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Review Article

STUDY OF ANAEROBIC THRESHOLD IN HEALTH

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Abstract

Introduction: The anaerobic threshold (AT), also known as the lactate threshold, lactic acid threshold, gas exchange threshold, or ventilatory threshold, is considered an estimator of the onset of metabolic acidosis caused predominantly by the increased rate of rise of arterial [lactate] during exercise. It is an accurate marker of fitness or exercise tolerance of an individual. The objective of the study was to study anaerobic threshold 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 anaerobic threshold. **Results:** Anaerobic threshold (AT) in healthy adults was higher in males compared to females. As the age increased Anaerobic threshold decreased. There was a positive correlation between AT and height. The weight showed no significant correlation with AT. There was significant inverse correlation between Body Mass Index (BMI) and AT. The AT of nonsedentary subjects was significantly higher than sedentary subjects. Majority of subjects showed significant improvement in their AT after lifestyle modification in the form of moderate physical activity for three months. **Conclusion:** The Anaerobic threshold varied in the population studied as per their age, gender and anthropometric parameters. AT was more in males and younger subjects. Height and BMI and physical activity showed a more consistent correlation with AT than weight.

Key words: Anaerobic threshold, Age, Gender, Height, Weight, BMI, lifestyle.

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Introduction:

The anaerobic threshold (AT), also known as the lactate threshold, lactic acid threshold, gas exchange threshold, or ventilatory threshold, is considered an estimator of the onset of metabolic acidosis caused predominantly by the increased rate of rise of arterial lactate during exercise. The purpose of this study was to measure anaerobic threshold (AT) in normal healthy adults and to evaluate variations in exercise tolerance as per age, gender and anthropometric parameters and lifestyle.

Materials and Methods:

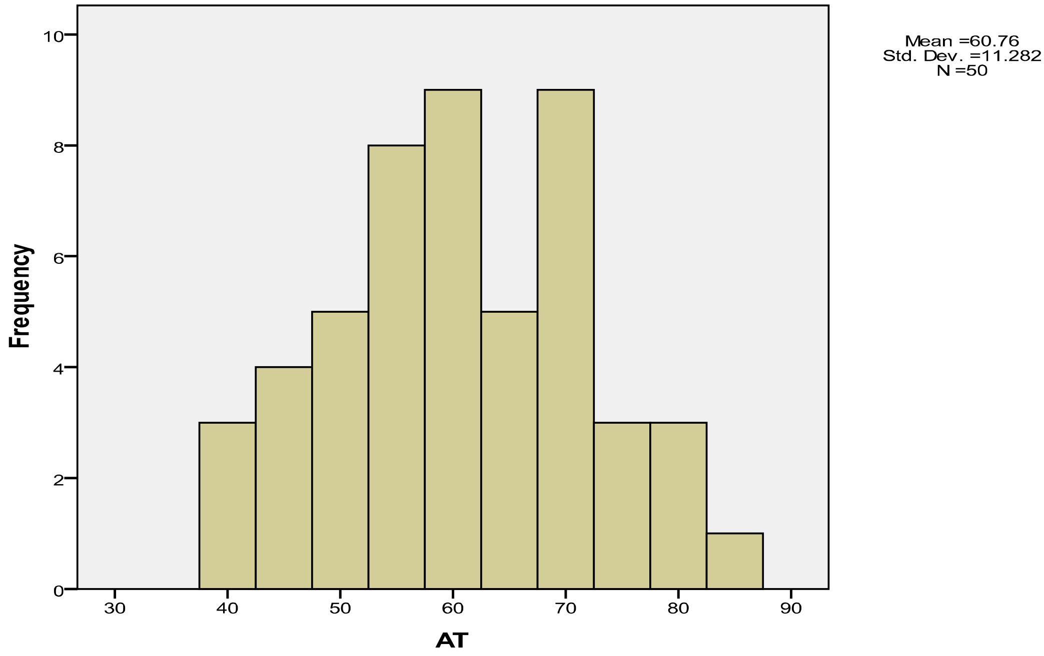
This prospective study was conducted at a Cardiopulmonary exercise testing unit of a tertiary care public hospital. The participants of the study were 50 adult subjects of either sex from the age of 18 years to 45 yrs. Subjects with no active complaints were selected randomly at our centre and were screened 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. Anaerobic threshold (AT) was 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.

Subjects were classified as sedentary, which was defined as reporting less than 30 min per day of moderate exercise on two days per week over the previous six months. Subjects were told to increase their regular walking and advised to accumulate at least 30 min of moderate physical activity on most, preferably all days of the week or at least 5 days a week, in a manner consistent with their lifestyle and daily schedules. Subjects were followed up for further evaluation after 3 months when Cardiopulmonary Exercise Testing was repeated. The statistical analysis of the data was done, for quantitative data mean, standard deviation, correlation co-efficient, paired and unpaired t test were used. The qualitative data was analyzed using proportional method. P value <0.05 was considered significant, p <0.01 was considered highly significant and $p<0.0001$ was considered very highly significant. The exercise tolerance of the population was measured using Anaerobic Threshold. The exercise tolerance was then correlated with age, gender and anthropometric parameters such as height, weight, Body Mass Index (BMI) and statistical analysis was done for determination of significance of correlation. Unpaired t test was used to establish significance of difference in exercise tolerance of sedentary and nonsedentary subjects. The subjects were told to follow a lifestyle modification, which included any form of physical activity preferably brisk walking for duration of 30 minutes at least 5 times a week for 3 months. The paired t test was used to study the exercise tolerance of subjects after 3 months.

Results:

In our study, the youngest subject was 18 years old and the oldest subject was 45 years old. The mean age was 28.88 years old. The population of male was 58% and females was 42%. The average height in males was 172.59 centimeters while in females it was 162.48 centimeters. The average height of the population was 168.34 centimeters. The maximum height was 183 cms and minimum height was 150 cms. The average weight in males was 66.31 kilograms, whereas the average weight in females was 61.10 kilograms. The average weight for the population was 64.12 kilograms. The maximum weight was 80 kilograms and minimum weight was 42 kilograms. The average BMI in males was 22.348 kg /m^2 and the average BMI in females was 23.127 kg/m^2. The average BMI in the population was 22.67 kg/m^2. The maximum BMI was 29.74 kg/m^2 and minimum BMI was 16.56 kg/m^2.

1. DISTRIBUTION OF AT (ANAEROBIC THRESHOLD) IN THE POPULATION: (Figure: 1)
Distribution of AT (Anaerobic Threshold) in the population



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

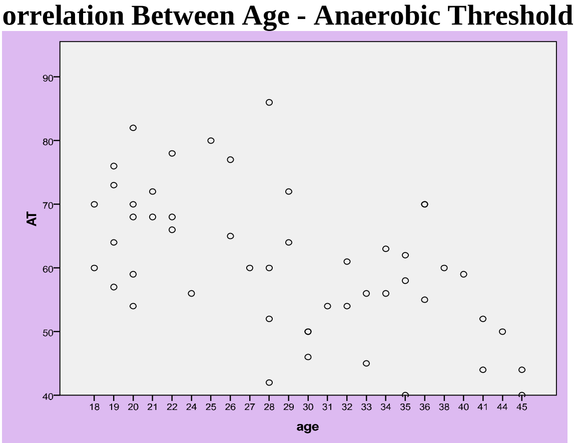
The average Anaerobic Threshold in males was 62.59% of VO2max while in females it was 58.24% of VO2max.The average Anaerobic threshold of the population was 60.76% of VO2max.The maximum AT was 86% and minimum AT was 40% of VO2max.

2. CORRELATION OF ANAEROBIC THRESHOLD: (Table. 1)

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).		

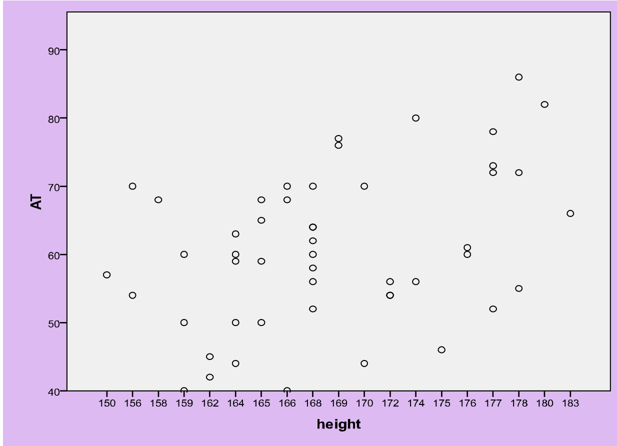
Using correlation coefficient test it was found that there was very highly significant inverse correlation between age ($p<0.001, r= -0.556$) and AT i.e. as age increases AT decreases. There was highly significant positive correlation ($p<0.01, r=0.368$) was found between height and AT i.e. as height increases AT increases. There was no correlation($p>0.05$) was found between weight and AT. There was a significant inverse correlation ($p<0.05, r= -0.292$) was observed between BMI and AT i.e. as BMI increases AT decreases.

Correlation Between Age - Anaerobic Threshold



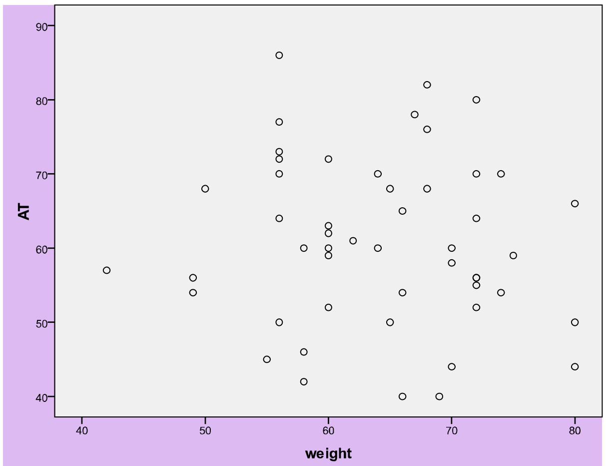
(Fig. 2)

Correlation Between Height - Anaerobic Threshold



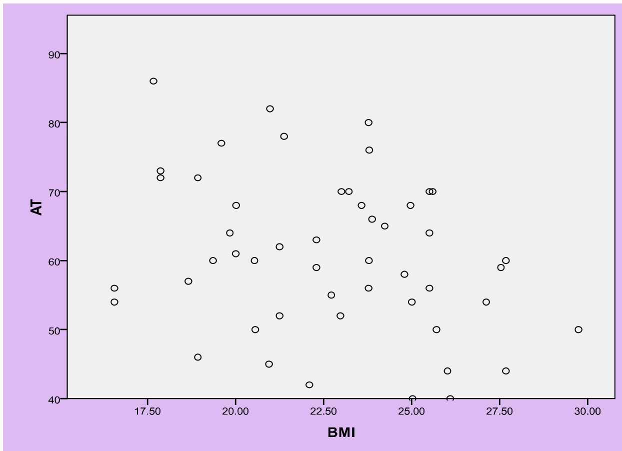
(Fig. 3)

Correlation Between Weight - Anaerobic Threshold



(Fig. 4)

Correlation Of Bmi - Anaerobic Threshold



(Fig. 5)

Comparison Between Sedentary & Nonsedentary Individuals: (Table 2)

Baseline comparison between sedentary & non-sedentary					
	Lifestyle	N	Mean	Std. Deviation	Std. Error Mean
AT	Sedentary	25	57.60	9.032	1.806
	Non-sedentary	25	63.92	12.550	2.510

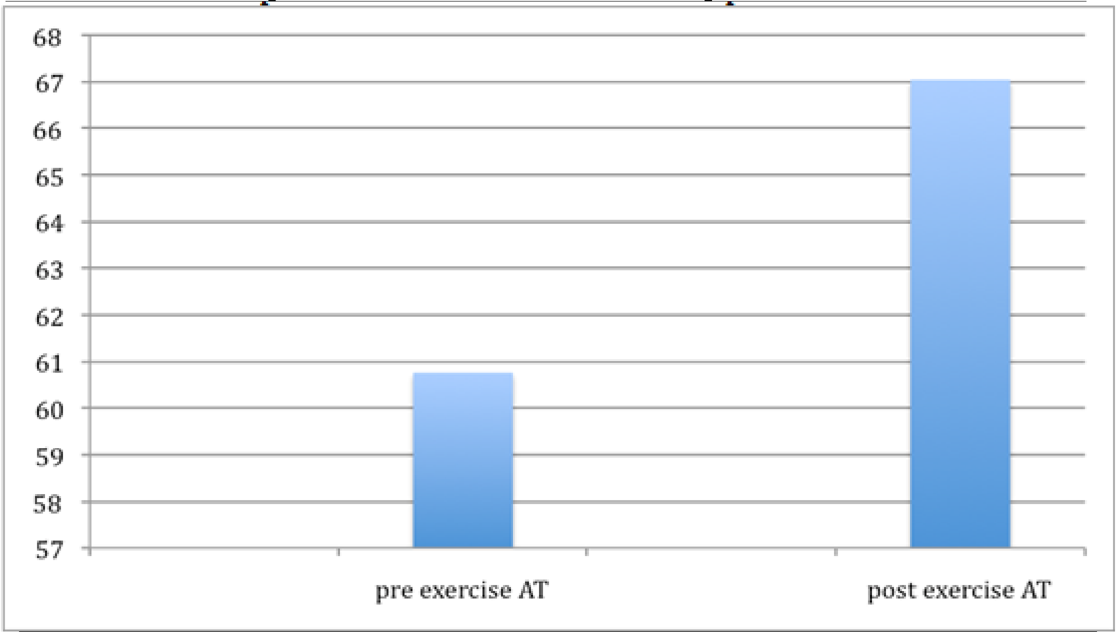
The average anaerobic threshold in sedentary individuals was 57% of VO2 max and in non-sedentary individuals it was 63.92% of VO2max.

Comparison based on lifestyle							
		t-test for Equality of Means				95% CI	
		t	df	Sig.	Mean Difference	Lower	Upper
AT	Equal variances assumed	-2.044	48	.046	-6.320	-12.538	-.102
	Equal variances not assumed	-2.044	4.360E1	.047	-6.320	-12.554	-.086

There was significant difference between AT of sedentary and non-sedentary subjects ($p<0.05$).

Paired T Test For At Before And After Exercise: (Fig.6).

Improvement in Anaerobic Threshold post exercise



Number of patients (n)		50
Mean AT	Pre exercise	60.76
	Post exercise	67.04
'p' value		0.0035

There was highly significant improvement in Anaerobic Threshold after exercise ($p<0.01$). The average AT after exercise was 67.04% of VO2max, i.e. there was 10.33 % improvement in AT post exercise. In our study, 47 subjects showed improvement in AT, 3 subjects showed no improvement and no subject showed deterioration.

Discussion:

The anaerobic threshold (AT), also known as the lactate threshold, lactic acid threshold, gas exchange threshold, or ventilatory threshold, 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)[1-5]**.** Estimation of the onset of metabolic acidosis occurs at approximately 50-60% VO2max in normal individuals [6,7].

Low (early) AT suggests problems in O2 delivery, muscle oxidative capacity, or both

1. More important is whether it occurs, rather than at what %VO2max.
2. Indicates test is at least close to maximal exercise.
3. Not under voluntary control, not affected by psychological factors.

The AT demarcates the upper limit of a range of exercise intensities that can be accomplished almost entirely aerobically. Whereas work rates below the AT can be sustained essentially indefinitely, a progressive increase in work rate above AT is associated with a progressive decrease in exercise tolerance [8]. Values below 40% of predicted $\dot{V}O_2max$ may indicate a cardiac, pulmonary (desaturation), or other limitation in O_2 supply to the tissues, or underlying mitochondrial abnormality (e.g., muscle dysfunction in cardiopulmonary diseases, mitochondrial myopathies, etc.). AT determination is helpful as an indicator of level of fitness, for exercise prescription, and to monitor the effect of physical training

The minimum Anaerobic Threshold (AT) was 40% of VO2 max and the maximum AT was 86%. 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%. **(Fig. 1).** The correlation coefficient test was used to study the correlation between Age and AT. 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 ($r= -0.556$, $p<0.0001$). Naoya Matsumura et all in 1983 [9] 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 ($r= -.697, p<.001$).

It was observed that 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. Agnieszka Zak-Golab et all in their article in 2010 [10] showed that after weight reduction blood lactate concentrations and RQ (Respiratory quotient) at rest did not change significantly. Also the increase of lactate concentration and RQ at exercise was similar as before weight reduction. The higher lactate threshold noted in obese women was may be related to the increased fat acid usage in metabolism. There was a significant inverse correlation between BMI and AT i.e. as the BMI increases, AT decreases ($r= -0.292$, $p<0.05$).

In the present study, there were 25 people with a sedentary lifestyle and 25 people with non-sedentary lifestyle.There was significant difference between AT of sedentary and non-sedentary subjects ($p<0.05$). Laura Stefani et all in 2010 [11] conducted a study in which the aim of the study was to estimate the behavior of the Aerobic threshold (AerT) and also Anaerobic Threshold (AT), VO2max in sedentary people.. The AerT, AT (assessed by V slope method) and VO2max were evaluated. The statistical analysis was performed with T student test ($P < 0.05$ significant). The average AT in sedentary individuals was 57.60 % of VO2 max and the average AT in non sedentary individuals was 63.92 % of VO2 max Thus the AT in non-sedentary individuals was more than sedentary individuals by 10.9 %.

The subjects were advised to follow an exercise regimen which involved moderate physical activity such as brisk walking for 30 minutes at least five times a week for three months and their cardiopulmonary exercise testing was repeated. A lifestyle of physical activity from childhood throughout the adult years fosters health and longevity. Even brisk walking as a physical activity/exercise habit promotes health benefits. This is the simplest program for most individuals and has clear benefits. This improved state of health is enhanced by weight control, restricted intake of saturated fat and cholesterol, abstinence from cigarette smoking, and control of high blood pressure and glucose intolerance.

In our study, 47 subjects showed improvement in AT, 3 subjects showed no improvement and no subject showed deterioration. The paired t test was used to evaluate the significance of improvement post exercise. The average AT after exercise was 67.04% of VO2max, i.e. there was 10.33 % improvement in AT post exercise. There was significant improvement in AT after exercise ($p<0.01$). American College of Sports Medicine (ACSM) issued guidelines for cardiovascular fitness. Basic aerobic endurance training that following the ACSM's recommended guidelines for cardio respiratory fitness training was known to improve VO2max. For an average unfit person following the ACSM's guidelines to experience a 15% improvement in VO2max after 2 to 3 months of regular training.

Conclusion

The Anaerobic threshold (AT) as a measure of exercise tolerance in healthy adults was higher in males compared to females. As the age increased the exercise tolerance measured by Anaerobic threshold decreased. There was a positive correlation between AT and height. The weight showed no significant correlation with AT. There was significant inverse correlation between Body Mass Index (BMI) and AT. The AT of nonsedentary subjects was significantly higher than sedentary subjects. Majority of subjects showed significant improvement in their AT after lifestyle modification in the form of moderate physical activity.

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