Step test. Weight was measured using calibrated weighing machine in light clothing and bare feet and height was measured using measuring scale in centimeters which was fixed to the wall. Body mass index was calculated using Quetlet's index:BMI=Weight (kg) / height (m^2).

Queen's College Step Test

Step test was performed using a stool of 16.25 inches (41.30cms) height. Stepping was done for a total duration of 3 minutes at the rate of 24 cycles per minute which was set by a metronome. After completion of the exercise the subjects were asked to remain standing comfortably and the carotid pulse rate was measured from the 5^{th} to 20^{th} second of recovery period. This 15 second pulse rate was converted into beats per minute and the following equation was used to predict VO_2max.

VO_2max (ml/kg/min) = 111.33 - (0.42 x pulse rate in beats per min)

All experiments were performed at room temperature.

Statistical Analysis

The results were expressed as mean ± standard deviation (SD). A p value of < 0.05 was considered statistically significant. Statistical Analysis was done by using Statistical package of social & sciences. Pearson correlation was used to correlate BMI and VO_2max (ml/kg/min).

III. RESULTS

100 young healthy males in the age group of 18-22 years(19.38 ± 1.49yrs) were subjected to Queen's College Step Test. Cardio respiratory Fitness in terms of VO_2max was evaluated and then the effect of Body mass index (22.04± 3.96 kg/m^2) on cardio respiratory Fitness was studied. There was a significant negative correlation between BMI and VO_2max (ml/kg/min), (r=-0.48, p<0.01) (table 1). There was a significant positive correlation between BMI and QCT pulse rate (bpm), (r=0.63, p<0.01) (table 2).

Table 1. Correlation between BMI and VO_2max

	Variable	VO_2max
BMI	r	-0.48
	p	<0.01

Figure 1. Scatter diagram showing the relationship between BMI and VO_2max

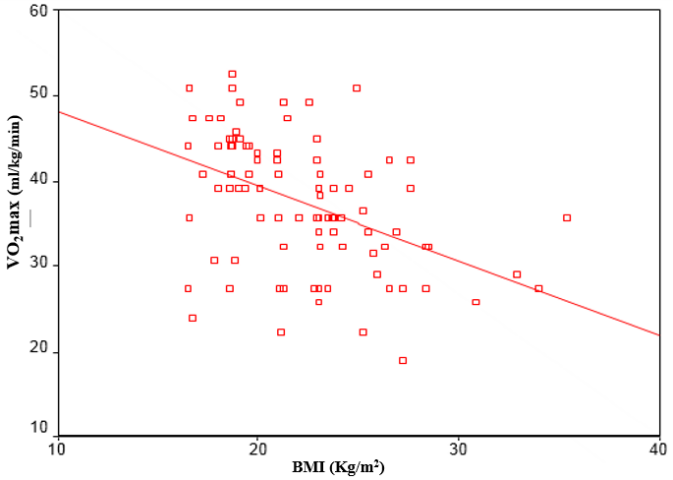
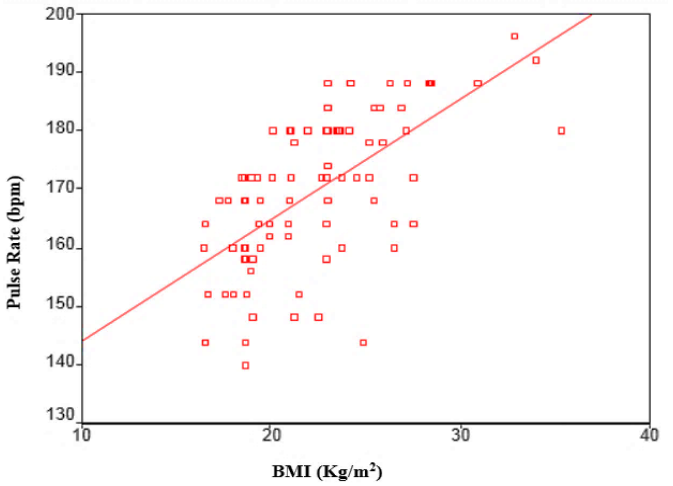


Table 2. Correlation between BMI and QCT pulse rate

	Variable	QCT Pulse rate
BMI	r	0.63
	p	< 0.01

Figure 2. Scatter diagram showing the relationship between BMI and QCT pulse rate



IV. DISCUSSION

VO_2max is a measure of the functional limit of cardio respiratory system and single most valid index of maximal exercise capacity. The absolute value of VO_2max is one of the indices of an individual's cardiorespiratory fitness to transport oxygen to working muscles. Earlier studies have used VO_2max values in ml/kg/min to assess the level of cardio respiratory fitness.

Chatterjee et alin 2005 used Queens College step test in their study to assess cardiorespiratory fitness in obese and non-obese boys aged 10-16 yrs and it was found that VO_2 max per kg of body weight was relatively less in obese subjects indicating reduced aerobic capacity.They concluded that during exhaustive exercise, the excessive hyperactive body musculature fails to

uptake sufficient amount of oxygen due to deposition of proportionately high amount of fat mass (12). It was found that during of weight reduction program in obese, their VO_2max (ml/kg/min) increased due to withdrawal of fat induced inhibitory action toward oxygen utilization by body musculature (13). In obese individuals there is increase in type II muscle fibers and decrease in type I muscle fibers which may have important effect on reduced oxygen uptake.Bandyopadhyay A studied cardiorespiratory fitness in obese girls and found that VO_2max was less in obese girls. This was probably due to hindering effects imposed due to excess deposition of fat (14). P Setty et al 2012 in their study used treadmill exercise test in adults and found that there was negative correlation between obesity and cardiorespiratory fitness (15). Similar results were observed by Welch et al (16), Ozcelick et al (17) & Rowland et al (18).

Norman et al in2005 studied influence of excess adiposity on exercise fitness and performance in overweight children and adolescents by cycle ergometry fitness test and found that overweight and non-over weight adolescents had similar absolute cardiorespiratory fitness but the functional impairment was significantly associated with increased energy demands needed to move their excess bodyweight (19). Several previous studies have found no significant differences in VO_2max between obese and non-obese. Patkar and Joshi in 2011 compared CRF between obese and non-obese subjects and concluded that cardiorespiratory efficiency was not affected in obese group as compared to normal weight group, however ability to do exhausting work was less in obese (20).

In this study we found a significant negative correlation between BMI and VO_2max (ml/kg/min) ($r= -0.48$, $p<0.01$). This indicates the striking effects of increasing BMI on Cardio respiratory fitness. This is in line with the findings of the earlier studies (12-15).

Chatterjee et al reported significantly higher value of peak heart rate during QCT in obese group which indicates greater cardiac load among them. Overweight individuals have increased sympathetic nerve firing rate than normal subjects. Obesity results in a state of chronic volume overload because heart is required to pump blood through large and relatively low resistance depot of adipose tissue. Increased preload and stroke volume is associated with hypertension. Overweight and hypertension leads to thickening of ventricular wall and larger heart volume and thus greater likelihood of cardiac failure.

In this study we found a significant positive correlation between BMI and QCT pulse rate during Queen's college step test ($r=.63$ & $p<0.01$).

V. CONCLUSION

In this study, there was a significant negative correlation between BMI and VO_2max (ml/kg/min) which suggests possible effect body fat on cardiorespiratory functions. It also demonstrates the importance of low cardiorespiratory fitness in young adults with increased body fat which could be a factor for developing cardiovascular comorbidities later in middle age. BMI can be used in clinical settings to estimate body fat as it is a rapid and inexpensive method. Queen's College Step Test is a valid method for the estimation of VO_2max in young males. Additional study including detailed measurement of cardiac function is needed to clarify whether cardiac impairment (or initial stages of impairment) exists. Given the current obesity trend and observations of a decline in daily energy expenditure among the people, improving cardiorespiratory fitness in young men by engaging in physical activities is important.

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