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Indirect Determination of Maximal Oxygen Consumption (VO_2Max) and Its Correlation with Body Mass Index.

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ABSTRACT

Background: The current study was designed to evaluate cardio respiratory fitness in terms of VO2max in young healthy males and to correlate between body mass index and cardio respiratory fitness. **Methods:** One hundred twenty-five apparently healthy male subjects in the age group of 18 to 25 years were included in this study group. Body mass index was measured as weight in kilograms divided by height in meters square. Cardio respiratory fitness in terms of VO2max was predicted by following the protocol of Treadmill Jogging Test (TMJ). **Results:** There was a highly significant negative correlation between body mass index and VO2max, r = -0.75 p<0.0001. **Conclusion:** The result suggests that the reduced cardiac performance during progressive work rate exercise in obese individuals. Greater the BMI, more severe will be the functional impairment, suggesting excessive amount of body fat on cardio-respiratory functions and oxygen uptake by working muscles.

Keywords: VO2max, sub-maximal exercise, treadmill test, physical fitness.

INTRODUCTION

Aerobic power is the maximum capacity of an individual to transport and utilize oxygen during incremental exercise, which reflects the physical fitness (PF) of the individual.[1] Cardio-respiratory fitness (CRF) is a health-related component of PF defined as the ability of the circulatory, respiratory, and muscular systems to supply oxygen during sustained physical activity (PA). CRF is not only a sensitive and reliable measure of habitual PA but also a relatively low-cost and useful health indicator for both symptomatic and asymptomatic patients in clinical practice.[2-5] CRF is usually expressed in metabolic equivalents (METs) and maximal oxygen consumption (VO2max) measured by exercise tests such as treadmill or cycle ergometer (CE). Each 1-MET increment in CRF was associated with a 13% and 15% risk reduction from all-cause mortality and CV disease events, respectively.[6] VO2max is widely accepted as the single best measure of CRF and maximal aerobic power. VO2max is internationally accepted parameter & is the first choice in measuring a person's cardiopulmonary status.[7] Those who are more fit have higher VO2max and can exercise more intensely and longer than those who are not as well conditioned. Accurately measuring VO2max involves a physical effort sufficient in duration and intensity to fully tax the aerobic energy system.[8]

Variations in body mass explain nearly 70% of the difference in VO2max scores among individuals. Excessive amount of body fat exerts an unfavourable burden as well as hindering action towards cardiac function particularly during exhaustive exercise when excessive hyperactive body musculature fails to uptake sufficient amount of oxygen due to deposition of proportionately high amount of fat mass. High intensity physical training improved CV fitness in obese individuals.[9] Loss of weight during weight reduction program of obese increased their VO2max (ml/kg/min) due to withdrawal of fat induced inhibitory action towards oxygen utilization by body musculature.[10]

Direct measurement of VO2max is restricted within a well-equipped laboratory because of its exhausting, cumbersome, hazardous, complicated, expensive and the time spent to measure it and standardization. Moreover, it requires maximal exertion and is not advisable for compromised and debilitating advancing cardio-respiratory individuals. In indirect

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tests the subject works below, maximal effort. These are similar to a VO2max test, but do not reach the maximum of the respiratory and CV systems and are called sub-maximal tests. In Sub-maximal test, extrapolation is used to estimate maximal capacity. Although it may be efficacious to use an exercise test requiring maximal efforts young fit and willing participants, sub-maximal exercise tests, which are relatively safer requires less time, are practical in a variety of settings.

The current study was designed to evaluate cardio respiratory fitness in terms of VO2max in young healthy males and to correlate between body mass index and cardio respiratory fitness.

MATERIALS AND METHODS

One hundred twenty five apparently healthy male subjects were selected for the study after applying inclusion and exclusion criteria.

Inclusion Criteria

Apparently healthy male subjects between 18 to 25 years of age, pre-exercise BP <140/90 mmHg and having a normal pre-exercise ECG were included in the study.

In addition, subjects had to fill a Physical Activity Readiness (PAR-Q) Form before exercise. Subjects who had answered NO to all the questions were selected for the study.[11]

Exclusion Criteria

Subjects with history suggestive of cardio-vascular, respiratory, metabolic, musculo-skeletal and emotional disorders were excluded.

Evaluation Informed written consent was taken from all the subjects. The study was approved by the Institutional Ethical Committee (IEC).

Subjects were divided into small groups and then they were familiarized with the instruments. Experimental protocol was explained to them in detail. They were also given a trial run on treadmill to relieve the anxiety related to the treadmill running during actual testing and data collection.12 For treadmill testing guidelines from American College of Sports Medicine (ACSM) were followed.

Height, weight, pre-exercise blood pressure and pre-exercise ECG were measured following standard procedures.

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 (m2).

PC Based Stress Test Analysis (Stress-INVX1) system (CARDIVISION Exercise Stress Test System and Rest ECG Analysis System) was used for treadmill testing.

Protocols

Treadmill Jogging Test[13]

In this test subjects were made to walk at brisk walking speed at zero level grade for three minutes. This is followed by jogging at a sub-maximal jogging speed between 4.3 and 7.5 mph at zero level grade until a steady state HR (two consecutive HR within 3 BPM 30 sec apart) was achieved. Heart rate, BP and RPE were recorded for walking and then for jogging stage.

The following equation was used to predict VO2max.

VO2max = 54.07 + 7.062×gender [male= 1, female =0] -0.1938×Weight [kg] + 4.47×speed [mph] – 0.1453× heart rate [BPM]

Statistical Analysis

The results were expressed as mean ± standard deviation (SD). A p value of < 0.05 was considered statistically significant.

Data analyses were performed on SPSS software (PSAW, Windows version 18.0).

Pearson correlation was used to correlate BMI and VO2max (ml/kg/min).

RESULTS

125 young healthy males were subjected to Treadmill jogging Test.

The age, Ht, Wt and BMI of all subjects ranged from 18 to 25 yrs (21.17 ± 1.98 yrs), 162-187 cm (172.26 ± 4.62 cm), 51-79 kg (64.42 ± 6.19 kg) and 18.17 to 25.06 kg/m2 (21.70 ± 1.79 kg/m2) respectively.

The mean value of VO2max was 47.20 ± 2.27 ml/kg/min (range 40.51 to 51.17 ml/kg/min). The effect of Body mass index on cardiorespiratory Fitness was studied.

There was a significant negative correlation between BMI and VO2max (ml/kg/min), (r=-0.75, p<0.01) [Table 1].

Table 1: Correlation between Obesity & VO2max

Variable		VO2max
BMI	r	-0.75
	p	<0.0001.

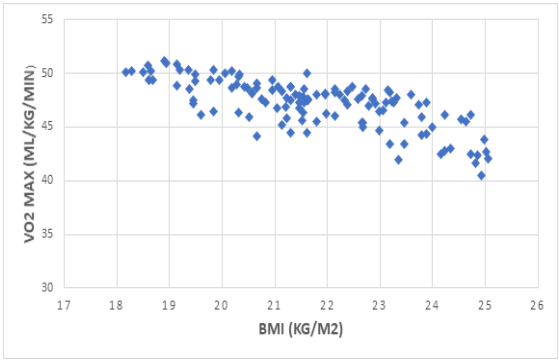

Figure 1: Scatter diagram showing the relationship between BMI and VO2max

DISCUSSION

VO2max is internationally accepted parameter & is the first choice in measuring a person's cardiopulmonary status. Those who are more fit have higher VO2max and can exercise more intensely and longer than those who are not as well conditioned. Accurately measuring VO2max involves a physical effort sufficient in duration and intensity to fully tax the aerobic energy system.

Setty P, et.al. [2013] in their study evaluated the CRF in terms of VO2max in young healthy males (n=60, age 18 to 22 yrs) and determined the correlation between obesity and CRF. They found a highly significant negative correlation between obesity and VO2max, r= -0.88 p<0.05. Their result suggested that there was reduced cardiac performance during progressive work rate exercise in obese individuals. Greater the body mass index (BMI), more severe will be the functional impairment, suggesting excessive amount of body fat on cardio respiratory functions and oxygen uptake by working muscles.[14]

Chatterjee et al [2005] assessed cardiorespiratory fitness in obese and non-obese boys aged 10-16 yrs and found that VO2 max per kg of body weight was relatively less in obese subjects indicating reduced aerobic capacity, concluding that high amount of fat mass inhibits uptake of sufficient amount of oxygen by excessive hyperactive body musculature during exhaustive exercise.[10] It was found that during of weight reduction program in obese, their VO2max (ml/kg/min) increased due to withdrawal of fat induced inhibitory action toward oxygen utilization by body musculature.[15] 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 VO2max was less in obese girls. This was probably due to hindering effects imposed due to excess deposition of fat.[16] Similar results were observed by Welch et al,[17] Ozcelick et al,[18] & Rowland et al.[19] Norman et al [2005] studied influence of excess adiposity on exercise fitness and performance in overweight children and adolescents 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.[20] Several previous studies have found no significant differences in VO2max 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.[21]

In this study we found a significant negative correlation between BMI and VO2max (ml/kg/min) (r= -0.75, 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.[10,14-16]

CONCLUSION

1. Treadmill jogging Test is a valid and safe method for the estimation of VO2max in young males.
2. Jogging is a popular form of exercise and treadmills are readily available in laboratories, can be employed for exercise prescription.
3. There was a significant negative correlation between obesity and VO2max, suggesting the effect of excessive amount of body fat on cardio respiratory functions and oxygen uptake by working muscles.
4. These findings demonstrate the importance of low cardio respiratory fitness in young adults with increased body fat which could be a factor for developing cardiovascular co-morbidities later in middle age.
5. In view of current obesity trend and increasing cardiovascular disease, it's advisable to decrease the daily caloric intake also; improving cardio respiratory fitness in young men by engaging in physical activities is important.
6. Health promotion policies & physical activity programs should be designed to improve Cardio-respiratory fitness.

REFERENCES

1. Hermansen L, Anderson LK. Aerobic work capacity in young Norwegian men and women. J Appl Physiol 1965; 20(3): 425-431.
2. American College of Sports Medicine American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardio-respiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc. 1998; 30: 975–991
3. Church TS, Earnest CP, Skinner JS, Blair SN. Effects of different doses of physical activity on cardio-respiratory fitness among sedentary, overweight or obese postmenopausal women with elevated blood pressure: a randomized controlled trial. JAMA. 2007; 297: 2081–2091
4. Jackson AS, Sui X, Hebert JR, Church TS, Blair SN. Role of lifestyle and aging on the longitudinal change in cardio-respiratory fitness. Arch Intern Med. 2009; 169: 1781–1787.
5. Wang CY, Haskell WL, Farrell SW, LaMonte MJ, Blair SN, Curtin LR, Hughes JP, Burt VL. Cardio-respiratory fitness levels among US adults 20–49 years of age: findings from the 1999–2004 National Health and Nutrition Examination Survey. Am J Epidemiol. 2010; 171: 426–435.
6. Lee DC, Artero EG, Sui X, Blair SN. Mortality trends in the general population: the importance of cardio-respiratory fitness. J Psychopharmacol. 2010; 24(4): 27–35.
7. Chatterjee S, Chatterjee P, Bandopadhyay A. Validity of Queen's College Step Test for estimation of maximal oxygen uptake in female students. Indian J Med Res.2005; 121: 32-35.
8. Shephard RJ, Allen C, Benade AJS, Davies CTM, Pamperao PE, Hedman R, Marriman JE, Myhre K, Simmons R. The

Maximum Oxygen Intake. Bull. Wld Hlth Org. 1968; 38: 757-764.
9. Gutin B, Barbeau P, Owens S, Lemmon CR, Bauman M, Allison J, Kang HS, Litaker MS. Composition, and visceral adiposity of obese adolescents. American Journal of Clinical Nutrition 2002;75(5):816-826.
10. Chatterjee S, Chatterjee P, Bandyopadhyay A. Cardio-respiratory fitness of obese boys. Indian J Physiol Pharmacol 2005; 49:353-357.
11. Physical Activity Readiness Questionnaire [PAR-Q], Public Health Agency of Canada and the Canadian Society for Exercise Physiology, 2007.
12. Health-Related Physical Testing And Interpretation. In ACSM,s Guidelines For Exercise Testing And Prescription 7th edition 2006 Lippincott Williams & Wilkins; 68-69.
13. George JD, Vehrs PR, Allsen PE, Fellingham GW, Fisher AG, Development of sub-maximal treadmill jogging test for college fit individual, Med. Sci. Sports Exer.;1993:25(5):643-647.
14. Setty P, Padmanabha BV, Doddamani BR. Correlation between obesity and cardiorespiratory fitness. Int J Med Sci Public Health .2013; 2(2); 298-302.
15. Bandyopadhyay A, Chatterjee S. Body composition, morphological characteristics and their relationship with cardiorespiratory fitness. Ergonomis SA 2003; 1: 19–27.
16. A Bandyopadhyay Cardiorespiratory fitness in obese girls. Indian J Physiol Pharmacol 2012;56(4):393-395.
17. Welsh BE, Rieneau RP, Crisp CE, Isenstein RS. Relationship of maximal oxygen consumption to various components of body composition. J Appl Physiol 1958;12:395-398.
18. Ozcelick O, Aslan M, Ayar A, Kelestimur. Effects of body mass index on maximal work production capacity and aerobic fitness during incremental exercise. Physiol Res 2004; 53:165-170.
19. Rowland TW. Effects of obesity on aerobic fitness in adolescent females. Archives of Pediatrics & Adolescent Medicine 1991;145(7).
20. Norman AC, Drinkard B, Jennifer R, Ghorbani BS, Lisa BY, Jack A. Influence of excess adiposity on exercise fitness and performance in overweight children and adolescents. Pediatrics 2005;115(6):600-696.
21. Patkar KU, Joshi AS. Comparison of VO2max in obese and non-obese young SIndian population. Indian J Physiol Pharmacol. 2011;55(2):188-192.

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