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# Effects of Intense Endurance Exercise on Serum Levels of Zinc and Copper in Elite Rowers

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The aim of this study was to investigate serum levels of zinc and copper in well-trained individuals of men's rowing team during and after aerobic maximal intensity endurance exercise. Eleven well-trained young male completed the exercise protocol. Blood samples were collected before, immediately after exercise and 1 h after exercise. Serum was analyzed for Zn and Cu by using inductively coupled plasma optical emission spectrometry (ICP-OES) method. Both of Zn and Cu levels decreased significantly ($p < 0.05$) in serum samples collected 1 h after exercise while no significant change ($p > 0.05$) for Zn and Cu was observed in serum samples collected immediately after exercise in comparison to the resting levels.

**Key Words: ICP-OES, Endurance exercise, Zn, Cu, Rowers.**

## INTRODUCTION

Zinc and copper are essential trace elements that are directly involved in a range of vital biochemical processes and are required for the activity of more than 200 enzymes. They are essential for membrane proteins and enzyme synthesis and regulation. Zinc-containing enzymes such as carbonic anhydrase and lactate dehydrogenase are involved in exercise metabolism while superoxide dismutase protects against free radical damage[1-3]. Controversies regarding plasma levels of trace elements and of their requirement during training in athletes have been reported. There is a little information concerning trace element consumption in athletes such as rowers who involved in intensive conditions of exercise.

Tissues such as muscle (60 %) and bone (30 %) include most of the Zn found in body. The balance of anabolic and catabolic processes that regulates renewal of muscle and skeletal tissues influences the systematic availability of zinc in tissues[2]. Zinc involves, directly or indirectly, in nucleic acid and protein synthesis, cellular differentiations and replication and hormone metabolism, therefore, is required in sufficient amounts for proper function of many physiological systems including development and functions of skeletal and muscular systems. Based on these over all metabolic requirements for zinc suggest that zinc status should regulate work performance of athletes[1].

In order to compensate zinc consumption during heavy training period, athletes should be supplied by zinc-rich diet. In fact, It has been reported that serum zinc levels in runners was found to be lower than normal values[4].

Copper is a critical nutrient for body functions. Muscle tissue contains *ca.* 23 % of Total body's copper found in adults[5]. Copper contributes to many enzyme systems including enzymes of energy metabolism, thus is directly involved in energy providing mechanisms for physical activities.

Despite the numerous studies investigating metabolic effects of zinc and copper in activity and performance of athletes[6], consumption of these trace elements during and after maximal exercise in rowers remains elusive. In this study, it was hypothesized that concumption of zinc and copper in rowers increases following heavy training of rowers, therefore, rowers needs to be supplied by those essential elements. To test this hypothesis, serum levels of zinc and copper before, immediately after and 1 h after aerobic (75 %) maximal endurance exercise were investigated in elite rowers.

## EXPERIMENTAL

Eleven males subjects who are the members of Turkish National Rowing Team participated in this study. Experimental results of this subject were presented separately as a case report in the result section. The median age of the participating subjects was 20.09 ± 1.45 (year) ranging from 19 to 22 (Table-1). The other physical characteristics of the subjects were as follows (mean ± SD) : wight (Kg) 67.09 ± 5.99 (range 58-77), height (cm) 175.91 ± 5.82 (range 167-187).

TABLE-1
PHYSICAL CHARACTERISTICS OF SUBJECTS (MEAN ± SD)

| | Range | Mean ± SD |
|---|---|---|
| Age (year) | (18-22)* | 20.09 ± 1.45 |
| Weight (Kg) | (58-77)* | 67.09 ± 5.99 |
| Height (cm) | (167-187)* | 175.91 ± 5.82 |

n = 11 subjects; *lowest-highest values.

The experimental protocol in this study was approved by the local ethics committee at Gazi University, Ankara, Turkey. All subjects were informed about the purpose and risks of the study before signing a written consent. Studies were performed according to the Declaration of Helsinki.

**Exercise protocol:** A 2000 meter ergometer test protocol was used to performed aerobic (75 %) maximal endurance exercise. Exercise tests were performed on a Concept IIC rowing ergometer (Morrisville, USA). Subjects completed a 10 min warm-up before the exercise. All subjects were asked to cover a distance of 2000 m in the least time possible. The test was performed at ambient temperature (21 ± 0.5 ºC).

**Blood sampling:** Blood samples were drawn from the antecubital vein of the subjects right before, immediately after and 1 h after exercise. Blood samples were collected in vacutainer tubes (Becton Dickinson,Franklin Lakes, NJ, USA) and centrifuged at 1500 g for 15 min. Samples were aliquoted and stored at -80 ºC until use for analyzing by inductively coupled plasma optical emission spectrometry (ICP-OES). Samples were only thawed once.

**Sample preparations and measurements:** On the 1 mL blood samples was added 2 mL $HNO_3$ and the samples were digested in Berghof/Microwave Digestion system MWS-3 microwave apparatus. The microwave were kept at 160 °C for 5 min and at 190, 100 and 80 °C for 10 min each. The totally digested samples were diluted to 10 mL with the addition of deionized water 18.3 mohm $cm^{-1}$. Zinc and copper were analyzed directly using inductively coupled plasma optical emission spectrometry (ICP-OES, Perkin-Elmer, Optima 5300 DV, USA).

**Statistical analysis:** Statistical analysis was performed with SPSS Ver. 15.0 for Windows. Statistical significance was set at $p < 0.05$ (with 95 % confidence levels). Statistical significance was set at $p < 0.05$. Data are expressed as mean ± SD. One-Sample Kolmogorov-Smirnov Testi was performed for the normal distribution. For paired samples, student's t-test was used.

## RESULTS AND DISCUSSION

All atletes participating the study completed the exercise protocol successfully. The 2000 meter ergometer test results were shown in Table-2. All subjects completed the test at very close times by spending very close affords.

TABLE-2
2000 METER ERGOMETER TEST RESULTS (MEAN ± SD)

| Rowers | Time spent | Mean power (Watt) |
|---|---|---|
| 1 | 7:11.7* | 278.63 ± 9.58** |
| 2 | 7:21.1 | 261.60 ± 17.09 |
| 3 | 7:06.0 | 291.95 ± 37.03 |
| 4 | 7:29.9 | 235.50 ± 43.62 |
| 5 | 7:12.5 | 277.18 ± 13.49 |
| 6 | 6:57.0 | 309.50 ± 20.64 |
| 7 | 7:07.3 | 288.08 ± 23.88 |
| 8 | 7:33.6 | 241.80 ± 30.60 |
| 9 | 7:29.6 | 250.68 ± 50.50 |
| 10 | 7:35.6 | 238.73 ± 29.15 |
| 11 | 7:48.2 | 218.30 ± 9.48 |

n = 11, *Time spent to complete 2000 m. (minute:second); **Mean power spent for 500 m (mean of the first, the second, the third and the forth 500 meters).

Before exercise, immediately after exercise and 1 h after exercise, serum zinc levels were found to be 276.44 ± 44.62, 271.12 ± 49.71 and 239.98 ± 47.96 mg/L, respectively while values for copper levels were 38.93 ± 6.31, 38.20 ± 12.08 and 26.00 ± 6.14 mg/L, respectively (Table-3). This data indicated that both serum levels of zinc and copper did not decrease during exercise period, however, begun to decrease 1 h after exercise.

TABLE-3
MEAN SERUM ZINC AND COPPER LEVELS OF ROWERS BEFORE, IMMEDIATELY AFTER AND 1 h AFTER EXERCISE

| Time | Zinc | Copper |
|---|---|---|
| Before | 276.44 ± 44.62 | 38.93 ± 6.31 |
| Immediately after | 271.12 ± 49.71 | 38.20 ± 12.08 |
| After 1 h | 239.98 ± 47.96 | 26.00 ± 6.14 |

n = 11 subjects, data in Mean ± SD.

Zinc and copper levels of serum samples collected at different time points were also compared statistically. The difference between copper levels in serum samples collected before and immediately after exercise was not significant ($p > 0.05$). However, the decrease in copper levels 1 h after exercise was significant ($p < 0.05$) according to that of before exercise. Likewise, the decrease in copper levels of serum samples collected 1 h after exercise was also significant in comparison to that of before exercise ($p < 0.05$) (Table-4).

TABLE-4
p VALUES FOR COMPARED TIME POINTS AT WHICH SERUM SAMPLES WERE COLLECTED

| Element | Comparison | p value |
|---|---|---|
| Zinc | Before - Immediately after | 0.6910 |
| | Before - 1 h after | 0.0140 |
| | Immediately after - 1 h after | 0.0103 |
| Copper | Before - Immediately after | 0.8400 |
| | Before - 1 h after | 0.0001 |
| | Immediately after - 1 h after | 0.0150 |

n = 11 subjects.

Similarly, differences in serum zinc levels between before and 1 h exercise and between immediately after and 1 h after exercise were found to be significant ($p < 0.05$).

Serum zinc levels in different groups of athletes have been reported with controversial results. For example, plasma levels of copper, iron and zinc stayed within the normal ranges and did not change in male and female swimmers before and after a competitive season. Thus it was concluded that copper, iron and zinc were not affected by physical training[7]. In contrast, blood zinc constitutes decreased following exercise, but copper remained unchanged in elite female judo athletes[8]. In another study hypozinchemia was observed two hours after running exercise in runners. In agreement with this previously published results, in the present study, serum zinc levels reduced significantly 1 h after exercise. The decrease in zinc may reflect redistribution of zinc from serum to the tissue such as muscle where zinc requirement emerges following exercise.

Copper is the other essential element studied in the present investigation. Like zinc status, numerous controversies exist regarding effects of exercise in blood levels of copper among various athlete groups. For examples, it was reported that runners were found to have lower copper serum levels in comparison to subjects engaged in normal physical activity[9]. In a study comparing professional soccer players who involved in alternating training aerobic-anaerobic physical activity and control subjects, serum copper levels were found to be comparable[10]. In contrast, serum copper levels decreased significantly after acute maximal aerobic exercise in 16 healthy male university students[11]. Likewise, results of the present study showed that copper level begun to decrease 1 h following aerobic maximal endurance exercise in rowers.

In conclusion, the findings of this study showed that, both zinc and copper concentrations in serum of rowers did not change during exercise, however did decreased after 1 h post exercise. Results of this study confirmed that the hypothesis for the study was correct. Reduction in serum mineral level begun after 1 h indicating that effective consumption of both minerals in tissue might be required in time for metabolic reactions that were involved in repair and tissue renewal to compensate the tissue damage occurred during heavy endurance exercise. This report provides information that rowers may be supplied by zinc and copper diet during their heavy training seasons. However, extensive studies may be required to draw the conclusion.

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