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Serum Selenium, Lipoproteins and Testosterone Responses to a Single Session of Circuit Resistance Exercise in Male College Students

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Abstract

The purpose of this study was to examine serum selenium (Se), lipoproteins and testosterone responses to a single session of circuit resistance exercise. Fourteen male college students volunteered in the present study. Blood samples were taken at 30minutes before, immediately after 25 and 60minutes of single session of circuit resistance exercise (10 exercise, 20s for each exercise, and at 60%1RM). A significant increase in serum selenium and a decrease in testosterone, very low density lipoprotein cholesterol (VLDL-C), and low density lipoprotein were found during recovery period. The present data indicate that a single session of circuit resistance exercise was able to change serum Se, lipoproteins and testosterone levels. An acute increased Se and decreased testosterone might indicate an energy deficiency following a circuit resistance exercise.

Keywords: Selenium (Se), Testosterone (T), Circuit Resistance Training, VLDL-C, LDL-C

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Introduction

Selenium is an essential nutrient trace element because of its defense against oxidative stress, regulation of thyroid hormone action, and regulation of the redox status of vitamin and other molecules [1]. Selenium (Se) is also essential for the efficient and effective operation of many aspects of the immune system, particularly in neutrophil function [2]. It is believed that there is a relationship between Se and lipoproteins and as such, Se binding on lipoproteins might play a significant role in the transportation of Se in plasma [3]. In human, serum Selenium is associated with the three types of proteins: Selenoprotein (SeP) (52%), extra cellular glutathione peroxidase (GSHPx) (39%), and selenomethionine (binding albumin) (9%) [4,5,6].

The previous research have indicated that percentage of total plasma Se varied from 52% to 70% for SeP selenium, from 15% to 39% for GSHPx selenium, and from 9% to 17% for albumin selenium compartments [7]. Among antioxidant micronutrients, Se supplement has shown a beneficial effect for individual undergoing intensive exercise training according to the data based on animal study [8]. Selenium recognized as an essential trace element for both mammalian and human, is part of the selenium-dependent enzyme and glutathione peroxidase which act as a protector of the organism from an exercise-induced oxidative damage [9, 10]. A change in the glutathione system has been studied during oxidative exercise and after prolonged aerobic training (9, 11). It was also observed that blood GSSG concentrations were 72% higher immediately after the exercise than at the rest and in young men, intermittent exercise bouts to exhaustion, increased blood GSSG by 39% [12,13]. Dufax et al [14] reported a significant decrease in blood GSH and increase in GSSG immediately after a 2.5hrs run. There are a few studies, which focused on blood lipid peroxidation and antioxidants after a single sprint anaerobic, a short-duration aerobic exercise, and power-anaerobic based sports [15, 11]. Gohil et al [15] were the first to report that even sub-maximal exercise induces blood GSH oxidation. A 100% increase in blood GSSG concentration was seen within the first 15 minutes of exercise at 65% of peak oxygen uptake [11,15]. Gohil et al [15] found that all four-test exercise bouts (2 maximal exercise bouts lasting 14 minutes and two bouts of 30 minutes at their aerobic and anaerobic threshold) notably increased the concentration of blood GSSG. On the other hand, few divergent results are available with respect to Se concentration during or following physical activities in athletes [11, 12, 16]. In this regard, Dragan et al[17] studied selenium in top athletes (weight lifter and rowers, girls) while Rokizki et al [9] and others observed no significant plasma Se changes in 13 athletes who completed a marathon race which means serum Se was 77.7±20.8µg/L [17]. Emre et al [16] observed a significant decrease in serum Se (from 89.44 to 83.33 ng/ml) after the maximum exercise test, consisting on an anaerobic –loading coordination test that lasted about 45s in group I (involving those who were training more than 5h a week). However, to our knowledge, up to now, there is no information about the effect of

circuit resistance exercise on serum Se changes, immediately and during post-exercise recovery periods. The purpose of this study is to examine the serum Se, testosterone (T) and lipoproteins after a circuit resistance exercise in male college students.

Material and Methods

Subjects: Fourteen male students of physical education volunteered to participate in this study. Age, height, weight and BMI of those subjects are shown in Table1. All the subjects had some experience with circuit weight training exercises, however they were not involved in any weight training programs.

Study Design: Before the main trial, participants were invited into the laboratory twice. For collecting anthropometrical data during the first visit all the subjects provided written consent and underwent preliminary health screening to insure that they were healthy and free from metabolic diseases. All the participants also performed strength test to determine their one- repetition maximum (1 RM) for each of the 10-resistance exercises, employed in the study. Subjects were allowed to take as long time as they felt necessary to recover from each attempt. On their second visit, subjects completed a practice session to insure that each of them was able to complete entire exercise session. Three days before the main trial, participants were asked to avoid any physical exercise and activities except gentle walk and very light daily works.

Exercises: The program of the circuit resistance training session consisted of ten exercises to strengthen group of muscles, i.e. bench press, shoulder press, abdominal curl, triceps extension, biceps curl, dead lift, leg flexion, trunk extension, seated row and squat (90 degree). Each load corresponded to 60% of the individual 1RM that was determined during the second visit. The participants performed a three circuit at maximal possible speed, using 20s work for each exercise without any rest (3.20minutes work time). Each circuit was separated by a 3minutes-rest period. The duration of the whole program was 21 minutes. The training sessions were held in the morning between 8.30am and 10.30am.

Biochemical analyses: Blood samples were obtained from antecubital vein 30minutes before exercise, immediately after exercise and after 25 and 60 minutes period of recovery. Serum was separated by centrifugation within 15 minutes of collection and divided into aliquots, then frozen and stored at -20°C for subsequent analyses (within 2-3 weeks). Atomic absorption spectrophotometer is the reference method for the trace element Se analysis that was accomplished by Furnace atomic absorption spectrophotometer using an AA670G Shimatzu model . Serum testosterone (T) concentration was measured by RIA, using kit from Immunotech a Beckman Coulter Company, France (Ref. IM119). The coefficient variations were found below 14.8% and15% while intra and inter-assay coefficient variations were below 14.8 and 15, respectively. Hemoglobin and hematocrit were also determined using the system K-4500 automated hematology analyzer. Changes in plasma volume were calculated using the Dill-Costill method, based on hemoglobin and hematocrit estimations.

Statistics: Data were analyzed with the general linear model program of SPSS (version 10.1)

package by personal computer. The acquired data for all variables were analyzed using one way-analysis variance (ANOVA) with repeated measure variables. For difference between each time point, pair-wise comparison was employed. The data was presented as mean ±SE and significance was accepted at $P<0.05$.

Results

The descriptive characteristic features of all subjects are highlighted in Table 1. There was no significant change in plasma volume (PV) at any point of time. Serum selenium (Se) showed an insignificant increase ($p<0.12$), immediately after exercise, but its concentration increased significantly ($p<0.001$) from 50.5±1.76 to 62±2.11 and 78.7± 5 µg/L (24-57.4%) respectively during 25 and 60minutes of recovery period. A significant reduction ($p<0.01$) in testosterone (T) was also observed during the same period (Figure 1). Change in serum VLDL-C was only found ($p<0.05$) after 25 minutes of recovery and was still low during 60 minutes of post-exercise period. However, reduction in serum LDL-C levels was significant ($p<0.03$) during 25 and 60 minutes of recovery period (Figure 2).

Table 1 Physical characteristics of the participants (mean ± standard error, n =14)

Age (Years)	20.57± 0.52
Height (m)	1.75 ± 2.26
Body weight (kg)	78.25 ± 5.01
Body mass index ($kg.m^2$)	25.27 ± 1.180

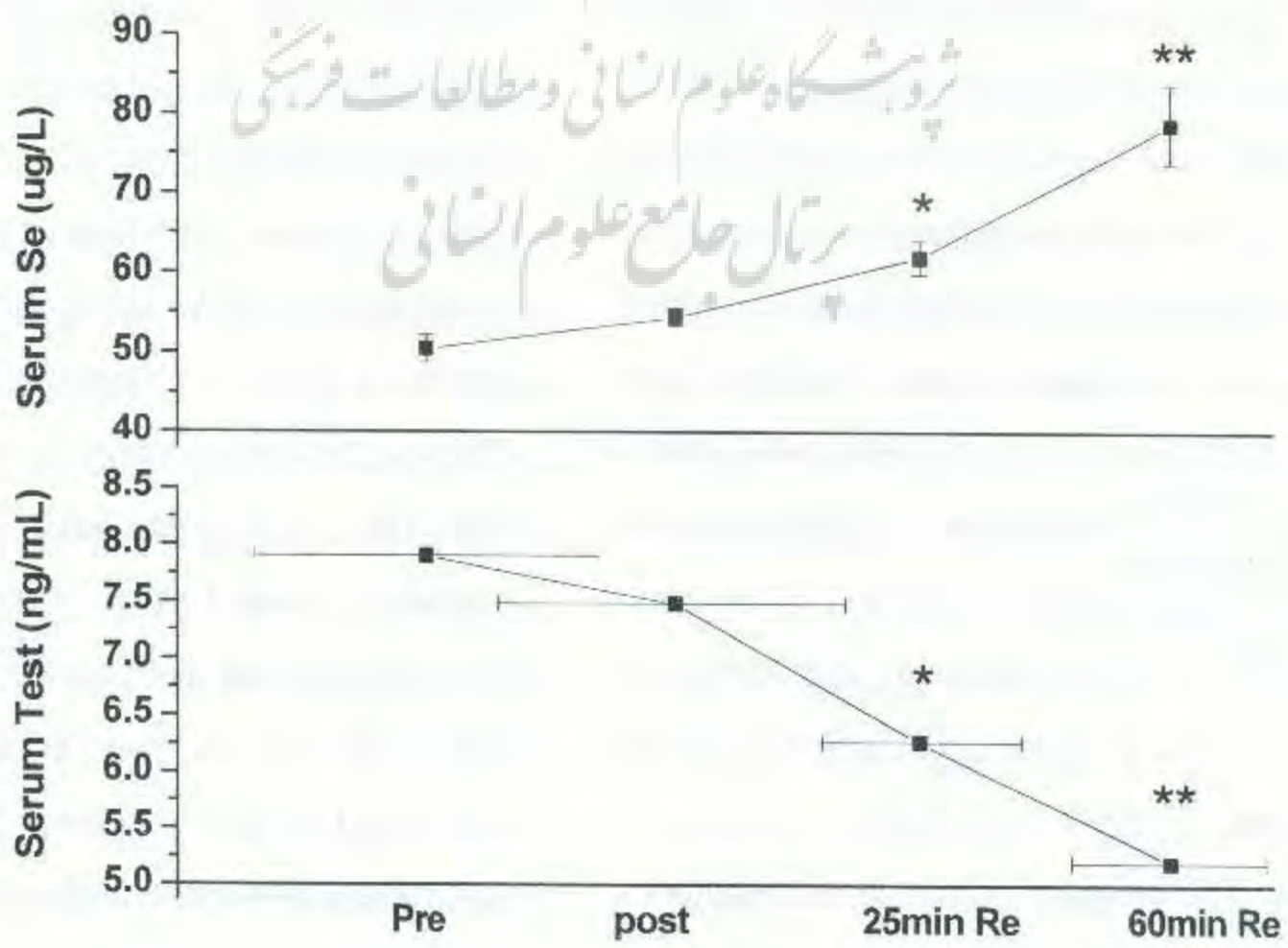

Figure 1 Time courses of pre-and post-serum selenium (Se) and testosterone (Test) concentrations, in a single circuit resistance training session at 25 and 60minutes of recovery. Results have been showed as Mean± SE. * Changes over time were significant at $p<0.05$. ** Changes over time at $p<0.01$. Number of subject: n=14.

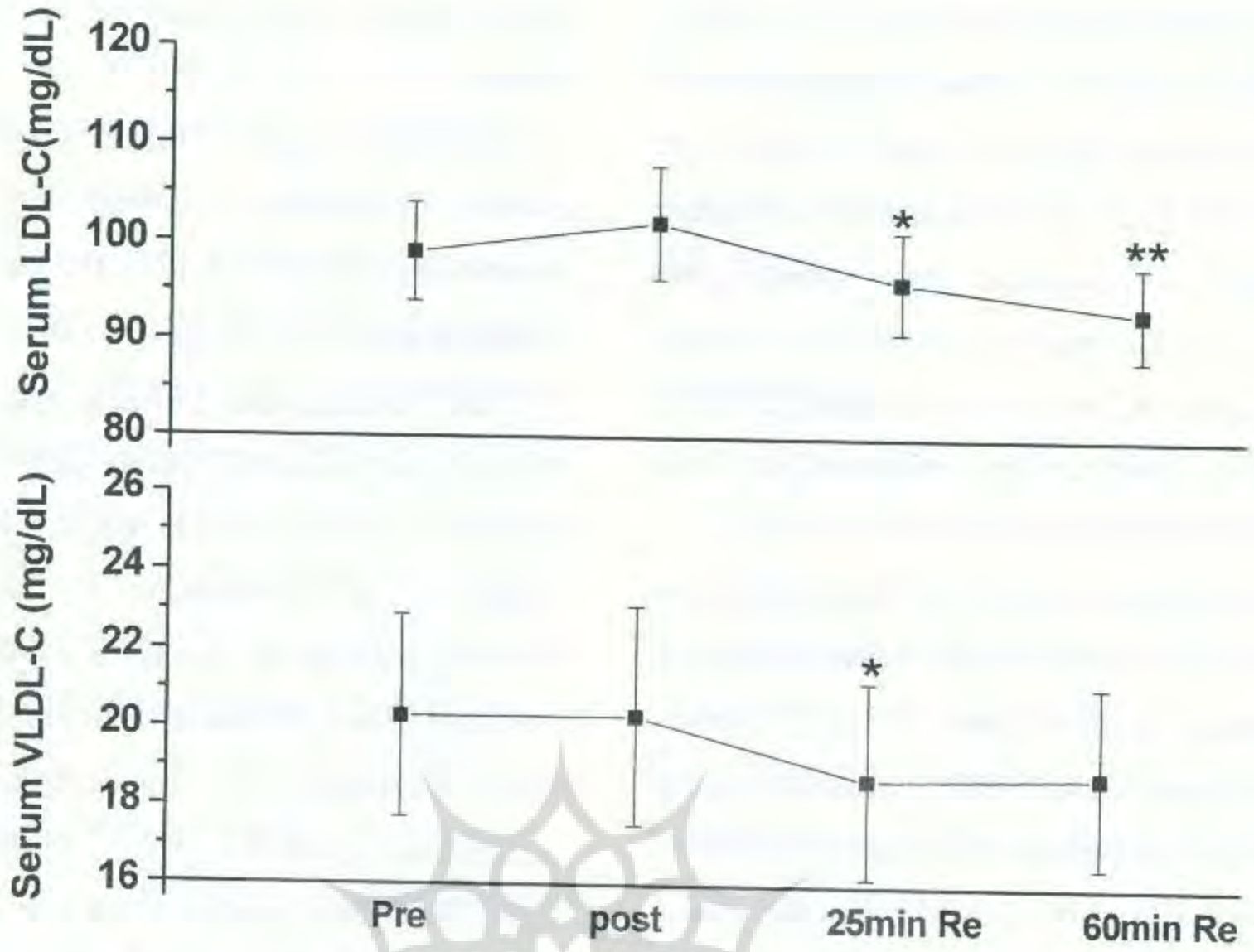

Figure 2 Time course of serum, very low-density cholesterol (VLDL-C) and low-density lipoprotein cholesterol (LDL-C) concentrations, before and immediately after a single circuit resistance training session during 25 and 60minutes of recovery. Results are indicated as Mean± SE. * Changes over time were significant at $p<0.05$. **Changes over time at $p<0.01$. Number of subjects: n=14

Discussion

The present study examined serum Se, VLDL-C, LDL-C, and testosterone (T) responses to single circuit resistance training (continuous-interval form). The study provided the first direct evidence of change in serum Se after a single session of circuit resistance exercise. In this regard, Emre et al [16] observed a significant decrease in serum Se concentration (from 89.44±5.52 to 83.33±5.18ng/ml) only in group I who exercised for 45s. Other studies also demonstrated that running a marathon does not lead to significant change in the standard Se plasma concentration of athletes [9, 18]. Rokitzki et al [9] meanwhile suggested that no significant change in the Se concentration of the blood plasma was observed. Margaritis et al [19] in their study also observed no significant change in Se concentration between pre and post-exercise before a tapering training. A significant increased Se concentration was observed in Standardbred horses immediately after a training jog [20]. It is not clear how and by which mechanism; Se concentration endogenously increases during a single session of circuit resistance exercise, lasting 21 minutes. It is a well established that oxidation of thiols to disulfide is a sensitive marker of oxidative stress. It has also been reported that Se can be mobilized from free selenocysteine in reaction, which is catalyzed by selenocysteine lyase. This in turn delivers Se to protein for selenophosphate

(H_3SePO_3). During this reaction L-alanine will be released [21]. It was found that selenopeptide had lost some of their selenium atoms during their characterization [22]. Cysteine acts as a precursor for synthesis for proteins and several other essential molecules and these metabolites include GSH, coenzyme A, and inorganic sulfur [23, 24]. On the other hand, a thiol oxidation has been indicated during physical exercise [11, 25, 26].

A 100% increase in blood GSSG concentration was seen within the first 15 minutes of exercise at 65% of peak oxygen uptake [11,15]. Studies involving human blood GSH oxidation during exercise are limited, but previous studies show that in healthy young men the 2 maximal exercise tests of 14 minutes duration at their aerobic and anaerobic thresholds increased the concentration of blood GSSG [15]. Tessier et al [13] observed that in trained men, blood GSSG concentrations were 72% higher immediately after the exercise than at the rest and in young men, intermittent exercise bouts to exhaustion, increased blood GSSG by 39%. Other study reported a significant decrease in blood GSH and increases in GSSG immediately after a 2.5h run [14]. It has been established that Se acts as a cofactors of glutathione peroxidase and selenium is necessary to maintain full strength GSH-dependent antioxidant defense [11, 26]. Although, we did not measure serum Se-containing proteins (GSH, selenocysteine, albumin and selenomethione) or cysteine but in the light of above studies, free selenocystine and selenocystine pools can be accounted as a source for Se elevation during a single circuit resistance exercise. Lipoproteins might be considered as another possible source for serum Se elevation in this study.

It has been suggested that Se content in human plasma lipoproteins is about 3-6% [27]. As reported by Ducros et al [27], the mean value was 1.99μg/g apo B in LDL fraction, 0.64 μg/g apo A-I in HDL fraction, and 2.57μg/g apo B in VLDL fraction, the Se content widely differed among the lipoprotein classes, being much higher in LDL. According to Vuorimaa et al [28], prolonged exercise reduced the levels of oxidized LDL by 24% and LDL-C by about 14%. Ferguson reported that decreases in low-density lipoprotein cholesterol (LDL-C) were observed during exercise at time-points corresponding to 4604.4 and 5441.5 KJ (1100 and 1300 kcal) of energy expenditure, and immediately after exercise [29]. It was also found that after an acute prolonged physical exercise serum triglyceride (TG), concentration was reduced (36%), as a consequence of a reduction about 31% was observed in very low-density lipoprotein (VLDL) particles [30, 31].

With regard to this, the present study shows a significant decrease i.e. 6mg/dl (6%) in LDL-C and 1.6mg/dl (7.69%) in VLDL-C (Figure 2). A sex hormone effect on selenium utilization has also been indicated in human as serum Se concentration in boys decrease during sexual maturation, whereas this change does not occur in girls [32,33]. Testosterone may also have a suppressing affect on liver GPx activity since castrated male rats experience an increase in liver GPx activity that approaches the levels of female. By this way, a gradual reduction of about 2.72ng/mL (34-43%)

was observed, 60minutes after single circuit resistance training that can be found in Figure 1. Therefore, an elevated serum Se concentration, perhaps, is a compensatory mechanism to help antioxidant system against oxidative stress, which is exerted by single circuit resistance training. Use of ESR (electron spin resonance) clearly demonstrated that a short-term supra-maximal anaerobic exercise, i.e. the wingate test, induced oxidative injuries because of the fact that a significant increase in lipid radical production was detected [34]. It seems that Se pools can regulate enzymatic antioxidants in antioxidant system requirement to defend free radicals, which is produced during long and acute exercise [35, 36, 37]. It is worth to mention here that in our study, the Se levels of the serum samples ranged from 42 to 112 micrograms/L.

Conclusion

Although this study does not indicate the exact source of elevated Se, it clearly demonstrates that single circuit resistance training (continuous-interval form) at the intensity of 60% 1RM was able to increase endogenous Se concentrations during post-exercise period. This has also opened an avenue for further investigation about possible relationship between serums T, lipoproteins profiles and Se concentrations. Further Study is needed to clarify the exact source(s) and mechanism(s), which involve in Se release during and after circuit resistance training.

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References

[1] Institue of medicine , food and nutrition board. *Selenium. In: Dietary reference intakes: vitamin Cm vitamin E, selenium, and carotenoides*. Washangton, DC: National Academy press, 2000. p284-324.

[2] Arthur JR, Mackenzie RC, Beckett GJ. Selenium in the immune system. *J Nutr* 2003; 133: 1457S-1459S

[3] Ducros V, Laporte F, Belin N, et al. selenium determination in human plasma lipoprotein fractions by mass spectrometry analysis. *J Inorg Biochem* 2000; 81: 105-109.

[4] Harrison I, Littlejohn D, Fell GS. Distribution of selenium in human blood plasma and serum. *Analyst* 1996; 121:189-194.

[5] Behne D, Kyriakopoulos A. Mamalian selenium-containing proteins. *Annu Rev Nutr* 2001; 21:453-473.

[6] Gao y, Liu Y, Deng G, Wang Z . Distribution of selenium-containing proteins in human serum. *Biol Trace Elem res* 2004; 100(2):105-115.

[7] Ferry M, Faure P, Belin N, et al. distribution of selenium in plasma of French women: relation to age and selenium status. *Clin Chem.* 2000; 46(5): 731-733.

[8] Reddy KV, Kumar TC, Prasad M, et al. Pulmonary lipid peroxidation and antioxidant

defenses during exhaustive physical exercise: The role of vitamin E and selenium. *Nutrition* 1998; 14(5):448-451.

[9] Rokitzki L, Logemann E, Keul J. Selenium metabolism and glutathione peroxidase activity of endurance athletes in rest and under exertion. Schweiz Z *Sportmed* 1993; 41(1): 21-27.

[10] Clarkson PM, Thompson HS. Antioxidant: what role do they play in physical activity and health. *Am J Clin Nutr* 2000; 27(Suppl): 637S-646S.

[11] Sen CK and Packer L. Thiol homeostasis and supplements in physical exercise. *Am J Clin Nutr* 2000; 72(Suppl): 653S-659S.

[12] Saster J, Asensi M, Gasco E, et al. Exhaustive physical exercise causes oxidation administration. *Am J Physiology* 1992; 263: 992-R996.

[13] Tessier F, Margaritis I, Richard MJ, et al. Selenium and training effects on the glutathione system and aerobic performance. *Med Sci Sports Exerc* 1995; 27(3): 390-396.

[14] Dufax B, Heine O, Kothe A, et al. blood glutathione status following distance running. *Int J Sports med* 1997; 18(2): 89-93.

[15] Gohil K, Viguie C, Stanley WC, et al. blood gluthatione oxidation during human exercise. *J Appl Physiol* 1988; 64: 115-119.

[16] Emar MH, Düzova H, Snacak B, et al. Serum selenium response to maximal anaerobic exercise among sportmen trained at various levels. *J Trace Elem Exp Med* 2004; 17: 93-100.

[17] Dragan I, Ploesteanu E, Cristea E, et al. Studies on selenium in top athletes. *Physiologie* 1988; 25(4): 187-190.

[18] Logemann E, Krutzfeldt B, Rokitzki L. Selenium determination in blood plasma samples of high performance athletes. *Beitr Gerichtl Med* 1989; 47: 97-102.

[19] Margaritis I, Palazzetti S, Rousseau AS, et al. Antioxidant supplementation and tapering exercise improve exercise-induced antioxidant respons. *J Am Coll Nutr* 2003; 22(2) :147-156.

[20] Gallagher K, Stowe HD. Influence of exercise on serum Selenium and peroxide reduction system of racing Standardbreds. *Am J Vet Res* 1980; 41(8): 1333-1335.

[21] Lacourciere GM. Selenium is mobilized in vivo from selenocystein and is incorporated specifically into formate dehydrogenase H and tRNA nucleotide. *J Bacteriology*; 184(7):1940-1946.

[22] Ma S, Caprioli RM, Hill KE, Burk RF. Loss of selenium from selenoproteins: conversion of selenocysteine to dehydroalanine in vitro. *J Am Soc Mass Spectrom* 2003; 14: 593-600.

[23] Moriarty-Craige SE, Jones D. Extracellular thiols and thiol/disulfide redox in metabolism. *Annu Rev Nutr* 2004; 24: 481-509.

[24] Stipanuk MH. Sulfur amino acid metabolism: pathways for production and removal of homocysteine and cysteine. *Annu Rev Nutr* 2004; 24: 539-577.

[25] Anuradha CV Balakrishnan SD Effect of training on lipid peroxidation, thiol status and antioxidant enzymes in tissues of rats. *Indian J Physiol Pharmacol*. 1998 ;42(1):64-70.

[26] Sen CK. Update on thiol status and supplements in physical exercise. *Can Journal of Applied Physiology*. 2001; 26 Suppl: S4-12.

[27] Ducros V, Laporte F, Belin N, et al. selenium determination in human plasma lipoprotein fractions by mass spectrometry analysis. *J Inorg Biochem* 2000; 81: 105-109.

[28] Vuorimaa T, Ahotupa M, Irjala K, Vasankari . Acute prolonged exercise reduces moderately oxidized LDL in healthy men. *Int J Sports Med.* 2005; 26(6):420-5.

[29] Ferguson MA, Alderson NL, Trost SG, Davis PG, Mosher PE, Durstine JL. Plasma lipid and lipoprotein responses during exercise. *Scan J Clin Lab Invest* 2003;63 (1):73-9.

[30] Baumstark MW, Frey I, Berg A. Acute and delayed effects of prolonged exercise on serum lipoproteins. II. Concentration and composition of low-density lipoprotein subfractions and very low-density lipoproteins. *Eur J Appl Physiol Occup Physiol.* 1993;66(6):526-30.

[31] Skinner ER, Watt C, Maughan . The acute effect of marathon running on plasma lipoproteins in female subjects. *Eur J Appl Physiol Occup Physiol.* 1987;56(4):451

[32] Marano G, Spagnolo A, Morisi G, et al. "Changes of serum selenium and serum cholesterol in children during sexual maturation". *Journal of Trace Elementary Electrolytes Health Dis* (1991); 5: 59-61.

[33] Ha EJ, Smith AM. Plasma selenium and plasma glutathione peroxidase activity increase with estrogen during the menstrual cycle. *J Am Coll Nutr* 2003; 22(1): 43-51.

[34] Groussard C, Rannou-Bekono F, Machefer G, et al. Changes in blood lipid peroxidation markers and antioxidants after a single sprint anaerobic exercise. *Eur J Appl Physiol* 2003; 89(1): 14-20.

[35] Maughan RJ. Role of micronutrient in sport and physical activity. *Br Med Bull* 1999: 55: 683-690.

[36] Margaria I, Tessier F, Marconnet P, et al. Effect of endurance training on skeletal muscle oxidative capacities with and without selenium supplementation. *J Trac Elem Med Biol* 1997; 11:37-43.

[37] Dragan I, Dinu V, Mohora M, et al. Studies regarding the antioxidant effects of selenium on top swimmers. *Rev Roum Physiol* 1990; 27(1): 15-20.

پاسخهای سلنیوم، لیپوپروتئینها و تستوسترون سرم به یک جلسه فعالیت مقاومتی دایره‌ای در مردان دانشگاهی

عباس قنبری نیاکی[۱]، اعظم افشار نادری[۲]، مرتضی طیبی[۳]

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هدف از تحقیق حاضر بررسی و ارزیابی پاسخهای سلنیوم، لیپو پروتئینها، و تستوسترون به یک جلسه فعالیت دایره‌ای مقاومتی بوده است. چهارده مرد دانشگاهی در رشته تربیت بدنی از بین واجدین شرایط داوطلبانه در این مطالعه شرکت کردند. از افراد در قبل، بلافاصله، ۲۵ و ٦۰ دقیقه پس از فعالیت جهت اندازه‌گیری سلنیوم، لیپوپروتئینها و تستوسترون سرم در حال ناشتا نمونه خونی گرفته شد. نتایج به دست آمده نشان می‌دهد که متعاقب یک جلسه فعالیت مقاومتی دایره‌ای (در شدتی برابر با ٦۰٪ 1RM) غلظت سلنیوم به تدریج افزایش و غلظتهای لیپوپروتئین خیلی کم چگال و کم چگال و تستوسترون سرم به طور معناداری کاهش یافته‌اند. نتایج تحقیق حاضر از این حکایت دارد که یک جلسه فعالیت دایره‌ای در شدت مذکور می‌تواند به افزایش سلنیوم سرم یکی از عناصر شناخته شده در فرایند ضد اکسایشی و تغییراتی در متابولیسم لیپوپروتئینها منجر شود. کاهش تستوسترون نیز می‌تواند به عنوان شاخصی جهت تأخیر در روند فرایند انابولیکی متعاقب یک فعالیت مقاومتی دایره‌ای مورد تأمل قرار گیرد.

واژگان کلیدی: سلنیوم، فعالیت مقاومتی دایره‌ای، مردان دانشگاهی، لیپوپروتئین و تستوسترون

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