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ORIGINAL ARTICLE

The Effect of Swimming Training on Bone Mineral Metabolism in Female Swimmers

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ABSTRACT
In this study, the effects of 8-week swimming training applied to swimmers aged 19-25 on bone alkaline phosphatase (bALP), magnesium, calcium, Unsaturated Iron Binding Capacity (UIBC), iron and ferritin parameters were investigated. Mean age of 23.12±5.46 years, 12 swimmers participated in the study. A swimming training program was applied to the participants for 8 weeks/3 days. All tests and measurements were performed before starting the 8-week training program and after the program was completed. The data obtained from the study were analyzed using the SPSS 15.0 package program. The normality distribution of the data was made with the shapiro-wilk test, and the pre-post-test measurements of the participants were analyzed with the Wilcoxon signed-rank test. According to the results of the data, it was determined that there was a statistically significant difference between the metabolic rate, iron, UIBC pre-post test data. ($p<0.05$). As a result, it can be said that the 8-week swimming training program, which is applied regularly, can positively affect performance with the changes in bone mineral metabolism.
Keywords: Ferritin, alkaline phosphatase, calcium, magnesium, metabolic rate

INTRODUCTION
Iron is a mineral found naturally in many foods and can also be used as a dietary supplement, and it has a function in many biochemical reactions in the human body (Domínguez, et al., 2014). Iron; It is one of the most important minerals in terms of oxygen transport, storage, playing a role in DNA synthesis and functions in the body as a pro-oxidant. Iron is a key element required for oxygen delivery to tissues and utilization of oxygen at cellular levels. If the athlete has iron deficiency, there is a possibility that the athlete gets tired easily after exertion. Iron deficiency anemia is diagnosed when the total iron binding capacity is higher than 400 µg/dL, hemoglobin is 12 g/dL in men and less than 13 g/dL in women. The upper limit of iron (UL) is 45 mg for adults (Dietary, 2017).

Ferritin is the main iron storage protein in cells. When the iron level in the cell is low, the ferritin level also decreases. At high iron levels, the ferritin concentration also increases. Ferritin is synthesized as apoferritin, and when iron is bound, it is called ferritin. 1 µg of ferritin is equivalent to approximately 10 mg of body iron storage. Serum ferritin level, which can vary between 18-250 µg/L, may increase or decrease in inflammation and stress states, since ferritin is an acute phase reactant (Arosio et al., 2014).

Bone alkaline phosphatase (bALP) is a membrane-bound osteoblast enzyme and a specific product of osteoblasts. Bone-specific alkaline phosphatase accounts for approximately 50% of circulating bALP in normal individuals (Rosemary et al., 2006). It is a glycoprotein localized in the osteoblast plasma membrane. Its exact role in the bone formation process is unknown, but it is thought to be involved in the calcification of the bone matrix. As a result of increased osteoblastic activity, the serum level rises (Serafini, 2001). Fujimura et al. (1997) reported that bone alkaline phosphatase activity, one of the most important biochemical markers of bone formation, increased significantly in the first month of the program and remained high until the end, during four months of high-intensity endurance exercise in 17 men aged 23-31. reported that they remained. In serum, bone alkaline phosphatase activity reflects bone mineralization and bone formation (Fujimura et al. 1997).

Energy expenditure in swimming; It occurs due to the body's progress on the water surface and acting against water resistance. Bone mineral density is very important in swimmers because lean muscle mass is effective and swimming is a low-impact sport. In the light of this information, the effect of exercise program applied to swimmers on bone mineral metabolism was investigated.

Statistical analysis: The data obtained from the study were analyzed using the SPSS 15.0 package program. The normality distribution of the data was made using the shapiro-wilk test. Participants' pre-post test measurements were analyzed with the Wilcoxon signed-rank test. All parameters of the participants were shown as minimum, maximum, mean and standard deviation. The significance value was accepted as $p<0.05$.

METHOD
Female athletes (N=12) with a mean age of 23.12±5.46 years participated in the study and the training was carried out under the supervision of expert trainers. After the participants were informed about the study, they signed a "voluntary consent form" declaring that they voluntarily participated in the study.

Training Protocol: Swimming training was applied to the participants for 2 hours a week for 8 weeks/3 days. The exercises started with 20 minutes of warm-up exercises. Warm-up exercises consisted of 10 minutes of warm-up run, 10 minutes of mobility and flexibility exercises. The main working phase of the training lasted 60-80 minutes. 20 minutes were finished with cooling movements (Table 1).

Table 1. Swimming training program

Days	Program
Monday	Dynamic Warm-up 50 meters freestyle swimming, 50 meters footstroke (hands fixed in front of the body), Main Set 4X50m Free kick interval 1min' (200 free kicks). 4X100m mixed style break 1min' (30 seconds rest in every 100m) 2X100m back max swimming interval 1min' 2X100m breaststroke swimming interval 1min' cooling down 200m freestyle slow swim & 25X4m Back deep arm slow swim
Wednesday	Dynamic Warm-up 50 meters freestyle swimming, 50 meters footstroke (hands fixed in front of the body). Main Set 2x100m free preferential foot kick interval 1min (30 s rest per 100m). 2x100m butterfly technical swimming 100m. 30 sec rest between 2x100m breaststroke 500m free technique broken 3 min break 10X25 freestyle, breaststroke, back, butterfly cooling down 200m 25m breaststroke slow & 25m back slow
Friday	Dynamic Warm-up 100m freestyle 50m breaststroke slow pace Main Set 300m preferential kick free 300m backstroke unlimited 300m breaststroke, no kicks 300m butterfly 300m mixed four styles 300m freestyle cooling down 200m 25m breaststroke slow & 25m back slow

Anthropometric Measurements: In our study, height measurement was measured with a Seca 769 (Hamburg, Germany) brand device while the athlete was barefoot on a flat surface (Akyüz et al., 2020), and body weight was measured with a Tanita (Innerscan BC532/ Japan) brand device.

Blood Measurement: Biochemical analyzes were performed with venous blood samples (9 ml) taken by experts at the Siirt Training and Research Hospital Public Health Laboratory between 08:00 and 10:00 in the morning after 12 hours of fasting. In the samples taken; bone alkaline phosphatase (bALP), magnesium, calcium, Unsaturated Iron Binding Capacity, (UIBC), iron and ferritin tests were studied. Serum and plasma samples separated by centrifugation were stored at -80 °C and were studied collectively. Measurements were made before and after 8 weeks of complete rest for 48 hours (Girginer et al., 2019; Doğru et al., 2021).

RESULTS

The demographic information of the swimmers participating in the study (age 23.12±5.46, height 164.8±5.32, BW 55.15±9.13, fat ratio 24.58±5.64, BMI 20.34±2.96) is shown in Table 2.

Table 2. Descriptive Parameters of Participants

Parameters	Minimum	Maximum	Mean ± SD
Age (year)	19	25	23.12±5.46
Height (cm)	154.00	170.00	164.8±5.32
BW (kg)	41.10	68.00	55.15±9.13
Fat ratio (%)	18.50	36.20	24.58±5.64
BMI (kg/m^2)	17.20	25.60	20.34±2.96

The comparison of the pre-test and post-test values of the 8-week swimming training program is shown in Table 3. According to this; Statistically significant difference was found between metabolic rate, iron, UIBC pre-post test data ($p<0.05$). Although not statistically significant, there was a decrease in body weight, fat ratio, body mass index, and an increase in muscle mass.

Table 3. Comparison of Participants' Pre- and Post-Test Values

Parameters	Pre Test		Post Test		P
	Min-Max.	Mean ± SD	Min-Max.	Mean ± SD	
BW (kg)	41.10-68	55.15±9.13	41.40-68.10	53.82±8.26	.215
Fat ratio (%)	18.50-36.20	24.58±5.64	14.40-36.20	22.83±6.52	.125
Muscle mass (kg)	17.90-27.10	22.45±3.13	18.20-35.30	24.40±2.35	.095
BMI (kg/m^2)	17.20-25.60	20.34±2.96	17-25.60	20.18±2.76	.325
Metabolism speed (kcal)	1093-1426	1260.77±112.48	1101-1890	1324±86	.049*
Waist/hip ratio	.74-.89	.81±.05	.75-.89	.82±.04	.254
Calcium (mg/dl)	9.43-10.10	9.82±.22	9.20-10.20	9.62±.32	.112
Magnesium (mg/dl)	1.82-2.60	2.01±.25	2.12-2.26	2.17±.05	.354
bALP (U/L)	46-64	51.14±6.28	41-62	49±21.7	.079
Iron (ug/dl)	17-70	43.42±20.02	19-98	57.11±22.82	.020*
UIBC (ug/dl)	165-393	248.81±66.27	225.4-331.2	296.25±40.07	.012*
Ferritin (ng/ml)	5.80-23	14.91±6.23	7.20-49	18.32±14.42	.089

$p<0.05$

DISCUSSION

Various studies have been carried out to date to determine body structure and performance on athletes. It is known that physical activity or mechanical loading is a necessary and important factor in increasing bone density and strength. In the study of Jürimäe et al., it was reported that there was a moderate relationship between the performance of swimmers in the pre-adolescent and early adolescence period and their body muscle mass density, and that lean muscle mass positively affected swimming performance (Jürimae et al., 2007).

Kara (2012) investigated the effects of a 24-week exercise program on calcium, sodium, potassium, iron and magnesium parameters in young men. As a result, while significant changes were detected in calcium, potassium and sodium parameters, he reported that the exercise program he applied did not change magnesium and iron levels. In our study, a decrease in sodium levels and an increase in magnesium were detected with swimming exercises.

Çay et al., (2017) investigated the effects of aerobic running and quick strength exercises on body composition, maximal oxygen consumption (MaxVO2), bone mineral density (BMD) and bone turnover (turn-over) markers bALP in men aged 20-40 years and bALP significantly increased. In our study, no significant difference was observed in terms of bALP.

Büyükyazı et al., (2017) reported that iron, ferritin and total iron binding capacity increased in the brisk walking group (BWG) in their study examining the chronic effects of walking exercises on markers of iron metabolism in premenopausal women. Yücer (2019) examined the effect of an 8-week training program on mineral levels in 11-12 age group swimmers. As a result; stated that there was no statistically significant difference in sodium, calcium, potassium, magnesium and iron values ($p>0.05$).

The formation and development of bone tissue necessary for a healthy skeleton is dependent on hormonal, nutritional and mechanical factors. The deficiency of any of these factors adversely affects bone tissue and causes bone loss. Teegarden et al., (1996), based on the assumption that exercise accelerates bone development and reduces the risk of osteoporosis, in a study conducted on 204 sedentary and weight-bearing young women, they reached results showing that bone density depends on age, type and level of activity. In addition, it is stated that physical activity programs in which low and high loading for 3 days a week and 20 minutes a day for a year are effective in bone restructuring of women who have just entered menopause (Grove & Londeree., 1992). Karacan and Çolakoğlu (2018) reported that regular and long-term moderate-intensity aerobic exercises performed in the premenopausal period will reduce the risk of osteoporosis and related fractures, which are frequently seen after menopause, and may be effective in preserving bone mineral density. İlçin and Hazar (2020) investigated the effect of physical activity level and sports history in middle-aged individuals on bone mineral density of individuals with a sports background and sedentary life. It has been determined that the bone mineral density of individuals with a sports background is better than the bone mineral density of individuals with a sedentary life. This also reported that sports history has positive effects on bone mineral density. The results of this study, it is possible to say that the 8-week swimming training program has a positive effect on metabolic rate, iron and UIBC. The application of our training program to women between the ages of 19-25 may have positive effects on bone metabolism.

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