

The Effects of Physical Exercise on Soluble Transferrin Receptor and other Indicators of Iron Status in Female Taekwondoist

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Abstract. Iron and iron-binding proteins play a significant function in the physiology of various human systems. The aim of this study was to evaluate the effect of two different types of physical activity on soluble transferrin receptor concentration and other indicators of iron status in female taekwondoist. Thirteen members of the National Taekwondo team aged 18-25 yrs with about 4.5 yrs training experience participated in this study. Body mass and height of subjects were accordingly 57.5 ± 13.7 kg and 168.3 ± 7.1 cm. They performed two different laboratory tests: A, incremental treadmill running test and B, 30 – min running test at constant speed at 50% of the HR max. The interval between the tests was 5 – days and the subjects were instructed to refrain from strenuous physical exercise for 2 – days before test – A and throughout interval test A and B. Blood sample was withdrawn 20 – min before and immediately after two types of tests and were analyzed iron, ferritin, transferrin, sTfR, hemoglobin and hematocrit. Data were analyzed by student t –test. Our results showed that hematocrit increased significantly ($P < 0.05$) after test A, but not in test B. Soluble transferrin receptor increased after tests A and B, but increases were significant ($P < 0.05$) after test A only. Also, iron decreased significantly ($P < 0.05$) after test A and B. However, there were not significant differences ($P > 0.05$) in ferritin, transferrin receptor and hemoglobin after exercise. It can be concluded that variable of the iron status responded to physical stress and erythropoietic activity and if iron deficiency do not compensate, athletes may experience anemia.

Keywords: Soluble transferrin receptor (sTfR); Ferritin; Hemoglobin; Hematocrit; Anemia

1. Introduction

Depletion of iron is associated with mineral disorder of training athletes. An insufficient iron balance in male and female athletes (10-20% respectively) has been reported [Balaban *et al.*, 1989; Magnusson *et al.*, 1984].

Iron and iron-binding proteins play a significant function in the physiology of various human systems, including the immune system as well as cellular processes such as DNA synthesis and electron transport. Moreover, it is a vital component of hemoglobin, the oxygen carrying protein in the blood. Thus poor iron status can affect physical performance [Lamanca *et al.*, 1993].

Ferritin has been the most frequently used indicator of iron stores in the body. Low ferritin levels evidence decreased or exhausted iron stores while normal ferritin levels do not necessarily reflect adequate iron stores as ferritin concentrations increase in various infection or inflammatory states. Namely ferritin is an acute phase protein and may thus cover actual iron deficiency [Ahluwalia, 1998; Baynes, 1996]. That problem pertains also to athletes since physical exercise may induce inflammatory – like reactions, which in turn may induce an acute phase response [Pattni *et al.*, 1990; Weight *et al.*, 1991]. Moreover, high physical loads may frequently bring about inflammatory reactions in the joints and muscles, which may also augmented levels of acute phase proteins [Raczynska, 1996]. It has been demonstrated that increased ferritin levels in plasma may persist for 3-4 days following a strenuous exercise [Pattni *et al.*, 1990; Lampe *et al.*, 1986; Seilier *et al.*, 1989].

According to most recent studies the soluble transferrin receptor (sTfR) in plasma appears to be a

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particular value for detecting iron deficiency [Ahluwalia, 1998; Skikne, 1998; Thorstensen and Romslo 1993; Malczewska et al., 2000]. Transferrin receptor is a transmembrane glycoprotein present on the surface of erythroblasts, the principal factor controlling its surface density being the iron stores. The number of receptors starts to increase when the tissue iron stores are exhausted and the functional iron pool, i.e. iron contained in hemoglobin, myoglobin, enzymes, and iron ions in circulation starts to decrease [Skikne et al., 1990]. Feelders et al. [1999] have indicated that elimination of sTfR from the circulation is associated with transferrin degradation. But the sTfR levels are not affected by inflammatory reactions or other diseases and can therefore be used for diagnostic iron deficiency even under such conditions [Malczewska et al., 2000; Schumacher et al., 2002].

The effects of physical exercise on sTfR levels and erythropoietic activity which may be important in the assessment of iron status in training athletes are less documented. Therefore, the purpose of this investigation was to assess the effect of different types of physical activity on sTfR concentration, serum ferritin and hematological indices in female taekwondoist.

2. Methods

Thirteen female elite taekwondoist (member of the National Taekwondo team), aged 18-25 years, gave their informed consent to participate in the study. Before data collection, Ethical approval for the study was obtained from the Institute's Human Ethics Committee. All subjects underwent medical examinations 3 days prior to the study and were found in perfect health. No iron supplementation was used by any of the participant for three months before and during the study. Mean daily training volume was 2 hours. Other characteristics are presented in Table 1.

Table 1. Means (\pm SD) characteristics of subject

Variables	Means \pm SD
Age (years)	22.2 \pm 2.7
Body mass (kg)	57.5 \pm 13.7
Body height (cm)	168.3 \pm 7.1
Body fat percent	17.3 \pm 4.4
Fat free mass	46.6 \pm 5.1
Training experience	4.5 \pm 1.8

Subjects performed two different laboratory tests: A, incremental treadmill running test (Lafayette treadmill, USA) that was performed according the Bruce protocol [Powers and Howley 1996]; B, 30 – minutes running test at constant speed, at 50% of the maximal heart rate. Also, heart rate was monitored (pacer model; polar Electro, Oy, Finland). After the subjects been familiarized with treadmill running the tests were performed. No food was allowed for three hours before the test. The interval between the tests was 5- days and the subjects were instructed to refrain from strenuous physical exercise for 2 days before test – A and throughout interval tests A and B as used in the similar study by Schumacher et al. [2002].

In the morning, 1 day prior to the treatment, height, body mass and body fat percent were recorded; then blood sample was withdrawn with the subject in a supine position from an antecubital vein into a vacutainer system. Blood sampling was repeated 20 – min before and immediately after two types of tests.

The variables which were analyzed in the serum samples consisted of: sTfR (kit: Dade Behring N – latex sTfR analyzer, Dade Behring BNA 1000; Dade behring, Marburg, Germany), ferritin, transferrin, iron, and protein (kits: Roche/Hitachi Modular analyzer; Roche Diagnostics, Mannheim, Germany). According to the

manufacturer of the sTfR analyzing system, the intra – assay coefficient of variation is 1.4 – 2.1% and the interassay coefficient of variation 0.8 – 1.2% [Schumacher et al. 2002].

The test which were administered is specific for sTfR hemoglobin and hematocrit concentration, erythrocyte count were measured using an automated cell counter (Serono – Baker Diagnostics, Allentown, Pennsylvania, USA; model 9000 Diff) within 3 hours of sampling [Schumacher et al. 2002]. Data were analysed by student t –test and level of significance on all tests was set at $P < 0.05$.

3. Results

Mean (\pm SD) values of iron metabolism indices in pre and post-tests are presented in Table 2.

Table 2. Hematological and iron metabolism indices in female athletes (Means \pm SD)

Variable	Test A		Test B	
	Pre	post	Pre	post
Iron (ug/dl)	105[•].1 \pm 33.9	66.2 \pm 19.8	85[•].8 \pm 19.8	70.9 \pm 15.2
Ferritin (ng/dl)	13.6 \pm 10.67	11.4 \pm 8.66	13.9 \pm 8.6	12.9 \pm 13.2
Transferrin receptor (mg/dl)	446.3 \pm 89.17	446 \pm 75.07	426.2 \pm 82.8	413.8 \pm 99.3
Hemoglobin (g/dl)	13.84 \pm 1.7	14.39 \pm 0.95	13.8 \pm 1.2	14.2 \pm 1.6
Hematocrit (%)	41[•].4 \pm 3.1	42.1 \pm 3.23	41.5 \pm 2.9	41.8 \pm 2.7
sTfR (mg/l)	1[•].85 \pm 1.27	3.54 \pm 1.65	2.1 \pm 0.9	2.8 \pm 1.14

- ($P < 0.05$)

It should be noted that all variables were within the normal range suggested by the manufactory of assay kits, which have been reported in [Schumacher et al. 2002].

Soluble transferrin receptor (sTfR) was increased significantly ($P < 0.05$) after test A, but had not changed after test B. Hematocrit volume increases significantly after tests A ($P < 0.05$). Iron had decreased significantly ($P < 0.05$) after the laboratory tests regardless of the type of exercises. No significant changes ($P > 0.05$) were found for hemoglobin, ferritin and transferrin receptor after tests A and B.

4. Discussion

The purpose of this investigation was to find out the effect of 2 different types of physical exercise on indicators of iron status in elite female taekwondoist.

Hematocrit variables in the present study affected by physical exercise mostly which is in agreement with the existed data in the literature [Green et al., 1991; Selby and Eichner 1994]. After exercise, this parameter increase as the result of exercise induced haemoconcentration.

Normal range of serum iron is 50-160 U μ g/dl and %77 of subjects in the present study was in normal range before of tests. We reported that training experience of our subjects was about 4 years and this status demonstrates that deficiency of iron is not serious problem for them. After, test – A serum iron level decreased %37 and after test – B was %17.4 which is in agreement with previous reports indicating decreasing of iron level after physical activity [Mahlamaeki and Mahlamaeki 1989; Spodaryk 2000]. Iron depletion after training can be related to sweating, hematuria, gastrointestinal bleeding and sometimes ingestion of anti – inflammation drugs [Deakin, 2000]. It is important that after 5 – days of test – A, iron level have not reached to normal range. Of course, ferritin changes was same iron after tests A and B and we

conclude our subjects experienced malnutrition iron diet interval test A and B. As described in literature [Pattni et al., 1990; Seilier et al., 1989; Deakin, 2000] iron levels returned to normal range when endurance athletes ingested iron supplements or iron rich diet.

In the present study sTfR increased after exercise (test A). Only a few studies on the impact of physical exercise on sTfR have been conducted. It has been suggested that exercise has no effect on serum sTfR levels [Malczewska et al., 2000]. It is known that red blood cell mass and therefore erythropoietic activity is increased in trained athletes [Schumacher et al., 2002]. As sTfR reflects the overall erythropoietic activity, this Variable should therefore be higher in athletes than in untrained subjects. No reports on higher sTfR levels in athletes are available to date. Nevertheless, the observed levels were still well within the normal range.

5. Conclusion

Therefore, we can conclude that changes in variable of iron status mainly attribute to exercise induced changes and if iron deficiency do not compensate, athletes may experience anemia.

6. References

- [1] E.P. Balaban, et al. The frequency of anemia and iron deficiency in the runner. *Med Sci Sports Exerc.* 1989, **21**: 643–648.
- [2] B. Magnusson, et al. Iron metabolism and sports anemia. A hematological comparison of elite runners and control subjects. *Acta Med Scand*, 1984, **216**: 157-164.
- [3] J. J. Lamanca and Hymes, E. M. Effect of iron repletion in VO_2 max, endurance and blood lactate in women. *Med Sci Sports Exerc.* 1993, **25**: 1386-1396.
- [4] N. Ahluwalia. Diagnostic utility of serum transferrin receptor measurements in assessing iron status. *Nutr Rev.* 1998, **56**: 133-141.
- [5] R.D. Baynes. Assessment of iron status. *Clin Biochem.* 1996, **29**: 209– 215.
- [6] A. Pattni, F. Schena. and G.C. Guidi. Serum ferritin and serum iron changes after cross – country and roller ski endurance races. *Eur J Appl Physiol.* 1990, **61**:55-60.
- [7] L.M. Weight, D. Alexander. and P. Jacobs. Strenuous exercise: analogous to the acute – phase response? *Clin Sci.* 1991, **81**: 677-683.
- [8] B. Raczyńska. Ferritin as a diagnostic index of iron status in athletes. *Med Sport.* 1996, **56**: 2-5.
- [9] J.W. Lampe, J.L. Slain. and F.S. Apple. Poor iron status of women runners training for a marathon. *Int J Sports Med.* 1986, **7**: 111-114.
- [10] D. Seilier, et al. Effects of long – distance running on iron metabolism and hematological parameters. *Int J Sports Med.* 1989, **10**: 357-362.
- [11] B.S. Skikne. Circulating transferrin receptor assay-coming of age. *Clin Chem.* 1998, **44**: 4-9.
- [12] K. Thorstensen. and I. Romslo. The transferrin receptor: its diagnostic value and its potential as therapeutic target. *Scand J Clin Lab Invest.* 1993, **53**(215): 113-120.
- [13] J. Malczewska, W. Blach. and R. Stupnicki. The effects of physical exercise on the concentration of ferritin and transferrin receptor in plasma of female Judoist. *Int J Sports Med.* 2000, **21**: 175-179.
- [14] B.J. Skikne, C.H. Flowers. and J.D. Cook. Serum transferrin receptor: A quantitative measure of tissue iron deficiency. *Blood.* 1990, **75**: 1870-1876.
- [15] R.A. Feelders, et al. Structure, function and clinical significance of transferrin receptors. *Clinical Chemistry and Laboratory Medicine.* 1999, **37**: 1-10.
- [16] T. Takubo, et al. The value of serum soluble transferrin receptor (sTfR) determination in hematological malignancies. *Haematologica.* 1998, **29**: 259 -260.
- [17] Y. O. Schumacher, et al. Effects of exercise on soluble transferrin receptor and other variables of the iron status. *Br J Sports Med.* 2002, **36**: 195-199.
- [18] H.J., Green, et al. Response of red cell and plasma volume to prolonged training in humans. *J Appl Physiol.* 1991, **70**: 1810-1815.
- [19] G.B. Selby and E.R. Eichner. Hematocrit and performance: the effect of endurance training on blood volume. *Semin Hematol.* 1994, **31**:122 – 127.
- [20] E. Mahlamaeki and S. Mahlamaeki. Iron deficiency in adolescent female dancers. *Br J Sports Med.* 1989, **22**: 55 – 56.

- [21] K. Spodaryk. Iron metabolism in boys involved in intensive physical training. *Physiology and Behavior*. 2000, **75**: 201-207.
- [22] V. Deakin. Iron depletion in athletes. In Burke, Louise, Deakin, Vicki [Eds.] *Clinical Sports Nutrition*. The McGraw – Hill, New York. 2000, 273 – 310.
- [23] S.K. Powers and E.T. Howley. *Exercise physiology: theory and application to fitness performance*. 3rd ed. Baltimore, M.D: Williams and Waverly. 1996.

