

Relationship between Anthropometric Factors, Respiratory Exchange Ratio and Energy Expenditure with Maximal Oxygen Uptake among Sedentary Men

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Article information	Abstract
<p>Article history: Received: 8 May 2012 Accepted: 30 May 2012 Available online: 22 Apr 2013 ZJRMS 2014; 16(6): 20-24</p> <p>Keywords: Anthropometric factors Respiratory exchange ratio Energy expenditure VO₂ max Sedentary men</p> <p>*Corresponding author at: Department of Sports Sciences, Bou-Ali Sina University, Hamedan, Iran. E-mail: Kamal_Ranjbar2010@yahoo.com</p>	<p>Background: Studies reported conflicting results about the relationship between anthropometric factors, respiratory exchange Ratio, energy expenditure and VO₂ max. Therefore the aim of this study was to investigate the relationship between anthropometric factors, respiratory exchange ratio and energy expenditure with VO₂ max in sedentary men.</p> <p>Materials and Methods: Thirty one sedentary healthy men (23.67±2.45 years old age, BMI=22.49±1.58 kg/m²) volunteered for participation in this study. After the measurement of anthropometric factors, subjects performed an acute endurance exercise on the ergometer for determination of VO₂ max. Subjects performed major protocol, one hour cycling on ergometer via 70% VO₂ max for the determination of the respiratory exchange ratio and the rate of energy expenditure, 72 hours later.</p> <p>Results: The results of this study showed that there is not any significant relationship between VO₂ max and anthropometric factors, respiratory exchange ratio and energy expenditure. Also, regression analysis indicated that all these variables cannot predicate the VO₂ max.</p> <p>Conclusion: According to the results of this study anthropometric factors, respiratory exchange ratio and energy expenditure are not strong predictors of VO₂ max in sedentary young men.</p>

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Introduction

Investigations have been shown that people with high fat mass (FM), have defect in oxygen consumption per each Kilogram of their body weight and subsequently has lower VO₂ max [1, 2]. On the other hand, Sanada et al. showed that (according to Fick equation) people with high Fat free mass (FFM), have greater arterial-venous blood oxygen different and therefore have a high VO₂ max [3]. Additionally, studies have revealed that concomitant with increment of Body mass index (BMI), VO₂ max reduces per Kg of the body weight [4, 5]. On the other hand, in the few studies which done about the relationship between anthropometric factors and VO₂ max in sedentary young people reported conflicting results. In this respect, Amani et al. showed that there is an inverse significant correlation between VO₂ max and FM in sedentary young people [6]. But, Folgelholm et al. concluded that the relationship between VO₂ max and FM in young, is not significant [7]. Also, Riou et al. found that VO₂ max in sedentary men is more under the influence of lean mass and the FFM has a significant relationship with VO₂ max (compared to other anthropometric factors) [8]. But, Ozcelik et al. reported that in inactive young people, VO₂ max is mainly influenced by BMI [4]. Also, many studies have shown that regular physical activity (through reducing carbohydrates metabolism and increasing fat oxidation) resulting in exposure of fat tissue as the main fuel for active muscles,

causes decrement of respiratory exchange ratio (RER) and untimely switched it toward the fat oxidation criteria (0.7) [9, 10]. According to this issue, many studies confirm that during endurance activities, people with a high level of cardiovascular fitness show more dependency on fat as the main fuel than sedentary people as well as have lower RER [11, 12]. Jimenez et al. reported a negative significant correlation between VO₂ max and RER [13]. In addition, many studies have reported that doing physical activities can increase the mechanical efficiency and subsequently reduce the energy expenditure (EE) in a given physical activity [14, 15].

So, compared with sedentary people, active people have better mechanical efficiency and consequently consume less energy in a same physical activity [16]. In this respect, Keytel et al. showed a significant correlation between the rate of energy expenditure and cardiovascular fitness in the young people [14]. But, Tanskanen et al. found that there is no significant relationship between VO₂ max and rate of energy expenditure in a given endurance activity [17]. Therefore, the aim of this study was to investigate the relationship between anthropometric factors (body fat mass, fat free mass, body mass index), respiratory exchange ratio and energy expenditure with VO₂ max and explanation the relationship between these factors with VO₂ max in young sedentary men.

Materials and Methods

Thirty-one healthy young inactive men (23.67 ± 2.45 years, $BMI = 22.49 \pm 1.58$ Kg/m²) volunteered for participation in this study. At first, the subjects filled the personal and medical information and signed consented form to take part in this study. The subjects did not have any history of cardiovascular diseases, smoking and drugs administration. The subjects were invited to the laboratory in a given day for the assessment of body composition and maximal oxygen uptake (VO₂ max). For this mean, they were recommended not to do vigorous activities 48 hours before the trial. They were also asked to avoid caffeine consumption 12 hours before the test and heavy meals 3 hours before the test. The subjects' weight and height were measured with Seca scale (precision 0.1 kg) and Seca stadiometer (precision 0.01 cm), respectively. Also Seca Scales calculated the BMI by the height (m)/Weight (Kg)² equation. Subject's descriptive and physiological parameters shown in table 1.

Determination of Body fat mass

Body fat mass was measured with skin fold from three area (chest, abdominal, femur) using caliper (Bata international, RH159LR, ENGLAND). In this assessment, the skin was dry and has a low temperature. To determine body density (BD), three areas of skin fold (SSF) were placed in formula 1, and then, formula 2 was used for determination of body fat percent.

1: $BD = 1.10938 - (0.0008267 \times SSF) + (0.000016 \times SSF^2) - (0.0002574 \times \text{age})$

2: $\text{Body Fat\%} = (495/BD) - 450$, FFM was calculated by the formula 3, 3: $FFM = BW - BF$

Determination of VO₂ max and main protocol

VO₂ max was measured by ergometer (Monark-Sweden) and gas analyzer Metalyser (Cortex, Germany). For each subject, the ergometer seat and steering was regulated. Subjects warmed for 5 minutes without any resistance. After the warm-up, they started cycling with 50 W resistances, added 25 W every two minutes until they were exhausted. The following three criteria were used for determination of VO₂ max: 1-When the heart rate reaches over 90% of the calculated maximum heart rate ($220 - \text{age}$). 2-When the respiratory exchange ratio reaches more than 1.1. 3-When the oxygen consumption reaches the plateau despite increment of test intensity. Reaching to two these criteria were enough to stop the protocol [18]. At least 72 hours after the determination of VO₂ max, subjects performed the main protocol including one hour cycling on the ergometer via 70% VO₂ max. During the trial, the gas analyzer was attached to the subjects and the volume of oxygen consumption, carbon

dioxide expiration; respiratory exchange ratio, heart rate, energy expenditure and cardiac output were recorded every moment.

Statistical analyses

Research data were analyzed by SPSS-16. The data's normality test was verified by Kolmogorov-Smirnov test. Therefore, Pearson correlation test was used to determine the relationship between the study variables. Then the relationship between anthropometric indices (body fat mass, fat free mass, body mass index), respiratory exchange ratio and energy expenditure (as predictive variables) and maximal oxygen uptake (as the criterion variable) were analyzed in the regression linear equation. Significant level was set $p \leq 0.05$.

Results

Statistical analyses showed that there was no significant relationship between VO₂ max and BF ($r = -0.11$) (Fig. 1). Also, in sedentary young men there was no significant relationship between VO₂ max and the FFM ($r = -0.12$) (Fig. 2). VO₂ max and BMI have not a significant relationship ($r = -0.17$) (Fig. 3). Also, VO₂ max relationship with the respiratory exchange ratio was not significant ($r = -0.17$) (Fig. 4). There was not any significant relationship between VO₂ max and energy expenditure ($r = 0.20$) (Fig. 5). The analysis of the relationship between anthropometric factors (body fat mass, fat-free mass, body BMI), respiratory exchange ratio and energy expenditure (as predictive variables) and maximum oxygen consumption (as criterion variable) in the regression equation (Table 2), showed that the F value was not significant and only 0.27% of the variance related to VO₂ max can be explained by Anthropometric factors, respiratory exchange ratio and energy expenditure. Also, the results of multivariate linear regression coefficients and the impact factor of BF ($B = -0.223$, $t = -0.288$) FFM ($B = -0.014$, $t = -0.046$), BMI ($B = 0.381$, $t = -0.220$), respiratory exchange ratio ($B = -7.779$, $t = -0.675$) and energy expenditure ($B = -0.0001$, $t = -0.025$) indicated that none of these variables can predict the changes of VO₂ max in sedentary young men (Table 3).

Table 1. Subject's descriptive and physiological data (Mean±SD)

Number of cases	31
Age (year)	23.67±2.45
VO ₂ max (ml/kg.min)	36.29±4.86
Body fat mass (kg)	13.17±2.16
Fat free mass (kg)	55.38±7.46
BMI (Kg/m ²)	22.49±1.58
Respiratory exchange ratio	0.89±0.07
Energy expenditure (Kcal)	487±90

Table 2. Summary of regression model, analysis of variance and regression statistical properties of variables: maximal oxygen uptake, anthropometric factors, respiratory exchange ratio and energy expenditure

Model Index	SS	DF	MS	F	p-Value	R	R ²
Regression	63.098	5	12.60				
Remaining	504.579	19	26.557	0.475	0.79	0.519	0.27

MS= mean of squares

Table 3. Summary of regression model, analysis of variance and regression statistical properties of variables: maximal oxygen uptake, anthropometric factors, respiratory exchange ratio and energy expenditure

Variable	Index	p-Value	t	Beta	SE	B
Body fat mass		0.95	-0.288	-0.020	26.39	0.223
Fat free mass		0.94	-0.046	-0.029	0.284	-0.014
Body mass index		0.77	-0.220	-0.155	1.64	-0.381
Respiratory exchange ratio		0.20	-0.675	-0.292	17.69	-7.779
Energy expenditure		0.82	-0.025	-0.052	0.015	-0.0001

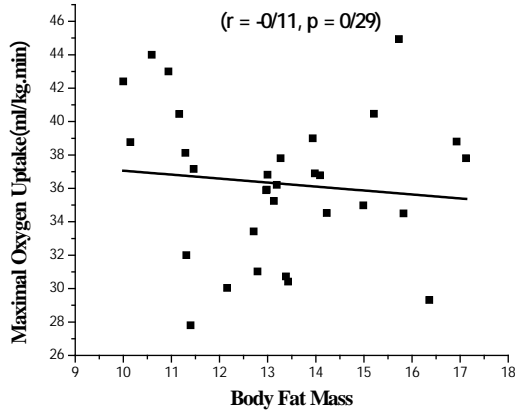


Figure 1. Relationship between body fat mass and maximal oxygen uptake

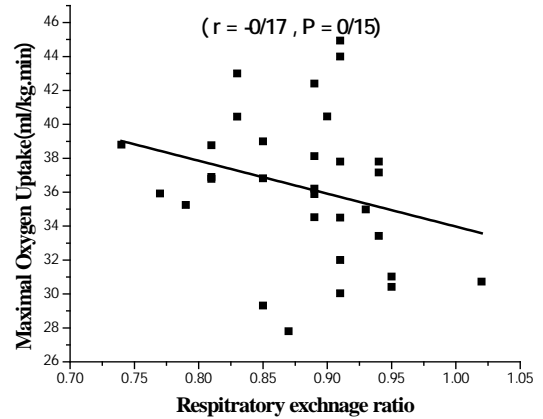


Figure 4. Relationship between respiratory exchange ratio and maximal oxygen uptake

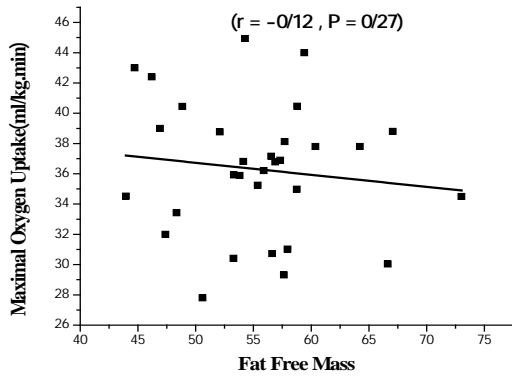


Figure 2. Relationship between fat free mass and maximal oxygen uptake

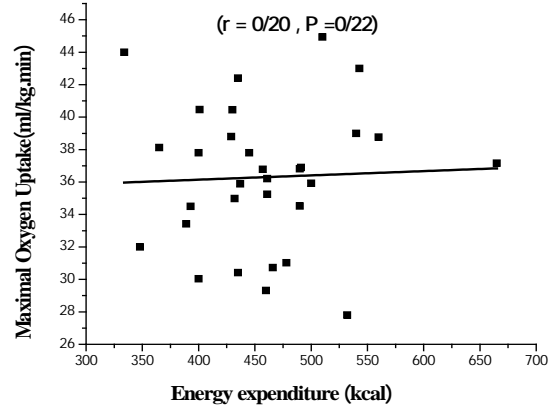


Figure 5. Relationship between energy expenditure and maximal oxygen uptake

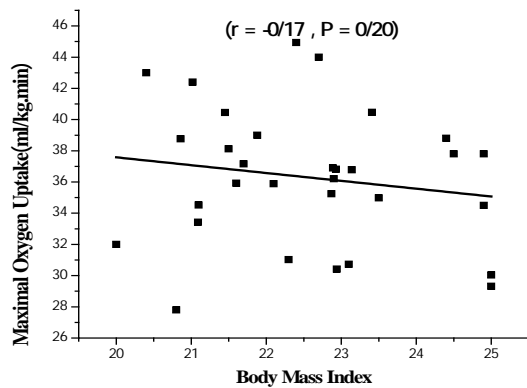


Figure 3. Relationship between body mass index and maximal oxygen uptake

Discussion

The findings of this study showed that amount of VO₂ max in sedentary young men have not significant relationship with anthropometric factors. In turn, in this study it was observed that VO₂ max and BF correlation was not significant (despite the negative correlation). This finding in conformity with the results of Goran et al. [19] and in conflict with the results of Amani et al. [6]. Presumably, the reason for this contradiction derived from the subject's high BF in study of Amani et al. In this study, it could be said that the lack of any significant relationship between VO₂ max and BF in young people, derived from the subject's normal BF and the kind of protocol which used for determination of VO₂ max.

Artero et al. showed that enduring extra fat mass during performing the graded test reduced the VO_2 max [20]. But since, in this study the subjects had a relatively normal BF and due to using the ergometer test, they were not compelled to bear the fat mass. Probably lack of significant relationship between VO_2 max and the subject's BF, was the result of using the ergometer. But, possibility the reason for the negative correlation between body fat and VO_2 max was that concomitant with increment of body fat mass, the vascular endothelial growth factor (VEGF), as the most important mitogen builds capillaries in the body, reduced. Reduction in capillary density and VEGF leads to increment of endothelial cells apoptosis [21].

Reduction in capillary density decreased the arterial blood oxygen difference reduced the amount of VO_2 max, according to Fick equation. Also, the results of this research showed that between VO_2 max and FFM, there was no significant relationship (despite the inverse correlation). This finding is in accordance with the results obtained by Folgelholm et al. [7]. But, opposed the results which found by Wong et al. [22]. Probably, the reason for this contradiction could be explained by the fact that Wong et al. used the subjects were from both sexes and has greater age range (20-64 years-old age). The strange and unexpected finding of this study was the non-significant negative relationship between VO_2 max and FFM. Since the capacity of aerobic metabolism in skeletal muscle is very important for the determination of VO_2 max, the lack of oxygen supply for skeletal muscle (due to weakness of heart muscle in pumping of blood or low capacity to carry oxygen by the blood) or disability of inactive people's skeletal muscle in oxygen consumption, could reduce the efficiency of FFM in aerobic power production and therefore leads to VO_2 max reduction [8]. Another finding of this study was that there is no significant relationship between VO_2 max rate and BMI in young people, despite inverse correlation. These findings are in conformity with the result obtained by Riou et al. [8] and in contradiction with the findings of Ayoma et al. which reported a significant inverse relationship between VO_2 max and BMI [23].

Possibility the reason for this difference derived from the fact that Ayoma et al. [23] used older people as their study subjects. Concomitant with aging BMI increased and VO_2 max decreased. But a reason for the lack of significant relationship between VO_2 max and BMI could be derived from the fact that the average BMI of the subjects of our study was very close to the normal range. This study showed that, there was no significant correlation between VO_2 max and respiratory exchange ratio of sedentary young men (despite the inverse

correlation). These findings contradict the results of Jimenes et al. [13]. The possible reason for this contradiction could be the high physical fitness of study subjects of Jimenez et al. It appears that the lack of a significant relationship between VO_2 max and RER derived from low fitness levels and the low level of energy preparation during the trial. Studies have demonstrated that along with increment of physical fitness, the energy metabolism system was dependent on the fat oxidation as a major source of energy during endurance activities. This issue resulting in significant reduces the RER in endurance activities [9, 10]. Another finding of this study was that there is no significant relationship between VO_2 max and energy expenditure of endurance activity in young men. These findings are in contrast with the results obtained by Keytel et al. [14]. This contradiction probably is derived from age range (18-45 years) and high physical fitness of subjects of the study of Keytel et al. Lack of significant relationship between VO_2 max and EE in this research, is probably due to poor performance of subjects (due to inactivity). Because the studies have been shown that sedentary people (when performing endurance activities) have low mechanical efficiency as well as high energy expenditure [14, 24]. In summary, the findings of this study showed that there is no significant relationship between VO_2 max and anthropometric factors (body fat mass, lean body mass, body mass index), respiratory exchange ratio and energy expenditure in the sedentary young men. Therefore, anthropometric factors, respiratory exchange ratio and energy expenditure in young sedentary people are not strong predictors of VO_2 max. This study finding is in conformity with the studies which concluded that cardiovascular factors (such as: heart rate, stroke volume and etc.) are the most important predictor factors of VO_2 max.

Acknowledgements

This article is from the first author master's thesis (Shahid Beheshti University) with the code number 159. We thank the management of laboratory of exercise physiology for the necessary cooperation with us on implementing this project.

Authors' Contributions

All authors had equal role in design, work, statistical analysis and manuscript writing.

Conflict of Interest

The authors declare no conflict of interest.

Funding/Support

Shahid Beheshti University.

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Please cite this article as: Ranjbar K, Nourshahi M, Gholamali M. Relationship between anthropometric factors, respiratory exchange ratio and energy expenditure with maximal oxygen uptake among sedentary men. *Zahedan J Res Med Sci (ZJRMS)* 2014; 16(6): 20-24.