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Effects of exercise at the anaerobic threshold on respiratory quotient in young male subjects

Anaerobik eşikte yapılan egzersizin genç erkek deneklerde solunum katsayısı üzerine etkileri

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ABSTRACT

Aim: Exercise has great influence on increasing metabolic system functions. The work load corresponded to anaerobic threshold provide optimal aerobic strain for metabolic activity in exercising muscle. In the present study we intended to evaluate body substrate oxidation ratio during constant load exercise test at the intensity of anaerobic threshold in healthy young male subjects.

Material and Method: Total of 15 male performed an incremental ramp exercise test to estimate anaerobic threshold. Standard V-slope method used to estimate anaerobic threshold. Then each subjects performed a constant load exercise test for a 30 min period with a work load corresponded to their anaerobic threshold. Respiratory quotient (RQ) used to evaluate substrate oxidations during exercise. Anova test used to evaluate significance of data obtained every 5 minutes of constant load exercise.

Results: The subjects' anaerobic threshold occurred at approximately 63% of their maximal exercise capacity. RQ varied markedly among the subjects but as a mean values, but it systematically decreased with increasing exercise time. Body mass index and exercise time has great importance on fat and carbohydrate oxidation ratio.

Conclusion: Exercise intensity at the anaerobic threshold provides meaningfully fat oxidation and could be acceptable in subjects with high body fat mass.

Keywords: Exercise, anaerobic threshold, respiratory quotient, metabolism

ÖZ

Amaç: Egzersizin metabolik sistem fonksiyonlarını artırmada büyük etkisi vardır. Anaerobik eşiğe karşılık gelen iş yükü, kas egzersizinde metabolik aktivite için optimal aerobik zorlanma sağlar. Bu çalışmada, sağlıklı genç erkek deneklerde anaerobik eşiğin yoğunluğunda sabit yük egzersiz testi sırasında vücut substrat oksidasyon oranını değerlendirmeyi amaçladık.

Gereç ve Yöntem: Toplam 15 erkek, anaerobik eşiği belirlemek için artan yüke karşı yapılan egzersiz testine katıldılar. Anaerobik eşiği belirlemek için V-slope yöntemi kullanıldı. Daha sonra her denek, anaerobik eşiklerine karşılık gelen bir iş yükü ile 30 dakikalık bir süre boyunca sabit bir yük egzersiz testi yaptı. Egzersiz sırasında substrat oksidasyonlarını değerlendirmek için solunum katsayısı (RQ) kullanıldı. Anova testi, her 5 dakikada bir sabit yük egzersizinden elde edilen verilerin istatistiksel olarak önemini belirleme için kullanıldı.

Results: Deneklerin anaerobik eşiği, maksimum egzersiz kapasitelerinin yaklaşık %63'ünde meydana geldi. RQ denekler arasında belirgin farklılıklar gösterdi, ancak ortalama değerler olarak egzersiz süresinin artmasıyla sistematik olarak azaldı.

Sonuç: Anaerobik eşikteki egzersiz yoğunluğu anlamlı oranda yağ yakımını sağlamaktadır bu ise yüksek yağ oranına sahip kişilerde önemli bir egzersiz noktası olarak kabul edilebilinir.

Anahtar Kelimeler: Egzersiz, anaerobik eşik, solunum katsayısı, metabolizma

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INTRODUCTION

Due to the physical inactivity induced increased health problems, exercise has gained more attention and recognition from clinicians and researchers for its vital role in improving cardiopulmonary and metabolic fitness in subjects with varied fitness levels (1-3).

It is generally accepted that exercise is one of the preeminent way used to regulate energy homeostasis efficiently (4-6). Aerobic exercise intensity has great influence on energy expenditure results educed body weight and prevents weight regains (7). The concept of metabolic flexibility which defined as the ability to regulate substrate oxidation rates in response to the variation in substrate availability (8). Respiratory quotient (RQ) simply describes the ratio between CO_2 production and O_2 consumption while substrate is being metabolised. RQ values depends the type of substrate oxidation. When carbohydrate is the only substrate oxidised, RQ becomes 1.0, reflects the similar amount of CO_2 production and O_2 consumption. RQ is equal 0.7 when fatty acid is being oxidised solely. Therefore, RQ values between 0.7 and 1.0 reflects mix substrate oxidation (9).

The anaerobic threshold concept that indicate a shift in metabolism from aerobic to anaerobic and associated with systematic increases in blood lactate levels, has been used as an effective moderate intensity exercise protocol for improving fitness levels (10,2).The exercise induced increase metabolic activity is accompanied with altered substrate oxidations with different rate of fat and carbohydrate (8,11). Increased fat oxidation during exercise is primarily target in management of energy homeostasis (12). The aim of this study was to evaluate substrate utilization rate considering contribution of fat and carbohydrate during constant load exercise performed workload corresponded to the anaerobic threshold.

MATERIAL AND METHOD

Total of 15 healthy young male age between 18 years to 25 years old (averaged as 20.9±1.3 years) were participated to this study. The subjects' body mass index was in normal ranges (between 18.5 kg/m² to 25 kg/m²) and averaged 22.7±1.1 kg/m². Before participating to this study, all subjects gave signed informed contents which were approved by Çoruh University Ethical Committee (date: 06.05.2014, number: 09-01).. The subjects were in a good health and free of any medical problem including cardiac respiratory, metabolic or muscular.

The subjects' body compositions were evaluated using foot to foot bioelectrical impedance analysis in morning under standard condition (13). The subjects were advised to avoid any medication, smoking, taking alcohol, caffeine or vitamin during study period. There were told to avoid high fat or carbohydrate containing food consumption. The subjects were performed 2 exercise test in separate days (3 days between each test).

Initially, each subject performed a ramp incremental exercise test to using an electromagnetically braked cycle ergometer (VIA sprint TM 150/200P) with a work load of 15 W/min increments (14). The subjects maximal exercise capacity (Wmax), anaerobic threshold (AT), O_2 uptake (VO_2) was measured during incremental exercise test. During exercise test, the subjects were carefully controlled for nonspecific non-exercise hyperventilation to avoid pseudo-threshold phenomenon (15).

Anaerobic threshold was estimated using standard V-slope method based on CO_2 output to O_2 uptake ratio (16) and other metabolic and respiratory gas exchange parameters (17). After measurements of anaerobic threshold for each subjects, they were performed a constant load exercise test with a work load corresponded to their anaerobic threshold levels for a 30 minutes.

During exercise, the subjects breathed through a low resistance, low dead space turbine volume transducer to measure ventilatory parameters. The subjects gas exchange parameters were measured breath–by-breath using a metabolic gas analyser (Master Screen CPX, Germany).

Statistical Analysis

Anova test used to analyse data obtained from each five minutes of exercise tests. P<0.05 was accepted as statistically significant. Pearson correlation analysis was applied to evaluate significance between data and subjects physical characteristic.

RESULTS

The subjects work rate at maximal exercise and at the AT was found to be 232±26 W and 147±20 W respectively. AT occurred at approximately 63% of maximal exercise capacity. Work production capacity for each kg of body weight at maximal exercise and at the AT was found to be 3.04±0.3 W/min /kg and 1.93±0.2 W/kg, respectively. O_2 uptake for each kg of body weight at maximal exercise and at the AT was found to be 40.2±4.0 ml/min/kg and 25.7±2.9 ml/min/kg, respectively.

Fat and carbohydrate oxidation ratio have been shown in **Figure 1**. There was significant increase in fat oxidation and decrease in carbohydrate oxidation ratio with increasing exercise time (F=4.163, P=0.001).

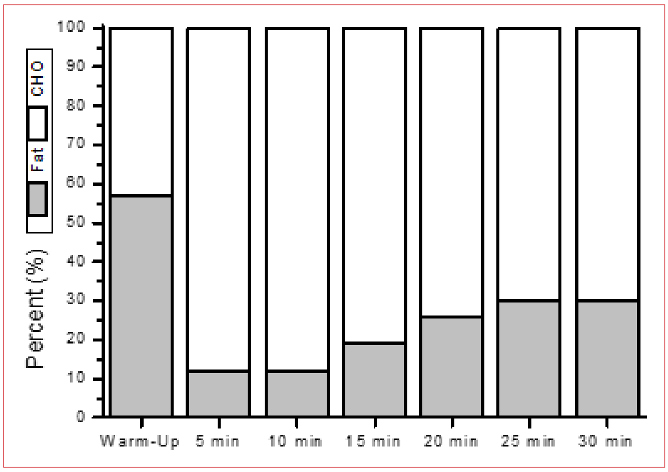

Figure 1. Mean (±SD) values of fat (grey column) and carbohydrate (white column) oxidation ratio at warm-up period and every five minutes of exercise test (n=15).

Respiratory quotient for response to the last five minutes of exercise for each individual subjects are shown in **Figure 2**. There was marked variation in substrate oxidation among the subjects, between lowest value of 0.857 (55% of fat and 45% of carbohydrate) and highest value of 0.990 (35% of fat and 97% of carbohydrate), averaged 0.911±0.04 (29% of fat and 71% of carbohydrate).

There was a negative significant correlation between increased body mass index and values of respiratory quotient during constant load exercise (r=-0.55321, p=0.003) (**Figure 3**).

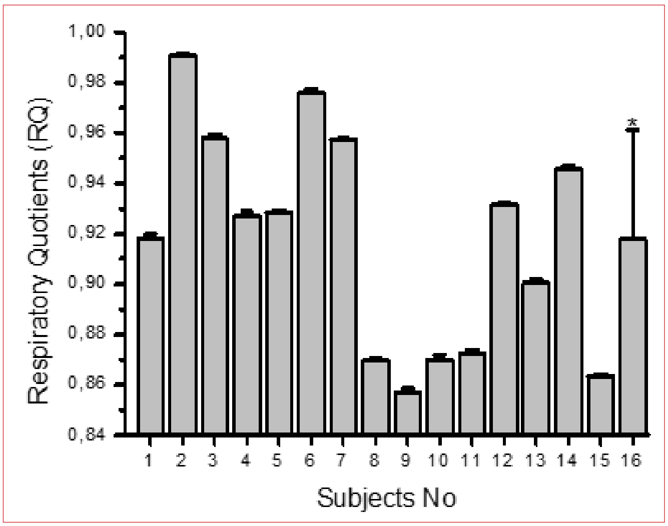

Figure 2. Individual mean (±SD) values of respiratory quotient during last five minutes of constant load exercise test (n=15). *represent mean (±SD) values of all subjects

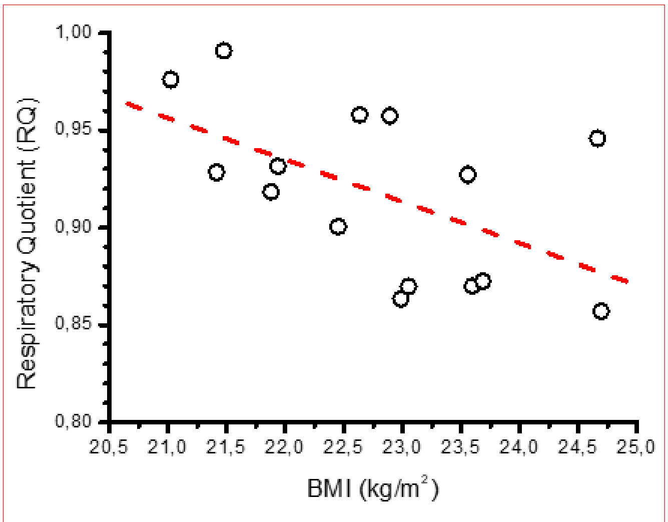

Figure 3. The correlation between body mass index (BMI) and respiratory quotient for each subjects during last five minutes of constant load exercise test for each subjects. The dashed red line shows a negative correlation r=-0,55321 (p=0.003).

DISCUSSION

During exercise, metabolic flexibility plays an important role in regulation of energy metabolism by affecting fat and carbohydrate oxidation ratio. In this study, we have found that constant load exercise intensity corresponded to anaerobic threshold provides increasing fat oxidation rate with increasing exercise time (**Figure 1**).The exercise intensity corresponded to the anaerobic threshold provide a steady state condition for cardiac metabolic and respiratory systems (18). The exercise training protocol corresponded to anaerobic threshold in obese females showed increase in fat oxidation and marked decrease in body fat mass (5).

In the present study, RQ values decreased after 30 min compared to first 5 and 10 min of exercise, reflecting increase fat oxidation and decrease in carbohydrate oxidation. Fat oxidation ratio increased 3 fold compared to beginning of exercise (**Figure 1**). The exercise study performed in normal subjects showed marked increase in fat oxidation in anaerobic threshold compared to low and heavy exercise intensity (11). There is a close relationship between lactate and substrate utilisation (19). Anaerobic threshold is the highest point of without increase of blood lactate levels (2). The constant load exercise below anaerobic threshold showed RQ value of 0.90 reflecting 66% carbohydrate oxidation and 34% of fat oxidation (20).

The subjects participated in this study are healthy and normal body composition. The subjects work production capacity and O_2 uptake for each kg of body weight and percent of anaerobic threshold values are associated with the normal range values (21,2). The other important finding is the observation of variation in RQ values among the subjects at the end of the test (**Figure 2**). It has been suggested that high RQ levels could be associated with increased body weight and also fat mass (22). A higher percent of carbohydrate oxidation has been shown during incremental exercise test work load below anaerobic threshold (23). Hypoxia causes increase in carbohydrate oxidation during incremental exercise (24). Body mass index could be a factor on variation of fat and carbohydrate oxidation ratio during exercise (**Figure 3**). RQ have inverse relationships with increasing BMI (25). Aerobic exercise above 20 min provides systematic decrease in RQ reflecting increase in fat oxidation ratio compared to carbohydrate. This could be related with substrate storage capacity or effectiveness of metabolic flexibility (26,27).

CONCLUSION

Individual variation for considering RQ values among the subjects under the similar metabolic strain may be reason for the exercise and benefits of body fat mass loss. This could be evaluated in further studies in subjects with higher body mass index and higher body fat contents. There is a need for clear findings concerning the variance of RQ among the subjects in response to the aerobic exercise.

ETHICAL DECLARATIONS

Ethics Committee Approval: The ethical approvement for this study has been taken from Çoruh University Ethical Committee (date: 06.05.2014, number: 09-01).

Informed Consent: A signed informed consent was obtained from each subject before participating to the study.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper and approved the final version.

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