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A COMPARISON OF CERTAIN TRACE ELEMENTS IN WRESTLERS BEFORE AND AFTER AEROBIC AND ANAEROBIC EXERCISES

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ABSTRACT

The purpose of the study was to observe reactions of serum levels of zinc, calcium, magnesium, iron and copper during different exercise intensities (aerobic-anaerobic). Male wrestlers (N=24) with a mean age of 21.91±2.08 years, currently studying at the Physical Education and Sports Academy of Niğde University, volunteered for this research. Height and weight, body fat percentage (skinfold), maximal oxygen uptake (Astrand-Ryhming nomogram) and anaerobic values (Wingate test) were measured. The participants were given exercises performed at two different intensities until exhaustion in which subjects exercised for 30 minutes at 70% of their maximal oxygen uptake (60rpm on the bicycle ergometer) and at 125% of their VO_{2max} *load (60rpm on the bicycle ergometer) as an anaerobic exercise. Blood samples were taken at rest after both aerobic and anaerobic exercises. Subsequently, serum samples were measured by the flame atomic absorption spectrophotometric method. Statistically significant changes were determined in all levels of serum zinc, calcium, magnesium, iron and copper. The duration and the intensity of the exercises had significant effects on the levels of the used trace elements.*

Key words: Aerobic exercise, Anaerobic exercise, Trace elements, Wrestlers.

INTRODUCTION

All living organisms need minerals to survive for various reasons. Magnesium alone is responsible for more than 300 biochemical reactions in the human body (Shils *et al*., 1993). Studies conducted by Lukaski (2000) and Kara *et al*. (2010) demonstrate that exercise increases the need to metabolise specific minerals in the body. Elite sportspeople could be particularly exposed to excessive mineral loss through urination and perspiration. This is a normal reaction due to the nature of their bodies, weight training and physical activity. A single intensive weight training session can cause the magnesium levels in elite sportspeople's bodies to enter an 18-day depletion period. Zinc and other important minerals inevitably have the same reaction (Anderson *et al*., 1988). Trace elements play a role in physiological activities in the organism. Zinc and copper especially play a part in the carbohydrate, protein and lipid metabolisms. Trace elements are affected by a number of factors such as aging and exercise.

The acute and chronic effects of exercise on trace elements have been examined in many studies. Research has shown that regular exercise causes a change in the levels of trace elements (Lukaski, 2000; Michelle *et al*., 2001; Pourvaghara & Shahsavarb, 2009). Human health depends on a very delicate balance. The reactions of the organism relating to nerves, muscles, blood, bones, endocrine and visceral tissue are constantly renewed. Minerals activate vital centres and many enzymatic systems (Speich, 2001). Iron (Fe) is a component of oxygen-binding molecules (haemoglobin, myoglobin), cytochromes and many enzyme co-factors (Fe-S clumps) (Andrews, 1999; Speich, 2001). On the other hand, copper (Cu) and zinc (Zn) are related to life-supporting and mostly biochemical processes such as cellular respiration, the use of oxygen, DNA and RNA reproduction, maintenance of membrane integrity and the elimination of free radicals through sequential enzyme systems (Chan *et al*., 1998; Maughan 1999; Speich 2001).

The amounts of trace elements in sportspeople and people doing physical exercises, and the correlation between the serum/plasma density and the tissue concentration of trace elements are not clearly defined. Furthermore, there is no well-established information on how, when and how much mineral supplementation should be used during exercise. However, it is an undeniable fact that adequate nutrition is of high importance for physiological balance because of the changes in trace element levels both during exercise or training and during the hours or days of recuperation in addition to the temporary or permanent changes in blood volume and homeostasis (Altan *et al*., 2008).

PURPOSE OF THE STUDY

Various studies have dealt with the exercise effect on different trace elements (Rodriguez *et al*., 1996; Nuviala *et al*., 1999; Metin *et al*., 2003). Exercise effects on trace elements are well known but the literature lacks reports of research presenting the effect of exercise of different intensities on trace elements. Therefore, the purpose of this study was to investigate the effect of aerobic and anaerobic exercise on trace element levels of wrestlers.

METHODS AND PROCEDURES

Subjects

The participants of the study were chosen from wrestlers who voluntarily offered to participate after being informed of the purpose of the study. The participants were also informed about the procedures to be followed in the study. They signed an informed consent form before participating the study.

The study investigated the response of serum zinc, calcium, magnesium, iron and copper levels during different exercise intensities (aerobic-anaerobic). Male wrestlers (N=24) (mean age=21.91±2.08) were recruited for participation in this study. The mean height of the participants was 174.00±6.00cm and their mean weight was 75.29±10.82kg. After determining the aerobic and anaerobic capacities of the wrestlers, blood samples were taken just before and after exercise followed by determining the zinc, calcium, magnesium, iron and copper levels before and after the exercises of different intensities.

Preparation of materials and samples

Storage boxes, polyethylene and glass materials used for the storage and analysis of the samples were demineralised. Materials used during the preparation of the samples and during analysis were washed with a hot detergent, rinsed and washed an additional three times with distilled water. After being dried in a disinfector, samples were kept in nitric acid (6N HNO_3). The materials were then taken from the acid and washed three times within tri-distillated water and dried ready for use (Elmer, 1982; Kayakırılmaz & Oral, 1989).

Collection of blood samples and preparation for analysis

The blood samples of the subjects were taken during their resting period before the anaerobic exercises, after the anaerobic and finally after the aerobic exercise session. Approximately 10ml of blood were taken from the subjects. Disposable plastic syringes with stainless steel needles were used. The blood samples were placed into demineralised centrifuge tubes. The samples were centrifuged in plastic tubes for 15 minutes at 3000 revolutions per minute (rpm). The serum portion was separated with a pasteur pipette and put into plastic tubes. Lids were closed and tubes were tightly wrapped in parafilm and kept in a deep freezer (–20^{o}C) until the day of the analysis.

On the day of the analysis, the serums were interfused with 20% of trichloride acetic acid (TCA) in pyrex tubes. A ratio of 1:1 was used. They were heated to 90^{o}C for 15 minutes in the hot water bath and then cooled. The samples were centrifuged for 15 minutes at 3000 rpm at room temperature. The transparent upper layer liquid (supernatant) portion was put into plastic tubes with plastic pipettes. Lids of the tubes were closed and then wrapped with parafilm and they were kept in plastic jars in plastic bags at –20^{o}C until the day of the zinc analysis (Elmer, 1982; Kayakırılmaz & Oral, 1989).

Assessment of trace elements by the atomic absorption spectroscopic method

The levels of zinc, calcium, magnesium, iron and copper in the serum samples taken from the participants were measured by the flame atomic absorption spectrophotometric method (Elmer, 1982).

Body fat percentage

After measuring the body mass and heights of the participants, the percentage body fat (%BF) was determined by applying the Sloan and Weir formula to the skinfold values taken from triceps and the supra-iliac (Zorba, 2005).

Aerobic capacity (Astrand-Ryhming nomogram)

Aerobic capacity depends on the heart response in a single-phase and six-minute submaximal exercise. The initial workload was selected according to the individual’s fitness level and gender. The heart rate must be between 125-170/min. The individual should reach the steady state heart rate in the last two minutes of the test. VO_{2max} was determined from the heart rate at steady state and from the workload by nomogram. The measurement of the aerobic capacity was the Astrand Bicycle Ergometer test on the Monarch Ergomedic 884 E5 bicycle (Günay *et al*., 2006).

Anaerobic capacity (Wingate Test)

The Wingate test was based on pedalling at maximal speed for 30 seconds against a predetermined constant load. During the 30 seconds, the number of pedal revolutions per five seconds was determined. A Monarch brand and 884 E5 model bicycle ergometer was used for the test (Günay *et al*., 2006).

Exercise presented

The aerobic exercise was performed on a bicycle ergometer with the 70% of the subjects' individual maximal oxygen uptake for 30 minutes at 60 rpm (revolution/minute). As an anaerobic exercise, they continued the bicycle ergometer at 60 rpm until exhaustion with 125% of their VO_{2max} load (Cicioğlu, 1998). The aerobic and anaerobic exercises were conducted consecutively to the subjects with a three-hour rest between the exercise sessions. At first the anaerobic exercise was conducted because it was supposed that a three-hour rest was enough for the recovery (Bowers & Fox, 1988). Their serum zinc, calcium, magnesium, iron and copper levels were determined at rest, after aerobic and after anaerobic exercise.

Statistical analysis

In the statistical analysis, the one-way ANOVA for repeated measures was used to establish whether there were any difference between the three measurements of the subject group and the Bonferroni test was used for comparisons between the measurements of the participants (Büyüköztürk, 2006). For the statistical analysis, Statistical Package for the Social Sciences (SPSS) 15 was employed.

RESULTS

The age, height, weight, %BF, aerobic and anaerobic measurements of the participating wrestlers are shown in Table 1.

TABLE 1: **SCORES FOR AGE, HEIGHT, WEIGHT, %BF, AEROBIC AND ANAEROBIC CAPACITY**

Variables	**Mean ± SD (N=24)**	**Mean SD**	**Minimum score**	**Maximum score**
Age (yrs.)	21.91±2.08	0.42	21.03	22.79
Height (cm)	174.00±6.00	1.22	171.46	176.53
Weight (kg)	75.29±10.82	2.21	70.71	79.86
Body fat %	11.71±2.86	0.58	10.50	12.92
Aerobic Capacity (ml/kg/min)	3.26±0.41	0.08	3.08	3.43
Anaerobic Capacity (g/kg)	22.16±5.37	1.09	19.90	24.43

The zinc, calcium, magnesium, iron and copper levels of the serum samples obtained from the participants were measured at rest after both aerobic and anaerobic exercises by the flame atomic absorption spectrophotometric method**.** The resultant scores including the standard deviation and arithmetic mean values of the zinc, calcium, magnesium, iron and copper levels are presented in Table 2. The arithmetic mean of the data indicates that the highest decrease occurred in zinc, copper and magnesium values, while iron and calcium decreased less after anaerobic exercise. On the other hand, the levels of zinc, copper and magnesium decreased less than iron and calcium.

TABLE 2: **ZINC, CALCIUM, MAGNESIUM, IRON AND COPPER LEVELS DURING THE TESTING CONDITIONS**

Condition	**Zinc** µg/dL	**Calcium** µg/dL	**Magnesium** µg/dL	**Iron** µg/dL	**Copper** µg/dL
Resting condition	129.72±28.63	9.39±0.86	1.77±0.31	102.18±7.95	122.97±29.97
After *aerobic* exercise.	114.54±23.88	8.09±0.65	1.65±0.24	70.54 ±20.42	115.37±28.26
After *anaerobic* exercise.	77.94±14.54	8.53±1.19	1.50±0.42	91.32±14.28	78.87±10.21

The serum trace element values for zinc, calcium, magnesium, iron and copper acquired were statistically evaluated for significant differences (Table 3).

TABLE 3: **ANOVA TEST RESULTS FOR ZINC, CALCIUM, MAGNESIUM, IRON AND COPPER AFTER AEROBIC AND ANAEROBIC EXERCISES**

Elements	Source of variance	Sum of squares	SD	Mean square	F-value	p-value	Significant difference (Bonferroni)
ZN	Subjects	23712.760	36	658.688	55.588	0.000	1-2,1-3,2-3
	Measurement	52434.378	2	26217.189			
	Error	33957.622	72	471.634			
	Total	110104.760	110				
CA	Subjects	26.331	36	0.731	17.389	0.000	1-2,1-3,2-3
	Measurement	32.517	2	16.258			
	Error	67.320	72	.935			
	Total	126.168	110				
MG	Subjects	3.565	36	.099	5.881	0.004	1-3
	Measurement	1.434	2	.717			
	Error	8.776	72	.122			
	Total	13.775	110				
FE	Subjects	7752.631	36	215.351	40.808	0.000	1-2,1-3,2-3
	Measurement	19136.991	2	9568.495			
	Error	16882.342	72	234.477			
	Total	43771.964	110				
CU	Subjects	43190.198	36	1199.728	68.293	0.000	1-2,1-3,2-3
	Measurement	41127.927	2	2056.964			
	Error	21680.206	72	301.114			
	Total	105998.331	110				

Significant differences were found between the measurements of zinc ($F_{(36-2)}$=55.588, p<0.05), calcium ($F_{(36-2)}$=17.389, p<0.05), magnesium($F_{(36-2)}$=5.581, p<0.05), iron ($F_{(36-2)}$=40.808, p<0.05), and copper ($F_{(36-2)}$=68.293, p<0.05). The Bonferroni test results showed that significant differences were found between the 1st and 2nd, 1st and 3rd, and 2nd and 3rd measurements of zinc and copper, as well as between calcium and iron. The mean values of the measurements displayed a decrease from the highest to the lowest respectively. In magnesium there was a significant difference between the 1st and 3rd measurements according to the Bonferroni test.

DISCUSSION AND CONCLUSION

According to the results, the levels of zinc, magnesium, copper and calcium changed with the exercise intensity. Since iron is an important component of the haemoglobin in the blood and plays an important role in the transport and use of oxygen, the decrease in iron was higher following the aerobic exercise (Günay *et al*., 2006). Campbell and Anderson (1987) reported that aerobic exercise could cause a decrease in zinc levels and intense workout could change the metabolism or nutritive mineral levels could be changed in individuals performing exhausting exercises, which could be caused by perspiration. The results of the present study are consistent with these findings.

Lukaski *et al*. (2000) found no statistically significant difference between the pre- and post-season values in their research including 16 women and 13 men swimmers to investigate the effects of physical training on zinc values. Bordin *et al*. (1993) researched the effects of high intensity physical exercise on plasma levels of copper and zinc and observed that plasma zinc intensity increased in both men and women, while the copper intensity decreased after exercise. The high zinc levels determined in the present study support these findings (Lukaski, 2000).

In the study by Kara *et al*. (2010), attention was paid to the importance of zinc intake in the sportspeople's diet and zinc deficiency was claimed to affect both the performance and the cellular immune system negatively, thus increasing the tendency in sportspeople towards infections This could be explained by the increase in the use and need for Fe by the tissues activated during the exercise, as well as the hormonal changes provoked by stress and the change of behaviour in the Fe proteins (Navas & Cordova, 2000). Kikukava and Kobayashi (2002) studied the changes in zinc and copper levels in urine with 11 hours of intense physical exercise in people working for the Japanese air rescue team. They found that essential and intense exercise zinc levels changed significantly before the control. Similar results were also found in this study.

According to the results of the abovementioned studies, it can be concluded that the levels of many trace elements show variation depending on the kind of exercise. In addition, the correlation between the serum/plasma density and the tissue concentration of trace elements was not clearly defined. There is no well-established information on how, when and how much the mineral supplementation should be used based on the duration and the intensity of the exercise. However, because of the temporary or permanent changes in the blood volume and homeostasis through the changes in the levels of trace elements in the current three sets of data reported, it is an undeniable fact that adequate nutrition is important in terms of physiological balance. In this study, the observation of changes in the level of the used trace elements depends on the duration and the intensity of the exercises.

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