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Determine Of the Exercise Intensity That Elicits Maximal Fat Oxidation In Untrained Male Students

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ABSTRACT: Fat and carbohydrate are the main sources of energy for consumption during rest, exercise and training activities, and they are related to factors like duration and intensity of exercise. The present study was designed to determine the maximal fat oxidation rate in untrained male students following an incremental training session. To do so, 9 untrained male students (VO2max: 36.58 ± 2.95 ml.kg.min and BMI 24.28 ± 1.83) 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 0.23±0.02 g.min in untrained subjects. The total fat oxidation rate in untrained subjects was 1.20 ± 0.13g/min. There was a significant different between the fat oxidation rate during 7 levels of exercise. Based on VO_2max and HRmax percentage, the maximal fat oxidation was occur in 42.72±3.01 percent of VO_2max and 60.09±3.37 percent of HRmax in untrained subjects. Based on the results, with increase the exercise intensity until Fatmax 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 main sources of energy for consumption during rest, exercise and training activities, and they are related to factors like duration and intensity of exercise, type of sport activity, the level of physical fitness, the composition of food consumed before the sport activities, environmental conditions and consumption of complementary (Powers and Howley, 2001; Mogues, 2006; Gibney et al, 2003; Achten and Jeukendrup, 2004).

When activity intensity increases, the kind of fuel substance and its consumption will change (Martin and Klein, 1998). The relative share of carbohydrate oxidation in supplying energy will increase progressively and thus the relative share of fat oxidation in supplying energy will be decreased, though with the increase in activity intensity from low to moderate, the absolute value of fat oxidation (value of fat oxidation in grams per minute) will be increased and if the intensity increases, it will be decreased (Martin and Klein, 1998; Romijn et al, 1993; Jones. 1980; Brooks, 1998).

Some of the previous studies have estimated, through incremental exercises with 2 to 4 intensity of training, an exercise intensity in which the Maximal Fat Oxidation will occur(Bergman BC, Brooks, 1999; Romijn et al, 1993; Van Loon et al, 2001). Achten et al(2002 and 2003) and Achten and Jeukendrup(2003) using by a multi-level graded exercise test, found that Fat oxidation rate in exercise intensities between VO2max % 64±4 and 62±3 will reach its climax and then decreases dramatically in higher exercise intensities and reaches a slight level. A similar study by Nordby et al(2006) showed that trained men have higher rates of FATmax oxidation, and these rates will be found in relatively higher FATmax intensities compared to untrained men (50 and 43% VO2max respectively).

In most studies the levels of maximal fat oxidation have been examined only in 2 intensities (Arons et al, 1997; Broeder et al, 1991; Friedlander et al, 1998), 3 intensities (Romijn et al, 1993; Romijn et al, 2000) or 4 intensities (Bergman and Brooks, 1999; Howley et al, 1997) 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 and 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 untrained subjects.

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 has not participated in any regular sports activity during the last 3 years.

RESEARCH METHOD

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_2max. VO2max 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).

Fat oxidation (g.min) *= 1.67* VO_2 *- 1.67* 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 (LF_8) 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 1. Individual characteristics of subjects.

Group / Feature	Untrained (n= 9)
Age (years)	24 ± 1.11
Height (cm)	177.88 ± 6.69
Weight (kg)	76.11 ± 4.04
BMI ($kg.m^2$)	24.28 ± 1.83
(ml.kg. min) VO_2 max	36.58 ± 2.95
LBM (kg)	59.70 ± 3.57
PBF (%)	22 ± 3.14

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 42.72±3.01 percent of VO_2max(Fatmax)(Figure 1). Also the quantities mentioned as maximal fat oxidation are appropriate for intensities of activity equal to 60.09±3.37 percent of HRmax in untrained subjects (Figure 2). Also the level of overall fat oxidation in untrained subjects was 1.20±0.13g/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 untrained subjects

statistical index / Variable		The total squares	Degree of freedom (df)	The average squares	F amount	p-value (P)
The amount of fat oxidation during 7 stages	Untrained	0.091	6	0.015	28.459	* 0.001

Table 3. Results of LSD test in untrained group

Level of treadmill protocol	Amount of fat oxidation (g.min)	Results of LSD test						
		7	6	5	4	3	2	1
1	0.11 ± 0.01		*	*	*	*	*	
2	0.15 ± 0.02		*	*	*	*		*
3	0.20 ± 0.03	*	*		*		*	*
4	0.22 ± 0.01	*	*	*		*	*	*
5	0.19 ± 0.02	*	*		*		*	*
6	0.17 ± 0.03	*		*	*	*	*	*
7	0.13 ± 0.04		*	*	*	*		

* Significant difference of mean fat oxidations in different intensities (P≤0/05)
* The most significant difference of means in different intensities

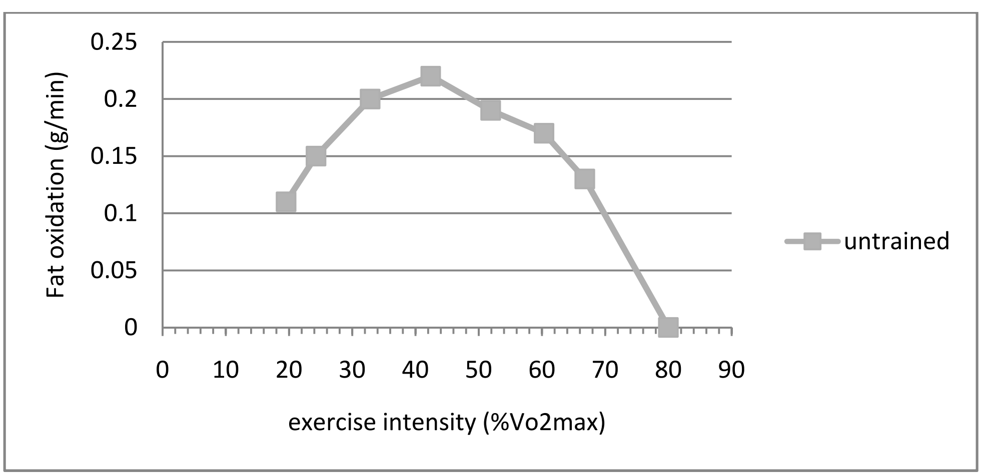

Figure 1. The amount of appropriate fat oxidation with intensity of activity according to %VO2max.

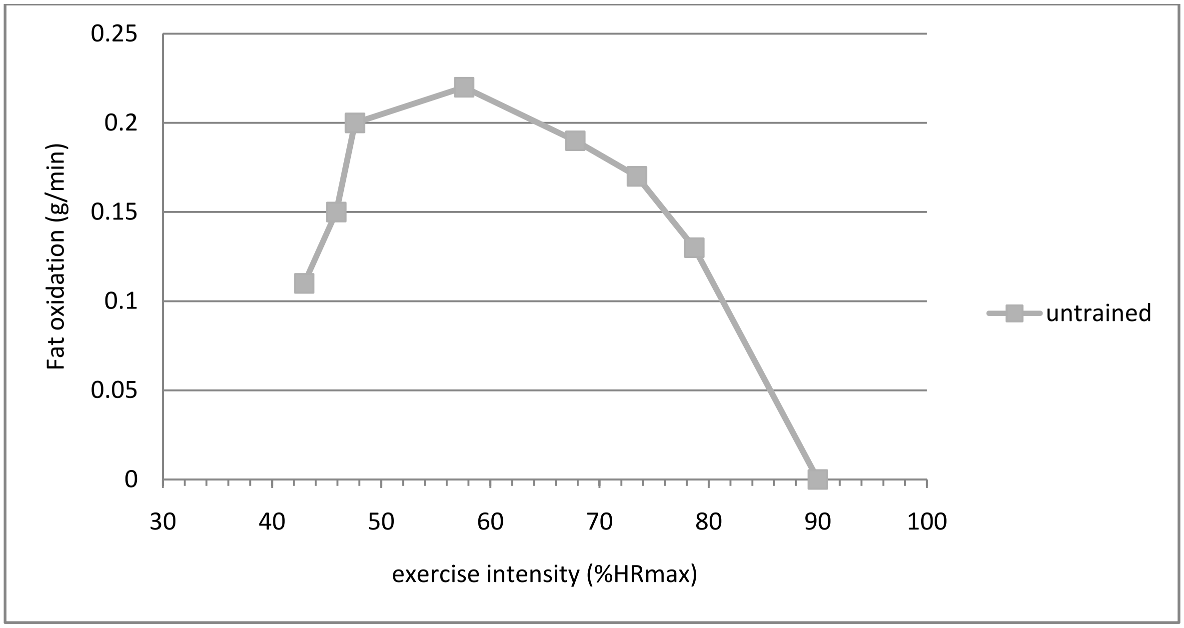

Figure 2. The amount of appropriate fat oxidation with intensity of activity according to %HRmax.

DISCUSSION AND CONCLUSION

This study was aimed at determine the maximal fat oxidation levels after an incremental exercise for untrained 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 FATmax 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. Many studies, have reported the maximal fat oxidation in the low to moderate intensities (between 33 to 65 percent VO_2max)(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 FATmax. 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_2max is equal to its amount in 65 percent VO_2max. 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, 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. On the other hand, malonyl-CoA enzyme which is a medium for FA synthesis prevents the activity of carnitine palmitoyl transferase-1 which provokes transfer of fatty acids into mitochondrion (Winder, 1998). The results of a research in which the mice have been running in various exercise intensities, emphasizes on the role of malonyl-CoA enzyme in decreasing fat oxidation in higher exercise intensities (Rasmussen and Winder, 1997). In addition, it is shown that CPT-1 sensitivity to malonyl-CoA depends on PH (Mills et al, 1984); in 6.8 PH compared to more normal PH, CPT-1 connects more effectively to malonyl-CoA. As exercise with higher intensity increases the muscle activity, decrease of fat oxidation in higher exercise intensities can be a result of provoked PH which increases the sensitivity of CPT-1 to malonyl-CoA. In laboratory studies done on skeletal muscles of mice (Guzman and Castro, 1988) and human (Starritt et al, 2000) it is shown that even small decreases of muscle PH can decrease CPT-1 activity, significantly. 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 level 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 and 2003) and Achten and Jeukendrup(2003), the levels of VO_2max were determined by continuous graded test up to inability(30 to 35 minutes). While in the study by Stisen et al(2006), VO_2max 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 untrained male students. As it is showed in studies by Venables et al(2005), and Friedlander et al(1998), women have rather more FATmax 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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