The effect of zinc supplementation on the urinary excretion of elements in female athletes

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Abstract: This study was carried out to find out how oral zinc supplementation to elite athletes affects the element changes in the urine. The study registered 10 female athletes who were on the women's volleyball team of Gazi University Sports Club and whose mean age, weight, and height were 14.2±0.42 years, 59.8±7.79kg and 173.6±6.15 cm. The study protocol was approved by the local ethics committee. The athletes who continued their daily routine training sessions (6 days/week) were supplemented with 220mg/day oral zinc sulfate for 4 weeks. In order to induce exhaustion, the subjects were put to a 20-meter shuttle run test before and after supplementation. A total, 7 times urine samples were collected follows as pre and post exercise before the start of the experiment and at the end (4 times), at the end of first, second and third week (3 times). Urinary levels of magnesium, phosphorus, and calcium (mg/dl), as well as zinc, copper, and selenium (µg/dl) were analyzed in the atomic emission device (ICP-MS). Arithmetic means and standard errors of the data were calculated. Kruskal Wallis test was used to determine differences between weeks. Values for which $p<0,05$ were considered significant. When compared to resting values, urinary excretion of copper and selenium decreased in exercise ($p<0,05$), but increased with zinc supplementation ($p<0,05$). Pre- and post-supplementation exercise resulted in reduced urinary zinc excretion ($p<0,05$). Zinc supplementation increased urinary zinc excretion in one-week intervals over the course of 4 weeks ($p<0,05$), and reduced selenium levels ($p<0,05$). When zinc is supplemented to athletes, the relation between the duration and dose of supplementation is important. The results of the study indicated that zinc does not have any negative effect on the urinary excretion of the concerned elements. It can thus be concluded that athletes may benefit from zinc support.

Keywords: Female Athletes, zinc supplementation, element metabolism, urinary excretion

INTRODUCTION

Many researchers emphasize the relationship between nutrition, development and maintaining performance. Two methods are commonly used to determine the interaction between physical activity and diet. The first of these methods consists of administering various nutrients to individuals engaged in physical activity and examining their physiological and performance responses to these nutrients and the other method involves determining the effects of physical activity on diet (Brotherhood, 1984; Short and Short, 1983). Thus, a growing research interest in the relation between exercise, and minerals and elements can be observed (Finstad *et al.*, 2001). Zinc is known to be a trace element significantly involved in the energy metabolism, but too little is known about its effects on performance. Studies into the relation between zinc and exercise focus mainly on the distribution of this element in the body in response to exercise (Cordova, 1992; Dress ender for *et al*., 1982). Long-term endurance training was shown to significantly reduce serum zinc levels in both male and female athletes, in comparison to the levels in sedentary individuals (Haralambie, 1981).

Cordova and Alvarez (1992) reported that muscle zinc concentration decreased due to low serum concentrations in athletes. As zinc is necessary for many enzymes found in the metabolism, serious zinc deficiency will have a negative impact on muscle functions. Low muscle zinc level will, in turn, reduce endurance capacity (Khaled *et al.*, 1997).

Although several mechanisms can account for the reduced zinc levels observed in endurance athletes, a zinc-deficient diet may be the major factor (Khaled *et al.*, 1999). It was shown in a study based on this premise that oral zinc supplementation significantly elevated the serum zinc levels of runners. It is already known that zinc loss through perspiration and skin is greater in athletes than in the non-athlete population (Campbell and Anderson, 1987). It was noted that moderate exercise increases zinc loss through perspiration in athletes and, given the amount of perspiration, this loss is greater in males than females. This finding may be related to increased urinary zinc loss resulting from skeletal muscle breakdown in regularly training athletes (Tipton *et al.*, 1993). It was suggested that, since exercise increases zinc excretion from the body and female athletes in particular do not get enough zinc through diet, zinc support to athletes with

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zinc deficiency is essential (Clarkson, 1991; Gleeson and Bishop, 2000).

The purpose of the present study was to determine the effect of oral zinc supplementation to elite athletes on the changes in urinary element levels.

MATERIALS AND METHODS

Study group

The study registered 10 female athletes who were on the women's volleyball team of Gazi University Sports Club and whose mean age, weight, and height were 14.2±0.42 years, 59.8±7.79 kg, and 173.6±6.15 cm. After being verbally informed about the study, the subjects (and/or their parents) signed a copy of the Helsinki declaration explaining who is conducting the study and why. The study protocol was approved by the Ethics Committee of Selcuk University School of Physical Education and Sports.

The athletes who continued their daily routine training sessions (6 days/week) were supplemented with 220mg/day oral zinc sulfate for 4 weeks. In order to induce exhaustion, the subjects were put to a 20-meter shuttle run test before and after supplementation (Gunay *et al.,* 2006).

A total of 7 times urine samples were collected follows as pre and post exercise before the start of the experiment and at the end (4 times), at the end of first, second and third week (3 times).

As the subjects were female athletes, analyses were interrupted in the menstruation weeks. The study was conducted in the 8- to 10-week general preparation period of the athletes (which consisted of 70 to 80% strength and 20 to 30% technical-tactic training).

Zinc supplementation

Zinc sulfate preparations were supplied by Berko Drug and Chemistry Industry Limited Company in the form of capsules each containing 220mg zinc sulfate.

Urinary zinc, magnesium, phosphorus, calcium, copper and selenium analyses

Urinary samples of 10ml collected from the subjects were put into Teflon tubes and thoroughly mixed to obtain a homogenized sample. Then, a sample of about 1.0g was weighed and burned in a microwave. The burned samples were then read in the inductively-coupled plasma mass spectrometry (ICP-MS) device (AGILENT 7500 ce, Agilent Technologies, Santa Clara, CA 95051-7201 USA) to determine levels of magnesium, phosphorus, and calcium as mg/dl and copper, zinc and selenium as µg/dl.

STATISTICAL ANALYSIS

Computer software was used in the statistical evaluation of data. Arithmetic means and standard errors of all parameters were calculated. Kruskal Wallis test was used to determine differences that appeared on a weekly basis. Values for which $p<0,05$ were considered significant.

RESULTS

Exercise did not affect urinary magnesium, phosphorus, and calcium levels, in comparison to resting values. Pre- and post-supplementation exercise reduced urinary excretion of zinc ($p<0.05$). Pre-supplementation exercise brought about a decrease in urinary copper and selenium excretion ($p<0.05$), while post-supplementation exercise increased these values ($p<0.05$, table 1). Zinc supplementation increased urinary zinc excretion ($p<0,05$), reduced selenium levels and did not affect urinary excretion of magnesium, phosphorus, calcium, and copper in one-week periods over the course of 4 weeks (table 2).

DISCUSSION

It can be said that there is no consensus as to how physical activity affects urinary excretion of elements in the literature. It was reported that a decrease in urinary magnesium was found in the blood samples collected from marathon runners after the run, in comparison to resting values, but that there was no corresponding change in copper values (Buchman *et al.,* 1998). Conversely, physical activity in female athletes performing in different sports branches was reported to cause no change in urinary magnesium or copper excretion (Nuviala *et al.,* 1999). It was shown that two-hour physical activity significantly increased urinary calcium excretion, but did not affect phosphorus levels in adult men (Turgut *et al.,* 2000). In the same study, physical activity did not cause any change in either calcium or phosphorus in male children (Kikukawa and Kobayashi, 2002; Turgut *et al.,* 2000). In the present study, zinc supplementation did not significantly alter urinary levels of magnesium, phosphorus, or calcium. The results of the study are partially consistent with the results of studies cited above.

Exercise before and after zinc supplementation lowered urinary zinc levels in this study. It was reported that physical activity increased zinc excretion and urinary zinc levels measured 2 hours after exercise were shown to be significantly higher than resting levels in long-distance runners (Anderson *et al.,* 1984). In the same vein, 12-week zinc gluconate supplementation at a dose of 22 mg/day to child footballers was found to significantly elevate urinary zinc excretion (Oliveira *et al.,* 2009). It was reported that urinary zinc values in elite marathon

Table 1: Level of significance of the changes in pre- and post-exercise urinary element levels both before and after zinc supplementation

Group 1	Before zinc supplementation		After zinc supplementation		Kruskall Walls'in Z level	P
	Pre-exercise	Post-exercise	Pre-exercise	Post-exercise		
Elements	X±SD	X±SD	X±SD	X±SD		
Mg (mg/dl)	6.75±4.98	7.45±6.60	10.05±1.76	9.39±4.86	1.418	0.701
Ca (mg/dl)	0.73±0.60	0.69±0.41	0.83±0.88	1.10±1.18	0.181	0.981
Cu (µg/dl)	1.90±2.31	1.44±1.49	1.70±0.90	1.86±0.71	8.212	0.042*
Se (µg/dl)	4.53±1.65	3.96±1.48	2.11±1.38	2.47±0.93	15.381	0.002*
P (mg/dl)	70.60±53.22	91.93±57.99	82.65±69.33	118.48±97.56	2.229	0.513
Zn (µg/dl)	26.59±9.68	25.80±13.92	78.07±61.02	72.92±61.59	20.560	0.000*

Table 2: Changes that occurred in the urinary element levels of athletes over the course of zinc supplementation

Physiological dose	Supplementation time	N	Means standard errors	Kruskall Walls'in Z level	p
Mg (mg/dl)	Resting before supplementation	10	6.75±4.98	5.400	0.249
	The end of first week	10	7.80±3.12		
	The end of second week	10	6.99±4.06		
	The end of third week	10	9.11±3.33		
	The end of fourth week	10	10.05±1.76		
P (mg/dl)	Resting before supplementation	10	70.60±53.22	2.407	0.661
	The end of first week	10	45.18±32.28		
	The end of second week	10	54.73±39.03		
	The end of third week	10	50.80±38.55		
	The end of fourth week	10	82.65±69.33		
Ca (mg/dl)	Resting before supplementation	10	0.73±0.60	0.967	0.915
	The end of first week	10	0.70±0.80		
	The end of second week	10	0.59±0.42		
	The end of third week	10	0.73±0.46		
	The end of fourth week	10	0.83±0.88		
Cu (µg/dl)	Resting before supplementation	10	1.90±2.31	8.233	0.083
	The end of first week	10	1.45±1.62		
	The end of second week	10	0.92±0.69		
	The end of third week	10	1.62±1.04		
	The end of fourth week	10	1.70±0.90		
Zn (µg/dl)	Resting before supplementation	10	26.59±9.68	16.936	0.002*
	The end of first week	10	37.40±32.56		
	The end of second week	10	49.12±29.17		
	The end of third week	10	72.11±36.83		
	The end of fourth week	10	78.07±61.02		
Se (µg/dl)	Resting before supplementation	10	4.53±1.65	15.432	0.004*
	The end of first week	10	2.08±1.54		
	The end of second week	10	1.40±0.93		
	The end of third week	10	2.26±1.70		
	The end of fourth week	10	2.11±1.38		

*P<0.05

runners after the run were not different from resting values (Buchman *et al.,* 1998) and, similarly, that moderate- and high-severity exercise did not affect urinary zinc levels (Mundie and Hare, 2001). Buchman and colleagues (1998), on the other hand, found significantly lower urinary zinc levels in marathon runners after the run. These reports about the relation between exercise and urinary zinc excretion are contradictory. This contradiction probably results from the differences in the type, duration and severity of exercise, as well as the doses of zinc supplementation. The result showing that exercise before and after zinc supplementation reduced urinary zinc levels in our study is partially consistent with the results of Buchman *et al*. 1998).

In the present study, zinc supplementation significantly elevated urinary zinc levels and reduced urinary selenium levels in one-week periods over the 4-week study period, but did not alter concentrations of magnesium, phosphorus, calcium and copper in the urine.

Especially, zinc application to reduce the urinary excretion of selenium can be said quite an important finding. That selenium deficiency was shown to cause weakening of muscle concentrations in exercising individuals is a remarkable report concerning the relationship between selenium and exercise (Milias *et al.*, 2006). It has been noted that selenoprotein levels that dropped as a result of selenium deficiency is correlated with several muscle pathologies (Hornberger *et al.*, 2003). And also reported that intensive swimming exercise in rats significantly inhibited zinc and selenium levels, while combined supplementation of zinc and selenium prevented the oxidative stress caused by swimming exercise in rat testis tissues (Jana *et. al.*, 2008). An overall evaluation of our current knowledge on this topic inevitably suggests that there is an important relationship between selenium and physical performance. The effect of selenium on antioxidant activity in particular may foreground this element in the prevention of the harmful effects of free radicals that emerge in exercise. Besides, selenium is associated with muscle tiredness. The fact that selenium is abundantly found in the muscles may be critical in the correlation between selenium and muscle exhaustion in exercise. Supplementation of 25 mg oral zinc to individuals engaged in endurance training resulted in increased urinary zinc excretion and it was suggested that this increase could be attributed to the conversion in the skeletal muscle (Deuster *et al.*, 1989). Likewise, increased urinary zinc excretion in athletes after zinc supplementation was reported by Oliviera *et al*. (2009). Reports of increased urinary zinc excretion following oral zinc supplementation are remarkable results that support elevated urinary zinc found after zinc supplementation in the present study. However, possibly the most critical result that needs emphasis here is the lack of any change in the urinary excretion of magnesium, phosphorus, calcium, and copper. It was noted that oral zinc supplementation to athletes was important, but that the interaction between zinc and other elements should be known when zinc supplementation was considered (Baltaci *et al.*, 2010). It was cautioned that excess zinc intake could impair copper absorption (Haymes, 1991), while excess dietary iron could cause zinc deficiency (McDonald and Keen, 1988). In this study, zinc supplementation did not affect urinary calcium and phosphorus excretion either. This result is noteworthy, as it can be suggested, in consideration of the results of the present study, that 4-week supplementation of 220 mg/day zinc would not cause any negative impact on other elements in athletes. It is known that the relation between duration and dose is crucial when giving zinc support to athletes (Haymes, 1991). Therefore, it can be concluded that 4-week zinc support at a physiological dose can benefit athletes.

The results of the study indicate that 4-week zinc support did not have any undesirable effect on the urinary excretion of concerned elements. The relation between duration and dose of supplementation is important when zinc support is given to athletes. The results of the present study show that athletes can benefit from 4-week supplementation of zinc at physiological doses.

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