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EFFECT OF DIFFERENT DOSAGES OF ZINC SUPPLEMENTATION ON NUTRITIONAL STATUS, AEROBIC AND ANAEROBIC PERFORMANCE IN ELITE FEMALE VOLLEYBALL PLAYERS

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ABSTRACT

Zinc is an essential element for the performance of athletes. This study aims to determine the effect of two different dosages of zinc supplementation in elite female volleyball players on nutritional status, aerobic, anaerobic performance and fatigue. The research involved 20 female athletes who played in Gazi University Sports Club volleyball team. Subjects were divided into two groups equal in number. Different dosages of zinc sulphate were applied for four weeks: (1) Group 1 (220mg/day zinc sulphate; (2) Group 2 (440mg/day zinc sulphate). Athletes who were already engaged in their daily training routines were given a 20m-shuttle run test to create fatigue before and after supplementation. Also, a Wingate test was performed to determine the anaerobic power before and after the supplement. Zinc supplementation did not cause a significant change in both groups in both anaerobic and aerobic performance. However, zinc supplementation in both groups caused a substantial shift in plasma lactate levels ($p<0.05$). Pre-supplementation exercise elevates plasma lactate levels, while zinc supplementation led to a fall in plasma lactate. Zinc supplementation caused a significant increase in daily energy, protein, and fat intakes in both groups.

***Keywords*:** Aerobic; Anaerobic; Female athletes; Nutritional status; Volleyball; Zinc.

INTRODUCTION

Zinc is an important trace element, essential for the structure and activity of more than 300 enzymes. It is involved in numerous biological functions, including immunity, energy metabolism and anti-oxidative processes (Campbell & Anderson, 1987; Vallee & Falchuk, 1993; Chu *et al*., 2018).

Since zinc is necessary for several enzymes activity in energy metabolism, low muscle zinc levels may lead to a reduction in the endurance capacity. Lactate dehydrogenase is a zinc-containing enzyme. An adequate muscle zinc concentration might facilitate the removal of lactic acid to pyruvate through the action of this enzyme in exercising skeletal muscle and consequently, may also decrease muscle fatigue (Cordova & Alvarez-Mon, 1995; Van Loan *et al*., 1999; Maynar *et al*., 2018). Considering the role of zinc in anti-oxidative systems, such as those involving superoxide dismutase and catalase, the maintenance of optimal zinc status may be critical in mediating oxidative stress in skeletal muscles and systemically (Chu *et al*., 2018).

The importance of zinc intake through the diet in athletes has been emphasised. It has been argued that zinc deficiency in the diet may unfavourably influence performance and the cellular immune system, enhancing the predisposition to infections (Singh *et al*., 1994). Good dietary sources of zinc include beef, liver, oysters, and dark meat from turkey and chicken. Whole grains and cereals, nuts and legumes may also contain zinc, but these non-meat sources may be less bio-available because of the presence of phytate and dietary fibre in foods derived from plants (Campbell & Anderson, 1987).

Adolescent athletes have increased energy needs because of physical activity and physical development. This is especially true for elite adolescent athletes who exercise strenuously to maximise their performance. Proper nutrition is essential for optimising athletic performance (Papadopoulou *et al*., 2002). During adolescence, individuals undergo significant growth and maturation, and notable changes occur in the body, thus causing an increase in nutritional needs. As adolescent athletes have energetic needs that are different from adult athletes' needs, one should pay heed not only to energetic suitability but also to the intake of energy and nutrients before, during and after the exercise (Almeida & Soares, 2003).

Vitamin, mineral and/or trace element supplements are beneficial if they supply a nutrient that is deficient in the diet (Zimmermann, 2003). Zinc is one of the minerals that are excreted from the body through sweat and urine during exercise. If dietary intake is insufficient, zinc supplements are required (Fink & Mikesky, 2018). Zinc deficiency may be an essential cause of the lower motor activity levels associated with hypo-nutrition. Zinc supplementation can positively affect growth and motor activity (Micheletti *et al*., 2001). In some studies, zinc supplementation has been found to increase muscle strength and endurance compared to placebo control (Maxwell & Volpe, 2007; McClung, 2019).

The role of adequate micronutrient status in supporting the beneficial adaptations of exercise has gained the attention of researchers, particularly with respect to the effects of physical activity on the zinc status and subsequent consequences on exercise performance and metabolic effects (Chu *et al*., 2017). In addition to the short-term impact of mild-intensity exercise on zinc metabolism, it has been shown that high-intensity continuous exercise can affect zinc metabolism for a long time (Cordova & Alvarez-Mon, 1995). Volleyball is a sport that requires an athlete not only to jump high and hit the ball hard, but also to perform for 1 to 3 hours. So, although volleyball is mainly an anaerobic sport, the aerobic capacity of volleyball athletes is of critical importance because of the long duration of a volleyball game (Scates, 1993). This situation has raised interest in the effect of zinc support on the volleyball branch.

In this study, the effect of different dosages of zinc supplementation on nutritional status, aerobic and anaerobic performance, and fatigue was evaluated in adolescent female volleyball players.

METHODOLOGY

Participants

The research was conducted on 20 female athletes playing in the volleyball team in the Super League of Sport Club Gazi University whose age, body weight and height were 15.1±1.07 years, 59.9±6.4kg, and 175.3±6.5cm, respectively. After being verbally informed of the study, the subjects (and/or their parents) signed a copy of the Helsinki Declaration explaining who is conducting the research and why. The study protocol was approved by the Ethics Committee of Selcuk University School of Physical Education and Sports (Meeting number: 2009/005).

Procedures

Zinc supplement

The athletes were divided into two groups equal in number (n=10):

Group 1: The group was administered 220mg/day of zinc sulphate;
Group 2: The group was administered 440mg/day of zinc sulphate.

Zinc sulphate preparations were supplied by Berko Drug and Chemistry Industry Limited Company in the form of capsules, each containing 220mg zinc sulphate. Athletes used supplements for four weeks.

Training programme

This study was conducted in the first five weeks of the general preparation period (8-10 weeks) of the athletes (consisting of 70-80% strength/power, and 20-30% technical-tactical exercises).

Anthropometric measures

Anthropometric measurems of all individuals included in the study were made by the researcher in the appropriate environment prepared for the measurement by going to the sports centre where the athletes trained. The measurements were taken in the morning after starvation. To determine the body fat percentages, Tanita BC-418 body analysis monitor with 200kg capacity and 100gr sensitivity belonging to Gazi University School of Physical Education and Sports was used. For the measurements, the individuals removed their socks and metal items so as not to affect the electrical permeability. They were provided with shorts and a T-shirt only.

Height measurement with bare feet, feet adjacent, the head in the frankfort plane and the arms freely suspended from the shoulders to the sides. For measurement, a stadiometer (Holtain Ltd., UK), which was previously fixed to the wall (with a sensitivity of 0.1 cm), was used for athletes in the sports centre. For *waist circumference* measurement, it is prevented from pulling in the abdomen of the person, and it is located between the lower rib bone and the crystal iliac. The measurement was made with a measuring tape of 0.1 centimetres (cm) that did not stretch parallel to the horizontal plane from the midpoint. For *hip circumference* measurement, the tape measure ends were combined on the side of the person from the widest part of the hip, and the measurement was made with a 0.1 cm error margin with the tape measure that did not stretch parallel to the horizontal plane. *Body Mass Index* (BMI) was calculated by dividing the body weight in kilograms by the square of height in meters (BMI=kg/m^2). Normal weight was defined as a BMI 18.5-24.9kg/m^2 (Fink & Mikesky, 2018).

Food consumption records

Dietary intake was assessed using a 3-day food record (2 weekdays and one weekend day) by the dietitian. The food photograph catalogue was used to determine the amount of food consumed (Rakıcıoğlu *et al*., 2015). The energy and nutrient intake of the athletes was calculated using the Nutritional Information System (BEBIS) package programme. The data obtained from the BEBIS programme was compared with the recommended values according to age, gender and physical activity status in the 2015 Turkey Nutrition Guide (Turkey Specific Food and Nutrition Guide, 2015).

20m-Shuttle Run Test

The 20m-shuttle run test is an indirect method used to determine aerobic capacity. The aerobic performance of athletes was measured twice. (1) Before zinc supplementation, (2) after zinc supplementation (after four weeks). This test was used to assess cardiorespiratory fitness. Groups of participants were asked to run between two lines 20m apart while keeping pace with audio signals emitted from a CD. The speed corresponding to the initial beep was 8.5km/h and increased by 0.5 km/h every 1 min (1 min equals one stage). Participants were instructed to run in a straight line, to turn around on completing a shuttle, and to pace themselves in accordance with the audio signals. The test was considered complete when the participant failed to reach the end lines with the audio signals on two consecutive occasions or stopped because of fatigue. Maximal oxygen intake VO_2max (Y, ml/kg/min) was derived from the speed (X, km/h) corresponding to that stage (speed+0.5 stage no) and age (A, year) using the formula Y=31.025+3.238X-3.248A+0.1536AX (Léger *et al*., 1988). Obtained indirect VO_2 max values were used to compare physical performances.

Plasma lactate analyses

Athletes who were already engaged in their daily training routines were put to a 20m-shuttle run test to create fatigue before and after supplementation. At the beginning and the last week of the study, blood was taken twice, before and after exercise. Blood samples were taken by a nurse. Blood samples of 2ml were put into tubes containing fluoride-oxalate anticoagulants. The tubes were kept in ice blocks for 15 minutes and then centrifuged at 3000rpm at 4°C for 5 minutes to separate plasma. Plasma lactate levels were determined in Rocher Cobas Mira Plus brand device (Lot number: W253088) (read at 556nm wavelength) as mmol/l.

Wingate Test

The anaerobic performance of athletes was measured twice using the Wingate test, namely (1) before zinc supplementation and (2) after zinc supplementation (after four weeks). The Wingate Test was performed on a computer-connected bicycle ergometer (Monark 894 Ea, Peak Bike, Sweden). After adjusting the seat and handlebars for each subject, the subject's feet were fixed to the pedal with the help of clips. The test was initiated after the weight corresponding to 7.5% of the bodyweight of each subject was placed on the cage of the bike as the resistance to be applied during the test. In order to reach a certain pedal speed (130-150 rpm), initially 3-4 seconds without load, then loaded. They were asked to maintain the highest possible maximal pedal speed for 30 seconds.

Subjects were verbally encouraged throughout the test. During the test, the pedal speed was automatically recorded with the help of a photocell connected to the computer. The test parameters (maximum anaerobic power [MAG], maximum anaerobic capacity [average power], minimum power [MinG] and power drop [PD]) where values were calculated with the aid of the software programme on the computer. Fatigue Index (FI)=(MAG - MinG x 100) / MAG was determined by the formula (Inbar *et al*., 1996; Pavlovic *et al*., 2016).

Ethical approval

The study protocol was approved by the Ethics Committee of Selcuk University School of Physical Education and Sports (Meeting no: 2009/005).

Statistical analyses

In the statistical analysis of the data obtained in the study, a t-test or Mann-Whitney U test was used in determining the differences between the groups, and a two Wilcoxon paired-sample tests were performed to determine the effect of zinc application on the food consumption, aerobic and anaerobic performance for each group separately. Significance was set at $p<0.05$.

RESULTS

The research included 20 female athletes whose mean age was 15.1±1.07 years. The findings regarding the anthropometric measurements of the athletes included in the study are given in Table 1. There was no significant difference in body weight, height, BMI, body fat, fat-free mass, waist and hip circumference between the groups (p>0.05).

Table 1. **INITIAL ANTHROPOMETRIC MEASUREMENTS OF ATHLETES**

Anthropometric measurements	Group	n	Mean±SD	Min–Max	t	p
Weight (kg)	1 2	10 10	59.8±7.79 60.2±5.10	50.4–72.7 53.7–69.8	-0.156	0.878
Height (cm)	1 2	10 10	173.6±6.15 177.1±6.64	163.0–183.0 165.0–185.0	-1.223	0.237
BMI (kg/m^2)	1 2	10 10	19.8±2.24 19.2±1.64	16.1–22.7 16.5–22.3	0.662	0.517
Body fat (%)	1 2	10 10	21.3±4.44 17.3±5.49	12.5–27.7 8.4–27.5	1.823	0.085
Body fat mass (kg)	1 2	10 10	13.0±4.01 10.5±3.96	6.3–20.1 4.9–19.2	1.391	0.181
Body fat-free mass (kg)	1 2	10 10	46.7±4.42 49.7±4.10	39.9–52.6 43.1–56.1	-1.538	0.141
Waist circumference (cm)	1 2	10 10	74.9±4.63 74.9±4.53	66.0–80.0 68.0–81.0	0.000	1.000
Hip circumference (cm)	1 2	10 10	94.1±5.43 93.1±3.81	86.0–105.0 89.0–101.0	0.477	0.639
Waist/hip	1 2	10 10	0.8±0.04 0.8±0.05	0.73–0.86 0.73–0.88	-0.579	0.570
Waist/height	1 2	10 10	0.4±0.03 0.4±0.04	0.36–0.47 0.37–0.47	0.607	0.551

The average active years of sports of the participants is 4.8±1.8 and 5.9±1.3 years for Groups 1 and 2, respectively. Weekly training numbers are equal (6 days). Daily training hours are 2.4±0.5 hours/day for Group 1 and 2.1±0.3 hours/day for Group 2. There was no significant difference between the groups in terms of active years of sports and daily training hours. The energy and nutrient consumption of athletes before supplementation is provided in Table 2. In the study, it was determined that there was no significant difference between the groups in terms of energy and nutrient consumption in the 3-day food consumption of athletes before supplementation (p>0.05). In Group 1 and Group 2 athletes, the average energy was 1876.8±519.6kcal and 1749.3±315.6kcal respectively. The ratios of energy provided from carbohydrates, protein and fat were found to be 45.30±3.89%, 15.40±1.26% and 39.0±3.53% for Group 1 and 46.70±4.62%, 15.0±2.45%, 38.30±4.42% for Group 2 respectively. There was no statistically significant difference between the distribution rates of macronutrients (p>0.05).

Daily magnesium consumption of the athletes in Group 1 and Group 2 was respectively 271.53±90.80mg and 239.77±42.13mg; phosphorus consumption 1147.41±346.36mg and 1017.37±208.77mg; calcium consumption 789.82±292.62mg and 653.29±167.17mg; iron consumption 11.15±3.34mg and 10.27±1.89mg; copper consumption 1.57±0.55µg and 1.44±0.22µg; zinc consumption 10.64±3.43mg and 8.84±2.21mg.

***Table 2*. INITIAL ENERGY AND NUTRIENT CONSUMPTION OF ATHLETES**

Energy and nutrients	Group	n	Mean±SD	Min–Max	t	p
Energy (kcal)	1	10	1876.86±519.60	1287.33–3019.60	0.663	0.515
	2	10	1749.31±315.63	1416.23–2478.72		
Protein (g)	1	10	71.66±25.94	41.74–129.14	0.714	0.484
	2	10	64.68±16.81	43.22–88.92		
Protein (%)	1	10	15.40±1.26	13.00–17.00	0.459	0.652
	2	10	15.00±2.45	12.00–18.00		
Fat (g)	1	10	82.65±27.28	57.85–150.20	0.793	0.438
	2	10	74.84±15.02	53.12–95.39		
Fat (%)	1	10	39.00±3.53	35.00–46.00	0.391	0.700
	2	10	38.30±4.42	32.00–45.00		
Carbohydrate (g)	1	10	205.63±45.86	127.22–282.57	0.311	0.760
	2	10	199.55±41.64	165.30–309.26		
Carbohydrate (%)	1	10	45.30±3.89	38.00–50.00	-0.733	0.473
	2	10	46.70±4.62	38.00–53.00		
Fibre (g)	1	10	17.61±4.72	11.01–27.05	0.444	0.663
	2	10	16.80±3.38	11.85–22.53		
Beta carotene (mg)	1	10	2.81±0.97	1.36–4.16	0.680	0.505
	2	10	2.53±0.91	1.41–4.54		
Vitamin D (µg)	1	10	2.01±3.04	0.34–10.59	U=47.00[1]	0.821
	2	10	1.14±0.41	0.35–1.68		
Vitamin E (mg)	1	10	16.03±3.64	11.85–24.40	0.388	0.702
	2	10	15.37±3.98	9.26–20.66		
Vitamin B_1 (mg)	1	10	0.83±0.29	0.42–1.44	0.688	0.500
	2	10	0.76±0.13	0.54–0.98		
Vitamin B_2 (mg)	1	10	1.45±0.47	0.78–2.26	0.887	0.387
	2	10	1.29±0.31	0.90–1.80		
Niacin (mg)	1	10	11.37±5.35	5.74–24.17	0.075	0.941
	2	10	11.21±3.67	6.67–16.60		
Vitamin B_6 (mg)	1	10	1.34±0.54	0.68–2.41	-0.226	0.824
	2	10	1.38±0.35	1.01–2.16		
Folic acid (µg)	1	10	119.52±35.09	74.28–184.54	0.310	0.760
	2	10	115.59±19.38	85.99–151.03		
Vitamin B_{12} (µg)	1	10	4.18±1.42	2.83–6.96	1.436	0.168
	2	10	3.34±1.20	1.59–4.91		

Continued

***Table 2*. INITIAL ENERGY AND NUTRIENT CONSUMPTION OF ATHLETES**

Energy and nutrients	Group	n	Mean±SD	Min–Max	t	p
Vitamin C (mg)	1	10	118.08±50.42	54.55–201.08	0.817	0.425
	2	10	102.26±34.68	46.71–179.42		
Sodium (g)	1	10	3308.77±1027.52	1591.09–4382.12	0.191	0.851
	2	10	3233.46±705.52	2432.14–4616.61		
Potassium (g)	1	10	2533.72±890.37	1401.91–4067.53	0.629	0.537
	2	10	2339.62±397.83	1761.83–3033.68		
Calcium (mg)	1	10	789.82±292.62	374.21–1170.65	1.281	0.216
	2	10	653.29±167.17	472.03–932.06		
Magnesium (mg)	1	10	271.53±90.80	164.28–483.37	1.003	0.329
	2	10	239.77±42.13	178.39–309.66		
Phosphorus (mg)	1	10	1147.41±346.36	716.27–1849.44	1.017	0.323
	2	10	1017.37±208.77	694.88–1367.45		
Chlorine (g)	1	10	5147.86±1466.22	2695.47–6533.79	0.102	0.920
	2	10	5088.56±1115.72	3855.60–7172.09		
Iron (mg)	1	10	11.15±3.34	6.79–18.51	0.724	0.478
	2	10	10.27±1.89	7.76–13.75		
Zinc (mg)	1	10	10.64±3.43	6.66–17.84	1.389	0.182
	2	10	8.84±2.21	6.15–12.22		
Copper (µg)	1	10	1.57±0.55	0.83–2.77	0.689	0.500
	2	10	1.44±0.22	1.11–1.86		

Since the variable does not show a normal distribution, the Mann Whitney U test was applied for comparisons.

As a result of comparing the nutritional consumption of athletes with RDA, it was determined that both groups consume magnesium (40% of Group 1, 70% of Group 2), phosphorus (20% of Group 1, 20% of Group 2), calcium (50% of Group 1, 80% of Group 2), iron (50% of Group 1, 40% of Group 2) and copper (100% of Group 1, 100% of Group 2) insufficiently. In both groups, no athlete consumed zinc insufficiently. Also, 100% of all individuals consume sodium and potassium more than recommended, while folic acid consumes insufficiently. While there was a significant difference between the energy, protein, fat, carbohydrate and zinc consumption before and after zinc supplementation in Group 1 athletes ($p<0.05$), the difference between energy, protein, and fat consumption in Group 2 athletes was significant ($p<0.05$, Table 3)

The results of the 20m-shuttle run done before and after the zinc supplementation to the athletes are given in Table 4. There is no significant difference between the groups in terms of VO_2 max (ml/kg/min) values measured before and after the zinc supplementation ($p>0.05$, Table 4). Although plasma lactate levels after exercise (both before and after supplementation) showed a significant increase compared to before exercise, no statistically significant difference was found between the plasma lactate levels of the two groups of athletes ($p>0.05$). However, the measured plasma lactate levels of the athletes in Groups 1 and 2 varied significantly according to the weeks of supplementation ($p<0.05$, Table 5).

Table 3. **ENERGY AND NUTRIENT CONSUMPTION OF ATHLETES BEFORE AND AFTER ZINC SUPPLEMENT**

Energy and Nutrients	Group 1		Group 2					
	Before Supp.	After Supp.	Before Supp.	After Supp.	Wilcoxon z_1	p_1	Wilcoxon z_2	p_2
Energy	1876.8±519.6	2121.5±550.2	1749.3±315.6	1935.2±324.7	-2.803	0.005*	-2.090	0.037*
Protein (g)	71.6±25.9	83.1±27.2	64.6±16.8	81.1±23.1	-2.803	0.005*	-2.090	0.037*
Fat (g)	82.6±27.3	96.7±26.7	74.8±15.0	86.9±16.1	-2.803	0.005*	-2.599	0.009*
Carbohydrate (g)	205.6±45.8	229.7±56.1	199.5±41.6	207.1±38.6	-2.497	0.013*	-0.561	0.575
Zinc	10.6±3.4	12.3±3.7	8.8±2.2	9.2±1.6	-2.547	0.011*	-1.051	0.293

*p<0.05

Table 4. **VO_2 MAX (ML/KG/MIN) OF ATHLETES BEFORE AND AFTER ZINC SUPPLEMENTATION**

Supplementation	Group	n	Mean±SD	Mann-Whitney U	p
Before	1	10	37.96±2.89	40.500	0.471
	2	10	38.69±4.62		
After	1	10	40.23±2.91	43.500	0.631
	2	10	40.28±3.57		

Table 5. **PLASMA LACTATE LEVELS OF ATHLETES ACCORDING TO WEEKS ON SUPPLEMENTATIONS**

[*p<0.05]	Group	Supplementation time	n	Mean±SD	Z value	p
Plasma Lactate Level (mmol/L)	1	Before pre-exercise	10	1.78±0.64	33.282	0.000*
		Before post-exercise	10	8.26±1.86		
		After pre-exercise	10	0.95±0.18		
		After post-exercise	10	6.95±1.27		
	2	Before pre-exercise	10	1.98±0.93	33.218	0.000*
		Before post-exercise	10	9.79±2.13		
		After pre-exercise	10	1.13±0.41		
		After post-exercise	10	6.78±1.59		

The results of the Wingate test performed before and after the zinc supplementation to the athletes and whether there is a difference between the groups are given in Table 6. There was no significant difference between the groups in parameters related to anaerobic power (peak power, average power, minimum power, power drop and fatigue index) both before and after zinc supplementation (p>0.05).

Table 6. **ANAEROBIC POWER BEFORE AND AFTER ZINC SUPPLEMENTATION**

Supplementation	Parameters	Group	n	Mean±SD	Mann-Whitney U	p
BEFORE	Peak Power ($W.kg^{-1}$)	1 2	10 10	7.58±1.77 7.70±0.52	41.000	0.496
	Average Power ($W.kg^{-1}$)	1 2	10 10	5.84±1.20 6.04±0.43	45.000	0.705
	Min. Power ($W.kg^{-1}$)	1 2	10 10	3.06±1.28 3.88±0.76	27.000	0.082
	Power Drop ($\%W.kg^{-1}$)	1 2	10 10	4.52±1.18 3.82±0.99	30.000	0.130
	Fatigue Index (%)	1 2	10 10	60.76±13.9 49.31±11.30	25.000	0.059
AFTER	Peak Power ($W.kg^{-1}$)	1 2	10 10	7.95±1.86 7.77±0.58	39.500	0.427
	Average Power ($W.kg^{-1}$)	1 2	10 10	5.84±1.30 5.77±0.50	36.500	0.307
	Min. Power ($W.kg^{-1}$)	1 2	10 10	2.85±1.45 3.49±0.80	40.000	0.450
	Power Drop ($\%W.kg^{-1}$)	1 2	10 10	5.05±2.60 4.28±1.09	46.000	0.762
	Fatigue Index (%)	1 2	10 10	62.77±17.44 54.73±10.88	38.000	0.364

DISCUSSION

Proper nutrition is critical to enable the volleyball player to reach peak performance and replace the lost energy (Papadopoulou *et al*., 2002). The recommended dietary allowance (RDA) is the intake amount that is sufficient to meet the nutrient requirement for nearly all healthy individuals in a group. The RDA is used to guide healthy individuals to achieve adequate nutrient intake and represents a goal for average intake over time. The RDA is expressed as a single value set separately for each gender group and specific age group. If an individual meets or exceeds the RDA for a nutrient, there is a reasonable assurance that the intake is adequate. If the intake is less than the RDA, it can be inferred that there is an increased likelihood that intake is inadequate (Lukaski, 2004). There are no standard RDA values set for athletes. Besides the personal characteristics of each athlete, the features, such as sports branch, training intensity and frequency will be different so that total energy requirements will be different. Considering this situation while evaluating, evaluation is made based on RDA values.

In this study, as a result of the comparison of food consumption with RDA, 40% of athletes consumed magnesium, 20% of athletes consumed phosphorus, 50% of athletes consumed calcium, 50% of athletes consumed iron, 100% of athletes consumed copper insufficiently in Group 1, while 70% of the athletes consumed magnesium, 20% of those consumed phosphorus, 80% of those consumed calcium, 40% of the athletes consumed iron and 100% of athletes consumed copper insufficiently in Group 2. In both groups, no athlete consumed zinc insufficiently. Also, when evaluated in general, 100% of all individuals consume sodium and potassium more than recommended, while folic acid is insufficiently consumed.

Papadopoulou *et al*. (2002), in the study on female volleyball players, indicates that because of a 3-day food record, the mean energy intake of all the athletes was 1648±780kcal/day. Protein intake (16.0±4.9% of total energy intake) was satisfactory, whereas fat consumption (37.5±11.1%) was above recommended values and at the expense of carbohydrate intake (45.9±12.5%). As for micronutrients, the volleyball players fell short of meeting the RDA values for calcium, iron, folic acid, magnesium, zinc, vitamins A, B_1, B_2, and B_6 (Papadopoulou *et al*., 2002). In an investigation on 25 female adolescent volleyball players of Rio de Janeiro (15-20 years old), the zinc intake of the volleyball players was found to be 13.23mg/day. It was determined to be a low level of calcium, folate and vitamin E (Almeida & Soares, 2003). Another study states that women's energy and carbohydrate consumption is low (Pilis *et al*., 2019). It is emphasised that it will be beneficial to educate female athletes about nutritional information and food consumption (Rodriguez *et al*., 2009; Valliant *et al*., 2012).

As a result of the 3-days food consumption record taken before supplement application from the athletes, it was determined that there was no significant difference between the groups in terms of energy and nutrient consumption, especially in the zinc consumption of athletes. It was determined that supplement application causes a significant increase in energy, protein, fat, carbohydrate, and zinc consumption of Group 1 athletes and a significant increase in energy, protein, and fat consumption of Group 2 athletes. No significant difference was found in other nutrients. There are findings that zinc deficiency causes loss of appetite (Baysal, 2018) and that taking it as a supplement increases appetite (Demir, 2019). This situation may explain the increase determined for athletes' daily energy and, consequently, macronutrient consumption.

The emptying in the zinc stores negatively affects the working capacity and muscle strength of the skeletal muscle (Campbell & Anderson, 1987; Rodriguez *et al*., 2009). Zinc deficiency occurs in athletes due to inadequate zinc intake when they consume energy-restricted diets or a vegetarian diet. This situation may lead to an increased risk of injury and delayed recovery. Since some loss may occur during exercise (urine and sweat), zinc supplements are needed if there is an insufficient diet (Fink & Mikesky, 2018). There are findings that zinc supplements may increase muscle strength in athletes with zinc deficiency. (Maxwell & Volpe, 2007). In this study, an attempt was made to determine the effect of 4-week zinc supplements application on the nutritional status and aerobic and anaerobic performance of the volleyball players.

Aerobic capacity is measured by the maximum level of oxygen consumption (VO_2 max). In this study, VO_2 max values were determined as a result of a 20m-shuttle run test before and after four weeks of supplement, and it was determined that zinc supplement did not make a significant difference in both groups in VO_2 max (ml.kg/min). Despite the popularity of zinc supplementation among athletes, there is little quality evidence that zinc can improve athletic performance. Existing evidence relates to short trial periods (1-6 weeks) (Rodriguez *et al*., 2009; Heffernan *et al*., 2019).

There is limited evidence that 20-30mg/day may improve the estimated VO_2 peak, reduce blood viscosity (following high-intensity exercise over a period of one to six weeks) (Heffernan *et al*., 2019) and increase both aerobic and anaerobic power in athletes (McClung, 2019). In a study conducted on basketball players, it was determined that a 6-week zinc supplementation provided significant improvement at the VO_2 maximum level (Arulmozhi & Sundaramoorthy, 2012). The reason for the different results between studies may be that the duration of supplementation should be at least six weeks. On the other hand, athletes should be cautioned against single-dose zinc supplements because they often exceed this amount, and unnecessary zinc supplementation may lead to low HDL cholesterol and nutrient imbalances by interfering with the absorption of other nutrients, such as iron and copper (Rodriguez *et al*., 2009).

As a result of the 20m-shuttle run test administered to the athletes before and after the zinc supplement for four weeks, although plasma lactate levels after exercise (both before and after supplementation) showed a significant increase compared to before exercise, no statistically significant difference was found between the plasma lactate levels of the two groups of athletes. However, although there was no significant difference in plasma lactate levels due to dose difference, it was determined that there was a substantial decrease in both groups compared to pre-supplement.

In a study by İri (2003), the effect of 2mg/kg/day zinc given to athletes for 15 days with wrestling training on blood lactic acid levels was examined, and zinc loading caused lactic acid to be released later and fatigue to occur later. In another study conducted on rats, it was determined that zinc supplements caused a decrease in lactate levels after swimming exercise with zinc loading for four weeks (Kaya *et al*., 2006). A study involving sedentary individuals, determined that a 4-week zinc supplementation increased the VO_2 max level, while it caused a significant decrease in lactate level compared to before supplementation (Kilic *et al*., 2018). The results of the studies are in parallel with each other.

Anaerobic power measurement is vital in determining the peak power, maximum power, mean power, and fatigue index (Zupan et al., 2009). In this study, two different dosages of zinc supplements for both groups did not differ in anaerobic performance (peak power, average power, minimum power, power drop, and fatigue index). However, in some studies, it is stated that multivitamin/mineral supplements increase anaerobic performance and reduce fatigue (Fry *et al*., 2006). In a study conducted on female futsal players, it was determined that high-intensity interval training with zinc supplements for six weeks increased aerobic and anaerobic performance (Saeedy *et al*., 2016). Although there are studies suggesting that anaerobic performance may increase depending on the training methods (repetitive sprint type) in volleyball players (Kaynak *et al*., 2017), no studies were found on the effect of zinc supplements without changing the training programme.

CONCLUSION

As a result, it was determined that two different dosages of zinc supplements given to athletes did not cause any difference aerobic and anaerobic performance of athletes. Zinc supplementation caused a significant increase in daily energy, protein, and fat intakes in both groups. However, a substantial decrease in plasma lactic acid level was determined in both groups compared to pre-supplement. Based on the results obtained, it is said that the zinc supplement does not change the aerobic, anaerobic performance regardless of the dose difference, but since it decreases the lactic acid level, it may reduce fatigue and thus contribute to the athlete's performance.

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