Original article:

Study of cardiopulmonary exercise test in apparently healthy indivduals at a tertiary care centre.

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ABSTRACT

INTRODUCTION : Cardiopulmonary exercise testing (CPET) is increasingly being used in a wide spectrum of clinical applications for the evaluation of undiagnosed exercise intolerance and for the objective determination of functional capacity and impairment. The objective of the study was to study exercise tolerance in normal healthy adults and to study variations in exercise tolerance as per demographic and anthropometric parameters.

METHODOLOGY: This prospective study was conducted at a Cardiopulmonary exercise testing unit of a tertiary care public hospital. 50 healthy adult participants with no history of cardiac and respiratory disorders were screened for and included in the study to determine their exercise tolerance.

RESULTS: The males had a higher exercise tolerance compared to females. Significant inverse correlation was found between VO2max and age, weight, BMI whereas significant linear correlation was found between height and VO2max. Significant inverse correlation was found between AT and age, BMI, significant positive correlation was found between height and AT, no correlation was found between weight and AT.Significant inverse correlation was found between METS and age, BMI whereas significant linear correlation was found between height and METS and no correlation between weight and METS.

CONCLUSION: The exercise tolerance varied in the population studied as per their age, gender and anthropometric parameters. Exercise tolerance was more in males and younger subjects. Height and BMI showed a more consistent correlation with exercise tolerance than weight

KEY WORDS: Exercise tolerance , Cardiopulmonary exercise

INTRODUCTION:

Over the past decades, numerous scientific reports have examined the relationships between physical activity, physical fitness, and cardiovascular health. Expert panels, convened by organizations such as the Centers for Disease Control and Prevention (CDC), the American College of Sports Medicine (ACSM), and the American Heart Association (AHA) [1,2,3], along with the 1996 US Surgeon General's Report on Physical Activity and Health [4], reinforced scientific evidence linking regular physical activity to various measures of cardiovascular health. The purpose of this study was to measure exercise tolerance in normal healthy adults and to evaluate variations in exercise tolerance as per age,gender and anthropometric parameters.

MATERIALS AND METHODS:

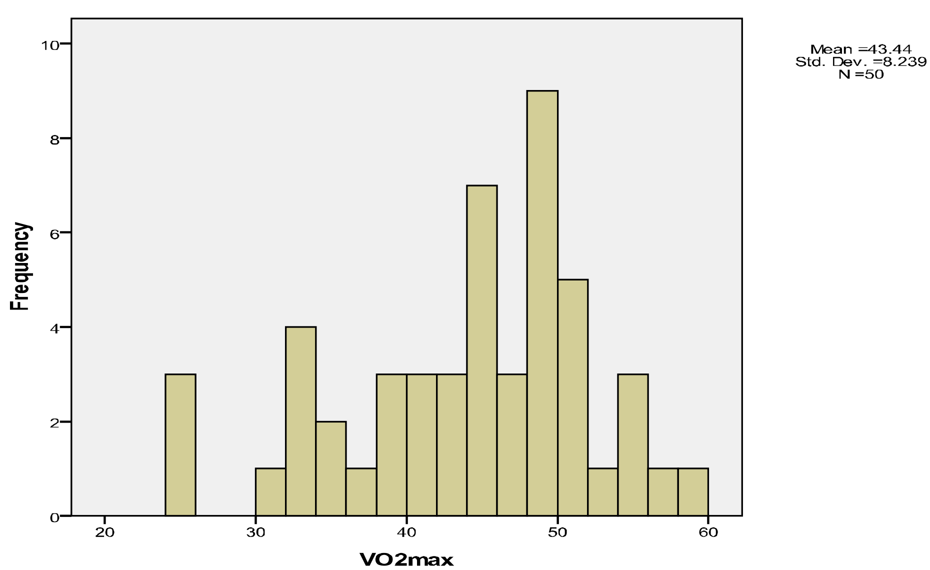
This prospective study was conducted at a Cardiopulmonary exercise testing unit of a tertiary care public hospital. The participants of the study were 50 adult subjects of either sex from the age of 18 years to 45 yrs. Before proceeding for the study, the required proforma and plan of the study were submitted to the Ethics Committee for Research on Human Subjects of the institute and were approved. Subjects with no active complaints were selected randomly at our centre and were screened for the presence of respiratory disorders (Chronic Obstructive Pulmonary Disease, Bronchial Asthma, Interstitial lung disease) and cardiac disorders (ischemic heart disease, angina, cardiac myopathy, rhythm abnormalities) by symptomatology, history, clinical examination and chest X-ray. After these preliminary investigations, Pulmonary Function was done to rule out respiratory disorders. Routine blood investigations were done to rule out anemia, renal, hepatic or metabolic abnormalities, which could compromise the exercise function testing. ECG was done to rule out cardiac disorder. VO2max (also maximal oxygen consumption, maximal oxygen uptake, peak oxygen uptake or aerobic capacity), anaerobic threshold (AT), and METS (metabolic equivalent) were used as objective measures of exercise tolerance. The exercise testing was stopped at the request of subject on feeling fatigued and breathless. None of the subjects had any cardiac event in the form of ECG changes or experienced any respiratory decompensation as fall in oxygen saturation or limitation of breathing reserve. The subjects having low exercise tolerance were all found to be deconditioned as their respiratory exchange ratio which is considered a marker for adequate effort was less than 1.1

RESULTS:

In our study the minimum age was 18 years and the maximum was 45 years. The population of male subjects was 58 % and female subjects was 42 %. The average VO2max was 43.44 ml/kg/min. The average VO2max in males was 45.41 ml/kg/min and in females it was 40.71 ml/kg/min. (**Fig. 1).**

Figure: 1

Distribution of VO2 max in the population



VO2MAX					
	N	Minimum	Maximum	Mean	Std. Deviation
VO2max	50	25	58	43.44	8.239

Descriptive characteristics for male and female					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
VO2max	Male	29	45.41	7.008	1.301
	Female	21	40.71	9.170	2.001

TABLE 1: . CORRELATION OF VO2MAX

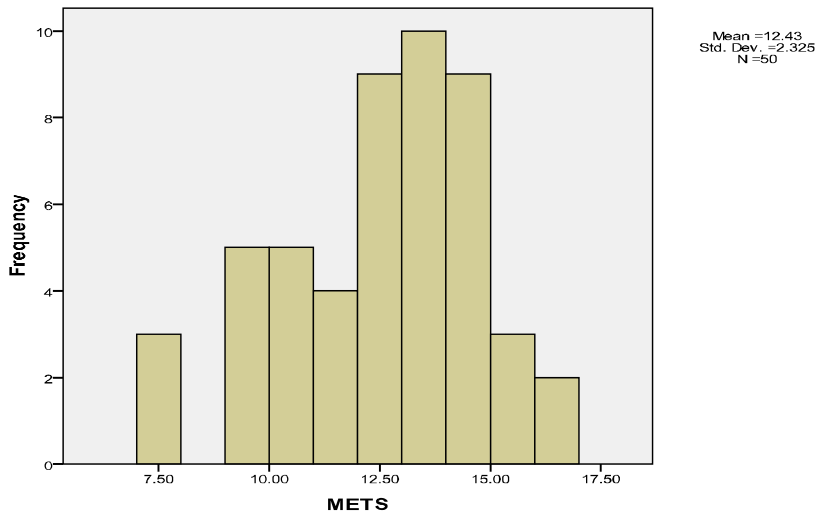
Correlations		
		VO2max
Age	**Pearson Correlation**	**-.507****
	Sig. (2-tailed)	**.000**
	N	**50**
Height	**Pearson Correlation**	**.297****
	Sig. (2-tailed)	**.021**
	N	**50**
Weight	**Pearson Correlation**	**-.137**
	Sig. (2-tailed)	**.021**
	N	**50**
BMI	**Pearson Correlation**	**-.301***
	Sig. (2-tailed)	**.011**
	N	**50**
***. Correlation is significant at the 0.05 level (2-tailed).**		
****. Correlation is significant at the 0.01 level (2-tailed).**		

The correlation coefficient test was used to study the correlation between Age and VO2 max **(Table. 1).** It was observed that there was a very highly significant inverse correlation between Age and VO2 max i.e. as the age increases, the VO2max decreases (r = -0.501,p <0.0001).There was a significant linear correlation between Height and VO2 max i.e. as the height increases, the VO2max decreases (r= 0.297, p< 0.05). There was a significant inverse correlation between Weight and VO2 max i.e. as the weight increases, the VO2max decreases (r= -0.137, p< 0.05). There was significant inverse correlation between BMI and VO2 max i.e. as the BMI increases, the VO2max decreases (r= -0.301, p<0.05).

The average METS were 12.43.The average METS in males were 12.97 and in females they were 11.68. Thus the METS were higher in males as compared to females by 11.04 % .There was no significant difference (p - > 0.05) between METS of males and females **(Fig. 2**).

2. DISTRIBUTION OF METS (METABOLIC EQUIVALENTS) IN THE POPULATION:

Figure: 2 Distribution of METS (Metabolic Equivalents) in the population



METS					
	N	Minimum	Maximum	Mean	Std. Deviation
METS	50	7.20	16.57	12.4310	2.32508

Descriptive characteristics for male and female					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
METS	Male	29	12.971379	2.0030614	.3719592
	Female	21	11.6800	2.5757060	.5621000

TABLE 2 : CORRELATION OF METABOLIC EQUIVALENT (METS):

Correlations		
		METS
Age	**Correlation Coefficient**	**-.531****
	Sig. (2-tailed)	**.000**
	N	**50**
Height	**Correlation Coefficient**	**.302***
	Sig. (2-tailed)	**.021**

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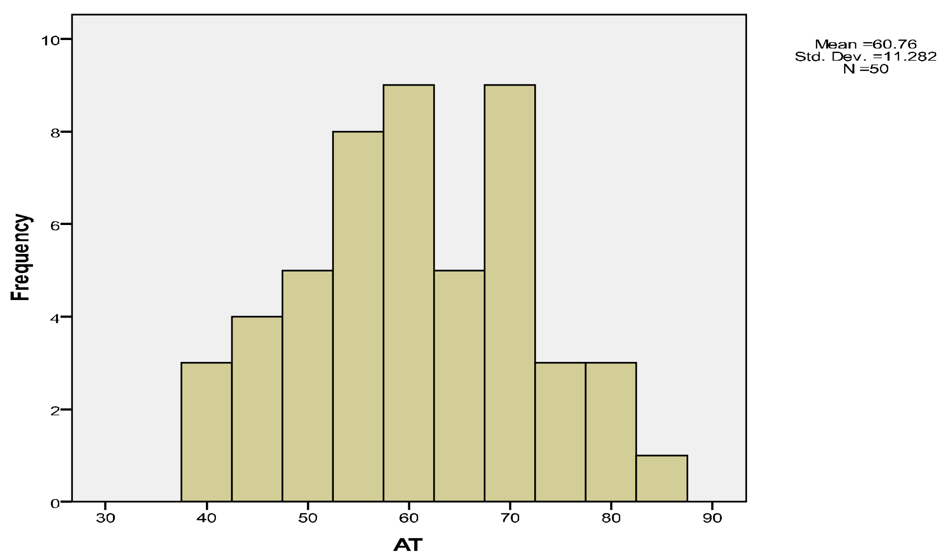
	N	**50**
Weight	**Correlation Coefficient**	**-.161**
	Sig. (2-tailed)	**.254**
	N	**50**
BMI	**Correlation Coefficient**	**-.306***
	Sig. (2-tailed)	**.011**
	N	**50**
****. Correlation is significant at the 0.01 level (2-tailed).**		
***. Correlation is significant at the 0.05 level (2-tailed).**		

The correlation coefficient test was used to study the correlation between Age and METS **(Table. 2).** It was observed that there was a very highly significant inverse correlation between Age and METS i.e. as the age increases, the METS decreases (r= -0.556, p< 0.0001).There was a highly significant linear correlation between Height and METS i.e. as the height increases, the METS increases (r= 0.368, p< 0.01).There was no correlation between Weight and METS. (p > 0.05) **.**There was a significant inverse correlation between BMI and METS i.e. as the BMI increases, METS decreases (r= -0.292, p<0.05).

The average AT was 60.76%. The average AT in males was 62.59% and in females it was 58.24%. Thus the AT was higher in males as compared to females by 7.4% There was no significant difference (p - > 0.05) between AT of males and females **(Fig. 3).**

Figure: 3 Distribution of AT (Anaerobic Threshold) in the population



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AT

	N	Minimum	Maximum	Mean	Std. Deviation
AT	50	40	86	60.76	11.282

Descriptive characteristics for male and female					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
AT	Male	29	62.59	12.188	2.263
	Female	21	58.24	9.612	2.098

TABLE 3 : CORRELATION OF ANAEROBIC THRESHOLD

Correlations		
		AT
Age	**Pearson Correlation**	**-.556****
	Sig. (2-tailed)	**.000**
	N	**50**
Height	**Pearson Correlation**	**.368****
	Sig. (2-tailed)	**.009**
	N	**50**
Weight	**Pearson Correlation**	**-.081**
	Sig. (2-tailed)	**.576**
	N	**50**
BMI	**Pearson Correlation**	**-.292***
	Sig. (2-tailed)	**.039**
	N	**50**
***. Correlation is significant at the 0.05 level (2-tailed).**		
****. Correlation is significant at the 0.01 level (2-tailed).**		

The correlation coefficient test was used to study the correlation between Age and AT **(Table. 3).** It was observed that there was a very highly significant inverse correlation between Age and AT i.e. as the age increases, the AT decreases (r= -0.556, p<0.0001).There was a highly significant linear correlation between Height and AT i.e. as the height increases, the AT increases (r= 0.368, p< 0.01).There was a no significant correlation between Weight and AT.There was a significant inverse correlation between BMI and AT i.e. as the BMI increases, AT decreases (r= -0.292, p<0.05).

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DISCUSSION

Cardiopulmonary exercise testing is done in healthy asymptomatic individuals an objective measure to evaluate cardiovascular fitness, diagnose asymptomatic cardiovascular disease and as a method to prescribe exercise to improve an individual's level of physical fitness. The purpose of this study was to assess role of cardiopulmonary exercise testing to evaluate the level of exercise tolerance in healthy individuals. Subjects attending the tertiary care public hospital with no active cardiac or respiratory complaints were screened for presence of any underlying disease and cardiopulmonary exercise testing was performed.

VO_2 max (also maximal oxygen consumption, maximal oxygen uptake, peak oxygen uptake or aerobic capacity) is the maximum capacity of an individual's body to transport and use oxygen during incremental exercise, which reflects the physical fitness of the individual. The name is derived from V - volume per time, O_2 - oxygen, max - maximum. The VO2max was measured in the population. VO_2 max is expressed either as an absolute rate in liters of oxygen per minute (l/min) or as a relative rate in milliliters of oxygen per kilogram of bodyweight per minute (ml/kg/min). A reduced VO_2peak is the starting point in the evaluation of reduced exercise tolerance

The VO2max was higher in males as compared to females by 11.54 %. There was significant difference (p - < 0.05) between VO2max of males and females. Untrained girls and women typically have a maximal oxygen uptake 20-25% lower than untrained men. However, when comparing elite athletes, the gap tends to close to about 10% [(5).] Cureton and Collins [(6)] suggest that sex-specific essential fat stores account for the majority of metabolic differences in running between men and women..

There was a very highly significant inverse correlation between Age and VO2 max. Katch et all in 2007[(7)] have shown a negative correlation between VO2max and age. Gerstenblith G et all in1987 [(8)] and Hodgson JL et all in 1977[(9)] had similar results in their cross-sectional data suggesting that aerobic power declines linearly throughout adulthood. Several studies have shown that maximal oxygen uptake (Vo2max) declines with age[.(10-15).] The average rate of decline is generally accepted to be about 1% per year or 10% per decade after the age of 25. One large cross sectional study found the average decrease was 0.46 ml/kg/min per year in men (1.2%) and 0.54 ml/kg/min in women (1.7%) [(16,17).]

There was a significant linear correlation between Height and VO2 max. There was a significant inverse correlation between Weight and VO2 max. There was significant inverse correlation between BMI and VO2 max. Singh et all in 2010[(18)] had similar observation in their study that all the physical parameters were well correlated with VO2max indicating dependence of the later on physical parameters. The data, suggesting a relatively modest decrement of maximal oxygen uptake scaled to total body weight (0.4 mL /kg/ min/per year), are consistent with the 2 prior studies[.(19,20)]

The metabolic equivalents (METS) were studied in the population. METS is a term that was developed to define the amount of oxygen consumed by the body to perform work. 1 MET = 3.5 ml/kg/min. of oxygen consumed (VO2).

This number was determined by measuring VO2 in multiple subjects at rest and then arriving at an average. Therefore, 1 MET = average VO2 at rest. METS were higher in males as compared to females by 11.04 % However there was no significant difference between METS of males and females in the population.

The correlation coefficient test was used to study the correlation between Age and METS **(Table. 2).** There was a very highly significant inverse correlation between Age and METS. In study conducted by CK Morris et all in 1993 [21] equations for predicted METs for age were derived for the entire clinical referral group (METs = 18.0-0.15[Age]) and for the subgroups of active (METs = 18.7-0.15[Age]) and sedentary (METs = 16.6-0.16[Age]) patients. All results achieved statistical significance, with p values < 0.001.

There was no correlation between Weight and METS**.** MET is used as a practical means of expressing the intensity and energy expenditure of physical activities in a way comparable among persons of different weight. Actual energy expenditure (e.g., in calories or joules) during a physical activity depends on the person's body mass, therefore the energy cost of the same physical activity will be different for persons of different weight. Nuala M et all in 2005 [22] showed that body composition (fat mass and fat-free mass) accounted for 62% of the variance in resting $\dot{V}O_2$ compared with age, which accounted for only 14%. For a large heterogeneous sample, the 1-MET value of 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$ overestimates the actual resting $\dot{V}O_2$ value on average by 35%, and the 1-MET of 1 kcal/h overestimates resting energy expenditure by 20%. The American College of Sports Medicine [23] has defined light, moderate, and heavy physical activity to equate with specific MET levels, and tables have been developed to enable prescription of exercise intensity [24]. However, there is evidence that the factorial system may be inaccurate for estimating activity energy expenditure in people of different body mass and body fat percentage [25,26]. Thus as body weight includes both fat and fat free body mass there is inaccuracy in calculations of METS and basal metabolic rates in individuals as per their weights.

There was a significant inverse correlation between BMI and METS i.e. as the BMI increases, METS decreases ($r= -0.292$, $p<0.05$).

The anaerobic threshold (AT), also known as the lactate threshold, lactic acid threshold, gas exchange threshold, or ventilatory threshold was studied in the population. It is considered an estimator of the onset of metabolic acidosis caused predominantly by the increased rate of rise of arterial [lactate] during exercise. The AT is referenced to the $\dot{V}O_2$ at which this change occurs and is expressed as a percentage of the predicted value of $\dot{V}O_2max$ (%VO_2max predicted) [27-31]**.** Estimation of the onset of metabolic acidosis occurs at approximately 50-60% VO2max in normal individuals [32,33].

The AT was higher in males as compared to females by 7.4% However there was no significant difference between AT of males and females.There was a very highly significant inverse correlation between Age and AT. Naoya Matsumura et all in 1983 [34] in their study noted that there was a considerable scatter in the values at any given age range. However, a consistent and negative correlation was noted between age and anaerobic threshold ($r= -.697, p<.001$) There was a highly significant linear correlation between Height and AT.There was a no significant correlation between Weight and AT and there was a significant inverse correlation between BMI and AT.

CONCLUSION

The VO2 max as a measure of exercise tolerance along with Anaerobic threshold (AT) and Metabolic equivalent (METS) in healthy adults was higher in males compared to females. However only VO2max was significantly higher in males. As the age increased the exercise tolerance measured by VO2max, Anaerobic threshold and METS decreased.There was a positive correlation between exercise tolerance and height.The weight was inversely correlated to VO2max, but showed no significant correlation with METS and AT. There was significant inverse correlation between Body Mass Index (BMI) and exercise tolerance.

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