Health Science Monitor
2023; 2(3): 167-173
Published online (http://hsm.umsu.ac.ir)

Original Article

Estimation of aerobic capacity among university students and determination of its related factors

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Abstract

***Background & Aims*:** Aerobic capacity has a significant impact on both health and work performance. Therefore, promoting the health and improving the performance of employees require examining and paying attention to their aerobic capacity. The primary purpose of the current study was to determine the aerobic capacity and to analysis individual factors associated with VO_{2max} among university students.

***Materials & Methods*:** One hundred and thirty male and female students with a mean age of 21.6 ± 0.4 years, voluntarily participated in the present study. Aerobic capacity was determined using ergometer and the Astrand protocol. Demographic information and body mass index (BMI) of participants were also collected. Data were analyzed by using single and multiple-regression techniques.

***Results*:** Mean maximum aerobic capacity was 2.18 ± 0.41 L/min. The maximum aerobic capacity was associated with weight, BMI and heart rate. The results of regression analysis indicated that BMI and heart rate could significantly predict the VO_{2max} of the students. The best VO_{2max} prediction equation has been developed based on regression analysis.

***Conclusion*:** The mean of students' VO2max is lower than the counterpart population in the same society. The lack of regular exercise and a subsequent increase in BMI may lead to a significant decrease in VO2max. The significant relationship between HR, BMI and VO2max could be used to predict VO2max in young people.

***Keywords*:** Aerobic capacity, Astrand protocol, BMI, Ergometer bicycle

Received 15 March 2023; accepted for publication 30 May 2023

Introduction

Modern lifestyle changes, inactivity, stress, unhealthy diet, and smoking are among the factors that make a person vulnerable by changing physiological parameters such as muscle strength and aerobic capacity (1). Prevention or reduction of injury and improving human performance require fitting the physical and mental requirements of work with the

person's capabilities (2). By assessment of human physiological abilities, work can be designed to the extent of the individual's physiological tolerance. Thus, in addition to maintaining worker health and preventing worker illness and injury, performance will also be improved (3, 4).

In ergonomics, maximum oxygen expenditure rate (VO_{2max}), or aerobic capacity is used as a measure of work capacity and physical ability of a person (5). The measurement methods include direct and indirect methods. The direct method is considered as the gold standard for measuring VO_{2max}, and in this method, it is necessary for a subject to perform maximal effort exercise using a bicycle or treadmill. In the indirect method, there is no need to perform maximal exercise, and VO_{2max} is estimated based on a series of formulas and equations. Bruce protocol, Astrand-Rhyming cycle ergometer test and the YMCA are common tests for VO_{2max} measurement. Having comprehensive data on human physical abilities especially aerobic capacity measure, can play a significant role in creating a desirable balance between work and human, and also in preventing work injuries (2).

Maximal oxygen uptake is affected by numerous factors. These factors can be classified into environmental factors (heat, humidity, altitude, and barometric pressure), individual factors (age, gender, body mass index, genetics and health conditions), and behavioral habits (smoking and sport/physical activity) (6-8). Good physical health and desirable environmental conditions along with physical activity and healthy lifestyle, regular exercises can optimize and improve aerobic capacity in individuals.

Several studies have been conducted in European, American, and different Asian societies, which can provide a comprehensive picture of aerobic capacity in different societies and show the differences and similarities in terms of ability to perform work. Examples of these studies are the measurement of VO_{2max} in the American male population (4.16 ± 0.62), Dutch male (2.66 ± 0.35) and Iranian male (3.89 ± 0.92) (3, 11, 12).

Several studies have been done to estimate the aerobic capacity of Iranian society in different population groups, but due to the ethnic and geographical diversity of the country, it is necessary to carry out similar studies to provide a comprehensive picture of physical and aerobic capacity throughout the country. Therefore, this study was conducted to estimate the amount of VO_{2max} among Urmia University of Medical Sciences students as a representative of the young age group and determine the related factors, as well as developing regression models to determine the rate of VO_{2max} by important components. The results of the present study can be used by community health planners, ergonomic and occupational health professionals in creating a balance between work demands and human abilities.

Materials & Methods

Participants:

One hundred and thirty male and female students who were voluntarily selected by simple random sampling from university students participated in this study. Inclusion criteria for the participants included the lack of history of respiratory problems, the lack of cardiovascular and musculoskeletal disorders, and also lack of heavy physical activities before the study. The study was approved by the Medical Ethics Committee of the Urmia University of Medical Sciences (IR.UMSU.REC.13950518).

Instruments and procedure:

The aerobic capacity (VO_{2max}) was determined using the ergometer bicycle model MONARK 839E. Six min Astrand's rhyming protocol was used. A consent form and demographic questionnaire containing information such as gender, age, height, etc. as well as questions about smoking or regular exercise activities (medium-intensity physical activity of three to five sessions per week for at least 30 minutes) were completed by the participants (6).

In order to carry out the test, the participant started to warm up by pedaling on an ergometer bicycle for a period of two minutes with a minimum of 25-watt hardness, and then pedaled for six minutes to reach the

heart rate of more than 120 beats per minute. The protocol was designed based on work load to determine aerobic capacity during work. During the test, the work load started at 300 kilopond meters per minute and gradually increased to 1500 for men and 900 kilopond meters per minute for women. At the end of the fifth minute, the heart rate was recorded. If at the end of the sixth minute the heart rate was less than or equal to four beats per minute compared with the fifth minute heart rate , the test ended; otherwise, the test would continue until the heart rate difference was less than or equal to four beats per minute with the previous minute. Heart rate monitoring during cycling was done using a transmitter installed on the participant's chest. After completing the test and considering the heart rate, maximum oxygen consumption (VO_{2max}) was determined in ml/kg body weight per minute (7, 8). In this study, in order to keep the results close to reality, the atmospheric conditions of the laboratory were kept at an optimum level during the experiment, and also all the measurements took place at a specified time interval (8, 10-14). Moreover, the weight and height of the participants were measured using scale and anthropometer respectively, and then the BMI was calculated for each person.

Statistical analysis:

Descriptive statistics were used for all of the variables. An independent sample T-test was used to compare the mean of VO_{2max} between different groups of the study; furthermore, the Pearson correlation and single-variable linear regression were used to examine the relationship between VO_{2max} and quantitative variables (age, height, weight, BMI, heart rate). A multi-variable regression equation was developed to estimate aerobic capacity.

Results

Table 1 presents the summary of descriptive statistics of all the variables used in this study. The studied population includes 78 female students (60%) and 52 male students (40%) with a mean age of 21.6 ± 0.4 years. The studied female did not smoke, but 17.3% of studied male did. The mean of VO_{2max} was 2.03 ± 0.320 and 2.43 ± 0.432 $lit.min^{-1}$ in male and female students, respectively.

Table 1. Mean and standard deviation of variables (N=130)

Variable	Group (Female,78, Male,52)	M±SD
Height	F	163.03 ± 5.80
	M	178.21 ± 5.66
Weight	F	62.01 ± 9.82
	M	71.88 ± 11.11
Age	F	18.2 ± 0.44
	M	27.5 ± 0.48
Body mass index	F	23.27 ± 3.16
	M	22.77 ± 3.02
Heart rate	F	140.38 ± 10.44
	M	136.35 ± 9.61
VO_{2max} ($l.min^{-1}$)	F	2.03 ± 0.32
	M	2.42 ± 043
Vo_{2max} ($ml.kg^{-1}.min^{-1}$)	F	33.45 ± 6.83
	M	33.73 ± 6.15

The study found no significant difference in the aerobic capacity values between the male and female students. (p>0.05). Additionally, the study revealed that 73.8 percent of the participants had a normal BMI, 19.2 percent were classified as overweight, and 3.8 percent were classified as obese. Furthermore, the study conducted linear regression analysis and Pearson correlation coefficient tests, which suggested a linear

and inverse relationship between BMI, heart rate, and VO_{2max}. In other words, as BMI and heart rate increased, VO_{2max} decreased significantly (Figure.1and 2).

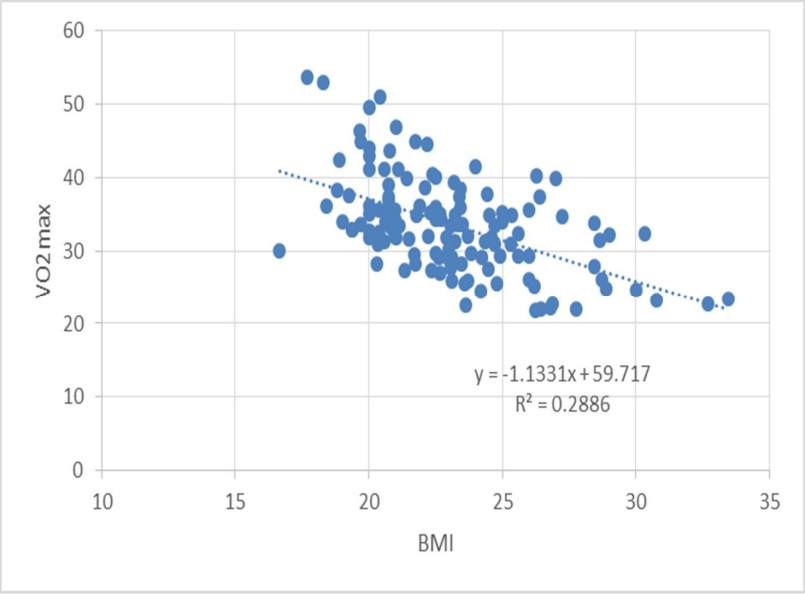

Fig. 1. BMI relationship with aerobic capacity

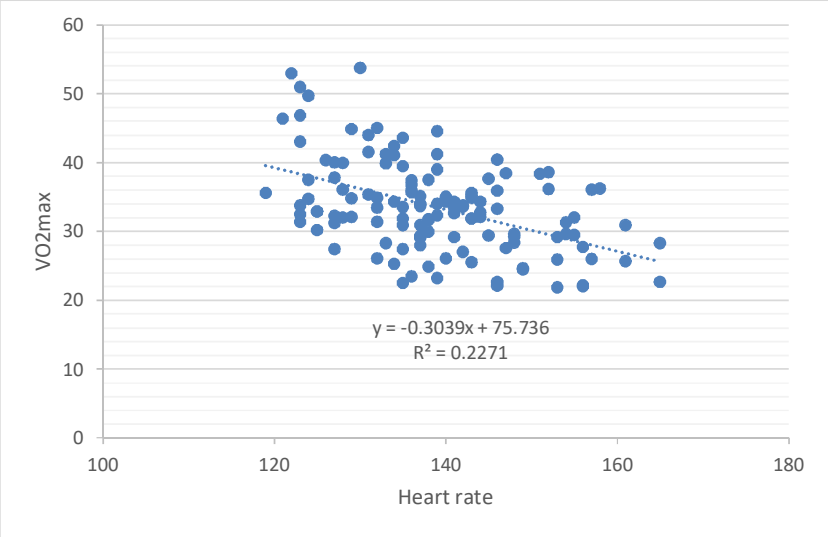

Fig. 2. Relationship between heart rate and aerobic capacity

The analysis of aerobic capacity values in smokers and non-smokers did not show a significant difference (P>0.05); however, a significant difference was found between VO_{2max} values of regular exercisers and non-athlete participants (Table 2).

Table 2. Aerobic capacity values in terms of smoking and exercise

Variable	Group	Mean	STD	T	DF	P
Smoking	Yes	32.08	6.60	-0.704	128	0.483
	No	33.67	6.56			
Exercise	Yes	35.34	6.86	2.08	128	0.039
	No	32.77	6.29			

To investigate the significance of the relationship between BMI, heart rate, and exercise with the aerobic capacity index, a multiple regression model was employed using the forward method to select the best model. The final model included only the BMI and heart rate variables, resulting in a coefficient of determination (R2) of 0.5. The equation that describes the relationship between these variables is as follows:

$$VO_{2max} = 100.048 - 1.107\ BMI - 0.295\ HR$$

Discussion

The aim of the present study was to determine aerobic capacity and investigate individual factors related to maximum Vo_2 among students. In the present study, the mean aerobic capacity was obtained 33.45 ± 6.83 and 33.73 ± 6.15 $ml.kg^{-1}.min^{-1}$, respectively. Based on the standard classification of aerobic capacity, an aerobic capacity value of less than 41 is considered in the very weak range for men, while a value of less than 35 is considered very weak for women (7). In a study carried out by Lehmi et al. on male students of a university in Iran, the mean aerobic capacity was obtained 2.9 liters per minute which is more than the mean aerobic capacity of the present study. This difference can be attributed to the lack of female student participants in that study. In a study conducted by Heidari et al. on medical emergency students, the reported VO_{2max} value was 1.94 liters per minute, which is lower than the VO_{2max} value found in the current study. The difference in results could be attributed to the smaller sample size of 36 participants in the previous study, as well as the absence of regular exercise among the participants (10). In another study, the mean aerobic capacity of firefighters was reported as 36.18 $ml.kg^{-1}.min^{-1}$, which is higher than the mean aerobic capacity found in the present study. This difference could be attributed to the high physical fitness level and regular aerobic exercise of the fire department personnel (11). In a study by Sharifi et al. that examined the aerobic capacity of 30 female workers in a spinning factory, the reported aerobic capacity was 55.1 $ml.kg^{-1}.min^{-1}$, which is higher than the aerobic capacity found in the present study. The difference in the results could be attributed to differences in the nature of work between the two studies, as well as the disparity in the sample size (12). In a study by Daneshmandi et al. to estimate the aerobic capacity of 500 employees in Shiraz, the aerobic capacity mean was 35.95 $ml.kg^{-1}.min^{-1}$, which is higher than the mean aerobic capacity in this study. The reason for this difference is the type of statistical population (only male) as well as the nature of the physical activity of the industrial workers with the student community (13).

The results of the present study revealed a significant correlation between BMI and VO_{2max}, indicating that as BMI increases, VO_{2max} decreases significantly. In this regard, findings are in line with the results of the studies by Shirley et al. (14), Daneshmandi (13), Zare Darisi (5), Richard (15) and Tarnus (6). Also, an indirect and significant relationship between VO_{2max} and heart rate was found. In other words, with increasing heart rate, their aerobic capacity reduces significantly. This finding is consistent with the findings of previous studies (6, 16, 17). Analysis of aerobic capacity values between subjects with regular exercise and lack of regular exercise showed a significant difference, which is

consistent with the findings of the similar studies in the field (18-20).

The findings of this study did not show a significant relationship between VO_{2max} and smoking which is contradictory with the findings of the studies by Richard et al (15), Betik and Hapless (21), but are consistent with the findings of the study by Morton et al. (22) and Song et al.'s survey (23). The reason for this may be attributed to the young age of the participants in the study, as well as their limited smoking history. Based on these findings, smoking did not appear to have a significant effect on the aerobic capacity of the participants.

Conclusion

In summary, the present study suggests that VO_{2max} is low among students, possibly due to low physical activity and inadequate exercise. Furthermore, the study revealed that among the examined factors, BMI, heart rate, and regular exercise activities had a significant impact on aerobic capacity. Using the multiple regression model, it was possible to estimate VO_{2max} by identifying these variables. The equation developed in this study should be validated on a larger population of students to ensure its accuracy. Once confirmed, the equation can be used to classify the physical work capacity of large population groups.

Acknowledgments

Acknowledgements are due to vice chancellery for research, Urmia University of Medical Sciences for funding this project.

Conflict of interest

The authors have no conflict of interest in this study.

Funding/support

This article was funded by Urmia University of Medical Sciences.

Data availability

The raw data supporting the conclusions of this article are available from the authors upon reasonable request.

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