Factors affecting Maximal Aerobic Capacity (VO2Max) in Iranian non-athletic women

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ABSTRACT

Background: Enhancement of health and life quality is available for all age groups by moderate to severe regular physical activities and exercise improves maximal and submaximal capacities and intensity of exercise has a significant role to achieve training results in healthy and ill individuals, so more intensive exercises are more beneficial. VO2 Max is the best independent predictor for determining aerobic capacity.

Objective: The main goal of this study was to determine the factors affecting aerobic capacity (VO2 Max) of Iranian non-athletic women as well as finding a relation between metabolic rate and muscle percentage among them. Among 70 randomly selected females, 62 were matched to study criteria. For exercise test, Bruce protocol was applied and body composition was measured by Direct/ Segmental/ Multi-frequency Bioelectrical Impedance Analysis (DSMF-BIA). All results of body composition and exercise test recorded and then analyzed by statistician with SPSS.

Results: Average of resting heart rate was 90 + 11 and mean of maximal heart rate during exercise test was 163 + 4.6. The average of VO2 Max was 35.2 with standard deviation of 6.65. Performing One-Sample Kolmogorov-Smirnov test on samples showed that distribution of all samples were normal. Pearson Correlation Coefficient was used and it showed that there was only a significant relationship between VO2 Max and Muscle Percentage (P Value=0) and there was not any significant relationship between VO2 Max / METs and weight, stature, visceral fat mass, body fat mass and Body Mass Index. The results demonstrated that although in 14 women in menstrual group the METs level was a little decreased (9.75 vs. 10.15) but there was not any significant relationship between Menstrual Period and level of METs or VO2 Max (P value > 0.05). In accordance to relationship between METs and Muscle Percentage (r =0.44 and P< 0.01), METs level was predicted by Muscle Percentage using linear regression.

Conclusion: Among all variables, Body Muscle percentage had a significant relationship with METs and VO2 Max (P=0.005) and we didn’t find any major link between VO2 Max and other variables (Age, Stature, Weight, Body Mass, Menstrual Period, Visceral Fat and Body fat Percentage).

INTRODUCTION

Enhancement of health and life quality is available for all age groups by moderate to severe regular physical activities [1, 2]. The effectiveness of physical activity on improvement of health and fitness is proven and there is agreement on it [3, 4 and 5]. Exercise improves maximal and submaximal capacities [6] and intensity of exercise has a significant role to achieve training results in healthy and ill individuals, so more intensive exercises are more beneficial [7]. Exercise could also help to reduce hospital admission time, morbidity and mortality [8,9,10,11 and 12]. Physical activity in Chronic Obstructive Pulmonary Disease (COPD), Ischemic Heart Disease, Diabetics, and the elderly is useful too [13]. Exercise in cardiovascular patients (cardiac rehabilitation) will increase functional capacities and hemodynamic responses [14]. To achieve high performance and success in various sports’ disciplines specially endurance running, swimming, soccer, tennis, and so on, it is important to improve Aerobic Capacity. VO2 Max is an evaluation measure which could be used for aerobic capacity [15]. VO2 Max is the best independent predictor for determining aerobic capacity in young people [16]. VO2 Max refers to maximum oxygen consumption by an athlete’s body during aerobic exercise and is depended to lungs, heart and muscles capability to absorb, transfer and use the oxygen [17].

In other words, VO2 Max is calculated by multiplying cardiac output to the difference between arterial and venous oxygen [18]. VO2 Max is used to monitor physical activity adaptation and for exercise prescription. It
also could be used as a predictor for mortality of individuals [19]. VO2 Max is depended to many factors including atmosphere oxygen, mitochondrial contents, pulmonary arterial diffusion capacity, cardiac output, oxygen transfer capability by blood vessels, and individual muscular characteristics [20]. Age, Gender, and physical activity levels are also important for measuring it. VO2 Max decreases with aging and reduction of physical activity [21, 22], and it is normally lesser in women comparing to men [23]. There are different methods for measuring VO2 Max including usage of steps, treadmill, and ergometer. Usage of treadmill shows a larger VO2 Max comparing to the other methods [24]. Despite Some studies have shown that Bruce protocol overestimates VO2 Max*, it is the best available method to measure this variable. The main goal of this study was to determine the factors affecting aerobic capacity (VO2 Max) of Iranian non athletic women as well as finding a relation between metabolic rate and body composition among them.

Metodology:
The subjects were selected randomly among active females in Tehran, Iran. They had at least one session of walking or another alternative exercise for half an hour per week and none of them were member of a sports team. Their age ranged from 18 to 42 and younger or older individuals as well as patients with Asthma, Bronchitis, Hypertension, and Cardiovascular diseases were excluded from study. For diagnosis of these illnesses; history taking, and physical examination and also consultation with related specialists were used. Among 70 randomly selected females, 62 were matched to study criteria. Weight and Stature were measured by Beurer® standard scale and Vernier® height Gauges accordingly three times and the mean were recorded. Blood Pressure also measured by Richter® mercury sphygmomanometer as follows. The subjects were requested to sit and rest at least for 10 minutes before measurement of blood pressure and heart beat. For heart beat rate, radial pulse at rest was evaluated for whole one minute.

For exercise test, Bruce protocol was applied and all tests’ sessions were in the morning. Before exercise test, in the fasting state, body composition was measured by Direct/ Segmental/ Multi-frequency Bioelectrical Impedance Analysis (DSMF-BIA) with Biospace®- InBody®. Then the subjects ate breakfast and after 3 hours they performed exercise test while wearing sportswear and sneakers. They also performed warm-up for 10 minutes before exercise test. All results of body composition and exercise test recorded and then analyzed by statistician with SPSS version 18.

Results:
Among 70 non athletic females, 62 individuals were matched to study’s criteria and 6 were excluded because of different diseases such as asthma and cardiac valve disorders. Age of final subjects were 23 to 42 with mean of 28.5 + 3.3 years old and average weight was 60.9 + 11 kilograms while mean stature was 161.6 + 5.8 centimeters. Results of body composition analysis are shown in Table No. 1. Average Body Mass Index (BMI) was 23.3 + 4.2, 21% of women had BMI larger than 25 and 4.5% had BMI more than 30 while more than 18% of them had BMI lesser than 20. Average of body fat mass was 34.1 + 6.4, mean Muscle Percentage was 26.8+2.2 and average of visceral fat mass was 4.2 +1.5. Average of basal metabolic rate was 1309 + 11.8.

Table 1: Distribution of body composition variables among testing population

<table>
<thead>
<tr>
<th>Body composition variables</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body fat Percentage</td>
<td>20.7%</td>
<td>48.9%</td>
<td>34.1%</td>
<td>6.4</td>
</tr>
<tr>
<td>Muscle Percentage</td>
<td>23%</td>
<td>32.8%</td>
<td>26.8%</td>
<td>2.2</td>
</tr>
<tr>
<td>Visceral fat Percentage</td>
<td>2%</td>
<td>9%</td>
<td>4.2%</td>
<td>1.5</td>
</tr>
<tr>
<td>Body mass index</td>
<td>16.9</td>
<td>40</td>
<td>23.3</td>
<td>4.2</td>
</tr>
<tr>
<td>Basal metabolic rate</td>
<td>1101</td>
<td>1618</td>
<td>1309</td>
<td>11.8</td>
</tr>
</tbody>
</table>

At the time of exercise test, 14 individuals (22.6%) were in menstrual period. Average of resting heart rate was 90 + 11 and mean of maximal heart rate during exercise test was 165 + 4.6. The average of VO2 Max was 35.2 with standard deviation of 6.65 (table No. 2). Comparison of resting heart rate between women in menstrual period and the others showed that first group had an average of 93.7 and the others had an average of 90.7 beat per minute.

Table 2: Distribution of physiological variables among testing population

<table>
<thead>
<tr>
<th>Physiological variables</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting Heart Rate</td>
<td>65</td>
<td>119</td>
<td>90</td>
<td>11</td>
</tr>
<tr>
<td>Maximal Heart Rate</td>
<td>149</td>
<td>183</td>
<td>164</td>
<td>4.6</td>
</tr>
<tr>
<td>METS</td>
<td>7</td>
<td>13.5</td>
<td>10</td>
<td>1.8</td>
</tr>
<tr>
<td>Vo2Max</td>
<td>24.5</td>
<td>47.3</td>
<td>35.2</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Performing One-Sample Kolmogorov-Smirnov test on samples showed that distribution of all samples were normal (table No. 3).
Table 3: Results of One-Sample Kolmogorov-Smirnov test

<table>
<thead>
<tr>
<th>Age</th>
<th>Stature</th>
<th>Weight</th>
<th>Fat Percentage</th>
<th>Muscle Percentage</th>
<th>Visceral Fat Percentage</th>
<th>Fat Mass Index</th>
<th>Body Mass Index</th>
<th>Basal Metabolic Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kolmogorov-Smirnov Z</td>
<td>1.1</td>
<td>0.7</td>
<td>0.85</td>
<td>0.33</td>
<td>0.76</td>
<td>1.3</td>
<td>1.06</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Asymp. Sig. (2-Tailed) | 0.12 | 0.7 | 0.45 | 1 | 0.6 | 0.05 | 0.2 | 0.69 |

Pearson Correlation Coefficient was used and it showed that there was only a significant relationship between VO2 Max and Muscle Percentage (P Value=0) and there was not any significant relationship between VO2 Max / METs and weight, stature, visceral fat mass, body fat mass and Body Mass Index. Then the subjects divided into menstrual and non-menstrual groups and again the Pearson Correlation Coefficient was applied. The results demonstrated that although in 14 women in menstrual group the METs level was a little decreased (9.75 vs. 10.15) but there was not any significant relationship between Menstrual Period and level of METs or VO2 Max (P value > 0.05).

In accordance to relationship between METs and Muscle Percentage (r =0.44 and P ≤0.01), METs level was predicted by Muscle Percentage using linear regression.

Table 4: Coefficients and Results of The Durbin-Watson test

<table>
<thead>
<tr>
<th>Model</th>
<th>Regression Level</th>
<th>Square r</th>
<th>Modified Square r</th>
<th>Squares' Mean</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.44</td>
<td>0.19</td>
<td>0.18</td>
<td>14.11</td>
<td>0.001*</td>
<td></td>
</tr>
</tbody>
</table>

Regarding the coefficients and results which are shown in table No. 4 the Durbin-Watson test result was 2.35 and it approved the regression. It has also demonstrated that according to Variance Analysis Test which was performed for Predicting METs by Muscle Percentage, the linear relationship between Muscle Percentage and METs was approved and the relationship is significant (F=14.11 and P≤0.01).

Table 5: Variance Analysis Test for Predicting METs by Muscle Percentage

<table>
<thead>
<tr>
<th>Predicting Variable</th>
<th>Model</th>
<th>Total Squares</th>
<th>DF</th>
<th>Squares' Mean</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle Percentage</td>
<td>Regression</td>
<td>41.83</td>
<td>1</td>
<td>41.83</td>
<td>14.11</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>Remained</td>
<td>177.84</td>
<td>60</td>
<td>2.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>219.67</td>
<td>61</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* It is significant on (P≤ 0.01)

The regression analysis also has confirmed that METs level could be predicted by Muscle Percentage (t=3.76 and P≤ 0.01). Based on Beta Coefficient results, increasing of each Muscle Percentage unit will result to increase of METs level for 0.44 (table No.6).

Table 6: Linear Regression Coefficients

<table>
<thead>
<tr>
<th>Model</th>
<th>Non-Standard Coefficients</th>
<th>Standard Coefficient</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Standard Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>0.024</td>
<td>2.68</td>
<td>0.009</td>
</tr>
<tr>
<td>Muscle Percentage</td>
<td>0.37</td>
<td>0.10</td>
<td>0.44</td>
<td>3.76</td>
</tr>
</tbody>
</table>

* It is significant on (P≤ 0.01)

Therefore the regression equation for predicting METs by Muscle Percentage is as follows:

METs = 0.024 + 0.37 (Muscle Percentage)

The aim of this study was to determine the factors affecting the aerobic capacity in non-athletic women and we tried to find a relation between body composition and metabolic rate among them. Mean Resting Heart Rate in these women detected 90 per minute which was above the mean Resting Heart Rate (RHR) in normal population. It was shown in a research conducted by Nauman et al in Norway that increasing RHR will result in more mortality due to Ischemic Heart Disease and it could be considered as a health issue warning [25]. In addition to this study, the relationship between cardiovascular disorders and RHR has proven in many other studies [26, 27, 28 and 29] It also should be considered that the measurements were done at hospital and some other issues like stress and anxiety may affect the RHR. The difference between RHR of women who were in menstrual period (93) and the others who were not in menstrual period (90) was not statistically significant. The results were match to the study of Sato N et al which was demonstrated no differences between RHR and Blood Pressure of women in Menstrual Period and the other females.

As described by National Institute of Health (NIH) Obesity defines as Body Mass Index (BMI) more than 30, while World Health Organization (WHO) recognized Obesity as Fat Percentage more than 25 in Men and 35
in women [31]. In our study 21% of women were overweight and 4.5% were obese based on BMI. Obesity is associated with Hypertension and Menstrual disorders in pregnancy [32] as well as many other conditions during and after childbirth [33]. Obesity also increases the risk of Asthma in women [34] as well as Diabetes and Ischemic Heart Disease [35, 36]. The mean of VO2 Max in obese women was 30ml/kg/min which was lesser than mean of VO2 Max in all subjects (35ml/kg/min) and it shows that changing the lifestyle and weight loss is too much important for their life quality and quantity.

Among all variables, Body Muscle percentage had a significant relationship with METs and VO2 Max (P<0.005) and we didn’t find any major link between VO2 Max and other variables (Age, Stature, Weight, Body Mass, Menstrual Period, Visceral Fat and Body fat Percentage). Lack of significant relationship between VO2 Max and visceral fat and body fat percentage may be due to the small number of subjects. It could be concluded that menstrual period doesn’t influence on aerobic exercise of women.

Regression analysis resulted to this equation:

\[ \text{METs} = 0.024 + 0.37 \times \text{Muscle Percentage} \]

This equation could be used to reduce costs of expensive exercise tests. It means that with measuring the body composition could be useful for Exercise Prescription. It is highly recommended to obtain the precise and accurate equation for measuring the METs with more studies.

**Conclusion:**

VO2 Max has a significant relationship with Muscle Percentage, but it had not any major link to Menstrual Period, Visceral Fat Mass, Body Fat Mass, BMI, Stature and Weight. It was shown that with measuring Muscle Percentage, VO2 Max could be calculated.

**REFERENCES**


