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Original Article

Effect of Mild Resistance Exercise on Serum Levels of Iron, Zinc, and Copper in Male Collegiate Recreational Bodybuilding Athletes: A Cross-sectional Study

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Abstract

Physical activity plays a crucial role in regulating whole-body metabolism, including the metabolism of minerals and trace elements, which are essential components of various metabolic pathways. Research has demonstrated that minerals such as iron (Fe), copper (Cu), and zinc (Zn) are involved in critical cellular processes, including antioxidant defense systems and cellular signaling, and their levels can significantly influence athletic performance. Therefore, this study aimed to investigate the differences in serum levels of Fe, Cu, and Zn between athletic and sedentary populations. Serum concentrations of Zn, Fe, and Cu were measured using commercially available kits in 60 healthy young male students, who were divided into two groups: athletes and sedentary individuals. An independent T-test was employed to assess differences in mineral levels between the groups, while the Pearson correlation coefficient was used to evaluate the relationships between Fe, Cu, and Zn levels and age as well as body mass index (BMI). The results revealed that the athletic group had significantly higher serum Fe levels compared to the sedentary group (p-value = 0.012). However, no significant differences were observed in the concentrations of Zn and Cu between the two groups. Additionally, a significant correlation was found between Zn levels and age within the athlete group. These findings suggest that exercise, particularly mild resistance training, may enhance Fe status, leading to higher serum Fe levels in athletes. Furthermore, the study indicated that recreational bodybuilding athletes do not require Cu and Zn supplementation, as the levels of these elements were found to be sufficient in the athlete group. This highlights the importance of regular physical activity in maintaining optimal mineral balance and suggests that targeted supplementation may not be necessary for individuals engaged in recreational bodybuilding.

Keywords: Exercise, Trace Elements, Minerals, Iron, Zinc, Copper.

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Introduction

The impact of physical activity on mineral metabolism in body fluids remains one of the least explored areas in exercise physiology [1]. It is well-established that physical activity induces numerous metabolic changes in the human body, and intensive training can increase the demand for essential minerals due to heightened degradation rates or elevated losses [2–4]. Recent studies have suggested that exercise may alter serum levels of various biological minerals [5, 6]. These changes are particularly significant given the critical roles minerals play in metabolic processes and antioxidant activities [7, 8].

Although trace element concentrations are tightly regulated by homeostatic mechanisms, fluctuations in their levels in organs and body fluids can negatively affect athletic performance [9]. Among these trace elements, iron (Fe), zinc (Zn), and copper (Cu) are especially vital for optimal performance during acute exercise [10, 11]. These essential elements are required in varying amounts in the human body [3]. For instance, Zn and Cu are integral components of the major cellular antioxidant enzyme, Cu-Zn superoxide dismutase (Cu-Zn-SOD) [12]. Deficiencies in Cu can impair bodily functions and reduce physical performance [3], while Zn, which is widely distributed in human tissues, plays a key role in maintaining structural integrity and supporting the enzymatic functions of metalloenzymes, particularly in skeletal muscle [13]. Iron, on the other hand, is involved in numerous exercise-related processes, but its status can be influenced by exercise through mechanisms such as foot strike hemolysis, exercise-induced inflammation, and losses via sweat or urine [14].

While much of the research on exercise-induced changes in mineral status has focused on aerobic forms of exercise, there is limited understanding of how resistance training, such as bodybuilding, affects mineral metabolism. This study aimed to investigate differences in serum Fe, Cu, and Zn levels between resistance-trained athletes and sedentary individuals, as well as to determine whether resistance exercise, like bodybuilding, induces significant changes in serum mineral concentrations.

Study Design and Methodology

This cross-sectional case-control study included 60 healthy young male students aged 20–30 years. Participants were recruited and screened at Shiraz University of Medical Sciences (SUMS) based on specific inclusion and exclusion criteria. The study population was divided into two groups:

1. Athlete Group: Bodybuilders who engaged in heavy resistance training at least three times per week.
2. Control Group: Sedentary individuals who did not participate in any regular sports or physical activities, such as bodybuilding, football, running, or swimming.

All participants were college students residing in SUMS dormitories and shared a similar diet without any supplementation of iron (Fe), zinc (Zn), or copper (Cu). Individuals with a history of smoking, underlying diseases (e.g., diabetes, malignancy, cardiovascular or hematological disorders), or other chronic conditions, as well as those who were ill during the study period, were excluded. Simple random sampling was used to allocate participants to the two groups. Written informed consent was obtained from all participants, and the study protocol was approved by the Ethics Committee of SUMS.

Laboratory Assessments

A 5 mL blood sample was collected from each participant between 8:00 and 9:00 AM after a 24-hour period without exercise. Blood samples were drawn into clot tubes and centrifuged at

3000 × g for 10 minutes to separate the serum. The serum was then stored at -20 °C until further analysis. Serum levels of zinc and copper were measured using commercially available kits (Pars Azmoon, Iran) and analyzed with a Hitachi autoanalyzer (Hitachi Medico 717, Japan).

Statistical Analysis

Data analysis was performed using SPSS version 25.0 (SPSS, Inc., Chicago, IL, USA). An independent T-test was used to compare the differences in mineral levels (Fe, Cu, and Zn) between the athlete and control groups. The Pearson correlation coefficient was calculated to assess the relationships between mineral levels and age or body mass index (BMI). A two-sided *P*-value of < 0.05 was considered statistically significant.

Results

As shown in Table 1, there were no significant differences between the athlete and non-athlete groups in terms of age or body mass index (BMI). The mean ± standard deviation (SD) for the concentrations of each trace element (Fe, Cu, and Zn) is presented in Figure 1.

Table 1. The mean (± SD) for characteristics of athletes and non-athletes.

Characteristics	Athletes (N=30)	Non-athletes (N=30)	P-value
Age	25.86 ± 3.14	25.23 ± 2.81	0.41
BMI (kg/m²)	22.5 ± 1.7	25.9 ± 1.69	0.66

SD= standard deviation, BMI=body mass index.

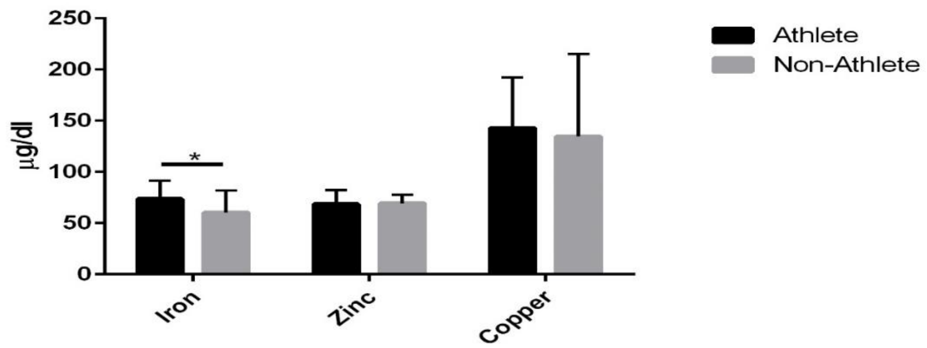

Figure 1. Comparison of iron, zinc and copper in athletic and non-athletic groups.
* Significant difference when compared to non-athlete group.

Compared to the non-athlete group, the athletic group exhibited significantly higher serum iron levels (p = 0.012). Although copper levels were slightly elevated in the athletic group, this difference was not statistically significant (p = 0.62). No significant differences were observed in zinc or iron concentrations between the athlete and non-athlete groups. Pearson correlation analysis revealed a significant positive correlation between zinc levels and age in the athlete group (r = 0.42; Table 2).

Table 2. Pearson correlation coefficient between elements with age and BMI.

	Age		BMI	
	Athletes	**Non- Athletes**	**Athletes**	**Non- Athletes**
Iron	-0.058	-0.136	0.342	0.006
Copper	0.106	0.065	0.087	-0.063

Zinc	0.422*	0.240	0.177	0.174

bmi=body mass index, * p-values are statistically significant.

Discussion

The primary aim of this study was to evaluate the effects of mild resistance exercise and age on serum levels of trace elements, including iron, zinc, and copper. Our findings revealed that recreational bodybuilding athletes engaging in mild resistance exercise had significantly higher serum iron levels compared to their sedentary counterparts. These results align with previous studies demonstrating that mild resistance exercise improves iron status in the body [15–20]. While earlier research suggests that mild exercise does not enhance iron absorption from the gastrointestinal tract [16–18], it may promote iron recycling within the body, thereby improving iron status. The elevated iron levels in moderately active individuals indicate that moderate physical activity could help maintain iron levels, particularly when dietary intake is insufficient. Matsuo et al. [19] demonstrated that even a brief daily dumbbell exercise (15 minutes) could improve iron status in young females with non-anemic iron deficiency, highlighting the potential economic advantages of exercise as a strategy to combat iron deficiency, especially in developing countries with high rates of iron deficiency [16].

In contrast, endurance exercises such as long-distance running and swimming have been associated with detrimental effects on iron levels due to factors like gastrointestinal hemorrhage, sequestration of iron in macrophages, and reduced iron absorption caused by increased hepcidin production during inflammation [16, 18, 21–23]. Our findings further emphasize that the impact of exercise on iron status varies depending on the type and intensity of physical activity [18].

Regarding zinc metabolism, while the effects of acute endurance exercise have been well-documented, the long-term effects of regular exercise training on zinc status remain unclear [24]. A recent meta-analysis by Chu et al. [24] reviewed six studies, with three supporting our findings of no significant difference in serum zinc levels between athletes and sedentary individuals. However, two studies reported increased serum zinc levels in athletes, while one observed lower levels in the exercise group. Notably, our study is the first to examine the effects of mild resistance exercise on serum zinc levels in recreational bodybuilding athletes, as previous research primarily focused on aerobic or mixed aerobic-anaerobic activities. Further studies are needed to clarify the relationship between exercise type and zinc status.

For copper, our results showed a non-significant increase in serum levels among athletes compared to the sedentary group. These findings are consistent with Maynar et al. [3], who reported non-significant increases in serum copper levels in anaerobic athletes. However, other studies have observed significant increases in copper levels following endurance-strength training [25] or in moderately active individuals [26], suggesting that moderate activity may help maintain copper levels in individuals with inadequate dietary intake. Conversely, some studies found no significant changes in copper levels among athletes [27–29], reinforcing the notion that physical training does not adversely affect copper status.

Limitations

This study has several limitations. To fully understand the metabolic behavior of each trace element, additional biological matrices such as urine or sweat should be analyzed. For a comprehensive assessment of iron metabolism, parameters like transferrin, ferritin, unsaturated iron-binding capacity, and total iron-binding capacity should be included. Similarly, detailed investigation of copper metabolism would require additional markers such as serum ceruloplasmin and superoxide dismutase activity.

One strength of this study is the inclusion of only male participants, which eliminated gender-related confounding factors. Additionally, all participants were students from the same institution, consumed meals from the same canteen, and were evaluated during a single time point in winter, minimizing variations due to diet and seasonality.

Conclusion

This study demonstrated that mild resistance exercise significantly increases plasma iron levels compared to a sedentary lifestyle, suggesting that moderate physical activity may help maintain iron levels when dietary intake is insufficient. Furthermore, plasma copper and zinc levels were well-maintained in the athletic group without supplementation, indicating that recreational bodybuilding athletes do not require additional supplementation if their dietary intake is adequate. These findings highlight the importance of exercise type and intensity in influencing trace element status and provide valuable insights for optimizing nutritional strategies in athletes.

Abbreviations

Fe: Iron; **Zn**: Zinc; **Cu**: Copper; **BMI**: Body Mass Index; **SD**: Standard Deviation; **SUMS**: Shiraz University of Medical Sciences; **Cu-Zn-SOD**: Copper-Zinc Superoxide Dismutase.

Ethical approval

The Ethics Committee of Shiraz University of Medical Sciences (SUMS) exempted this study from requiring a specific code of ethics. All participants provided written informed consent, and their personal information was kept confidential and protected throughout the study.

Availability of data and materials

Please contact the corresponding author if you would like access to the datasets used and/or analyzed during this study.

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Authors' Contribution

M.S: Contributed to the study design, data collection, and analysis, particularly in the hematology aspects; **P.N.S.**: Participated in the biochemical analysis and interpretation of trace element data; **M.F.**: Conducted statistical analysis and data interpretation; **M.E.**: Assisted in biochemical assessments and laboratory work; **G.T.**: Supervised the study, contributed to the study design.

Acknowledgment

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Consent for publication

The authors provided their consent for the publication of the study results.

Competing interests

The authors declare no competing interests.

References

[1]. Maynar M, Muñoz D, Alves J, Barrientos G, Grijota FJ, Robles MC, et al. Influence of an acute exercise until exhaustion on serum and urinary concentrations of molybdenum, selenium, and zinc in athletes. Biological trace element research. 2018;186(2):361-9. https://doi.org/10.1007/s12011-018-1327-9

[2]. Jablan J, Inić S, Stosnach H, Hadžiabdić MO, Vujić L, Domijan A-MJJoTEiM, et al. Level of minerals and trace elements in the urine of the participants of mountain ultra-marathon race. 2017;41:54-9. https://doi.org/10.1016/j.jtemb.2017.02.004

[3]. Maynar M, Llerena F, Bartolomé I, Alves J, Robles M-C, Grijota F-J, et al. Seric concentrations of copper, chromium, manganesum, nickel and selenium in aerobic, anaerobic and mixed professional sportsmen. Journal of the International Society of Sports Nutrition. 2018;15(1):8. https://doi.org/10.1186/s12970-018-0212-4

[4]. Dressendorfer RH, Petersen SR, Lovshin SEM, Keen CLJIjosn, metabolism e. Mineral metabolism in male cyclists during high-intensity endurance training. 2002;12(1):63-72. https://doi.org/10.1123/ijsnem.12.1.63

[5]. Soria M, González-Haro C, Ansón M, López-Colón JL, Escanero JFJJoteim, biology. Plasma levels of trace elements and exercise induced stress hormones in well-trained athletes. 2015;31:113-9. https://doi.org/10.1016/j.jtemb.2015.04.004

[6]. Maynar M, Llerena F, Grijota FJ, Alves J, Robles MC, Bartolomé I, Muñoz D. Serum concentration of several trace metals and physical training. Journal of the International Society of Sports Nutrition. 2017 Dec;14:1-5. https://doi.org/10.1186/s12970-017-0178-7

[7]. Dalbo VJ, Roberts MD, Hassell SE, Moon JR, Kerksick CM. Effects of a mineral antioxidant complex on clinical safety, body water, lactate response, and aerobic performance in response to exhaustive exercise. International journal of sport nutrition and exercise metabolism. 2010;20(5):381-92. https://doi.org/10.1123/ijsnem.20.5.381

[8]. Kara E, Gunay M, Cicioglu İ, Ozal M, Kilic M, Mogulkoc R, et al. Effect of zinc supplementation on antioxidant activity in young wrestlers. Biological trace element research. 2010;134(1):55-63. https://doi.org/10.1007/s12011-009-8457-z

[9]. Wang L, Zhang J, Wang J, He W, Huang H. Effects of high-intensity training and resumed training on macroelement and microelement of elite basketball athletes. Biological trace element research. 2012;149(2):148-54. https://doi.org/10.1007/s12011-012-9420-y

[10]. Zhao J, Fan B, Wu Z, Xu M, Luo Y. Serum zinc is associated with plasma leptin and Cu–Zn SOD in elite male basketball athletes. Journal of Trace Elements in Medicine and Biology. 2015;30:49-53. https://doi.org/10.1016/j.jtemb.2014.10.005

[11]. Martínez AC, Cámara FJN, Vicente GVJBter. Status and metabolism of iron in elite sportsmen during a period of professional competition. 2002;89(3):205-13. https://doi.org/10.1385/BTER:89:3:205

[12]. Zhang K, Zhang Y, Zi J, Xue X, Wan Y. Production of human Cu, Zn SOD with higher activity and lower toxicity in E. coli via mutation of free cysteine residues. BioMed research international. 2017;2017. https://doi.org/10.1155/2017/4817376

[13]. Chu A, Petocz P, Samman S. Plasma/serum zinc status during aerobic exercise recovery: a systematic review and meta-analysis. Sports Medicine. 2017;47(1):127-34. https://doi.org/10.1007/s40279-016-0567-0

[14]. Myers SA, Nield A, Chew G-S, Myers MA. The zinc transporter, Slc39a7 (Zip7) is implicated in glycaemic control in skeletal muscle cells. PLoS One. 2013;8(11):e79316. https://doi.org/10.1371/journal.pone.0079316

[15]. Fujii T, Asai T, Matsuo T, Okamura K. Effect of resistance exercise on iron status in moderately iron-deficient rats. Biological trace element research. 2011;144(1-3):983-91. https://doi.org/10.1007/s12011-011-9072-3

[16]. Fujii T, Matsuo T, Okamura K. Exercise, nutrition and iron status. The Journal of Physical Fitness and Sports Medicine. 2012;1(1):133-7. https://doi.org/10.7600/jpfsm.1.133

[17]. Fujii T, Matsuo T, Okamura K. Effects of resistance exercise on iron absorption and balance in iron-deficient rats. Biological trace element research. 2014;161(1):101-6. https://doi.org/10.1007/s12011-014-0075-8

[18]. Fujii T, Okumura Y, Maeshima E, Okamura K. Dietary Iron Intake and Hemoglobin Concentration in College Athletes in Different Sports. Int J Sports Exerc Med. 2015;1:029. http://doi.org/10.23937/2469-5718/1510029

[19]. Zhu YI, Haas JD. Iron depletion without anemia and physical performance in young women. The American journal of clinical nutrition. 1997 Aug 1;66(2):334-41. https://doi.org/10.1093/ajcn/66.2.334

[20]. Matsuo T. Effects of resistance exercise on iron metabolism in iron-adequate or iron-deficient rats. The Korean Journal of Exercise Nutrition. 2004;8:1-15. https://doi.org/10.1007/s12011-014-0075-8

[21]. Döker S, Hazar M, Uslu M, Okan İ, Kafkas E, Boşgelmez İİ. Influence of training frequency on serum concentrations of some essential trace elements and electrolytes in male swimmers. Biological trace element research. 2014;158(1):15-21. https://doi.org/10.1007/s12011-014-9912-z

[22]. Moretti D, Mettler S, Zeder C, Lundby C, Geurts-Moetspot A, Monnard A, et al. An intensified training schedule in recreational male runners is associated with increases in erythropoiesis and inflammation and a net reduction in plasma hepcidin. The American journal of clinical nutrition. 2018;108(6):1324-33. https://doi.org/10.1093/ajcn/nqy247

[23]. Wouthuyzen-Bakker M, van Assen S. Exercise-induced anaemia: a forgotten cause of iron deficiency anaemia in young adults. Br J Gen Pract. 2015;65(634):268-9. https://doi.org/10.3399/bjgp15X685069

[24]. Chu A, Varma T, Petocz P, Samman S. Quantifiable effects of regular exercise on zinc status in a healthy population—A systematic review. PloS one. 2017;12(9):e0184827. https://doi.org/10.1371/journal.pone.0184827
[25]. Skrypnik D, Bogdanski P, Skrypnik K, Madry E, Karolkiewicz J, Szulinska M, et al. Influence of endurance and endurance–strength training on mineral status in women with abdominal obesity: a randomized trial. 2019;98(12):e14909. https://doi.org/10.1097/md.0000000000014909
[26]. Rakhra G, Masih D, Vats A, Verma SK, Singh VK, Rana RT, et al. Effect of physical activity and age on plasma copper, zinc, iron, and magnesium concentration in physically active healthy males. Nutrition. 2017;43:75-82. https://doi.org/10.1016/j.nut.2017.06.005
[27]. Alshammari E, Shafi S, Nurmi-Lawton J, Taylor A, Lanham-New S, Ferns G. Altered antioxidant and trace-element status in adolescent female gymnasts. International journal of sport nutrition and exercise metabolism. 2010;20(4):291-8. https://doi.org/10.1123/ijsnem.20.4.291
[28]. Karakukcu C, Polat Y, Torun YA, Pac AK. The effects of acute and regular exercise on calcium, phosphorus and trace elements in young amateur boxers. Clin Lab. 2013;59(5-6):557-62. https://doi.org/10.7754/clin.lab.2012.120505
[29]. Lukaski HC, Hoverson BS, Gallagher SK, Bolonchuk WW. Physical training and copper, iron, and zinc status of swimmers. The American journal of clinical nutrition. 1990;51(6):1093-9. https://doi.org/10.1093/ajcn/51.6.1093

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