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DETERMINATION OF FUEL UTILISATION DURING SUBTHRESHOLD EXERCISE INDUCED METABOLIC SYSTEM ACTIVITY IN HEALTHY SUBJECTS

" Sağlıklı Deneklerde Eşik Altı Egzersize Bağlı Metabolik Sistem Aktivitesi Sırasında Yakıt Kullanımının Belirlenmesi"

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ÖZET

Amaç: Düşük yoğunluklu egzersiz sırasında substrat oksidasyonundaki metabolik değişimleri değerlendirmeyi ve sağlıklı erkek deneklerde yağ ve karbonhidrat yakımlarının enerji üretimine katkısını analiz etmeyi amaçladık.
Materyal ve Metod: Bu çalışmaya toplam 12 sağlıklı erkek katıldı. Her denek başlangıçta maksimum egzersiz testi gerçekleştirdi. Daha sonra her denek 30 dakikalık bir süre boyunca maksimum egzersiz kapasitesinin %40-45'inde sabit bir yük egzersizi yaptı. Egzersiz sırasında deneklerin yağ ve karbonhidrat oksidasyonu, solunum gazı değişim formülü için standart stokiyometrik denklemler kullanılarak hesaplandı.
Bulgular: Solunum katsayısı (RQ) test sonunda 0.93±0.001'den 0.92±0.001'e önemli ölçüde azaldı. Test sonunda yağ oksidasyonunda 1.512±0.04 gr'dan 1.958±0.03 gr'a anlamlı bir artış (%29) vardı ($p<0.05$), ancak karbonhidrat oksidasyonunda 6.935±0.06 gr'dan 6.608±0.04 gr'a ($p<0.05$) önemli bir düşüş (-%4.7).
Sonuç: Artan yağ oksidasyonu, obezite hastalarında düşük ve orta şiddette egzersiz yoğunluğunun önemli bir yol olarak kullanılabileceğini gösterebilir.
Anahtar Kelimeler: Egzersiz, Yağ Oksidasyonu, Anaerobik Eşik, Karbonhidrat Oksidasyonu

ABSTRACT

Aim: We intended to evaluate metabolic shifts in substrate oxidation during low intensity exercise and analyse the contribution of fat and carbohydrate oxidations to energy production in healthy male subjects.
Material and Method: Total of 12 healthy male participated to this study. Each subjects initially performed maximal exercise test. Then each subjects performed a constant load exercise at their 40-45% of maximal exercise capacity for a period of 30 min. During exercise, the subjects' fat and carbohydrate oxidation was calculated using standard stoichiometric equations for respiratory gas exchange formula.
Results: Respiratory Quotient (RQ) decreased significantly in from 0.93±0.001 to 0.92±0.001 at the end of test. There was a significant increase (29%) in fat oxidation from 1.512±0.04 gr to 1.958±0.03 gr at the end of the test ($p<0.05$) but significant decrease in carbohydrate oxidation (-4.7%) from 6.935±0.06 gr to 6.608±0.04 gr at the end of the test ($p<0.05$).
Conclusion: In conclusion, increasing amount of fat oxidation may indicate that the low to moderate exercise intensity can be used as an important way in patients with obesity.
Keywords: Exercise, Fat Oxidation, Anaerobic Threshold, Carbohydrate Oxidation

INTRODUCTION

The human energy balance at rest and during exercise at the various intensities is a complex phenomenon (Hargreave and Spriet, 2018). Aerobic exercise is known to be essential tool used in regulation of energy balance and prevents body weight increase (Ozcelik et al 2015). Exercise has great stimulatory impact on body metabolic system activity. Exercise induced muscle activity is accompanied with an increased substrate utilisation. During exercise, fat and carbohydrate oxidations promotes increased energy demands. Optimal substrate availability and their rates of oxidations during various type of physical activity are highly important for performing targeted activity. The exercise intensity is one of the important determinant factor for oxidation of fat and carbohydrate (Ugras et al, 2020 and Brun et al 2022). During progressively increasing work rate exercise, carbohydrate oxidation becomes dominant compared to fat oxidation with increasing work load (Çolak & Özçelik, 2002). Importantly, an impairment of fat and carbohydrate oxidations may have been associated with development of obesity and type II diabetes (Corpeleijn et al., 2009).

The exercise workloads at/or above the lactate threshold which represents moderate and heavy intensity, are generally chosen for clinicians or scientist for health related situations (Whipp, 1994 and Ugraş ve Ozcelik, 2021). However, the physical activity in humans' daily life is frequently occurs in low level intensity. Any significant role of low level of exercise intensity on energy expenditure, substrate utilisation, and behaviour of fat to carbohydrate oxidations is not widely known.

The main objective of the present study was to gain insight into the energy consumption, metabolic shift in substrate oxidation during low intensity exercise and evaluate the contribution of fat and carbohydrate oxidations to energy production in healthy male subjects.

MATERIAL AND METHOD

Total of 12 healthy male subjects (22.4±0.4 yr, 1.82±0.01 m, 76.3±1.3 kg,) were participated to this study. Each subjects gave a signed written informed consents which were approved by the local ethical committee. The subjects were all in normal body mass index and averaged 23±0.3 kg/m2. Body composition analysis was performed using foot-to food bioelectrical impedance analysis (Ugras, 2020). They were all free of any disease in metabolic, cardiac, respiratory systems. They were non-smokers and taking no alcohol or medication. All subjects performed an incremental exercise test with a 15 W/min work increments until exhaustion on a cycle ergometer to estimate lactate threshold (Whipp et al, 1981). Lactate threshold was estimated using standard V-slope (Beaver et al, 1986) and other conventional methods based on ventilator and pulmonary gas exchange parameters (Ozcelik ve Kelestimur, 2004). During the onset of study, the subjects' ventilation was controlled carefully to avoid pseudo-threshold (Ozcelik et al., 1999). Than each subjects performed a constant load exercise test work load below the lactate threshold and associated between 40-45% of maximal exercise capacity for a 30 min period. The subjects heart parameters were followed beat-by-beat with a 12 lead ECG. During exercise, ventilatory and pulmonary gas exchange parameters were evaluated breath-by breath using metabolic gas analyser. During exercise, the subjects' fat and carbohydrate oxidation was calculated using standard stoichiometric equations for respiratory gas exchange formula (Frayn, 1983). Linear regression analyses were carried out between the change between substrate oxidation and exercise time. Paired t-test was used to analyse data changes during each five-minute period. $P<0.05$ as accepted as statistically significance.

RESULTS

The subjects maximal exercise capacity and work load at the lactate threshold (mean±SE) was found to be 208±6 W and 120.5±5 W, respectively. Lactate threshold occurred at approximately 57.7±1 % of maximal exercise capacity. Each subjects performed a constant load exercise tests with a low intensity averaged 88.5±2 W and associated with 42.5±0.2% of maximal exercise capacity. The work load for each kg of body weight at the maximal exercise and at the low intensity was 2.736±0.11 W/kg and 1.177±0.04 W/kg, respectively.

Respiratory Quotient (RQ) response to the low intensity constant load exercise test is shown in figure 1. The low intensity exercise caused significant decrease in RQ from 0.93±0.001 after 4 min of test to 0.92±0.001 at the end of test. The correlation between RQ during exercise have shown a negative linear decreases (R=0.76903, p<0.0001).

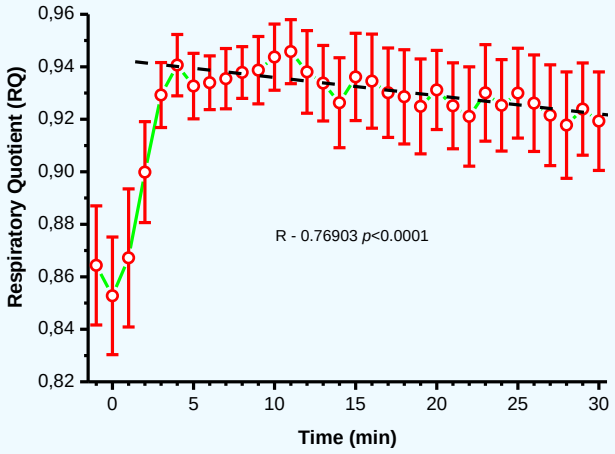

Figure 1. *The mean (±SE) values of respiratory quotient during exercise*

Table 1. *The mean (±SE) amount of fat and carbohydrate oxidation in response to each 5 minutes' period of exercise.)*

	Fat Oxidation (gr)	CHO oxidation (gr)
5-10 min	1.512±0.04	6.935±0.06
10-15 min	1.573±0.08 (4%)	6.914±0.08 8 (-0.3%)
15-20 min	1.746±0,04 (15%)	6.735±0.02 (-2.88%)
20-25 min	1.845±0.04 (22%)	6.622±0.05 (-4.5%)
25-30 min	1.958±0.03 (29%)	6.608±0.04 (-4.7%)

During exercise percent change of fat and carbohydrate oxidations were presented in figure 2. There was a significant increase (29%) in fat oxidation from 1.512±0.04 gr to 1.958±0.03 gr at the end of the test (p<0.05). In contrast to fat oxidation, there was significant decrease in carbohydrate oxidation (-4.7%) from 6.935±0.06 gr to 6.608±0.04 gr at the end of the test (p<0.05). Fat oxidation rates increased from 21±0.6 % to 27±0.5 % onset of test and end of test. In contrast CHO rates decreased 79±0.6% to 73±0.5%.

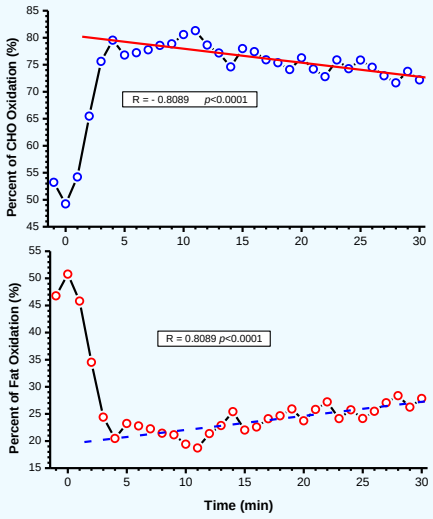

Figure 2. *The mean values of percent of carbohydrate (upper graph) and fat (lower graph) oxidations during exercise.*

As shown in figure 3, during exercise, fat to carbohydrate oxidation ratio increased linearly (R=0.81765, p<0.0001).

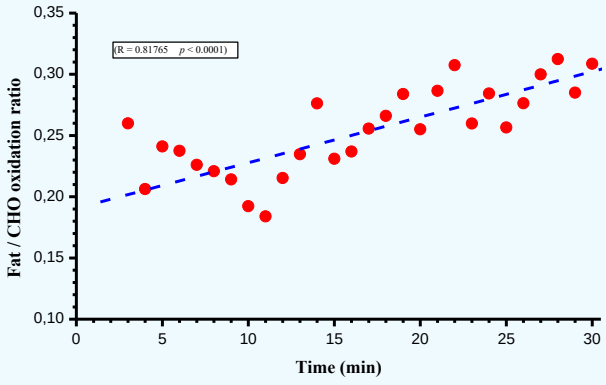

Figure 3. *Fat to carbohydrate ratio during constant load exercise test*

DISCUSSION AND CONCLUSION

The energy balance and substrate oxidation at rest and at the various levels of exercise intensity is a complex phenomenon. It is difficult to conclude effective exercise intensity on optimal rate of fat and carbohydrate oxidations and improvement of cardiorespiratory fitness in subjects with different body weight and composition (O'Donoghue et al 2021). The main finding in this study in which substrate oxidation rates and amount were examined during low intensity exercise, was that 29% more fat oxidation observed while decrease of -4.7% in carbohydrate oxidation (Uğraş ve Özçelik, 2019). Interestingly, in our study it was observed that low intensity exercise led to increased fat oxidation rates and the contribution of carbohydrate to energy expenditure decreased even during low intensity exercise.

It has been shown that low intensity exercise caused more fat oxidation rate compared to high intensity exercise in subjects with obesity (Van Aggel-Leijssen et al., 2001 and Lazzer et al 2011).

In other study, significantly increase in fat oxidation rates at the work load corresponded to the lactate threshold has been shown (Özdenk ve Uğur 2021). It is known that exercise induced increased energy demands is accompanied with altered rate of fat and carbohydrate oxidations. However, a marked decrease in fat oxidation during hypoxic exercise has been shown (Ozcelik et al., 2003).

The study performed in obese women showed that exercise intensity corresponded to anaerobic threshold increases fat loss and improve body composition (Ozcelik et al., 2006 and Zak-Golab et al., 2010). In addition, it has been shown that exercise intensity in the region between anaerobic threshold to respiratory compensation point causes higher amount of fat oxidation (Ugras et al., 2020).

In this study, the participants were sedentary subjects with normal body composition and averaged exercise capacity at the lactate threshold and at maximal exercise capacity (Ozcelik et al., 2004). Our data obtained in sedentary subjects show significance inverse relationships between amount of fat and carbohydrate oxidations across the range of exercise period (Figure 3).

It has been shown that low physical activity in daily life significantly contributes to increased energy consumption with 2-4 times higher than at rest (Calonne, et al., 2021). During low to moderate intensity exercise, a shift from carbohydrate to fat oxidation, as determined from decrease in RQ levels, occurred with increasing exercise time (Figure 1). The low intensity exercise induced shifts in mitochondrial and peroxisomal metabolism could be explain this observation in substrate shift (Fuller et al., 2019). Aerobic exercise may also cause an increase in energy consumption via affecting energy regulatory hormones of irisin and nesfatin-1 (Uğraş ve Dalkılıç 2021 and Özdenk ve Kurudirek 2021). Thus, daily physical activity with a low to moderate intensity may also provide beneficially acceptable rate of fat oxidation.

Increasing amount of fat oxidation may indicate that the low to moderate exercise intensity can be used as an important way in patients with obesity.

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