Effects of An Acute Exercise Up to Anaerobic Threshold on Serum Anabolic and Catabolic Factors in Trained and Sedentary Young Males

Antrene ve Sedanter Genç Erkeklerde Anaerobik Eşiğe Kadar Yapılan Akut Egzersizin Serum Anabolik ve Katabolik Faktörlerine Etkileri

Zeynep Tuna, Nevin Atalay Güzel, Arzu ARAŞ, Şehri Elbeg, Çiğdem Özer, Gamze Erikoglu, Aységül Atak

ABSTRACT

Objective: The aim of the present study was to evaluate the effects of aerobic running exercise up to anaerobic threshold in trained (T) and sedentary (S) young males.

Methods: The catabolic factors such as interleukin-6 (IL-6), oxidants and cortisol and the anabolic factors such as testosterone, growth hormone (GH) and insulin-like growth factor (IGF-I) were evaluated in blood serum of subjects.

Results: It was found that running up to anaerobic threshold led to a significant increase in oxidants but not IL-6 in both groups. Indeed, oxidants returned to basal levels in 24 h in the T group. Cortisol decreased even below the basal levels 24 h after exercise in both groups. Anabolic hormones increased in both groups especially in the trained subjects after exercise.

Conclusion: Trained young people showed faster anabolic and catabolic adaptation to aerobic exercise comparing to age-matched sedentaries.

Key words: Aerobic exercise, oxidants, antioxidants, testosterone, cortisol

Received: 02.20.2014 Accepted: 04.11.2014

ÖZET

Amaç: Bu çalışmanın amacı antrene ve sedanter genç erkeklerde anaerobik eşige kadar yapılan aerobik egzersizin etkilerini araştırmaktır.

Yöntemler: Katılmakların kan örneklerinde Interlökin-6 (IL-6), oksidanlar ve kortizol gibi katabolik faktörleri ile testosteron, büyüme hormonu ve insulin benzeri büyüme faktörü-1 gibi anabolik faktörlerin düzeyleri ölçülmüştür.

Bulgular: Anaerobik eşige kadar yapılan koşu egzersizinin her iki grupta da oksidanları artırdığı fakat IL-6 düzeylerini etkilemediği görülmüştür. Ayrıca oksidanlar antrene grupta 24 saat içinde bazal düzeylere inmiştir. Kortizol miktarı egzersizden 24 saat sonra her iki grupta da bazal düzeyin alta alınımsıdır. Anabolik hormonlar ise, özellikle antrene grupta olmak üzere her iki gruba da egzersizden sonra artış göstermiştir.

Sonuç: Antrene gençler egzersize, aynı yaş grubundaki sedanterlere göre daha hızlı anabolik ve katabolik adaptasyon göstermektedirler.

Anahtar Sözcükler: Aerobik egzersiz, oksidanlar, antiksidanlar, testosteron, kortizol

INTRODUCTION

The field of exercise science extends to a very large portion of our daily life, ranging from elite sports performance to the maintenance of health and the management of diseases and disability (1). In bold outline, exercise can be divided into two categories: Aerobic or cardiorespiratory exercise involves large muscle groups and effects prominently the cardiovascular and respiratory systems increasing their capacity and improving blood lipid profile (1, 2). Anabolic or resistance exercise involves performing sets of repeated movements against a resistance during which neuromuscular fatigue occurs within a few repetition (1). The border between aerobic and anaerobic exercises is anaerobic (lactate) threshold. There are several methods used to determine an athlete’s lactate or anaerobic threshold. The most accurate and reliable method is through the direct testing of blood samples during a graded exercise test. Lactate threshold is the point during exercise of increasing intensity at which blood lactate begins to accumulate above resting levels (>0.8-1mmol/L), where lactate clearance is no longer able to keep up with lactate production.

During low intensity exercise, blood lactate remains at or near resting levels. As exercise intensity increases there comes a breaking point where blood lactate levels rise sharply. It is suggested that sharp rise shows a significant shift from predominantly aerobic metabolism to predominantly anaerobic energy production. It is also called lactate threshold, anaerobic threshold, onset of blood lactate accumulation or maximal lactate steady state. The anaerobic threshold is the slope of the increase in carbon dioxide output with respect to oxygen uptake during exercise (3). Most prominent effects of anaerobic exercise are on the nervous system but marked changes also occur to the endocrine and skeletal systems (1).

Exercise training efficiency depends on the intensity, duration and frequency of training (4). For last 20 years, it has been recognized that skeletal muscle cells release some cytokines in response to several kinds of exercise. The mostly produced cytokine by contracting muscle cells is interleukin 6 (IL-6) and called ‘myokine’ (5). IL-6 levels rise, especially under inflammatory conditions or stimulation of the anti-inflammatory pathways (6). After a destructive effect of a strenuous exercise, IL-6 activates the neutrophils for phagocytosis and triggers the oxidants, but concomitantly stimulates the antioxidant process (7). IL-6 also stimulates catabolic factors like cortisol, interleukin-1 receptor antagonist (IL-1ra) and anti-inflammatory cytokines like IL-10 (8,9).

Cortisol as a stress hormone has a catabolic (muscle breakdown) effect on muscle tissue is associated with increase in anabolic hormones like insulin-like growth factor (IGF-1) and growth hormone (GH) (10). Cortisol is a hormone produced by the adrenal cortex and known as the regulator of immune response. A prominent role of acute cortisol response is to meet the greater metabolic demands of resistance exercise.

Single heavy resistance exercise leads to acute increases in serum anabolic hormone concentrations (i.e., testosterone, GH and IGF-I). The magnitude of acute neuromuscular and hormonal responses are influenced by exercise variables such as the volume and the intensity of exercise (1). According to the literature it has been known that cortisol and testosterone serum values are altered due to exercise habits. Continuous training programs increase the testosterone levels and decrease the cortisol. Thus, reducing levels of cortisol is ideal for an athlete to achieve tissue growth and positive adaptations to exercise training (10).

Exercise is a robust physiological stimulator of the pituitary secretion of GH and within approximately 15 min after the onset of exercise, plasma GH starts to increase. GH and its primary mediator -IGF-1- play a critical role in formation, maintenance and regeneration of skeletal muscles. Studies have shown that there are positive correlations between circulating IGF-1 levels and GH secretion and the indices of fitness (11). The effects of GH in promoting body growth are IGF-1 dependent, but IGF-1 independent functions are beginning to be elucidated (12). In the literature, the most prominent catabolic and anabolic effects of exercise have been shown for the intense and long-lasting exercises. However, in daily life, majority of population rarely contributes to such intense and long lasting exercises. Moreover, in public health organizations, the established recommendation that regular physical exercise of at least 30- minutes for health has recently changed to the idea that shorter durations like 10 minute-periods could also be beneficial. It has been claimed that even such shorter duration exercise could be beneficial for antioxidant and anti-inflammatory effects (13). Studies have shown that exercise has an effect on tissue and is associated with a decrease in anabolic hormones like insulin-like growth factor (IGF-1) and growth hormone (GH) (10).

Effects of an acute exercise

Experimental procedure

Both groups performed ‘multi stage shuttle run test’ (15) following set up and calibration of equipments a day before the test. Exercise test and all blood samplings were completed between 8.00 and 10.00 a.m. in the morning.

Age, height and body weight of participants were recorded and exercise protocol was explained in detail before the test. The participant started running on a treadmill at 6 km/h speed for 3 minutes and continued at a 10 km/h speed for the next 2 minutes. From that point, the speed increased 1 km/h at the end of each 3-minute period. At each pause between 3-minute running periods blood samples were obtained from earlobe and the lactate level was measured immediately by lactate analyzer (YSI 1500 Sport, Yellow Sprint Ohio, USA). As long as the lactate level was under anaerobic threshold (<4 mmol/L) (16), the participant went on with the next step. For each participant the test finished when he reached or exceeded 4 mmol/L anaerobic lactate threshold for the first time.

Blood samples were obtained before the test (BT), immediately after the test (AT) and 24 hours after the test (24hAT) from antecubital vein. Samples were centrifuged at 3500 rpm at 4°C for 15 minutes and stored at -80°C until analysis. All analyses were performed in the research laboratories of Gazi University Faculty of Medicine.

Cytokine and Hormone Assays

IL-6, IL-10 and cortisol levels were measured using commercial Enzyme Linked Immunosorbent Assay (ELISA) kits in Immunology Research Laboratory according to the manufacturer’s instructions (Human IL-6 ELISA, Bender MedSystems GmbH, Austria; Human IL-10 ELISA, Bender MedSystems GmbH, Austria; Cortisol ELISA, DRG Instruments, Germany). Analytical sensitivities were 0.98 pg/ml for IL-6, and 1 pg/ml for IL-10. Optic densities (OD) developed after the study have been measured using a 450 nm filter with an automated ELISA reader spectrophotometrically. Serum free testosterone and IGF-1 levels were measured using commercial Radioimmunoassay (RIA) kits (Free Testo-RIA-CT, IGF-I-RIA-CT; DIAsource Immunoassays S.A., Belgium) and GH levels were measured using an immunoradiometric assay (NGH-IRMA, DIAsource Immunoassays S.A., Belgium) in Biochemistry Laboratory according to the manufacturer’s instructions. Analytical sensitivities were 0.13 pg/ml, 3.4 ng/ml and 0.04 µg/ml, respectively.

Malondialdehyde (MDA) and Total Sulfhydryl Groups (RSH) Assays

MDA and RSH levels were measured in the Physiology Laboratory. MDA, which is a predictor of lipid peroxidation, was measured by TBARS formation in the serum. (17). Antioxidant capacity was evaluated by measuring total sulfhydryl groups (RSH) spectrophotometrically (17).

Statistical Analysis

Statistical analyses were performed by SPSS Windows 16.0. Friedman test was used to evaluate the effect of time (pre-, post-exercise and 24 hours later) on parameters within groups. If analyses revealed a significant difference, Wilcoxon test was used to locate specific differences.
Also, Mann Whitney U test was used to compare groups for values at the same time point. Cytokine levels were calculated using Microstat software. For all analysis, a value of p<0.05 was considered statistically significant.

RESULTS

Age, height, weight and body mass index (BMI) of both groups are shown in Table 1. The mean duration of exercise test was 10.9 minutes.

Table 1: Age, height, weight and body mass index (BMI) comparison of both groups (p<0.05) (Data have been presented as ‘mean± standard error’).

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Body Weight (kg)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trained (N:16)</td>
<td>18.75±1.25</td>
<td>179.12±14.12</td>
<td>73.2±12.25</td>
<td>22.86±3.09</td>
</tr>
<tr>
<td>Sedentary (N:10)</td>
<td>20.60±3.40</td>
<td>172±17</td>
<td>71.6±19.4</td>
<td>24.10±4.04</td>
</tr>
</tbody>
</table>

Hormones

Testosterone

Baseline levels of testosterone were different slightly but insignificantly (p>0.05). In trained (T) group serum testosterone levels increased %25 as compared to the baseline (p<0.05). In sedentary (S) group serum testosterone concentration increased %16.5 but the difference was insignificant (p>0.05). Higher serum testosterone levels of both groups were maintained as compared to basal levels 24 hours later; but, the differences were not statistically significant (p<0.005) (Table 2).

In the T group, serum cortisol levels decreased below the baseline levels significantly (p<0.05) (Figure 1). In S group, post-exercise serum cortisol levels were found to increase slightly but this increase was insignificant (p>0.05). Twenty-four h after the running test, IGF-1/cor ratio returned to baseline in the T group, but increased in the S group, however the differences were not significant (p>0.05) (Figure 2).

IGF-1/Cortisol Ratio

IGF-1/cortisol (IGF-1/cor) ratio after running test was found higher in the T group than the S group (p<0.05). In T group, tes/cor ratio increased significantly with the exercise as compared to baseline and was maintained at this high level even 24 hours later (p<0.05). The slight increase in the tes/cor ratio in the S group after the test was not statistically significant (Figure 1).

Cytokines

IL-6 and IL-10 levels were all under detectable values in spite of high sensitivity of ELISA kits (0.38 pg/mL for IL-6 and 1 pg/mL for IL-10). All participants had cytokine levels over blank (0 pg/mL) but under minimal detectable point.

MDA and RSH

MDA levels increased after the acute exercise bout (5.01nmol/mL; 6.34 nmol/mL; p<0.01) and decreased to basal levels 24 hours later (5.36 nmol/mL; p<0.05) in the trained group. Also in sedentaries MDA increased with exercise (4.91 nmol/mL; 6.30 nmol/mL; p<0.05) but remained high 24 hours later (6.40 nmol/mL; p<0.05). Comparison of two groups showed that MDA levels were higher in sedentaries than the trained group only 24 hours later (p<0.05) (Table 1).

RSH levels of the trained group decreased after the exercise session (342.26 nmol/mL; 255.40 nmol/mL; p<0.01) but returned to basal levels 24 hours later (327.43 nmol/mL; p<0.05).

Figure 1: Testosterone/Cortisol ratio of both groups before, immediately after and 24 hours later exercise (*p<0.05)

Figure 2: IGF/Cortisol ratio of both groups before, immediately after and 24 hours later exercise (*p<0.05)
GMJ 2014; 25: 47-51

Testosterone and cortisol are both produced from the same raw materials which mean that the body can produce one or the other at any time. Thus, where cortisol is high, testosterone production is correspondingly low or vice versa. Ratios of anabolic to catabolic hormones (ie. Testosterone/cortisol or IGF-1/cortisol) may be important markers for the detection of beneficial effects on skeletal muscle. Scientists use the free testosterone/cortisol ratio (tes/cor) and IGF-I/cortisol (IGF-I/cor) to evaluate athletes’ training state (10). In our study, the free tes/cor and IGF-I/cor ratios were assessed. It was found that basal tes/cor ratio is high in trained subjects as compared to sedentaries; but the difference was not significant probably due to lower number of samples. In the trained group, tes/cor ratio began to increase clearly during the running period and kept on to increase after the running test in a moderate mode until 24 h later. This rise in tes/cor ratio was significant as compared to basal levels and tes/cor levels of S group. The ratio of tes/cor in S group increased not during the test but 24 h later. The test sharp increase of tes/cor after the test is preserved even 24 h later in S group. The literature reports that cortisol and testosterone serum values are altered due to exercise habits. Excessive cortisol suppresses one’s immune system and results in a catabolic state by breaking down muscle and storing fat. Continuous training programs increase the testosterone levels and decrease cortisol in turn. (10). In our study, the fact that tes/cor ratio was high in trained group just after the test and remained high throughout the recovery period for 24 h indicates that the anabolic adaptation of this groupo exercise was rather rapid than S group.

Also the IGF-I/cor ratio was higher in the trained group as compared to S group after the exercise. IGF-I/cor ratio returned to basal levels in trained group but not in the S group 24 h after the exercise. A study of Velliosa had shown that muscle-specific IGF-1 infusion has a hypertrophic effect in animal models and muscle cell culture system (12). Indeed, low levels of IGF-I were found to contribute to the impairment of muscle structure and mobility (28).

Schwarz et al. (29) measured the circulating levels of GH and IGF-I in response to brief exercise of different intensities. After 10 minutes of low-intensity exercise, IGF-I exceeded the pre-exercise baseline by 7.7±2.7%. In this study, GH reached its peak 10 min after the cessation of high intensity exercise, too. It was concluded that brief exercise leads to small but significant increases in circulating IGF-1, and these responses may be influenced by exercise intensity (29). We found basal GH levels in trained group to be significantly higher as compared to sedentary subjects. The test also led to a significant increase of the GH in both groups. While it returned to basal levels in the trained group 24 hours after the test, it did not in S group.

CONCLUSION

This study showed that a short duration aerobic exercise up to anaerobic threshold did not exert any catabolic effects in the exercise-trained and sedentary subjects. The increase in serum oxidants and cortisol levels after the test took place in both groups and remained high throughout the recovery period for 24 h. This rise in oxidants after the test was more rapid in the trained group as compared to sedentary subjects. Furthermore, the recovery of the systemic catabolic effects of the oxidants and cortisol after the test was more rapid in the trained subjects as compared to sedentary subjects. These findings reveal that a brief submaximal running exercise up to anaerobic threshold would not affect immune system response through myokines, but would increase the anabolic hormones like GH, IGF-1 and testosterone, especially in the trained people.

Conflict of Interest
No conflict of interest was declared by the authors.

REFERENCES


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