

Cardiorespiratory Fitness and its Relationship with Adiposity Indices

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ABSTRACT

Introduction

The cardiorespiratory fitness (CRF) and obesity greatly influence the cardiovascular health. Decrease in maximal oxygen consumption ($VO_2\text{max}$) and increase in fat mass can be used as an early marker for cardiovascular disease risk. The objective of this study was to assess the CRF and observe the relationship between CRF and adiposity indices.

Methods

A cross sectional observational study was performed in 174 students (87 males and females each) of National Medical College. The subjects were assessed for different adiposity indices; BMI, body adiposity index (BAI), total body fat percentage (BF %) and waist circumference (WC). $VO_2\text{max}$ was calculated from recovery pulse rate after Queen's College Step Test. $VO_2\text{max}$ was correlated separately with each parameter of body composition using Pearson's correlation test.

Results

The $VO_2\text{max}$ of male and female participants were 47.22 ± 9.09 and 35.67 ± 5.36 ml/kg/min respectively. The correlation of $VO_2\text{max}$ was significant with all the studied adiposity indices. WC ($r = -0.41$, $p < 0.001$) and BF% ($r = -0.38$, $p < 0.001$) correlation with CRF was highly significant in male whereas in female correlation was highly significant with BMI ($r = 0.49$, $p < 0.001$), WC ($r = -0.40$, $p < 0.001$) and BF% ($r = -0.56$, $p < 0.001$). $VO_2\text{max}$ correlated best with waist circumference in male ($r = -0.41$, $p < 0.001$) and BF% in female ($r = -0.56$, $p < 0.001$).

Conclusion

This study concludes that there is an adverse relationship between CRF and adiposity indices and females have low level of cardiorespiratory fitness.

Keywords

Body adiposity indices, cardiorespiratory fitness, Queen's college step test, total body fat percentage

INTRODUCTION

Cardiorespiratory fitness (CRF) is the combined ability of respiratory and circulatory system to provide oxygen to the active muscles. It is measured in terms of maximal oxygen consumption ($VO_2\text{max}$). $VO_2\text{max}$ is the maximum rate at which the person can consume oxygen during strenuous physical activities.¹ $VO_2\text{max}$ can be measured in laboratory by use of tread mill, cycle ergometer or stepping stools like Queen's college step test and Harvard step test.² Factors influencing $VO_2\text{max}$ are physical activity, gender, age, ethnicity and body composition. Cardiac output, ability of respiratory system to deliver oxygen and oxygen utilization by muscle also alter $VO_2\text{max}$.^{2,3}

Non skeletal solid portion of body is composed of fat and muscle. Increase in fatty tissues has various adverse effects. Excess adipose tissue is inversely related with CRF. Excess adiposity diminishes CRF and both are positively related with cardiovascular and other causes of mortality.^{4,5} Increasing CRF is not only protective against cardiovascular risk of obesity but it also reduces various hazards of obesity.⁶ Adiposity of the body can be measured by using Body mass index (BMI), Body adiposity index (BAI), Waist circumference (WC) and waist hip ratio (WHR).⁷ Bioelectrical impedance analysis (BIA) is the recently innovated, widely used non-invasive technique to determine body adiposity.⁸

Recently, life style in younger population has become sedentary due to excess table work, lack of physical activity, internet-based games and fast foods promoting obesity. Medical and nursing students devote more time in academics that decreases time for physical activities resulting overweight and even obese. This study is undertaken to assess the CRF of these individuals and to correlate CRF with different adiposity indices.

METHODS

It is cross-sectional observational study conducted in the Clinical laboratory of Department of Physiology, National Medical College, Birgunj. Sample was collected from September 2021 to December 2021 after obtaining ethical clearance from Institutional Review Committee, National Medical College (Ref. No: F-NMC/526/077-078).

Cluster random sampling was applied for the study. Each batch of MBBS and Nursing students was considered a cluster. Male participants were recruited from the randomly selected MBBS 17th, 19th and 20th batch clusters. For female, in addition to above randomly selected clusters, BSc Nursing 10th, 11th and 12th batch; and BNS 2nd and 4th batch students were also randomly selected as clusters. All available students from the selected clusters who met inclusive criteria of healthy and age

between 18 - 24 years were included in the study.

Students with cardiovascular diseases, respiratory diseases, electrolytes imbalance, functional impairments like fracture, muscle tear, muscular dystrophy and acute non-cardiopulmonary disorder like infection, renal failure and thyrotoxicosis that may affect exercise performance were excluded from the study. Students with drug history (beta agonist, beta blocker, thyroxin, antithyroid drugs, antidepressant, digoxin) and uncooperative were also excluded from the study.

After obtaining written consent from the participants, data was collected on general health and risk factors using questionnaire. Questionnaire was regarding general health and risk factors based on widely used American Heart Association (AHA) - American College of Sports Medicine (ACSM) Participation Screening Questionnaire.⁹ It was used to ensure safety of the participants to perform the Queen's College Step Test and also to rule out cardiorespiratory, musculoskeletal and metabolic disorders or risk factors in the participants that might affect the test results. The questionnaire was pretested among 30 students to check if the statements, language and order of the questions were appropriate.

Height, hip circumference and WC of subjects were measured in standing position. Waist Circumference was measured during end of expiration at the midpoint of the lower border of ninth rib and the iliac crest whereas hip circumference was measured at the widest part of the hip. Omron body composition monitor BF-214 was used to measure weight and total body fat percentage (BF%). Body mass index was calculated using Quetelet's formula (weight in kg/height in m^2). Body adiposity index (BAI) was calculated using the standard formula [hip circumference (cm)/height (m)^{1.5} - 18] and was expressed in percentage.

Wooden box of 16.25 inches height was used for the step test to determine $VO_2\text{max}$. Participants were refrained from food and caffeine 3 hours prior to testing. They were requested to avoid significant exertion and wear loose clothes on the test day. Resting pulse rate was recorded after minimum of 10 minutes rest. Participants were taught how to step on the box at the rate 24 steps/minute for male and 22 steps/min for female. The pace was set at 96 beats/minute and 88 beats/minute for male and female respectively i.e., four beats per complete step— right foot up, left foot up, right foot down, left foot down. Step test was stopped at 3 minutes and radial pulse was counted during fifth to twentieth second into recovery in standing position. $VO_2\text{max}$ was calculated using $VO_2\text{max} = 111.33 - (0.42 \times \text{step-test recovery pulse rate, b/min})$ in male and $VO_2\text{max} = 65.81 - (0.1847 \times \text{step-test recovery pulse rate, b/min})$ in female.

The collected data was entered in Microsoft Office Excel 2016. The data was processed and arranged in an appropriate format. SPSS software (IBM SPSS Statistics 20) was used for statistical analysis. For continuous variables, the data was expressed in means \pm standard deviations (SD). To correlate VO_2 max with adiposity indices, Pearson correlation was used. A “p” value of 0.05 or less was considered significant.

RESULTS

Total of 174 medical and nursing students (87 male and female each) were enrolled for the study. Mean age, weight and height of male were higher than female while pulse and recovery heart rate were higher in female. VO_2 max calculated from recovery heart rate was higher in male compared to female (Table 1). Table 2 shows the comparison of various adiposity indices between males and females. BMI and WC were higher in male while BAI and BF% were found to be higher in female.

Present study shows a significant negative correlation between CRF and different adiposity indices. The results showed strong negative correlation of CRF with WC and BF% in both

Table 1. Study variables and VO_2 max of participants

Parameters	Male (n=87)	Female (n=87)
Age (Years)	20.69 \pm 1.48	19.81 \pm 0.86
Weight (Kg)	64.85 \pm 9.15	52.94 \pm 0.06
Height (m)	1.68 \pm 0.05	1.55 \pm 0.06
Pulse (bpm)	74.51 \pm 6.71	76.39 \pm 9.57
Recovery pulse rate (bpm)	152.64 \pm 21.63	160.12 \pm 25.84
VO_2 max (ml/kg/min)	47.22 \pm 9.09	35.67 \pm 5.36

Table 2. Adiposity indices of participants

Parameters	Male (n=87)	Female (n=87)
Body mass index (kg/m ²)	22.88 \pm 3.14	21.91 \pm 3.81
Body adiposity index (%)	21.31 \pm 4.99	25.74 \pm 4.60
Body fat %	16.79 \pm 5.88	27.59 \pm 9.67
Waist circumference (cm)	80.83 \pm 9.16	71.63 \pm 7.69

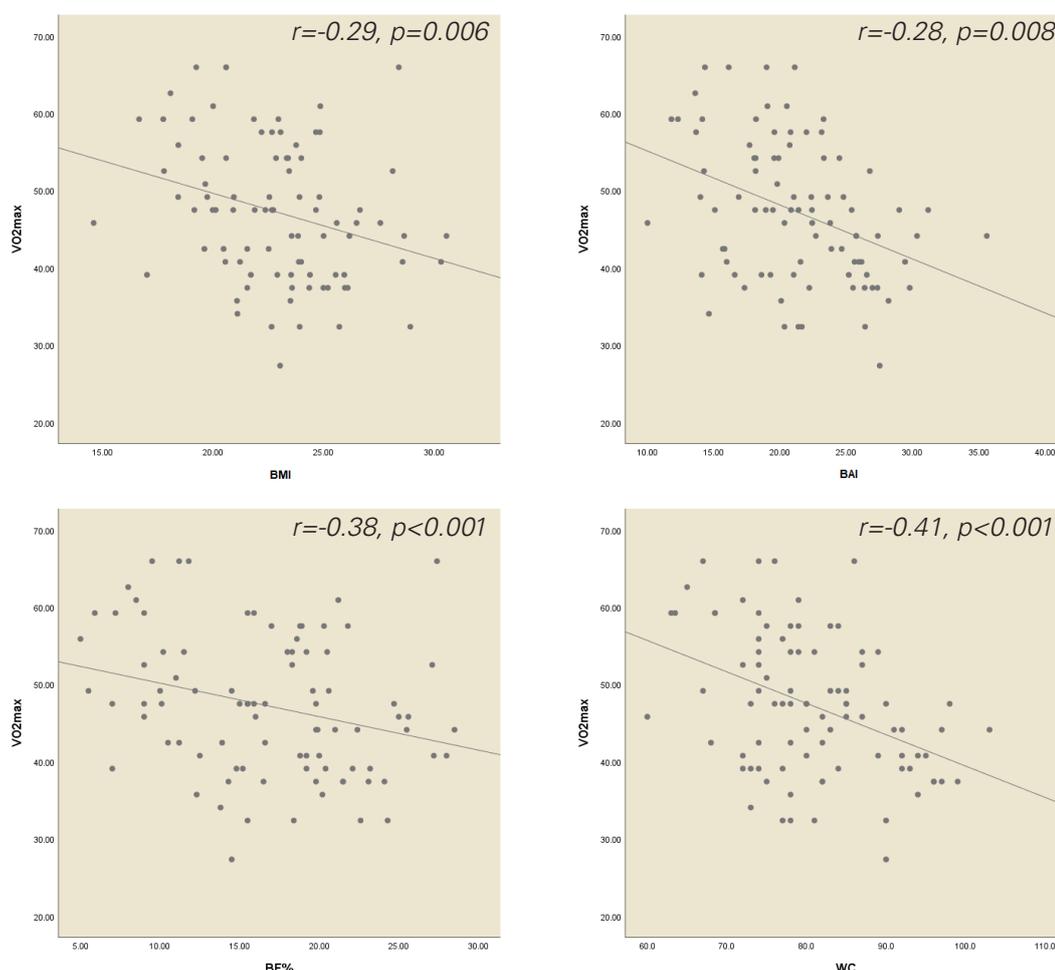


Figure 1. Scatterplot of cardiorespiratory fitness (VO_2 max) with adiposity indices in male

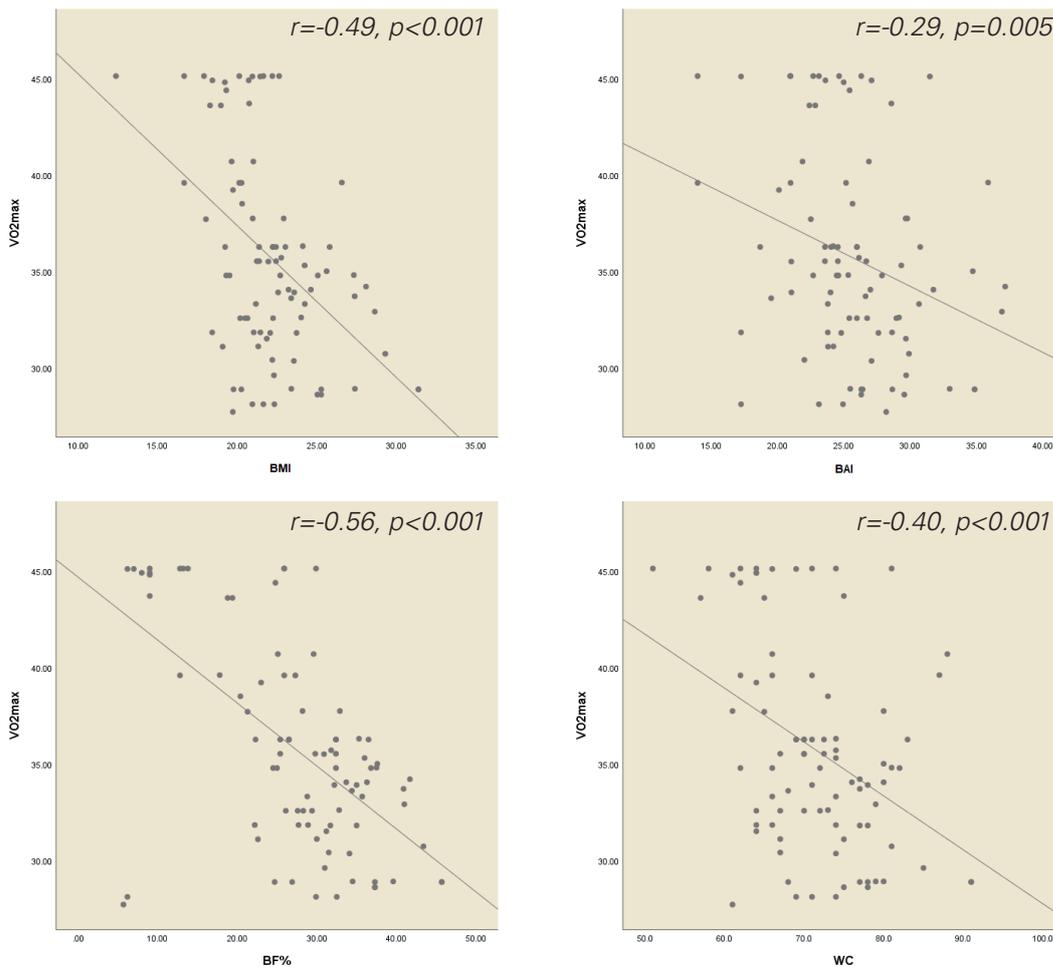


Figure 2. Scatterplot of cardiorespiratory fitness (VO_2max) with adiposity indices in female

male and female as shown in Figure 1 and 2. The best negative correlation was observed between VO_2max and BF% ($r = -0.56$, $p < 0.001$) in female and VO_2max and WC in male ($r = -0.41$, $p < 0.001$).

DISCUSSION

Higher education is challenging and students need to devote more time for studying, hence they have little time for physical activities. Inadequate physical activities can lead to overweight and decreased CRF. Several studies have been carried out in young adults from age group 18-24 years to show the association between obesity and CRF which are in line with this study. As the categorization of CRF differs in male and female the analysis was carried out separately which is also comparable with other studies.¹⁰⁻¹⁴

Present study showed that the CRF level was significantly high in males compared to females which are similar to other studies done among college attending young adults.^{13,15-19} Vivek et al¹⁵ conducted study only on males whereas Ali et al¹⁶ study participants were only females. Their findings were in accordance with our findings. Hingorjo et

al¹³, Vikawata et al¹⁷, Koju et al¹⁸, and Nabi et al¹⁹ assessed CRF in medical students and the result was comparable with ours. The fitness measured by Yadav et al in first year medical students was also closer to our study but Harvard Step Test was used to assess CRF. VO_2max observed in that study was 52.11 ± 8.80 and 43.70 ± 8.28 ml/kg/min in male and female respectively.²⁰

Excess adiposity diminishes CRF and increases cardiovascular diseases (CVDs) risk. CRF has preventive effects against CVDs whereas obesity promotes CVDs.^{4,5} Present study showed negative correlation of CRF with all considered adiposity indices which is close to the previous studies conducted in the same age group. Hingorjo et al observed negative correlation of CRF with BF%, visceral fat percentage (VF %) and WC. In their study, strong negative correlation of CRF was with BF% ($r = -0.60$, $p < 0.001$) and VF% ($r = -0.59$, $p < 0.001$) in male but in female the best negative correlation was with WC ($r = -0.32$, $p = 0.004$).¹³ Cardiorespiratory fitness, like above study is strongly correlated with BF% ($r = -0.38$, $p < 0.001$) in male. In addition to BF%, in present study CRF is also correlated with WC strong negatively in male. Unlike above study,

strong negative correlation of CRF is observed with BF% and WC in female in this study. As reported by Dagan et al the correlation between WC and VO₂max was negative and statistically significant in both males ($r = -0.38$, $p < 0.05$) and females ($r = -0.49$, $p < 0.05$).¹² This finding is also in accordance with our study.

The study demonstrated that in both gender BF% and WC is better index that reflect fat distribution than BMI, which is widely used index. Also, this study shows that individual with less fat mass has better cardiorespiratory fitness as compared to those with high fat mass. Welch et al reported similar finding. They found significant decrease in VO₂max in participants with high fat mass.²¹ To establish the finding further study is needed with rigorous methodology.

CONCLUSION

The study reports low level of CRF in female participants. The study concludes that there is significant negative correlation between CRF and adiposity indices. Observations made in the study suggest that BF% and WC may be the best adiposity indices to correlate negatively with CRF. Hence, estimation of body composition using BF% or WC can be a better option to evaluate CRF.

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CONFLICT OF INTEREST

The author(s) declare that they do not have any conflicts of interest with respect to the research, authorship, and/or publication of this article.

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