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Research article

RELATIONSHIP BETWEEN FAT OXIDATION AND LACTATE THRESHOLD IN ATHLETES AND OBESE WOMEN AND MEN

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ABSTRACT
The first aim of this study was to determine the exercise intensity that elicited the highest rate of fat oxidation in sedentary, obese subjects (OB; n=10 men, n=10 women) compared with endurance athletes (AT; n=10 men, n=10 women). The second aim was to investigate the relationship between VO_2 at the intensity eliciting the highest rate of fat oxidation and the corresponding VO_2 at the lactate threshold. Peak oxygen consumption (VO_{2peak}) was determined in 20 AT and 20 OB using an incremental exercise protocol on a cycle ergometer. Based on their VO_{2peak} values, subjects completed a protocol requiring them to exercise for 20 min at three different workloads (55, 65 and 75% VO_{2peak}), randomly assigned on two separate occasions. The oxidation rates of fat and carbohydrate were measured by indirect calorimetry. The highest rates of fat oxidation were at 75 % VO_{2peak} (AT), and at 65 % VO_{2peak} (OB). The rate of fat oxidation was significantly higher in AT (18.2 ± 6.1) compared with OB women (10.6 ± 4.5 kJ $min^{-1}·kg^{-1}$) ($p < 0.01$). There was no significant difference in the rate of fat oxidation for the men (AT 19.7 ± 8.1 vs. OB 17.6 ± 8.2 kJ $min^{-1}·kg^{-1}$). AT reached LT at a significantly ($p < 0.01$) higher exercise intensity expressed in VO_{2peak} than obese subjects (AT women 76.4 ± 0.1, men 77.3 ± 0.1 vs. OB women, 49.7 ± 0.1, men 49.5 ± 0.1% VO_{2peak}). A significant correlation was found between VO_2 at LT and VO_2 ($L·min^{-1}$) eliciting the maximal rate of fat oxidation in athletes (women; r = 0.67; p = 0.03; men: r = 0.75; p = 0.01) but not in the obese. In summary, we observed higher rates of fat oxidation at higher relative work rates in AT compared with OB. A significant correlation was found between LT and the exercise intensity eliciting a high rate of fat oxidation in AT (r=0.89; p < 0.01) but not in OB. Cardiorespiratory fitness, defined as VO_{2peak}, seems to be important in defining the relationship between a high rate of fat oxidation and LT.

KEY WORDS: Exercise intensity, substrate utilization, obesity, lactate threshold.

INTRODUCTION

The ability to mobilize and utilize fat as a fuel is important for a variety of populations. For endurance athletes the strong relationship between the capacity to oxidize fatty acids and exercise performance is of interest (Holloszy and Coyle, 1984; Jansson and Kaijser, 1987). For overweight and obese subjects an increased rate of fat oxidation might be beneficial in order to reduce body weight (Jeukendrup and Achten, 2001). Exercise training programmes at the intensity eliciting a maximal rate of fat oxidation are therefore helpful to treat and prevent obesity and the metabolic syndrome and to increase the capacity of endurance athletes to oxidize fat.

Endurance training is known to increase the rate of fat oxidation during submaximal exercise at a given workload (Hurley et al., 1986; Martin et al., 1993; Phillips et al., 1996). Dériaz and colleagues (2001) in humans and Weber and colleagues (1993) in animals reported a positive correlation between maximal aerobic power (VO_2 max) and the highest rate of fat oxidation. These findings suggest that the ability to oxidize fatty acids is related to high levels of cardiorespiratory fitness. In addition, results of biopsy studies of both rat (Wolfe et al., 1990) and human muscle (Kiens et al., 1993) indicated that training induced increases in free fatty acid (FFA) binding proteins and mitochondrial density enhance the ability for FFA oxidation. The evidence is that endurance trained athletes are able to oxidize more fat at a given exercise intensity compared with untrained subjects.

In endurance trained people the rate of fat oxidation increases from low to moderate intensities (Romijn et al., 1993) and declines at exercise intensities of approximately 80 to 85% VO_2 max (Astorino, 2000). The intensity associated with the highest rate of fat oxidation is between 55 and 75% VO_2 max, shown in several recent studies (Romijn et al., 1993; Astorino, 2000; Romijn et al., 2000; Van Loon et al., 2001; Achten et al., 2002; Knechtle et al., 2004). This wide range of exercise intensities may have been a consequence of different study protocols, subject groups or type of exercise.

The highest rate of fat oxidation in sedentary, obese subjects is not well documented. Several lines of evidence indicate that obese subjects may have an impaired capacity to oxidize fat (Kim et al., 2000; Pérez-Martin et al., 2001) compared with trained individuals. However, Steffan and co-workers (1999) compared rates of fat oxidation in obese and normal weight women with similar VO_2 max values ($ml\cdot kg^{-1}\cdot LBM^{-1}\cdot min^{-1}$) and found no difference in substrate use between the two groups. Also Ranneries and colleagues (1998) found no difference in fat oxidation between formerly obese women and normal weight women at 50% VO_2 max. Thus, it seems cardiorespiratory fitness level (defined as VO_2 max), rather than body composition influences the rate of fat oxidation.

Recommended training intensity at submaximal intensities is often given by percentages of maximal oxygen uptake (%VO_2 max) or heart rate (%HRmax). In athletes (Meyer et al., 1999; Weltman et al., 1999) and in obese subjects (Byrne and Hills, 2002) the proportion of peak or maximal cardiorespiratory capacity corresponds with wide ranges of exercise intensity as defined by individual lactate threshold (LT). Furthermore Achten and colleagues (2002) found a large between-subject variation for the maximal rate of fat oxidation expressed either in %VO_2 max or %HRmax. Consequently, relying on exercise intensity described by specific percentages of VO_2 max or HRmax, some individuals will be working well below and others well above the intensity that elicits the highest rate of fat oxidation. Thus, an individual determination of exercise intensities associated with a maximal rate of fat oxidation will ensure a more targeted and thus effective approach for exercise prescription (Jeukendrup and Achten, 2001).

A well known and established marker of an individual submaximal exercise criterion is the LT (Casaburi et al., 1995). Training at an intensity near the LT seems correlated with high rates of fat oxidation in athletes. Recently Knechtle and colleagues (2004) found in endurance athletes a relationship between the highest rate of fat oxidation and the LT in cycling but not in running. Achten and Jeukendrup (2004) showed a significant correlation between the intensity at which lactate concentration increased above baseline and the maximal rate of fat oxidation in endurance trained athletes. However, no previous study has investigated the relationship between the highest rate of fat oxidation and the LT in obese subjects. Due to the fact that studies concerning the relationship between fat oxidation and LT have only been performed with athletes, we included a group of highly trained athletes as a control group for our obese subjects in order to compare our results with the literature.

Therefore, a primary aim of this study was to determine the exercise intensity associated with the highest rate of fat oxidation in sedentary obese subjects. A secondary purpose was to compare the VO_2 at LT with the VO_2 ($L\cdot min^{-1}$) at the intensity that elicits a maximal rate of fat oxidation in athletes and obese subjects using the same exercise protocol.

METHODS

Subjects

Twenty endurance trained athletes (AT; 10 women, 10 men) and twenty sedentary, obese subjects (OB; 10 women, 10 men) were included in the study. The athletes were recruited from advertisements in a national sports journal, the obese subjects were recruited from circulated flyers and advertisements in the newsletters from the Swiss Foundation of Obesity. All of the athletes were either active triathletes (6 women, 7 men) or cyclists (4 women, 3 men) at either national or international level with a training background of at least five years. All obese subjects were sedentary, whereby sedentary was defined as exercising less than once per week for the previous 6 months. Obesity was defined as a body mass index (BMI) greater or equal than 30 $kg\cdot m^{-2}$.

Prior to all testing procedures, trained and sedentary subjects completed a screening questionnaire regarding their medical and exercise histories. None of them were following either an energy-restricted diet, or using medications that affected energy metabolism. Metabolic and endocrine disorders were excluded by measuring fasting plasma lipoprotein lipids (triglycerides, total cholesterol, HDL cholesterol) and fasting blood glucose and insulin levels. The following criteria lead to exclusion: a) total blood cholesterol > 5.7 mmol·L^{-1}; b) triglycerides > 2.0 mmol·L^{-1}; c) glucose > 6.1 mmol·L^{-1}. After analysis of the screening questionnaire and the fasting blood samples, five obese subjects were excluded. From the 42 athletes who responded to the advertisement, 20 were selected who most closely matched the OB with respect to age. Prior to testing all participants gave their written informed consent after explanations of the experimental procedures and possible risks and benefits. All procedures were approved by the local ethics committee.

Maximal Exercise Testing

Initially, height and body weight were measured and BMI (kg·m^{-2}) was calculated. The body fat percentage (BF %) was determined according the equation of Deurenberg (1991). To assess VO_{2peak}, the subjects performed an incremental exercise test on a stationary cycle ergometer (ergoline 900®, ergoline, Bitz, Germany). Women were tested without respecting their menstrual cycle. Obese subjects started at 40 W, athletes at 100 W. Workload was increased by 30 W at 3 min intervals until cessation of the test. During exercise, oxygen uptake (VO_2) and carbon dioxide production (VCO_2) were measured continuously (Oxycon Pro, Jaeger, Würzburg, Germany). Gas analyzers were calibrated prior to each test. Heart rate was recorded continuously by an electrocardiogram. At the end of every 3 min step, blood samples from the earlobe were collected in a 20 µl glass capillary to measure the concentration of lactate by an enzymatic method (Super GL ambulance, Ruhrtal Labor Technik, Möhnesee, Germany). Before each measurement of lactate the analyzer was calibrated with a 10 mmol·L^{-1} lactate standard solution.

Determination of lactate threshold (LT)

The LT was determined in the maximal exercise test. According to Coyle and colleagues (1983), LT was identified as the VO_2 at which lactate increased 1 mmol·L^{-1} above baseline, since this could be objectively determined in all subjects.

Submaximal testing protocol

Subjects completed submaximal exercise protocols, requiring them to exercise at three different workloads of 55, 65 and 75% VO_{2peak} in randomized order spread over two separate days (either one or two exercise bouts per day). Volunteers were advised to follow their normal diet, to avoid strenuous exercise the day before the test and to abstain from eating for 10 h before the submaximal tests. Each stage of the submaximal test lasted 20 min and was separated by at least 15 min of passive recovery. Oxygen consumption (VO_2) was measured continuously throughout the 20 min exercise bouts. Workload was adjusted in the first five minutes to reach the preset percentage of VO_2. Heart rate was measured continuously (Polar M52®, Kempele, Finland). At the beginning and at the end of each stage, the concentration of blood lactate was measured. To ensure that gas exchange was stable at the onset of exercise and subjects had recovered from the previous bout of exercise, subjects rested until their RER was maintained around 0.80 and lactate concentration reached baseline values.

The reproducibility of the submaximal exercise stages was tested pre-study. Five healthy female and male volunteers (age: 24.3 ± 2 years, BMI: 23.6 ± 1.2 kg·m^{-2}) performed the maximal test and the submaximal exercise protocol twice within one week. The VO_2 at LT and the ventilatory responses at the three exercise intensities (VO_2 and VCO_2) did not differ between the two tests (Student's t-test). The coefficients of variation (CV) for RER during each of the tested intensities were respectively 2.6, 2.3 and 3.9%. The reliability of LT was assessed by the CV for VO_2 at LT. The CV was found to be 2.9%.

Indirect calorimetry and calculations

VO_2 and VCO_2 measures from the last 5 min of each exercise intensity (55, 65, 75% VO_{2peak}) were used to calculate rates of fat and carbohydrate oxidation. Fat and carbohydrate oxidation and energy expenditure were calculated using the stochiometric equations of Frayn (1983), which defined oxidation of carbohydrates (g·min^{-1}) as 4.55 x VCO_2 – 3.21 x VO_2 – 2.87 n and oxidation of fat (g·min^{-1}) as 1.67 x VO_2 – 1.67 x VCO_2 – 1.92 n. Nitrogen excretion rate (n) was assumed to be 135 µg·kg^{-1}·min^{-1} in accordance with Carraro and colleagues (1990). Energy expenditure from fat and carbohydrate were converted to kJ·min^{-1} by multiplying the oxidation rate of fat by 37 and the oxidation rate of carbohydrate by 16 using the Atwater (1909) general conversion factor. VO_{2peak} was expressed per kg body weight and kg lean body mass (LBM). Fat and carbohydrate oxidation rates were expressed as kJ·min^{-1} per kg body mass (Figures 1 and 2).

Statistical analysis

All data from the maximal exercise test were reduced to group means. Comparisons between the athlete and the sedentary obese group for a single measurement (Age, BMI, LBM, VO_{2peak}, LT expressed in %VO_{2peak}, HR_{max}, and RER_{max}) were made with the Student's t-test for independent samples. ANOVAs with repeated measures were performed to detect statistically significant differences between intensity for each metabolic

Table 1. Anthropometric data of the subjects. Data are means (± SD).

Variables	Women		Men	
	Athletes (n = 10)	Obese (n = 10)	Athletes (n = 10)	Obese (n = 10)
Age (y)	34.3 (9.60)	33.5 (7.71)	34.6 ± 7.82	34.2 ± 8.99
Height (m)	1.68 (.03)	1.65 (.05)	1.78 ± 0.04	1.78 ± 0.05
Weight (kg)	58.6 (4.48)	94.7 ± 11.47*	71.85 ± 5.75	112.3 ± 33.61*
BMI ($kg \cdot m^{-2}$)	20.9 (1.8)	34.7 ± 4.6*	22.7 ± 1.3	35.4 ± 8.6*
LBM (kg)	48.4 (3.4)	47.4 ± 2.4	61.6 ± 4.3	65.6 ± 6.7
Body fat (%)	17.4 (1.3)	49.4 ± 5.8*	14.3 ± 1.0	39.7 ± 8.9*

* Significant difference between endurance trained and sedentary obese women and between endurance trained and sedentary obese men ($p < 0.05$). BMI = body mass index, LBM = lean body mass.

variable (rate of carbohydrate oxidation per kg body weight, rate of fat oxidation per kg body weight, percent fat oxidation of total energy oxidation, and total energy oxidation/consumption).

The strength of the relationship between VO_2 at lactate threshold and VO_2 eliciting the maximal rate of fat oxidation was assessed using the Pearson product moment correlation coefficient. All calculations were performed with SYSTAT (SYSTAT, Inc., Evanston, Illinois). Statistical significance was set at $p < 0.05$.

RESULTS

Subject characteristics and VO_{2peak} test

The anthropometric data of the subjects and physiological measures from the VO_{2peak} test are shown in Table 1 and 2 respectively. AT showed a significantly lower body mass ($p < 0.01$) and BMI ($p<0.01$) compared with OB. VO_{2peak} values expressed relative to body mass and expressed per kg of lean body mass were significantly higher in athletes compared with obese ($p < 0.01$).

Energy expenditure

The rate of energy expenditure increased with increasing intensity in AT and OB ($p < 0.01$) and showed significant differences between AT and OB in both genders ($p < 0.01$) (Figures 1 and 2). Absolute energy expenditure ($kJ \cdot min^{-1}$) at a defined intensity was significantly higher in men than in women ($p < 0.01$). Total energy expenditure expressed per kg of lean body mass showed no statistical difference between sexes in both groups. Relative rates of fat oxidation expressed in percent of total energy oxidation were not significantly different between the three tested intensities (55, 65 and 75% VO_{2peak}) in either sex (women: 36.2 ± 15.2, 35.5 ± 12.9, 31.4 ± 12.3%; men: 32.3 ± 14.5, 34.5 ± 15.3, 27.8 ± 11.1%). At 55% VO_{2peak} female AT attained a significantly higher percentage of fat to total energy expenditure at 75% VO_{2peak} (range 24-38%) than obese women ($p = 0.02$), whereas men showed no significant difference (AT, 28.6 ± 11.8 %; OB, 26.9 ± 11.9%).

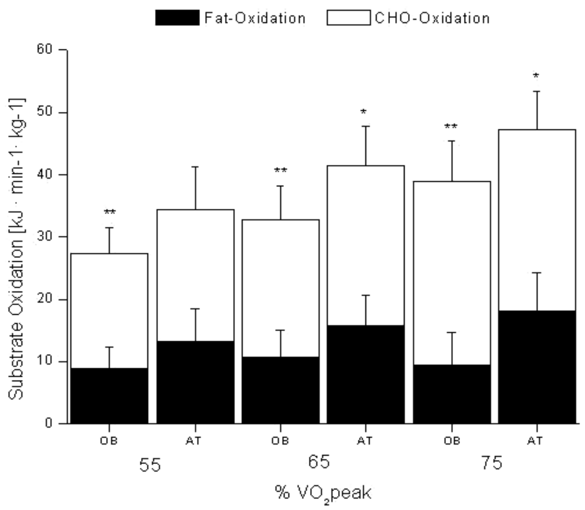

Figure 1. Means and standard deviations of substrate oxidation at different exercise intensities (in $\%VO_{2peak}$) during submaximal exercise in obese women (OB; n = 10) and female athletes (AT; n = 10). Significant differences between fat and carbohydrate oxidation are mentioned (* $p < 0.05$; ** $p < 0.005$).

Substrate oxidation

Within the tested intensities, AT (men and women) demonstrated their highest rate of fat oxidation at an intensity of 75% VO_{2peak}, sedentary obese subjects reached a maximal rate of fat oxidation at 65% VO_{2peak}. Female athletes showed a significantly higher absolute rate of fat oxidation ($kJ \cdot min^{-1}$) than obese women ($p < 0.01$). Also normalized rate of fat

Table 2. Physiological measures from the VO_{2peak} test. Data are means (± SD).

Variables	Women		Men	
	Athletes (n = 10)	Obese (n = 10)	Athletes (n = 10)	Obese (n = 10)
VO_{2peak} ($ml\cdot kg^{-1}\cdot min^{-1}$)	53.14 (5.21)*	25.94 (3.80)	61.29 (4.82)*	32.88 (5.42)
VO_{2peak} ($ml\cdot kg^{-1}\cdot LBM^{-1}\cdot min^{-1}$)	64.30 (6.10)*	53.57 (9.48)	71.44 (5.53)*	50.36 (9.64)
W_{max} (Watt)	253 (30)*	178 (29)	355 (35)*	246 (40)
HR_{max} ($b\cdot m^{-1}$)	175 (7)	174 (11)	170 (7)	170 (15)
$Lactate_{max}$ ($mmol\cdot L^{-1}$)	8.27 (1.61)	7.85 (1.63)	9.48 (2.36)*	7.27 (2.05)

* Significant difference between endurance trained and sedentary obese women and between endurance trained and sedentary obese men ($p < 0.05$).

oxidation, expressed in kg body mass ($kJ\cdot min^{-1}\cdot kg^{-1}$), was found to be significantly higher for female AT compared with OB (Figure 1). There was no significant difference between obese men and male athletes in fat utilization and normalized rate of fat oxidation at the intensity that elicited highest rates of fat oxidation (AT: 19.72 ± 8.05 $kJ\cdot min^{-1}$ kg^{-1} at 75% VO_{2peak}; OB: 17.57 ± 8.24 $kJ\cdot min^{-1}\cdot kg^{-1}$ at 65% VO_{2peak}). Carbohydrate utilization per kg body mass increased in athletes and obese with increasing workload (Figure 1 and 2). Between men, AT had a significantly higher absolute ($p < 0.01$) and normalized rate of carbohydrate oxidation ($p < 0.01$) than OB (Figure 2). Women AT and OB showed no significant difference in absolute and normalized carbohydrate utilization (Figure 1).

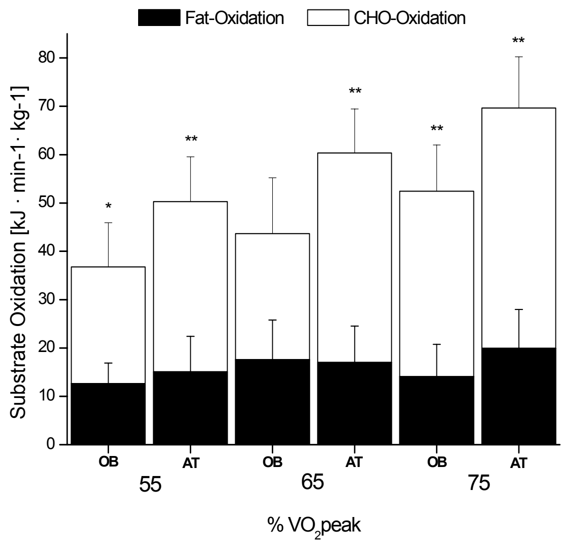

Figure 2. Means and standard deviations of substrate oxidation at different exercise intensities (in % VO_{2peak}) during submaximal exercise in obese men (OB; n = 10) and male athletes (AT; n = 10). Significant differences between fat and carbohydrate oxidation are mentioned (* $p < 0.05$; ** $p < 0.005$).

Lactate threshold (LT)

Female and male AT reached LT at a significantly higher intensity expressed in %Wmax ($p < 0.01$) and in %VO_{2peak} ($p < 0.01$) than obese women and men (Figure 3). Expressed in %Wmax, LT was near 35% Wmax in OB and similar for women and men. AT had their LT at approximately 74 and 77% VO_{2peak}, women and men respectively. There was a modest relationship between VO_2 at LT and VO_2 ($L\cdot min^{-1}$) at a work rate eliciting a maximum rate of fat oxidation in OB (women: r = 0.43, ns; men: r = 0.32, ns). In contrast for AT there was a strong relationship between VO_2 at LT and VO_2 ($L\cdot min^{-1}$) at a work rate eliciting a high rate of fat oxidation (women: r = 0.67, $p<0.05$; men: r = 0.75, $p=0.01$).

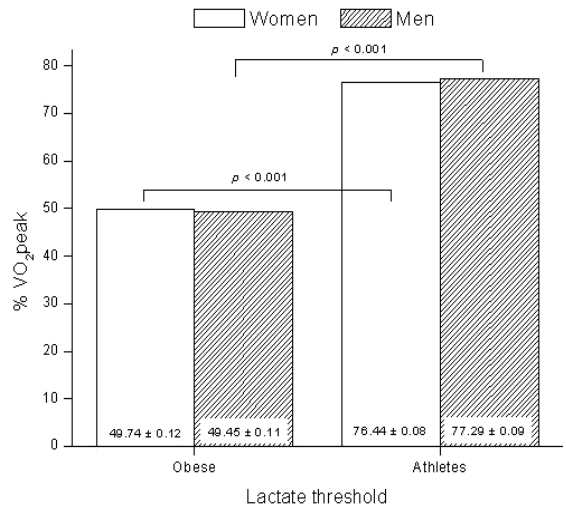

Figure 3. Lactate threshold expressed in percent (%) VO_{2peak} in sedentary obese and endurance trained women (white) and men (hatched).

DISCUSSION

Our first aim was to determine the intensity with the highest rate of fat oxidation in sedentary obese women and men compared with athletes using the same exercise protocol. Within the three tested intensities (55, 65 and 75% VO_{2peak}) we found the highest rate of fat oxidation at 75% VO_{2peak} in AT and at 65% VO_{2peak} in OB. Hence, obese subjects reached maximum rate of fat oxidation, whereas in athletes an increase in fat oxidation above an intensity of 75% VO_{2peak} still might be possible. The intensity with the highest rate of fat oxidation in OB is higher than reported in earlier studies at 42% VO_{2peak} (Dériaz et al., 2001) and 30.5% Wmax (Pérez-Martin et al., 2001). However, a direct comparison of the highest rate of fat oxidation with other studies is difficult due to differences in methodology and exercise protocols.

Substrate oxidation between athletes and the obese

Female and male AT reached a higher rate of fat oxidation at a higher exercise intensity than sedentary OB women and men. This is not surprising because endurance training is known to increase the rate of fat oxidation at a given submaximal work rate after training (Hurley et al., 1986; Martin et al., 1993; Phillips et al., 1996) and the capability to oxidize fat at high intensities depends on the level of cardiorespiratory fitness (Knechtle et al., 2004). Klein and co-workers (1994) found in trained versus untrained subjects, at the same relative intensity (70% VO_{2peak}), double the rate of whole body lipolysis, measured by the rate of glycerol appearance in plasma. In women we found (at 75% VO_{2peak}) twice the rate of fat oxidation per kg body weight in AT compared with the sedentary OB (Figure 1). Furthermore AT showed from the lowest to the highest exercise intensity a similar increase in rates of fat and carbohydrate oxidation, whereas we observed in obese women and men an increase in rate of carbohydrate oxidation and a decrease in fat utilization from 65 to 75% VO_{2peak} (Figure 1 and Figure 2). Hence, OB showed a lower rate of fat oxidation at higher workloads and a greater reliance on carbohydrate oxidation compared with AT. The comparison of substrate metabolism between AT and OB in the present study may be viewed with caution due to the different levels in cardiorespiatory fitness and body composition of the two groups. However, Ezell and co-workers (1999) compared subjects after weight loss with obese and non-obese subjects matched for fitness level and found no differences in rates of fat oxidation during 60 min of exercise at 60 to 65% VO_2 max. Also Steffan and co-workers (1999) and Ranneries and co-workers (1998) documented no difference in rates of substrate oxidation between subjects with different body mass and body composition. Consequently, not body composition per se, but rather different levels of cardiorespiratory fitness seem to influence substrate metabolism.

Relationship between the highest rate of fat oxidation and the lactate threshold

A secondary purpose of our study was to compare the VO_2 at LT with the VO_2 ($L\cdot min^{-1}$) at the intensity that elicited the maximal rate of fat oxidation. A modest correlation ($r=0.65$, $p<0.01$) between VO_2 ($ml\cdot min^{-1}$) at the intensity at which maximal fat oxidation occurred (63% VO_2 max) and the intensity at which lactate started to accumulate in plasma (61% VO_2 max) has been shown recently by Achten and Jeukendrup (2004). Furthermore Knechtle and co-workers (2004) reported a coincidence between the intensity at which LT occurred (77.6% VO_{2peak}) and the highest rate of fat oxidation (75% VO_{2peak}) during cycling. Both Achten and Jeukendrup (2004) and Knechtle and co-workers (2004) investigated endurance-trained athletes. Comparable with these results we found in our athletes a significant correlation between the VO_2 at the LT and the VO_2 at the intensity that elicited a high rate of fat oxidation, but no corresponding correlation was found between these two parameters in the obese.

As indicated in Figure 3, AT reached LT at a significantly higher exercise intensity expressed in %VO_{2peak} than OB. This result has also been documented by others who found a higher exercise intensity at LT in trained compared with untrained subjects (Gollnick et al., 1986). With around 50% VO_{2peak}, our obese subjects reached LT at a slightly lower intensity compared with the intensity which elicited the highest rate of fat oxidation (65% VO_{2peak}) - a finding, also shown by Astorino (2000) in moderately trained women. In moderately trained and sedentary obese subjects there appears to be a continuous increase of fat oxidation rate even after the first rise of lactate concentration (LT). Thus, the level of cardiorespiratory fitness seems to be important and may explain the weak correlation between LT and highest rate of fat oxidation in sedentary obese compared with endurance trained athletes. Due to the fact that lactate threshold in OB is at a lower intensity than in AT, we presume that peripheral muscle limits the rate of fat oxidation rather than the lower VO_{2peak} values of OB.

These findings have consequences for training recommendations. To maximize fat oxidation – according to the concept of 'Fatmax' by Jeukendrup and Achten (2001) - in athletes a recommended exercise intensity similar to the intensity at LT is appropriate. For obese people the detection of LT is not sufficient and the direct determination of the intensity that elicits the highest fat oxidation rate using indirect calorimetry remains necessary.

CONCLUSIONS

To summarize, the data of the present study showed that within the tested intensities female and male athletes have their highest fat oxidation rate at 75% VO_{2peak} and sedentary obese women and men at 65% VO_{2peak}. Obese subjects exhibit an earlier shift from fat to carbohydrate oxidation with increased exercise intensity compared with athletes. A correlation between VO_{2peak} at LT and VO_2 at the highest rate of fat oxidation rate was found in athletes but not in the obese. The lower fitness level (VO_2) of the obese subjects may explain the disassociation between the intensity that elicits the highest rate of fat oxidation and the intensity at LT.

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KEY POINTS

- Within the tested intensities of 55, 65 and 75% VO_{2peak} athletes reached higher rates of fat oxidation at higher relative work rates compared with obese subjects.
- We found in obese women and men the intensity of the highest rate of fat oxidation at 65% VO_{2peak}.
- Between the lactate threshold and the intensity eliciting a high rate of fat oxidation a significant correlation was found in athletes but not in obese subjects.

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