Maximal Fat Oxidation during exercise in trained Male students

Mohammad Rami¹, Abdolhamid Habibi², Saeid Shakerian³

1- MA in sport physiology, Department of physical education and sport science, Shahid Chamran University of Ahvaz-Iran
2- Associate professor in sport physiology, Department of physical education and sport sciences, Shahid Chamran university of Ahvaz-Iran
3- Assistant professor in sport physiology, Department of physical education and sport sciences, Shahid Chamran university of Ahvaz-Iran

Correspondence author: Email: M.rami@scu.ac.ir

Abstract

The purpose of this study was to determine appropriate intensity of activity with Fat max during incremental exercise in trained male subjects. To do so, 11 trained male students (VO2max: 42.87±1.75ml.kg.min and BMI 21.40±1.01) took an incremental running test with 3 minute intervals on the treadmill. During the test, fat oxidation rate was measured using indirect stoichiometry method. Maximal fat oxidation and total fat oxidation rate variables were determined during this test. The mean value of fat oxidation rates were compared in 7 levels of exercise intensity with repeated measurement and LSD test. The results showed that maximal fat oxidation rate was 0.29±0.03g.min in untrained subjects. The total fat oxidation rate in trained subjects was 1.47±0.11g/min. There was a significant different between the fat oxidation rate during 7 levels of exercise (p<0.001). Based on VO2max and HRmax percentage, the maximal fat oxidation was occurring in 40.09±2.58 percent of VO2max and 56.45±4.33 percent of HRmax in trained subjects. Based on the results, with increase the exercise intensity until Fat max point the fat oxidation rates were increase and afterward that decrease in higher exercise intensity.

Keywords: Maximal fat oxidation, incremental training, indirect stoichiometry method, exercise intensity.

Introduction

Fats and Carbohydrates are the major energy substrates during the exercise. This is a well-established fact that the absolute oxidation of carbohydrate increases in line with the increase in the exercise intensity, while fat oxidation increases to 60 percent VO2max, in an ascending progress from the rest position to intensive activity and then gradually will decrease so that the person reaches to VO2max (Achten, 2004; Van Loon et al., 2001; Venables et al., 2005). Achten et al (2002) have reviewed fat oxidation results across the previous studies on a wide range of exercise intensities and confirmed that the Fatmax oxidation is within a range of 63 percent VO2max. This range represents an appropriate intensity of activity for fat oxidation. In general, the highest level of fat oxidation has been reported to be at low intensity to moderate intensities (Bergman and Brooks, 1999; Broeder et al., 1992; Friedlander et al., 1998; Howley et al., 1997; Romijn et al., 1993; Sidossis et al., 1993). Fatmax or the exercise intensity in which Maximal Fat Oxidation (MFO) occurs was first introduced by Jeukendrup and Achten in 2001. Finding the effective factors on such a metabolic indicator, will lead us to a better understanding of it and makes us to benefit from it appropriately in exercise and weight control or weight loss diets.

At the very beginning of exercise the rout which will metabolize carbohydrate and fat should be adjusted in order to oppose the increase of required energy. Endurance training is related to various metabolic adaptations which occur both centrally and peripherally in skeletal muscle; Adaptations
including increase in value of muscle glycogen and HAD, HSL and CS enzymes which cooperate to have a higher metabolic productivity and improve metabolic performance constantly and thus, lead to increase of fat oxidation capacity during exercise (Langfort et al., 2003; Saltin et al., 1983). In any case, explaining the relationship between potential mechanisms which adjust fat metabolism and the mutual relationship between fat oxidation and carbohydrate, as a subsidiary to intensity of activity is still controversial. Some previous studies show that trained individuals have more potential for increase of fat oxidation during exercise, compared to untrained ones. But it is not obvious if there is any relationship between amounts of fat oxidation in trained individuals and untrained ones (Lima-Silva et al., 2010).

In most studies the levels of maximal fat oxidation have been examined only in 2 intensities (Arons et al., 1997; Broeder et al., 1991; Howley et al., 1997), 3 intensities (Romijn et al., 1993; Romijn et al., 2000) or 4 intensities (Bergman et al., 1999; Friedlander et al., 1998) and the level determined as the maximal fat oxidation is measured just in one point and it seems that such an estimate of maximal fat oxidation is not so accurate. A different and new method is used recently to determine the maximal fat oxidation. Achten et al., (2002) and Achten & Jeukendrup (2003) have used a protocol in which fat oxidation can be measured in a domain of various exercise intensities. However, few studies have been done to examine and compare the maximal fat oxidation and even some of them have shown inconsistent results. Therefore, the aim of this study is to measure the maximal fat oxidation in various intensities during an incremental exercise protocol in trained subjects.

### Materials and Methods

To conduct this semi-experimental study we selected 9 untrained male students, through announcement, on the condition that their fat percent should be less than 30 and their BMI should be less than 25 (to make the samples standard). The untrained subjects have not participated in any regular sports activity during the last 3 years. The test was conducted at 9 to 11 A.M for all subjects. We asked the subjects to be on fast when taking the test. Height and weight of the subjects were measured and their fat percent was estimated through bioelectrical impedance (In body 3.3).

Subjects took an incremental running test with 3 minute intervals on a treadmill (Achten et al., 2003). The running began by a speed of 3.5 km.h and a slope of 1 percent. In every 3 minutes, the device speed increased by 1 km.h until it reached 7.5 km.h. Then during all the three minute stages the speed was constant but the device slope was increased by 2 percent until reaching RER=1. After that, until reaching the limits of fatigue, speed and slope were increased at the same time, in every stage (2 percent slope and 1 km.h speed per 2 minutes). The aim of the last stage of the test was to measure the rate of \( VO_2 \text{max} \). \( VO_2 \text{max} \) value could be reached when: 1) RER> 1.10, 2) level of oxygen consumption did not increase in spite of increase in speed and slope of treadmill and 3) maximum heart rate (220 pulses per minute-age) had been provisioned to be 10 pulses per minute around the maximal zone. During the test, the energy consumption and carbon dioxide exhaustion was measured through breath to breath method using the gas analyzer (GANSHORN, made in Germany) and it was recorded in computer using an interface. The heartbeat was measured by Polar electrocardiograph during the test. The average \( VO_2 \) and \( VCO_2 \) were measured during the last 2 minutes of each stage. Then with the assumption that the amount of urinary nitrogen is negligible, fat oxidation level was measured by using the following equations to measure substrates (Frayn, 1983).

\[
\text{Fat oxidation (g.min)} = 1.67 \times VO_2 - 1.67 \times VCO_2
\]

In the above equation \( VCO_2 \) and \( VO_2 \) are in liters per minute and fat oxidation is in grams per minute. By including the values of \( VCO_2 \) and \( VO_2 \) in this equation, we can get the fat oxidation level in every stage and the value of maximal fat oxidation which comes in one of these 7 stages will be positive for each subject. The average fat oxidation of subjects was reflected on a diagram in accordance with the intensity of activity (in 7 stages) in order to get fat oxidation-intensity of activity diagram.

The data were filtered by gas analyzer software (LF8) to a standard form, for all the subjects. Also we used variance analysis with repetitive measurements and LSD test to compare the levels of fat oxidation in 7 intensities. Statistical calculations were done in \( P \leq 0.05 \) levels.
Results

Individual characteristics of the subjects are presented in table 1.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Group trained (n= 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>22.36±1.43</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>174.18±3.81</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.40±3.60</td>
</tr>
<tr>
<td>BMI ( kg.m$^{-2}$)</td>
<td>21.40±1.01</td>
</tr>
<tr>
<td>VO$_2$ max (ml.kg.min$^{-1}$)</td>
<td>42.85±1.75</td>
</tr>
<tr>
<td>LBM ( kg )</td>
<td>53.89±2.43</td>
</tr>
<tr>
<td>PBF ( % )</td>
<td>17.26±1.75</td>
</tr>
</tbody>
</table>

Results show that maximal fat oxidation (MFO) level is occur in the fourth stage of incremental running test that these results are appropriate for an intensity of activity equal to 40.09±2.58 percent of VO$_2$max(Fatmax)(Figure 1). Also the quantities mentioned as maximal fat oxidation are appropriate for intensities of activity equal to 56.45±4.33 percent of HRmax in trained subjects (Figure 2). Also the level of overall fat oxidation in trained subjects was 1.47±0.11g/min. In addition, results show that there is a significant difference between the fat oxidation level during various intensities of the incremental protocol (P=0.001) (Tables 2 and 3).

Table 2: Results of variance analysis with repetitive measurements in various intensities during running for trained subjects

<table>
<thead>
<tr>
<th>statistical index</th>
<th>The total squares</th>
<th>Degree of freedom ( df )</th>
<th>The average squares</th>
<th>F amount</th>
<th>p-value ( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>The amount of fat oxidation during 7 stages</td>
<td>0.133</td>
<td>6</td>
<td>0.022</td>
<td>22.653</td>
<td>* 0.001</td>
</tr>
</tbody>
</table>

Table 3: Results of LSD test in trained group

<table>
<thead>
<tr>
<th>Level of treadmill protocol</th>
<th>Amount of fat oxidation (g.min)</th>
<th>Results of LSD test</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.15 ± 0.02</td>
<td>* * * * *</td>
</tr>
<tr>
<td>6</td>
<td>0.18 ± 0.03</td>
<td>* * * * *</td>
</tr>
<tr>
<td>5</td>
<td>0.24 ± 0.02</td>
<td>* * * * *</td>
</tr>
<tr>
<td>4</td>
<td>0.28 ± 0.04</td>
<td>* * * * *</td>
</tr>
<tr>
<td>3</td>
<td>0.22 ± 0.03</td>
<td>* * * * *</td>
</tr>
<tr>
<td>2</td>
<td>0.20 ± 0.02</td>
<td>* * * * *</td>
</tr>
<tr>
<td>1</td>
<td>0.17 ± 0.03</td>
<td>* * * * *</td>
</tr>
</tbody>
</table>

* Significant difference of mean fat oxidations in different intensities (P≤0.05)
* The most significant difference of means in different intensities
Figure 1. The amount of appropriate fat oxidation with intensity of activity according to %VO2max.

Figure 2. The amount of appropriate fat oxidation with intensity of activity according to %HRmax.

Discussion and conclusion

The aim of the present study is to find an intensity of sport activity which has the highest productivity in fat metabolism for trained male students. The ability to diagnose the point for optimum oxidation of fat resources as a fuel in exercise protocols have always been of importance and different results have been reported in different groups. It is clear that exercise in intensities higher than the zone of $\text{FAT}_{\text{max}}$ will cause fatigue or lactic acidity, the exercise in intensities lower than this level does not guarantee the necessary and sufficient benefit as the individual expects from exercise. Activity in exercise programs in which fat resources will be used optimally, is very important for all communities. For example, there are solutions offered in some exercise programs for diseases like, heart-vascular
problems, obesity and diabetes. But it should be noted that trained individuals, due to physiological changes gained by exercise, have more compatibility for consumption of energy from fat resources of the body. Some of the compatibilities gained by exercise are as follows: Development of capillary network, increase in the number and volume of mitochondria, provoking carnitine palmitoyltransferase-i and transfer of fatty acids into mitochondrion with mediation of carnitine. Therefore, trained individuals use fat resources in a more optimal way than untrained individuals (Achten, 2004). Many studies, have reported the maximal fat oxidation in the low to moderate intensities (between 33 to 65 percent VO$_{2\text{max}}$(Broeder et al., 1992; Romijn et al., 1993; Van Loon et al., 2001; Rouhani et al., 2009). However, most studies have used 2 to 4 intensity protocols to determine the maximal fat oxidation and it seems that there might be more complete methods to estimate the maximal fat oxidation. We examined fat oxidation in an incremental exercise protocol that included seven stages with seven different intensities of activity in order to determine, more precisely, the appropriate intensity of activity that elicits maximal fat oxidation, known as FAT$_{\text{max}}$. Increase in fat oxidation from rest to moderate intensities, is often caused by the increase of access to FA. The rate of appearance for FA will be increased by increase of lipolysis and decrease of FA re-esterification. Wolfe et al (1990) reported that the percent of re-esterification will be decreased from 70 percent in rest to 25 percent during 30 minutes of low to moderate intensities. This decrease in composition with the tripled increase in FA release from triacylglycerol (TAG ) hydrolysis will lead to increase of FA access by 6 times for oxidation. In addition to more access to FA, transfer of FA from fat fiber toward active muscle will be increased. However, when the intensity increases up to high levels, there is no simultaneous increase in Glycerol RA.

Romijn et al (1993) have noted that the amount of lipolysis during exercise with intensity of 85 percent VO$_{2\text{max}}$ is equal to its amount in 65 percent VO$_{2\text{max}}$. They argue that a portion of FA will be kept in fat tissue because of the decrease of blood stream in fat tissue (Hodgetts et al., 1991). One common theory is that, when the exercise intensity increases from moderate to high level, concentrations of plasma FA do not change (Van Loon et al., 2001) or even decreases (Romijn et al., 1993; Jones et al., 1980) and they have argued that decrease of access to FA can be a reason for lower levels of fat oxidation in higher exercise intensities. Therefore, considering the mentioned facts, we can probably justify the reason for difference between the two groups in terms of fat oxidation level in an incremental exercise protocol.

In addition to these results, our study showed also that there is a significant difference between fat oxidation levels in seven stages of activity, which these findings are not consistent with findings of Stisen et al (2006). In study by Stisen et al., the significant difference in terms of fat oxidation was only reported at moderate and high intensities. While in our study there was a significant difference in all stages. This inconsistency of results of Stisen et al., might be due to their exercise protocol; Because in present study protocol, like the study by Achten et al (2002, 2003) and Achten and Jeukendrup (2003), the levels of VO$_{2\text{max}}$ were determined by continuous graded test up to inability (30 to 35 minutes). While in the study by Stisen et al (2006), VO$_{2\text{max}}$ was examined in a separate day, and when they were completely recovered, they used a shorter continuous incremental test (6 to 9 minutes) up to voluntary inability. On the other hand, another reason for this inconsistency can be the due to the subjects of the study. In Stisen et al study (2006), the subjects were untrained females, while in the present study the subjects were trained male students. As it is showed in studies by Venables et al (2005), and Friedlander et al (1998), women have rather more FAT$_{\text{max}}$ and maximal fat oxidation than men. Therefore, perhaps this higher fat oxidation level in women can be a reason for being no significant difference in terms of fat oxidation in early stages of activity, compared to the subjects of the present study.

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References


