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RESEARCH ARTICLE

AN INSIGHT INTO INTERRELATIONSHIP OF MAXIMAL OXYGEN INTAKE IN OBESE AND NON-OBESE YOUNG WOMEN

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ABSTRACT

Modern sedentary life style and faulty food habits are leading to development of early life obesity. The journey from early life obesity to cardiovascular disease will be evident by slow regression of their cardio-respiratory efficiency. As VO2 max is an accepted measure of cardio-respiratory efficiency, it was used in this study to estimate cardio-respiratory efficiency. Present study was aimed to find out whether obesity affects cardio-respiratory efficiency of young women or not. The study was conducted on 30 obese and 30 non-obese female volunteers aged between 18 and 22 years. VO_2 max was estimated by Queen's College Step test. Parameters measured and calculated were weight, height, BMI, Waist-Hip circumference Ratio[WHR], Pulse rate, Blood pressure and VO_2max. There was negative correlation between BMI and VO_2max but it was not significant ($p>0.05$). A negative correlation was observed between WHR and VO_2max but it was significant ($p<0.05$). In this study VO_2max per kg lean body mass shows no significant difference in obese and normal weight group indicating same cardio respiratory performance in both the groups No significant difference was observed in absolute VO_2max of obese and non-obese females. Therefore we concluded that cardio-respiratory efficiency was not affected in obese group as compared to normal weight group; however ability to do exhausting work was less in obese group.

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INTRODUCTION

Modern sedentary life style and faulty food habits are leading to development of early life obesity (Norman, *et al.*, 2005). People are prone to develop cardiovascular diseases and other chronic diseases at young age of their life because of early life obesity (Krauss, *et al.*, 1998). The journey from early life obesity to cardiovascular disease will be evident by slow regression of their cardio-respiratory efficiency. Cardio-respiratory efficiency refers to the ability of the circulatory and respiratory system to supply oxygen to skeletal muscles during sustained physical activity. VO2max is the maximum capacity to transport and utilize oxygen during incremental exercise. It is also known as aerobic capacity, which reflects physical fitness of a person. As VO2max is an accepted measure of cardio-respiratory efficiency (Anderson, *et al.*, 1971; Bannerjee, *et al.*, 1982), it has been used in this study to estimate cardio-respiratory efficiency. Overweight has been identified as a major health problem throughout the world (Freedman, *et al.*, 1997; Ogden, *et al.*, 2002; Troianao, *et al.*, 1998; Must, *et al.*, 1999). Overweight commonly signify adult obesity and is associated with the development of weight-related co morbid conditions and increased morbidity (Whitaker, *et al.*, 1997; Kuczmarski, *et al.*, 1994). Decreased physical activity and a more sedentary lifestyle have been implicated as important factors in the development of pediatric obesity (Must A, 1996; Gortmaker, *et al.*, 1996). Despite that aerobic exercise is widely used in the management of pediatric overweight, relatively few studies have examined the impact of excess adiposity on exercise fitness or functional performance in children and adolescents (Epstein, *et al.*, 1993; Drinkard, *et al.*, 2001; Goran, *et al.*, 2000). Increased fat mass is associated with decreased exercise performance in overweight adults and adolescents (Goran *et al.*, 2000). However, the cause of this limited exercise tolerance remains in question. Several investigators, primarily those who have studied moderately overweight and obese children and adolescents, have reported similar maximal oxygen uptake (VO2 max) relative to body weight compared with normal-weight control subjects. These studies have concluded that exercise intolerance in overweight children and adolescents is attributable primarily to the increased metabolic demands of carrying an excess load, rather

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than a true decrease in cardio- respiratory fitness (Maffeis *et al*., 1994). However, some studies have reported that overweight individuals have significantly decreased maximal heart rate; heart rate reserve, which is defined as maximal heart rate minus resting heart rate (Peterson *et al*., 2004); and myocardial work efficiency. Whether these differences significantly influence fitness and performance is unclear. Obesity-related changes in exercise catecholamine response, myocardial metabolism, and left ventricular morphology may be associated with these findings (Peterson *et al*., 2004). Peak oxygen uptake (VO2), that is, the highest oxygen uptake elicited during an exercise test to exhaustion, is recognized as the best single indicator of young people's aerobic fitness. It is used in the prescription of aerobic exercises, in the monitoring of physical training adaptations, and as a predictive parameter of associated morbidities (ACSM, 2006). To determine the extent to which the physiological markers of aerobic fitness change as result of exposition to regular endurance exercise in children and adolescents, it is required longitudinal studies, as well as to consider the influence of age and growth during pubertal development (Armstrong, *et al*., 2011). Also, it has been extensively noted that peak VO2 is highly correlated with body size, thus concurrent effects of size with age and maturation on peak VO2 need to be appropriately accounted for.

REVIEW OF LITERATURE

VO2 max, or maximal oxygen uptake, is one factor that can determine an athlete's capacity to perform sustained exercise and is linked to aerobic endurance. VO2 max refers to the maximum amount of oxygen that an individual can utilize during intense or maximal exercise. It is measured as "milliliters of oxygen used in one minute per kilogram of body weight. This measurement is generally considered the best indicator of an athlete's cardiovascular fitness and aerobic endurance. Theoretically, the more oxygen you can use during high level exercise, the more ATP (energy) you can produce. This is often the case with elite endurance athletes who typically have very high VO2 max values. A clear link exists between oxygen consumption (VO2) of the body and cardio-respiratory fitness because oxygen delivery to tissues is dependent on lung and heart function. VO2max (maximal oxygen uptake, maximal aerobic power) is the maximal rate at which oxygen can be used by the body during maximal work; it is related directly to the maximal capacity of the heart to deliver blood to the muscles. VO2max can be measured or predicted by fitness tests (e.g. maximal tests, submaximal tests, Polar Fitness Test). VO2max is a good index of cardio-respiratory fitness and a good predictor of performance capability in aerobic events such as distance running, cycling, cross-country skiing, and swimming. VO2max can be expressed either as milliliters per minute (ml/min = ml min^{-1}) or this value can be divided by the person's body weight in kilograms (ml/kg/min = ml $kg^{-1}min^{-1}$). Obesity is a complex condition that can lead to a plethora of health problems including decreased fitness, metabolic complications, and psychological co-morbidities (Wang, *et al*., 2006). Obesity is characterized by a greater than average increase in adiposity over time. If left untreated, obesity-related co-morbidities may develop in children at an early age that include sleep apnea, (Li, *et al*., 2010) cardiovascular disease risk factors, type 2 diabetes, and mental health issues, (Poirier, *et al*., 2006; Must, *et al*., 1999; Sanderson, *et al*., 2011). Additional evidence suggests that it is highly likely that obese children will carry their excess weight into adulthood and thus have an increased risk of becoming obese adults in the absence of intervention (Power, *et al*., 1997). It has been demonstrated that obese children have poor maximal cardio-respiratory fitness level than their normal weight peers, given the increased effort required to move a larger mass (Dupuis, *et al*., 2000). This is troublesome as physical fitness (VO2max) has been shown to be a modifiable health indicator in children and adolescents that may prevent the onset of metabolic complication, independent of the presence of excess adiposity (Ortega, *et al*., 2008). As a result, the physical fitness of obese children warrants further investigation, as it may serve to be a valuable component of clinical assessment of health risk in an obese pediatric population.

Research shows that although VO2 max has a genetic component it can also be increased through training. The two methods for increasing VO2 max include increases in both training volume and intensity. Research also indicates that the less fit an individual is, the more they can increase their VO2 max through training. In fact, novice exercisers have been able to increase VO2 max by 20 percent through proper training. Fit athletes have a harder time increasing their VO2 max, most likely because they are already so near their genetic potential. The point at which oxygen consumption plateaus defines the VO2 max or an individual's maximal aerobic capacity. It is generally considered the best indicator of cardio-respiratory endurance and aerobic fitness. However, as well discuss in a moment, it is more useful as an indicator of a person's aerobic potential or upper limit than as a predictor of success in endurance events. Aerobic power, aerobic capacity and maximal oxygen uptake are all terms used interchangeably with VO2 max. VO2 max is usually expressed relative to bodyweight because oxygen and energy needs differ relative to size.

It can also be expressed relative to body surface area and this may be a more accurate when comparing children and oxygen uptake between sexes. Evaluating cardio-respiratory fitness in a population with excess weight may be tough for exercise physiologists unfamiliar with the complexities of obesity. A measure of VO2max is defined as the maximum ability of the human body to transport and consume oxygen during sustained aerobic work (George, *et al*., 2009). Such levels of maximal exertion are seldom attained in untrained individuals, due to the strict criterion that define VO2max (i.e., plateau in oxygen consumption despite increases in workload, elevated lactic acid in blood, elevated respiratory exchange ratio [RER]) (Wagner, *et al*., 2000). When a maximal CRF test is completed with too few or none of these aforementioned VO2max criteria, VO2peak is more appropriate to report (Ortega, *et al*., 2008). Recently, Breithaupt, *et al*., found that only 18 obese children participants (n = 62) were able to attain a true VO_2max, reinforcing the notion that VO_2peak is a more realistic outcome in obese children (Breithaupt, *et al*., 2012). It has also been suggested that obese children may perceive various intensities of physical exertion differently than their normal weight counterparts (French, *et al*., 1995; Schwimmer, *et al*., 2003; Epstein, *et al*., 1992). One study has previously illustrated that obese children rated their perceived exertion on an incremental treadmill test significantly higher than a normal weight control group (Marinov, *et al*., 2002). However, there is very limited research available for evaluating rate of perceived exertion during graded exercise tests in obese children and no available research on perceived exertion for sub-maximal graded exercise tests in this population. Despite this finding, other research has found that children are successful at reporting subjective measures of physical exertion during graded exercise tests (Mahon, *et al*., 1998), and this may also be true for obese children. To our knowledge, no study has compared how obese children from a clinical cohort perceive their exertion while completing both maximal and sub-maximal graded fitness tests.

AIMS AND OBJECTIVES

1. To find out whether obesity affects cardio-respiratory efficiency of young women or not.
2. To alert them at proper time to take necessary action and will also help to plan the type of exercise suitable for their health need.

MATERIALS AND METHODS

The study was conducted on thirty (30) obese and thirty (30) non-obese female volunteers aged between 18 and 22 years in the department of physiology B.P.S Government medical college for women khanpur kalan, consent was taken. They were classified as obese and non-obese according to obesity classification based on Body Mass Index (BMI). The revised BMI cut-off for Asians as recommended by WHO was considered to classify overweight and obesity (WHO Expert Consultation, 2004). The purpose of the study was explained to all the participants. Institutional ethical committee approval had been taken before start of study. Pulse rate and blood pressure were measured at the brachial artery from the arm using the Omron T8 Automatic Blood Pressure instrument.

Inclusion criteria for both groups

1) Healthy young adults aged between 18-22 years
2) Sedentary life style.

Exclusion criteria for both groups

1) Subjects with history of cardiopulmonary disease
2) Chronically ill
3) Medication for long duration
4) History of any major surgery (cardiac, pulmonary, abdominal) related to study and
5) Subjects undergoing any physical conditioning program.

Participants were instructed to empty their bladder prior to anthropomorphic measurements. Weight was recorded to the nearest 0.1 kg with clothing using a standard scale. Height was measured to the nearest 1 cm without footwear. BMI was calculated using Quetlet's index as weight (kg) over height (m^2).

BMI = Weight (Kg) / (height in meter)^2

W/H Ratio (Waist-Hip Circumference ratio): The waist Circumference is the minimum Circumference between costal margin and iliac crest, measured in horizontal plane, with the subject standing. Hip circumference is the maximum Circumference in the horizontal plane, measured over the buttocks. The ratio of the former to the latter provides an index of proportion of intra-abdominal fat. Estimation of VO_2max by Queen College Step Test (McArdle, *et al*., 1972); It was performed using stepping bench of 16.25 inches height. Stepping was done for total duration of 3 minutes at the rate of 24 steps ups/min for boys and 22 Steps ups/ min for girls, which was set by a metronome. After completion of exercise subjects were allowed to remain standing comfortably and carotid pulse rate was measured from 5th to 20th sec. of recovery period. This 15 sec pulse rate counted to beats/min and the following equations (Mc Ardle, *et al*., 2001; Mc Ardle, *et al*., 1972) used to predict VO_2max.

For males – VO_2max (ml/kg/min.) = 111.33–(0.42 × pulse rate in beats/min)

For females – VO_2max (ml/kg/min) = 65.81–(0.1847 × pulse rate in beats/min).

The data obtained was analyzed using SPSS package (Version 19). Unpaired t-test was used to test the significance of difference between mean values of VO_2max of obese and normal weight group, to test the significance of difference between mean values of VO_2max in obese females and normal weight females.

RESULTS

ANTHROPOMETRICS PROFILES IN THE STUDY POPULATION (TABLE 1.1 & TABLE 1.2)

Table 1. Group statistics of baseline parameters of the study groups

Group Statistics					
Variables	Group	N	Mean	Std. Deviation	Std. Error Mean
AGE(years)	1	30	19.90	0.995	0.182
	2	30	19.62	0.942	0.175
HEIGHT (cm)	1	30	158.61	6.05	1.105
	2	30	159.82	5.72	1.062
BMI (Kg/m^2)	1	30	20.31	1.02	0.186
	2	30	26.39	3.28	0.6092
WAIST(Inches)	1	30	26.70	1.32	0.240
	2	30	30.55	3.32	0.61
WHR	1	30	0.74	0.043	0.0077
	2	30	0.75	0.058	0.0109

Group 1= normal weight,
Group 2= Overweight & Obese, WHR= Waist Hip Ratio, BMI= Body mass index.

Table 1.2

Independent Samples Test								
		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
AGE (Years)	Equal variances assumed	0.009	0.926	1.107	57	0.273	0.27	0.25
	Equal variances not assumed			1.108	56.97	0.273	.27	0.25
HEIGHT	Equal variances assumed	0.086	0.771	-.789	57	0.433	-1.210	1.53
	Equal variances not assumed			-.790	56.97	0.433	-1.210	1.53
BMI	Equal variances assumed	16.975	0.0001	-9.676	57	0.0001	-6.077	0.62
	Equal variances not assumed			-9.539	33.22	0.0001	-6.07	0.63
WAIST(in inches)	Equal variances assumed	21.584	0.0001	-5.890	57	0.0001	-3.85	0.65
	Equal variances not assumed			-5.816	36.340	0.0001	-3.85	0.66
	Equal variances assumed	0.880	0.352	-1.538	57	0.130	-.0205	0.013
	Equal variances not assumed			-1.530	50.888	0.132	-.020	0.013

Group 1= normal weight,
Group 2= Overweight & Obese, WHR= Waist Hip Ratio, BMI= Body mass index.

There are no significant differences observed in the age, Height & WHR in the obese group compared to normal control group (Age 19.90 ± .995 vs 19.62 ±.942, Height 158.61±6.053 vs 159.82±5.721, WHR 0.74 ± 0.043 vs 0.75 ± 0.058 respectively with a p values >0.05 , Table 1.1 and 1.2). But BMI and Waist circumference were significantly higher amongst obese & Overweight group compared to non obese group (BMI 26.39 ± 3.28 vs 20.31±1.02, Waist circumference 30.55±3.32 vs 26.70±1.32; p value 0.0001).

Pressure Pulse Profiles & VO2 Max in the study Population (Table 2.1 & 2.2) Table 2.1

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
PULSE RATE (basal)	1	30	80.33	9.711	1.773
	2	30	79.86	6.479	1.203
SBP (In mmhg)	1	30	118.80	4.944	0.903
	2	30	118.41	5.193	0.964
DBP (in mmhg)	1	30	78.13	3.319	0.606
	2	30	78.83	3.485	0.647
Pulse after exercise	1	30	146.10	13.397	2.446
	2	30	144.72	17.596	3.268
VO_2 MAX	1	30	56.8727	0.90960	0.16607
	2	30	56.8860	1.09740	0.20378

Table 2.2

Independent Samples Test								
		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2- tailed)	Mean Difference	Std. Error Difference
PULSE RATE (basal)	Equal variances assumed	5.708	0.020	.218	57	0.828	.471	2.157
	Equal variances not assumed			.220	50.720	0.827	.471	2.143
SBP (mmHg)	Equal variances assumed	0.146	0.704	.293	57	0.771	.386	1.320
	Equal variances not assumed			.292	56.605	0.771	.386	1.321
DBP (mmHg)	Equal variances assumed	.176	0.676	-.784	57	0.436	-.694	.886
	Equal variances not assumed			-.783	56.607	0.437	-.694	.887
pulse after exercise	Equal variances assumed	0.816	0.370	.339	57	0.736	1.376	4.063
	Equal variances not assumed			.337	52.311	0.737	1.376	4.082
VO2 MAX	Equal variances assumed	0.427	.516	-.051	57	0.960	-.01335	.26204
	Equal variances not assumed			-.051	54.382	0.960	-.01335	.26288

Group 1= normal weight,
Group 2= Overweight & Obese, SBP= Systolic blood pressure in mmHg,
DBP= Diastolic Blood Pressure in mmHg, VO_2 Max= Maximum Oxygen utilization

There are no significant differences observed in the Pressure pulse profile & VO2 max in obese or non obese after exercise.

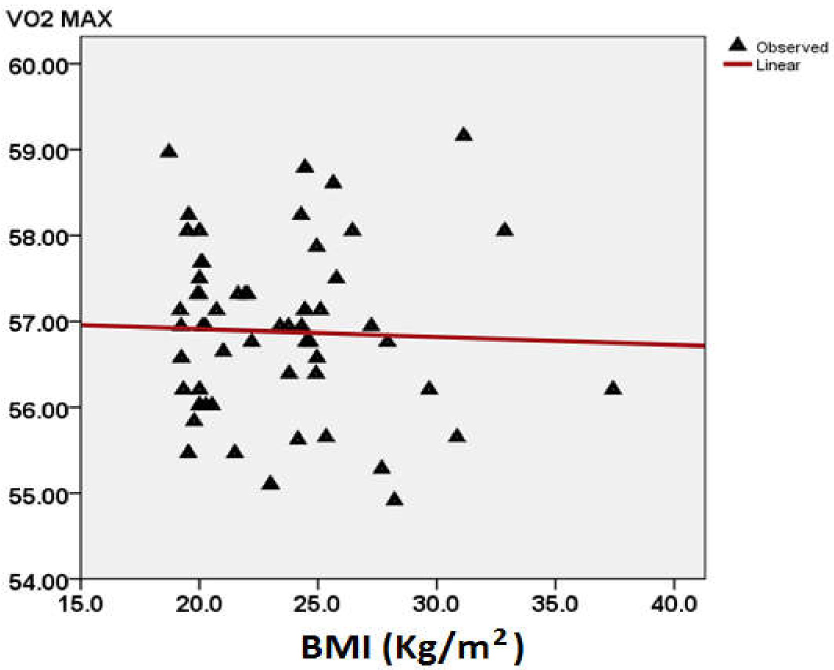

Figure 1. Regression analysis of VO2 max based on BMI

Model Summary and Parameter Estimates

Dependent Variable: VO2 MAX

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	0.001	.074	1	57	0.787	57.095	-.009

The independent variable is BMI.

The graph 1 depicts regression analysis of Vo2 max based on BMI. When we compared VO2 max of whole study population it was observed that there was a negative correlation between BMI & VO2 max however it was not significant (P=0.787).

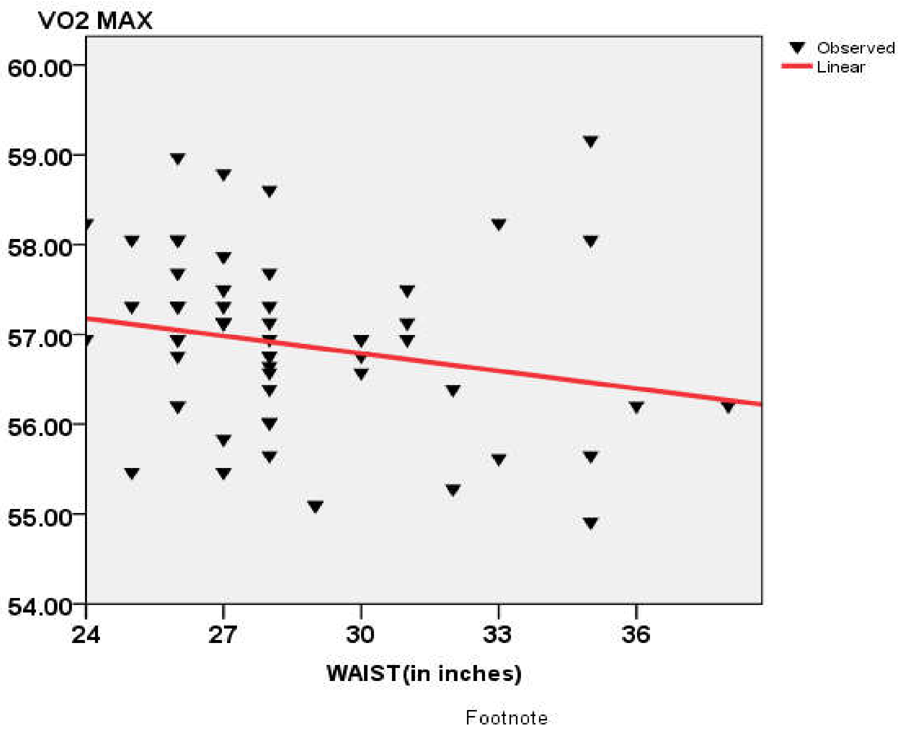

Figure 2. Regression analysis of VO2 max based on waist circumference

Model Summary and Parameter Estimates
Dependent Variable: VO2 MAX

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	0.042	2.51	1	57	0.118	58.737	-.065

The independent variable is Waist (in inches).

The graph 2 depicts regression analysis of Vo2 max based on waist circumference (WC). When we compared VO2 max of whole study population it was observed that there was a negative correlation between WC & VO2 max however it was not significant (P=0.118).

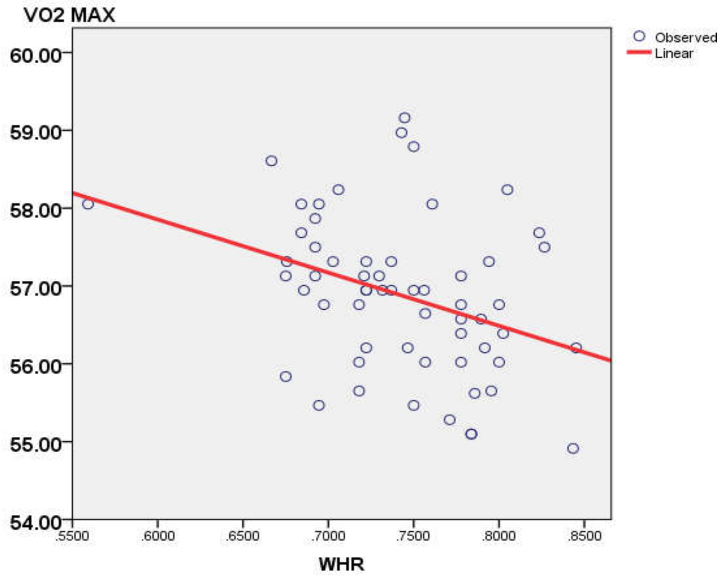

Figure 3. Regression analysis of VO2 Max Based on Waist Hip Ratio

Model Summary and Parameter Estimates
Dependent Variable: VO2 MAX

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	0.126	8.238	1	57	0.006	61.950	-6.827

The independent variable is WHR.

The graph 3 depicts regression analysis of Vo2 max based on waist Hip Ratio (WHR). When we compared VO2 max of whole study population it was observed that there was a negative correlation between WHR & VO2 max and it was significant (P=0. 0.006).

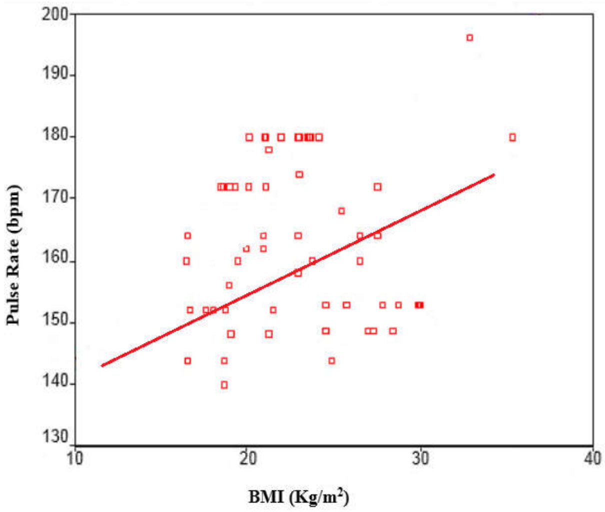

Figure 4. Scatter diagram showing the relationship between BMI and pulse rate

Variable		Pulse rate
BMI	r	0.8
	p	<0.05

DISCUSSION

VO2max is a measure of the functional limit of cardio respiratory system and single most valid index of maximal exercise capacity. The absolute value of VO2max is one of the indices of an individual's cardio-respiratory fitness to transport oxygen to working muscles. Earlier studies have used VO2max values in ml/kg/min to assess the level of cardio respiratory fitness. The aim of the present study was to investigate the association between aerobic test performance and body build measured by BMI and waist circumference & Waist Hip Ratio. We studied the performance of overweight, obese and normal weight adolescents, finding that overweight and non-overweight young individuals have similar absolute (mLO2/minute) cardio-respiratory fitness but that the functional impairment observed in overweight young individuals is significantly associated with the increased energy demands needed to move their excess body weight. The additional metabolic cost of excess adiposity in overweight adolescents was demonstrated most clearly during unloaded cycling.

For overweight young individuals simply moving their lower limbs induced significantly greater absolute oxygen uptake and led to consumption of a significantly larger proportion of their cardio-respiratory reserve. In addition, the greater metabolic cost of unloaded cycling was shown to predict a poorer performance during the functional performance evaluation walk/run test. Part of the metabolic cost of motion in significantly overweight young individuals likely is attributable to decreased mechanical efficiency. Chatterjee *et al* in 2005 used Queens College step test in their study to assess cardio-respiratory fitness in obese and non-obese boys aged 10-16 yrs and it was found that VO2 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 (Chatterjee, *et al.*, 2005). It was found that during the 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 (Bandyopadhyay, *et al.*, 2003).

Our result also depicts similar results. Absolute VO2max indicates an individual's cardio-respiratory fitness to transport oxygen to working muscles (Chatterjee, *et al.*, 2005). The present study shows that there is no significant difference in absolute VO2 max of obese and non-obese group indicating there is no extra stress on cardio-respiratory system because of excess fat. Buskirk and Taylor (1957), Davies *et al* (1975), and Anne-Caroline Norman *et al* (42), also have similar findings in their studies. In a recent study conducted by Wood *et al* (43) in overweight and obese adults also found results supporting present study. In their study comparison of VO2max in non-obese and obese was not done but they observed that VO2 platue was reached in 85% of overweight and obese adults after performing continuous incremental exercise and some tests fulfilling criteria for reaching VO2 platue. Chatterjee *et al.* (2009) have contradictory finding, in which absolute VO2max is higher in obese indicating higher cardiac load during working. In the current study VO2 max of whole study population was found to have a negative correlation between WHR & VO2 max and it was significant (P=0. 0.006, Graph 3). Ideal reference for the VO2max as a test of cardiovascular-respiratory performance might well be the weight of muscles actually performing the work. In this study VO2max per kg lean body mass shows no significant difference in obese and normal weight group indicating same cardio respiratory performance in both the groups. Chatterjee *et al.* (39) found similar results in their study. Davies *et al.* (1975) found contradictory result. Changes in body composition, that is, proportional increase in fat-free mass in relation to the decrease of total body mass, as end result of the endurance training-based intervention have a beneficial effect to aerobic fitness and consequently in the health status of the obese boys. Longitudinal data based on Canadian and Belgian studies indicated, on average, that peak velocity of growth in stature and peak VO2 tend to be coincident biological events (Geithner, *et al*., 2004).

Our results also indicate that utilization of oxygen at tissue level may be more efficient in proportion to total mass and active fat-free mass in obese individuals**.** In this study we found a significant negative correlation between WHR and VO2max (ml/kg/min) (p=0.006 Figure3). This indicates the striking effects of increasing WHR on Cardio respiratory fitness. This is in line with the findings of the earlier studies (Chatterjee, *et al.,* 2005; Bandopadhyay, *et al*., 2003; Bandopadhyay, 2012). Norman *et al* in 2005 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 cardio-respiratory fitness but the functional impairment was significantly associated with increased energy demands needed to move their excess bodyweight (Norman, *et al*., 2005). Patkar and Joshi in 2011 compared cardio-respiratory fitness between obese and non-obese subjects and concluded that cardio-respiratory efficiency was not affected in obese group as compared to normal weight group, however ability to do exhausting work was less in obese (Patkar, *et al*., 2011).

Summary

Incidence of obesity in early life is increasing nowadays because of faulty food habits and lack of exercise. This study was aimed to find out whether obesity affects cardio-respiratory efficiency of young adults. As VO2 max is the most accepted indicator of cardio-respiratory efficiency it was compared in 30 obese and 30 non-obese subjects aged around 18-22 years. VO2 max was estimated by Queen's college step test. Various other parameters measured and calculated were weight, height, BMI, skin fold thickness, percentage body fat, lean body mass, fat mass. The results showed that cardio-respiratory efficiency (absolute VO2max & VO2max/kg lean body mass) was not affected (P>0.05) in obese group. Ability to do exhausting work (VO2 max/kg body weight) was less in obese group (P=0.006, Graph 3) compared to non-obese group.

Therefore the exercise programs can be best designed to increase caloric expenditure and thus to decrease body fat rather than to improve aerobic fitness. There was no detrimental effect of obesity on cardio-respiratory efficiency in the study groups.

Suggestions

Considering these findings of the study, therapeutic exercise programs for obese young adults can be best designed to increase caloric expenditure and thus to decrease body fat rather than to improve aerobic fitness. Thus incorporation of activities need not be at high sustained intensities. This will increase their compliance for exercise programs. In addition accurate guidance regarding the type of food consumption will increase the tolerance for maximum exercise and reduce the incidence of obesity related health hazards in later years of life.

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