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Assessment of the relation of serum iron and ferritin levels to isokinetic muscle strength in elite athletes without anemia

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SUMMARY

Iron is an important mineral for the human body. In case of iron deficiency, problems in energy production and utilization occur. The energy required during exercise, and therefore the performance, is related to body iron levels. This study was performed to determine the relationship between isokinetic muscle strength and serum iron and ferritin levels. A total of 278 nonanemic elite athletes were included in the study. Serum iron and ferritin levels were determined, and the relationship between these levels and the results of isokinetic muscle strength measurements was investigated using Spearman correlation test. The relationship between the serum iron levels and isokinetic muscle strength was found to be statistically negligible ($P > 0.05$). However, ferritin levels were correlated with isokinetic muscle strength values ($P < 0.05$). In conclusion, iron was found to be associated with performance in athletes without anemia.

Key words: Ferritin, iron, isokinetic muscle strength, serum iron, sport performance

INTRODUCTION

Iron is a vital mineral for the human body. It is involved in oxygen transport, antioxidant defense reactions, and electron transport chain of oxidative phosphorylation (1, 2). About 80% of the iron is actively used (hemoglobin, myoglobin, enzymes, and so forth), and the remaining is stored as an inactive iron depot in the human body (2). The most important regulator of this balance is the peptide-structured hormone "hepcidin" (3). Hepcidin reduces iron absorption from enterocytes and inhibits iron mobilization from macrophages and liver deposits to plasma (3). This balance can be deteriorated by a variety of factors, and iron deficiency may occur. Iron deficiency is common in both the normal population and the athletes (4). Lack of dietary intake, blood loss, and inadequate absorption due to gastrointestinal system pathologies can cause iron deficiency (5). Iron deficiency is more common in women due to menstrual losses (5). Besides, high-intensity exercise increases hepcidin levels and these high levels can lead to iron deficiency (6-8).

Several tests are used to identify iron deficiency, including hemoglobin (Hb), mean cellular volume, mean cellular hemoglobin, serum iron, and ferritin (2). According to the severity of the deficit, the clinical status is defined as iron deficiency or iron deficiency anemia.

Performance parameters such as aerobic capacity, muscle strength, fatigue, and recovery after exercise are negatively affected by iron deficiency (2, 9). Some of the studies in the literature showed that these parameters are affected without anemia (10-13). Hence, it was suggested that the lower limit of normal iron levels of athletes should be higher than that of other individuals (2).

The aim of this study was to determine the associations of "serum iron" and "ferritin" levels with isokinetic muscle strength in nonanemic elite athletes so as to emphasize the importance of iron levels without anemia in sport performance.

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MATERIALS AND METHODS

Participants were selected from athletes who were in the camp with their national teams. A total of 278 elite nonanemic athletes without musculoskeletal problems, who had not exercised in the last 24 h, were included in the study. The distribution of participants according to their gender and branches is shown in Table 1. This study was designed according to the Declaration of Helsinki and approved by Yıldırım Beyazıt University School of Medicine Ethical Committee. All participants were fully informed about the study, and they all signed written informed consent.

Fasting blood samples were collected from the antecubital vein using two evacuated tubes [one containing EDTA and the other glued tube with a clot activator (SST II Advance)]. After collection, the blood samples were assessed for Hb and serum iron and ferritin. SYSMEX CBC XT2000İ and Bio-System A25 machines were used for the analysis.

Isokinetic muscle strength measurements were performed on participants without anemia and musculoskeletal complaints. Measurements were applied to the participant's dominant leg knee flexor and extensor muscles at 60°/s and 180°/s velocities. ISOMED 2000 (D.&R. Ferstl GmbH, Hemau, Germany) was used for the measurements. The peak torque (PT) values obtained as a result of the measurements were used for statistical analysis.

The distribution of variables was examined using Kolmogorov–Smirnov test, and the variables were not found to be distributed normally. Spearman correlation test was used to measure the degree of relationship between blood sample results and strength parameters. The level of significance was set at $\alpha = 0.05$. SPSS 20.0 was used for data analysis.

RESULTS

The age, height, weight, and body mass index (BMI) values of the subjects are shown in Table 2. Hb and ferritin and serum iron levels are shown in Table 3. Isokinetic PT values are shown in Table 4.

The relationship between ferritin and PT values of the subjects is shown in Table 5. The athletes' ferritin values were found to be positively correlated with the PT values ($P < 0.05$).

The relationship between serum iron and PT values of the subjects is shown in Table 6. The serum iron values were found to be moderately positively correlated with PT values ($P < 0.05$).

Table 1: Branches and genders of the participants.

	Male	Female	Total
Artistic gymnastics	22	26	48
Beach volley	5	8	13
Biathlon	9	7	16
Boxings	18	0	18
Ice hockey	0	14	14
Ice skate	10	1	11
Soccer	12	0	12
Greco-Roman wrestling	19	0	19
Judo	52	23	75
Rowing	18	11	29
Freestyle wrestling	0	22	22
Taekwondo	1	0	1
Total	166	112	278

Table 2: Age, height, weight, and BMI of participants.

	Mean	Standard deviation
Age	19.17	4.26
Height (cm)	169.37	13.20
Weight (kg)	66.60	16.38
BMI	23.39	10.24

Table 3: Hb and ferritin and serum iron levels.

	Mean	Standard deviation
Hb	13.98	1.27
Ferritin	57.32	37.34
Serum Iron	86.85	33.58

Table 4: Isokinetic peak torque.

	Mean	Standard deviation
60°/s Flexion PT	101.41	34.72
60°/s Extension PT	190.75	61.51
180°/s Flexion PT	78.97	26.42
180°/s Extension PT	128.21	39.48

Table 5: Spearman correlation of ferritin and peak torque measurements.

	60°/s Flex	60°/s Ext	180°/s Flex	180°/s Ext
Correlation C.	$p = 0.355$*	$p = 0.322$*	$p = 0.333$*	$p = 0.351$*
Significance	P < 0.01	P < 0.01	P < 0.01	P < 0.01

*Correlation is significant at the 0.01 level (two-tailed).
Ext: extension; Flex: flexion.

Table 6: Spearman correlation of serum iron and peak torque measurements.

	60°/s Flex	60°/s Ext	180°/s Flex	180°/s Ext
Correlation C.	$p = 0{,}153$**	$p = 0{,}186$**	$p = 0{,}143$**	$p = 0{,}146$**
Significance	P = 0.011	P = 0.002	P = 0.017	P = 0.015

**Correlation is significant at the 0.05 level (two-tailed).
Ext: extension; Flex: flexion.

DISCUSSION

The aim of this study was to determine the association of serum iron and ferritin levels with isokinetic muscle strength in nonanemic elite athletes. The significant findings of this study were as follows: (1) Serum ferritin levels were found to be weakly correlated with isokinetic muscle strength (14). (2) The relationship between SI and isokinetic muscle strength was found to be negligible (14). The results of the present study were consistent with a study in which iron deficiency was associated with muscle strength without anemia (15).

Several studies investigated the effects of iron levels and iron supplements on sport performance (16,17). In a study involving 15 athletes with iron deficiency, intravenous iron fortification increased ferritin levels but did not have an effect on aerobic capacity (16). In a study of nonanemic female athletes with iron deficiency, iron supplementation increased ferritin levels but did not have any effect on fatigue (17). Studies suggesting that iron supplements do not have a meaningful effect on performance support the weak correlation between ferritin levels and sport performance.

However, some studies support the correlation between iron levels and sport performance. In a study investigating the effect of intravenous iron supplementation on serum ferritin levels and long-distance running performance, the ferritin and VO2max values of the participants significantly increased, but this change did not occur in the oral iron supplement group (18). In another study conducted on female rowing athletes, iron supplementation was found to increase ferritin levels and lower lactate response compared with the control group (19). Iron supplementation to sedentary individuals without anemia significantly improved VO2max values compared with the control group (12). In another study with 40 elite athletes who did not have anemia, iron supplementation was found to increase ferritin levels and VO2max (20).

The aforementioned findings indicate that the relationship between iron levels and athletic performance is controversial. This is probably because that ferritin is an acute-phase reactant and its values change with inflammatory events (21-23). Another reason is thought to be the effect of hepcidin secreted after intense exercise on ferritin levels (6-8). Iron is vital for the contraction of especially slow (oxidative) fibers (24-27). Hence, isokinetic muscle strength was measured in the present study. Differences between types of exercise can be regarded as another reason for differences in the findings (28), which was consistent with the findings of the present study.

In conclusion, body iron levels are thought to be related especially to aerobic exercise performance. Serum ferritin levels, used as body iron indicator, are affected by many factors, thereby influencing the relation of body iron levels to athletic performance.

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