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Effects of Acute Swimming Exercise on Some Elements in Rats

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Abstract The objective of the present study is to explore the effects of acute swimming exercise on plasma levels of some elements in rats, immediately after the exercise, and 24 and 48 h later. The study included 40 adult male rats of Sprague Dawley species, which were equally allocated to four groups. Group 1: General Control Group; Group 2: Swimming Group, the group that was decapitated immediately after 30-min acute swimming exercise; Group 3: Swimming Group, the group that was decapitated 24 h after 30-min acute swimming exercise; Group 4: Swimming Group, the group that was decapitated 48 h after 30-min acute swimming exercise. Plasma copper (Cu), iron (Fe), magnesium (Mg), phosphorus (P), selenium (Se), zinc (Zn) levels were determined according to atomic emission method in the blood samples collected from the animals by decapitation method. Measurements conducted immediately after acute swimming exercise (group 2) showed a significant decrease in Se and Zn levels ($p<0,01$) and a significant increase in P levels ($p<0,01$), when compared to group 1. Measurements carried out 24 h after the exercise (group 3) demonstrated a significant increase in all parameters except for Mg, in comparison to groups 1 and 2 ($p<0,01$). It was seen in the measurements made 48 h after the exercise (group 4) that all parameters were restored to control values. The results of our study show that acute swimming exercise significantly changes plasma Cu, Fe, P, Se, and Zn levels.

Keywords Acute swimming exercise · Elements · Rat

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Introduction

Many researchers emphasize the relation between diet, and development and continuation of performance. Two methods are frequently used to determine the interaction between physical activity and diet. The first of these is to give various nutrients to people who are involved in physical activity and to examine their physiological and performance responses; the other is to determine the effects of physical activity on diet [1, 2]. Therefore, it can be said that there has been a growing interest in research into the relation between exercise, minerals, and elements [3]. Most of the elements play a role in the physiological events in the organism [4]. Especially elements like zinc and copper have functions in carbohydrate, protein, and lipid metabolism [4]. Results of the studies examining the relation between exercise and elements show that there is no consensus on this topic. Marrella et. al. [5] reported that physical exercise affected trace element metabolism, while Anderson et. al. [6] stated that urinary zinc and copper levels of athletes did not change after acute exercise. It was noted that heavy physical exercise could impair trace element metabolism, thereby inhibiting the immune system and causing infections, and the importance of this topic was emphasized in terms of not only performance but also athlete health [7]. It was shown that heavy physical exercise significantly modified copper and zinc metabolism alike and that there was a negative relation between zinc and copper [8]. It was claimed that zinc and magnesium had a favorable impact on muscle strength and metabolism, but acute and heavy exercise could lead to deficiencies in these minerals by increasing their discharge [9]. When compared to resting conditions, physical activity increases oxygen need by 10–15-folds. The resulting increase in mitochondrial oxygen consumption leads to oxidative stress, which brings about reactive oxygen species and lipid peroxidation. Increase in free radical formation causes muscle inflammation and muscle destruction, creating a negative effect on performance [10]. Zinc, which has antioxidant characteristics, has been shown to prevent free radical formation and have an important effect on physical performance [11]. Therefore, it is important to study the effects of exercise on trace element metabolism. The present study aims to explore how the plasma levels of these elements are affected in rats subjected to acute swimming exercise.

Materials and Methods

The study was carried out in Selçuk University Experimental Medicine Research and Application Center on the rats provided thereof. Mean weight of animals were 130–150 g. However, to prevent possible differences to measured parameters, male animals were used in the study. The study included 40 adult male rats of Spraque Dawley species, which were grouped as follows:

Group 1 (n=10) General Control Group: The group which was not subjected to any procedure and fed on a normal diet.
Group 2 (n=10) Swimming Group: The group fed on a normal diet and decapitated immediately after 30-min acute swimming exercise.
Group 3 (n=10) Swimming Group: The group fed on a normal diet and decapitated 24 h after 30-min acute swimming exercise.
Group 4 (n=10) Swimming Group: The group fed on a normal diet and decapitated 48 h after 30-min acute swimming exercise.

The animals were kept at 21±1°C room temperature and in 12 h dark/light cycle and were fed with normal rat diet. Diet was supplied as 10/100 g body weight.

Swimming Exercise

Swimming exercise was performed in a 50-cm-deep pool made of heat-resistant glass and having a thermostat that kept the heat of the water fixed at 37°C (12). The exercise was a one-time (lasting 30 min) acute swimming exercise. Experimental animals were made to swim at the end of the study and before decapitation in groups of two. Rats in group 1 (normal control group) were not subjected to swimming exercise. Blood samples were collected from the animals immediately after the exercise and 24 and 48 h later by decapitation method.

Opinion of blood samples taking by decapitation as suitable for ethical principles, aimed to determine parameters at the exhaustion just after the acute exercise.

Plasma Copper, Iron, Magnesium, Phosphorus, Selenium, and Zinc Analyses

At the end of the experimental part of the study, blood samples were collected from all experimental animals by decapitation method. Plasma copper, iron, magnesium, phosphorus, selenium, and zinc analyses were conducted in the samples using inductively coupled plasma emission spectrophotometry (Varian Australia Pty Ltd, Australia) atomic emission equipment found in the Soil Department of Selçuk University Faculty of Agriculture. The results were expressed as milligram per liter (Table 1).

Statistical Evaluations

The statistical evaluation of data was performed using Minitab for Windows release 13.0 computer package software. Arithmetic means and standard errors of all parameters were calculated. Variance analysis was employed to determine differences between groups. Level of significance was set at $p<0.01$.

Results

Mean plasma selenium and zinc levels were significantly lower ($p<0.01$), and phosphorus and iron levels were higher ($p<0.01$) in group 2, when compared to the control group (group 1). Mean values of all parameters, except for Mg, were higher in group 3, than in groups 1 and 2 ($p<0.01$). Measurements carried out 48 h after exercise showed that all parameters were restored to normal levels (Figs. 1 and 2).

Table 1 Plasma Copper, Iron, Magnesium, Phosphorus, Selenium, and Zinc Levels (mg/L) in the Study Groups

Group	Copper	Iron	Magnesium	Phosphorus	Selenium	Zinc
Control	0.19 ± 0.01^{B}	0.31 ± 0.04^{C}	3.73 ± 0.65	15.46 ± 2.50^{C}	0.12 ± 0.01^{B}	0.29 ± 0.03^{B}
Exercise	0.18 ± 0.01^{B}	0.43 ± 0.04^{B}	3.88 ± 0.70	22.95 ± 4.80^{B}	0.07 ± 0.01^{C}	0.19 ± 0.01^{C}
Exercise	0.47 ± 0.12^{A}	1.35 ± 0.10^{A}	3.68 ± 0.65	31.11 ± 5.75^{A}	0.18 ± 0.02^{A}	0.33 ± 0.05^{A}
Exercise	0.18 ± 0.02^{B}	0.34 ± 0.03^{C}	3.63 ± 0.60	15.54 ± 3.02^{C}	0.12 ± 0.01^{B}	0.28 ± 0.03^{B}
P value	0.01	0.01		0.01	0.01	0.01

Differences between means with different superscripted letters in the same column are statistically significant ($p<0.01$).

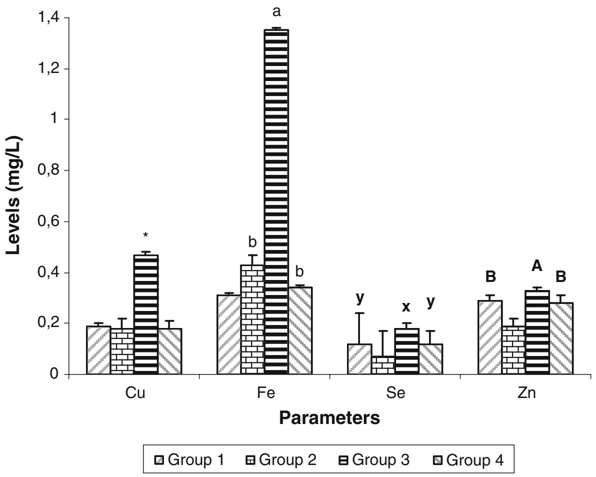

Fig. 1 *Cu*: compared to other groups ($p<0.01$), *Fe*: *a* compared to other groups, *b* compared to group 1 ($p<0.01$), *Se*: *x* compared to other groups, *y* compared to group 2 ($p<0.01$), *Zn*: *A* compared to other groups, *B* compared to group 2 ($p<0.01$)

Discussion

A significant decrease was established in the mean plasma selenium and zinc levels of group 2, when compared to the control group. There is fairly scarce information about the effects of zinc, which is known to be an important trace element in the energy metabolism on performance. Studies concerned with the relation between zinc and exercise generally focus on the distribution of this element in the body [12, 13]. Previous studies have revealed a decrease in plasma zinc levels after exercise [14–16]. Low plasma zinc levels may result in a decrease in muscle zinc concentrations. Because zinc is necessary for many enzyme activities in the energy metabolism, low muscle zinc levels may lead to a decline in endurance capacity [17]. Zinc deficiency found in athletes doing endurance training may be a factor stimulating various functional changes in different systems and tissues that could be associated with the pathogenesis of exhaustion [18]. Low zinc levels we obtained in the present study following acute exercise are consistent with literature information. We found in our study that not only zinc but also selenium levels significantly decreased after acute exercise in comparison to controls. It can be said that the number of studies concerned with the relation between exercise and selenium is not sufficient. It was reported that there was

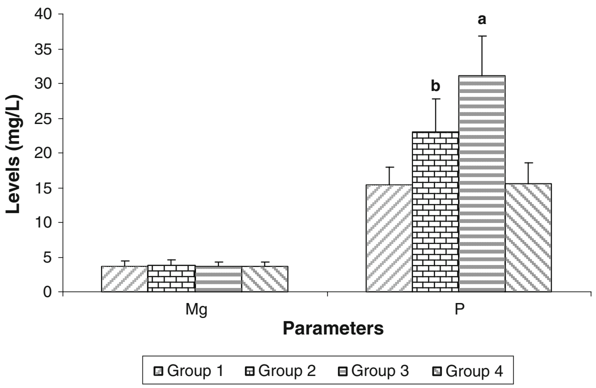

Fig. 2 *Mg* No statistical differences among the groups, *P*: *a* compared to other groups, *b* compared to groupS 1 and 4. ($p<0.01$)

nothing to cause selenium deficiency in athletes [19], and it was noted that selenium had an antioxidant effect [19]. We would like to draw attention to the fact that parallel to the decrease in zinc levels immediately after exercise, there was also a significant inhibition in selenium levels. Therefore, it can be recommended to carry out studies about the relation between exercise, zinc, and selenium. Besides, clarification of this topic may provide us with new information.

In the present study, we observed an increase in phosphorus and iron levels just after acute exercise, when compared to the control group. McDonald and Keen [20] noted that it was important to know the interaction between dietary zinc and other elements in athletes for athlete health and performance and stated that excessive iron intake could lead to zinc deficiency since there was an important relation between zinc and copper. The results of our study demonstrate an inverse relation between iron and zinc.

Measurements carried out 24 h after acute swimming exercise showed that mean values of all parameters except for Mg were significantly higher than those in groups 1 and 2, while the values were restored to control group values in the measurements conducted 48 h after exercise.

It is known that physical activity affects distribution of elements in the body (19). The balance between zinc, an important trace element, and iron and between iron and phosphorus has been emphasized [19–21]. It has been reported that high doses of zinc can impair copper–iron absorption [21], while high doses of phosphorus–iron–copper can damage zinc absorption [22, 23]. The results of our study demonstrate that acute swimming exercise significantly affects element levels in the plasma. It can be argued that the inhibition observed immediately after exercise in selenium and zinc levels may be a significant result. Because zinc is necessary for many enzymes in the metabolism, severe zinc deficiency will have a negative impact on muscle functions. Low muscle zinc level will consequently reduce endurance capacity.

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