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# CARDIORESPIRATORY FITNESS OF OBESE BOYS

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**Abstract :** Childhood obesity is increasing worldwide and may be linked to Coronary heart diseases that appear later in life but its risk related behaviour patterns are evident during childhood and adolescence. The present study aimed to evaluate the cardiorespiratory fitness in terms of maximum oxygen uptake ($VO_2$max) in obese boys of West Bengal, India. Obese boys (N = 49) in the age range of 10–16 years were separated from their non-obese counterparts (N = 70) according to international age-wise cut off points of body mass index (BMI) and $VO_2$max was evaluated by Queen's College Step Test (QCT). Lean body mass (LBM) was measured by skinfold method. Absolute $VO_2$max was significantly higher (P<0.001) among obese boys because of higher values of body mass and LBM, which in turn exhibited significant correlation (r = 0.82 and r = 0.93, respectively; P<0.001) with $VO_2$max. But $VO_2$max per kg of body mass was significantly higher among non-obese boys but the $VO_2$max per unit of body surface area was significantly higher (P<0.001) in obese group. $VO_2$max is largely dependent on body mass and LBM whereas excessive fat mass imposes unfavourable burden on cardiac function and oxygen uptake by working muscles. This indicates that reduced oxygen utilization by adipose tissue during exercise reduces the overall $VO_2$max.

**Key words :** obesity $VO_2$max QCT

## INTRODUCTION

The study of obesity in relation to diseases and physical fitness is of major concern to those interested in child health and development (1), especially now a days as the prevalence of childhood obesity is increasing rapidly worldwide (2). It is extensively associated with coronary heart diseases (CHD) whose manifestations appear quite later in life though risk related behavior patterns are evident in

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childhood and adolescence (3).

Obesity is to a large extent the result of reduced physical activity and is frequently observed to be associated with abundant as well as irregular diet. It may lead to occurrence of heart diseases with poor cardiorespiratory fitness (3). The later is globally evaluated as maximum oxygen uptake ($VO_2max$) that reflects the amount of oxygen utilized by working muslces during maximal exercise (3, 4, 5, 6). $VO_2max$ is therefore the parameter of immense importance to be assessed especially in obese children, as they are prone to suffer from cardiovascular disorder.

$VO_2max$ data in Indian children is lacking. The present study aimed to evaluate the cardiorespiratory fitness in terms of $VO_2max$ in obese boys of West Bengal, India and to compare the data with their non-obese counterparts.

## METHODOLOGY

**Selection of participants**

119 sedentary rural boys belonging to the age group of 10 to 16 years from the same middle class socio-economic background were recruited for the study on the basis of random sampling followed by purposive sampling from different secondary schools of West Bengal, India. The boys had no history of any major disease and were not under any physical conditioning program and or medication. The ethics committee of University of Calcutta (Faculty of Science), school authorities and the parents provided permissions to conduct the study after being thoroughly informed about the purpose, requirements and the experimental protocols of the investigation. All tests were performed in the respective schools.

Age of the participants was calculated in nearest years from the date of birth as recorded in their school register and obese boys were separated from their non-obese counterparts according to the international cut off points of body mass index (BMI) according to the proposal of Cole et al (2), as tabulated below :

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Age (Years) | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| BMI ($kg/m^2$) | 24.00 | 25.10 | 26.02 | 26.84 | 27.63 | 28.30 | 28.28 |

To determine the BMI, body mass and body height were measured with a standard weighing machine that included a height measuring stand (Avery India Ltd, India). Body mass was measured to an accuracy of ± 0.250 kg and height to an accuracy of ± 0.5 cm. Body surface area was calculated using the DuBois equation : BSA ($m^2$) = (Body Weight) 0.425 × (Body Height) 0.725 × 0.007184. To determine the oxygen utilisation by unit mass of lean body mass (LBM), the LBM was determined from skinfold method according to Chatterjee et al (1).

**Preparation of volunteers (5) :**

The volunteers came to the laboratory in the morning at their convenience after having light break fast at least *2* to 3 hours prior to the test and refraining from any activity during that period. Participants were evaluated in presence of their parents or guardians after explaining and demonstrating the experimental procedure to allay their apprehension.

**Prediction of cardiorespiratory fitness ($VO_2$max) :**

Participants were asked to take complete rest for half an hour before performing the exercise so that pulmonary ventilation and pulse rate might come down to a steady state.

The Queen's College Step Test (QCT) which has been recommended as a valid and reliable indirect method for prediction of $VO_2$max in this particular population (6) was adopted in the present investigation. Direct estimation of $VO_2$max is exhaustive, laborious and difficult experimental protocol (4, 8).

In brief the step test was performed using a stool of 16.25 inches (or 41.30 cm) 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 fifth to the twentieth second of the recovery period. This 15 second pulse rate was converted into beats per minute and the following equation was used to predict $VO_2$max.

$$\mathbf{VO_2max\ (ml/kg/min) = 111.33 - (0.42 \times pulse\ rate\ in\ beats\ per\ min)}$$

All experiments were performed at a room temp varying from 27–29°C and at a relative humidity ranging between 70 and 85%.

**Statistical analysis :**

Unpaired t-test was performed to test the significance of difference between mean values and Pearson's product moment correlation was adopted to establish the relationship between two variables.

## RESULTS

There was no significant variation in age between obese and non-obese participants. Though body height did not show any significant inter-group variation but body weight and LBM were significantly higher (P<0.001) in obese group, and BMI score was also significantly higher (P<0.001) among obese boys. BSA also showed

TABLE I : Physical and physiological parameters of obese and non-obese boys.

| *Category* | *Age (years)* | *Body mass (kg)* | *Body height (cm)* | *BSA ($m^2$)* | *BMI ($kg/m^2$)* | *QCT heart rate (beats/min)* | *$VO_2$max* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *(l/min)* | *($l/m^2$/min)* | *(ml/kg/min)* | *(ml/kg LBM /min)* |
| Obese (N=49) | 13.10±1.05 | 63.70±4.65 | 153.80±8.90 | 1.62±0.12 | 26.92±2.01 | 170.80±9.26 | 2.50±0.23 | 1.54±0.28 | 39.60±2.60 | 54.50±3.60 |
| Non-obese (N=70) | 13.00±1.08 | 35.53±6.10* | 149.00±12.00 | 1.23±0.11* | 16.00±1.50* | 149.80±6.29* | 1.70±0.16* | 1.38±0.21* | 48.40±1.80* | 55.80±2.70 |

Values are expressed as Mean ± Standard Deviation.

significantly lower (P<0.001) value in the non-obese group because of their significantly lower body weight. All results are tabulated in Table I.

## DISCUSSION

$VO_2max$ is a measure of the functional limit of the cardiorespiratory system and the single most valid index of maximal exercise capacity. $VO_2max$ has been expressed either in absolute value, i.e., in liter per minute (l/min) or as relative values, i.e., ml per kg of body weight per minute (ml/kg/min), ml per kg of lean body mass (ml/kg LBM/min) or liters per unit of body surface area per minute ($l/m^2/min$). The absolute value of $VO_2max$ is one of the best indices of an individual's cardiorespiratory fitness to transport oxygen to working muscles (9). Furthermore, it is useful when changes in maximal aerobic capacity of children are assessed during the period of pre-puberty to adolescence (10). The $VO_2max$ value in ml/kg LBM/min should be considered when we examine the performance of the cardiorespiratory fitness.

Some boys were pre-pubertal while others were post-pubertal. But as there is no significant difference in mean age (Table : I) and distribution of proportionate number of individuals from each age-group (Obese = 24 & 25, Non-obese = 34 & 36 in the age group of 10–13 years and 14–16 years, respectively) is almost same, hence chance of pre-pubertal and post-pubertal influence towards alteration of $VO_2max$ does not exist in the current study.

Significantly higher (P<0.001) value of absolute $VO_2max$ among obese boys in the present study is contradictory to other findings (11, 12, 13) where absolute $VO_2max$ did not vary significantly between obese and non-obese boys. Whereas, other pertinent studies (3, 14) reported that since body mass was higher and so was absolute $VO_2max$ in the obese group, indicating higher cardiac load among obese boys during working condition. In this study, existence of significant positive correlation of $VO_2max$ (l/min) with body weight (r = 0.82, P<0.001) and LBM (r = 0.93, P<0.001) also justifiably support the view. Significantly (P<0.001) higher value of peak heart rate in QCT in obese group also indicated the greater cardiac load among them.

In spite of having significantly (P<0.001) higher value of $VO_2max$ the oxygen consumption per unit of body mass was significantly less (P<0.001) in the obese group. This is probably because of the excessive amount of body fat that appeared to exert an unfavorable burden as well as hindering action towards cardiac function, particularly during exhausting exercise when excessive hyperactive body musculature fails to uptake sufficient amount of oxygen due to deposition of proportionately high amount of fat mass (11, 12, 13). This can further be supported with the findings that loss of fat weight during weight reduction program of obese children, increased their relative $VO_2max$ value due to withdrawal of fat induced inhibitory action towards oxygen utilization by body musculature (8). Similarly Dempsy et al (17) found excess body fat impairs cardiorespiratory functions and reduces mechanical efficiency for a given work load.

**CONCLUSION**

The results indicate that the obese have higher absolute $VO_2$max and $VO_2$max expressed per unit surface area as compared to non-obese. However, $VO_2$max per kg of body weight was actually less in obese than in non-obese (39.6 ± 2.6 vs 48.4 ± 1.8 ml/kg /min) indicating reduced aerobic capacity. At the same time $VO_2$max expressed per kg lean body mass was similar in both the groups (54.5 ± 3.6 vs 55.8 ± 2.7 ml/kg lean body mass/min : obese vs non-obese). This may point to a grossly reduced oxygen utilization by adipose tissue during exercise that reduces the overall $VO_2$max.

## REFERENCES


1. Chatterjee P, Chaterjee S, Muherjee PS, Bandyopadhyay A. Evaluation and inter-relationship of body mass index, percentage of body fat, skinfolds and girths measurements in boys of 10–16 years. *Biomedicine* 2002; 22: 9–16.
2. Cole TJ, Bellisi MC, Flagel EM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide. *BMJ* 2000; 320: 1–6.
3. Watanabe K, Nakadomo F, Maeda K. Relationship between body composition and cardiorespiratory fitness in Japanese junior high school boys and girls. *Ann Physiol Anthropol* 1994; 13: 167–164.
4. Fox EL. A simple accurate technique for predicting maximal aerobic power. *J Appl Physiol* 1973; 35: 914–916.
5. Banerjee PK, Chatterjee S, Chatterjee P, Maitra SR. Maximal oxygen uptake in boys. *Indian J Med Res* 1982; 75: 380–386.
6. Chatterjee S, Chatterjee P, Bandyopadhyay A. Enumeration of validity for predicted $VO_2$max by Queen's College Step Test in Bengalee boys. *Ind J Physiol and Allied Sci* 2001; 55: 123–127.
7. DuBois D, DuBois EF. A formula to estimate body surface area if height and weight be known. *Arch Int Med* 1916; 17: 863.
8. Bandyopadhyay A, Chatterjee S. Body composition, morphological characteristics and their relationship with cardiorespiratory fitness. *Ergonomis SA* 2003; 1: 19–27.
9. Taylor CI, Buskirk E, Henschel A. Maximal oxygen intake as an objective measure of cardiorespiratory performance. *J Appl Physiol* 1955; 8: 73–80.
10. Yamaji K. Science of maximum oxygen uptake. Tokyo, 1st Ed. Kyorin Shoin Publisher, 1992: pp. 14–191.
11. Buskirk E, Taylor HL. Maximal oxygen intake and its relation to body composition with special reference to chronic physical activity and obesity. *J Appl Physiol* 1957; 11: 72–78.
12. Kitagawa K, Miyashita M. Respiratory and cardiovascular system in obese men related to $VO_2$max and body composition. *J Phys Fit (Japan)* 1981; 30: 131–136.
13. Welch B, Riendeau RP, Crisp CE, Isenstei RS. Relationship of maximal oxygen consumption to various components of body composition. *J Appl Physiol* 1958; 12: 395–398.
14. Cooper DM, Weiler RD, Whipp BJ, Wasserman K. Aerobic parameters of exercise as a function of body size during growth in children. *J Appl Physiol* 1984; 56: 628–634.
15. Huttunen NP, Knip M, Paavilainen T. Physical activity and fitness in obese children. *Int J Obes* 1986; 10: 519–525.
16. Sharp TA, Reed GW, Sun M. Relationship between aerobic fitness level and daily energy expenditure in weight stable humans *Am J Physiol* 1992: 263: 12128.
17. Dempsy JA, Reddon W, Balke B, Rankin J. Work capacity determinants and physiologic cost of weight supported work in obesity. *J Appl Physiol* 1966; 21: 1815–1820.