STUDY OF IRON STATUS OF INDIAN FEMALE ATHLETES

Indranil Manna
Department of Physiology, Midnapore College (Autonomous), Midnapore, West Bengal, India
Dr. Indranil Manna
Assistant Professor, Department of Physiology (UG & PG),
Midnapore College (Autonomous),
Midnapore, West Bengal, India;
Tel: +9474823498; E-mail: indranil.manna@midnaporecollege.ac.in

ABSTRACT

Background: Iron status plays an important role in female athletes. Most of the female athletes are suffering from anemia which may limit their performance. Improved iron status may enhance their performance.

Objectives: The study was undertaken to investigate the iron status of Indian tribal and non-tribal female athletes.

Methods: A total of seven hundred (n= 700) females (age: 12-18 years) actively participating in sports activities were included randomly. The volunteers were divided into: (a) tribal athletes (n= 350) and (b) non tribal athletes (n= 350). The participants of each group were sub-divided into: (i) 12 yrs, (ii) 13 yrs, (iii) 14 yrs, (iv) 15 yrs, (v) 16 yrs, (vi) 17 yrs and (vii) 18 yrs age groups fifty volunteers in each. Assessment of total red blood cells count (TRBC), haematocrit (Htc), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), haemoglobin (Hb), serum ferritin (SF) and soluble transferrin receptor (sTfR) were performed.

Results: A significantly ($P<0.05$) lower TRBC, Htc, MCV, MCH, Hb, SF and sTfR were observed among the tribal female athletes when compared to non-tribal counter part. Significantly ($P<0.05$) higher TRBC, Htc, MCV, MCH, Hb, SF and sTfR values were were noted among the female athletes of both the groups with the advancement of age.

Conclusion: The low iron status may limit the performance of the tribal female athletes.

Keywords: haemoglobin, haematocrit, ferritin, transferrin receptor, female athletes

INTRODUCTION

Women participation in sports is increasing in recent times. Iron deficiency is common in female athletes. Iron is required for different functions of the body, and has direct and/or indirect effects various physiological and metabolic processes. Iron is an important part of haemoglobin and myoglobin which are essential for delivering oxygen to the tissues (1, 2). Iron requirement become high when person is performing hard work or sport activities (1, 2).Therefore iron deficiency (ID) has an adverse effects on sport performance, as ID may limit the aerobic capacity (3-5). Iron deficiency (ID) may occur due to poor nutrition. Dietary deficiency of iron, protein and vitamins may let to ID (6). Dietary deficiency of iron is a common problem in athletes who are performed heavy physical work during sports training and competition (6). Iron deficiency affects most of the people worldwide, and is the common cause of anemia (1, 7). The iron deficiency anemia (IDA) is the final step of ID. There is a gender difference in iron status among the athletes, and the female athletes are suffering more than their male counterpart (7-9). Female athletes are considered to be at a higher risk of compromised iron status which may lead to iron deficiency (with or without anaemia) due to negative iron balance contributed by insufficient dietary iron intake, menstruation, increased iron losses associated with haemolysis, sweating, gastrointestinal bleeding and exercise induced acute inflammation (7).

To investigate the iron dependent anemia it is important to differentiate between sport anemias (SA) and the iron deficiency anemia (IDA) (7, 10, 11). The excessive sweating can further exacerbate iron loss. As with all women, menstruation increases iron intake needs. Iron deficiency or inadequate iron stores can occur without anaemia and this is common in young female athletes (1, 12).Thus, decline the performance and hamper the general health of the athletes. Iron is required for the formation of oxygen-carrying proteins, hemoglobin and myoglobin, and for enzymes involved in energy production (13, 11). Oxygen-carrying capacity is essential for endurance exercise as well as normal function of the nervous, behavioural, and immune systems (11). Iron depletion (low iron stores) is one of the most prevalent nutrient deficiencies observed among athletes, especially females (12). Iron requirements for endurance athletes, especially distance runners, are increased by approximately 70% (2, 6). The factors which can interfere with iron status are vegetarian diets with low iron availability, periods of rapid growth, training, increased iron losses in sweat, feces, urine, menstrual blood, intravascular haemolysis, foot-strike haemolysis, regular blood donation, or injury (12, 13). Athletes, especially women, long-distance runners, adolescents, and vegetarians should be screened periodically to assess and monitor iron status (6, 12).

The term sports anemia (SA) is characterized by low iron status, which is indicated by low haemoglobin, serum ferritin, transferrin receptor and haematocrit. Vigorous physical exercise and/or training may cause enhancement of plasma volume by 10-20% (14, 15). Thus, low Hb level than normal due to low to normal serum ferritin in blood among the athletes are because of “dilutional anemia” (14, 15). Earlier investigations reported that iron deficiency anemia is not more frequent in athletes. High level of physical activity increases iron loss which may cause mild iron deficiency (iron deficiency but normal Hb concentration) (13-15). The true iron deficiency anemia can occur due to poor dietary intake of iron and/or iron loss is excessive as in case of menstrual bleeding in female athletes (14, 15). The exercise induced anemia is depending on the type of exercise training, intensity and duration of training programs (3,4). The studies reported that during the initial phase of a training program the changes in blood indicators are more prominent (3, 4). Thus, monitoring of iron status in female athletes is important for assessment of health and sports performance (3, 4). Iron deficiency anemia (IDA) is characterized by low Hb, serum ferritin and haematocrit. The difference between IDA from SA is that there is lack iron for the production of Hb in the RBC, which can be improved by iron supplements (5, 10).

A number of female athletes representing India at the International level in the present time are mostly coming from low socioeconomic status. The number of female athletes from tribal community is also rising in spite of socioeconomic and cultural barriers. Female are also facing gender discrimination, particularly in the socio-economically backward region. There are limited studies on iron status of female athletes in Indian context. Moreover, studies on the assessment of iron status of female athletes from tribal origin are lacking in India. In view of the above, a study was undertaken to investigate the iron status of female tribal and non- tribal athletes.

MATERIALS AND METHODS

Subjects

A total of seven hundred (n= 700) female (age: 12-18 years) actively participates in sports were included randomly. The volunteers were divided into: (a) tribal athletes (n= 350) and (b) non tribal athletes (n= 350). The participants of each group were sub-divided: (i) 12 yrs, (ii) 13 yrs, (iii) 14 yrs, (iv) 15 yrs, (v) 16 yrs, (vi) 17 yrs and (vii) 18 yrs. In each sub group fifty (50) female volunteers were selected. The basic data of all the volunteers including stature (height) and body mass were taken. Tribal female athletes [height (cm): 12 yrs- 145.8 ± 5.4, 13 yrs-147.7 ± 5.4, 14 yrs- 149.6 ± 6.7, 15 yrs-152.7 ± 5.4, 16 yrs-154.4 ± 6.1, 17 yrs-156.5 ± 5.27, 18 yrs- 157.8 ± 4.8; body mass (kg): 12 yrs- 38.6 ± 6.2, 13 yrs-39.7 ±4.9, 14 yrs- 42.9 ±5.2, 15 yrs- 45.6 ± 6.6, 16 yrs- 47.2 ± 6.4, 17 yrs-50.8 ± 4.1, 18 yrs- 52.7 ±5.2]; Non-Tribal female athletes [height (cm): 12 yrs-146.9± 3.4, 13 yrs-148.5± 4.1, 14 yrs-151.3± 4.6, 15 yrs-153.5± 5.5, 16 yrs-154.5± 4.7, 17 yrs-157.2± 5.6, 18 yrs-158.6± 5.7; body mass (kg): 12 yrs-39.8±4.2, 13 yrs-41.4±5.1, 14 yrs-44.8±6.3, 15 yrs-46.6±4.3, 16 yrs-49.8±4.6 , 17 yrs-53.4± 5.7, 18 yrs-54.6± 5.2].

Inclusion criteria: The subjects were included in the present study after proper medical checkups/screening by the Physicians. Subjects were excluded from the study if found medically unfit. Subjects free from history of recent disease and illness were included in the study. Subjects from the age of 12 to 18 years were considered eligible for this study.

Exclusion criteria: Participants were excluded from the study if they had a history of disease and illness for at least 03 months prior to the commencement of the study. Women who were pregnant and those within 3 days before and 3 days after their menstruating were also excluded. The subjects were informed about the possible complications of the study and a written informed consent was taken from them. Parental consent was also taken if the participant is below 18 years of age.

Ethical considerations:
The volunteers, parent/legal guardian, were informed about the study and written consent was taken. The volunteers maintained the same diet pattern. The Research Committee of the Institutional provides necessary permission for this investigation.

Estimation of Iron Status
All the volunteers were informed to take dinner at eight pm on the day before the collection of blood sample. Maintaining the aseptic condition, a five ml of blood was collected from an antecubital vein after a 12-hours fast and 24 hours after the last bout of exercise. The total red blood cells count, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), haemoglobin, serum ferritin (SF) and soluble transferrin receptor (sTfR) level were determined using standard methods (16).

Statistical Analysis
All the statistical tests were conducted by statistical software package (SSPSS20 Windows, IBM, USA). All the blood indices for analysis of iron status were expressed as mean and standard deviation (SD). To find out the between group and within the group difference, analysis of variance (ANOVA) followed by Post Hoc tests was performed. In each case the significant level was chosen at 0.05 levels (17).

RESULTS
Assessment of haematological status
A significantly lower ($P<0.05$) total red blood cells count (TRBC), hematocrit (Htc), mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) were observed among the tribal female athletes when compared to non-tribal female athletes of some age groups. Further, as the age progresses significantly ($P<0.05$) higher total red blood cells count (TRBC), hematocrit (Htc), mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) values were noted among the tribal and non-tribal female athletes.

[Enter Table 1 and 2 here]

Assessment of Iron status

A significantly lower ($P<0.05$) haemoglobin (Hb), serum ferritin and soluble transferrin receptor (sTfR) were observed among the tribal female athletes when compared to non-tribal female athletes of some age groups. Further, as the age progresses significantly ($P<0.05$) higher haemoglobin, Serum ferritin and soluble transferrin receptor (sTfR) values were noted among the tribal and non-tribal female athletes.

DISCUSSION

Iron is an important component of haemoglobin and myoglobin for oxygen transport and energy production in humans and thus is an important micronutrient for sport performance. Female athletes engaged in endurance sport are at high risk of low iron level due to menstrual loss and exercise-induced haemolysis. Iron deficiency is common among athletes. Iron deficiency may hinder sports performance. The blood indices such as total RBC count, haemoglobin, MCV, haematocrit, MCH and serum ferritin levels help in monitoring iron deficiency. In the present study a significantly lower total red blood cells count (TRBC), hematocrit (Htc), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), haemoglobin (Hb), serum ferritin (SF) and soluble transferrin receptor (sTfR) were observed among the tribal female athletes when compared to non-tribal female athletes of some age groups. Further, as the age progresses significantly higher TRBC, Htc, MCV, MCH, Hb, SF and sTfR values were were noted among the non-tribal and tribal female athletes. The tribal female athletes have to perform extensive physical wok for their livelihood apart from the athletic activities. This might cause haemolysis as indicated by decrease in red blood cells count, MCV, haemoglobin and hematocrit (18). The tribal female athletes participated in this study were from low socioeconomic back ground compared to non-tribal female athletes. There might nutritional deficiency among the tribal female athletes. This might be the reason for lower iron status among the tribal female athletes.

Research findings have note low ferritin values in athletes and reported that iron deficiency occurs in athletes, which can be overcome by dietary counselling and/or oral iron supplementation (19). Another study conducted by reported that female rowers with depleted iron stores who consumed supplemental iron during training improved their iron (Fe) status and energetic efficiency (EF) during endurance exercise (20). They have suggested that in endurance trained athletes iron depletion increased which may be overcome by dietary iron supplementation (20). In another study observed the iron, folate and vitamin B12 status of Ethiopian professional athletes and suggested that supplementation should be

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based on clinical signs and/or laboratory testing to prevent trace element toxicity (21). A recent study aimed to assess the iron status in professional female athletes and non-athletes, differences in iron status in different sports. They reported that the female athletes are at increased risk of ID compared with non-athletes (2). They also reported that similar prevalence of ID and IDA found across athletes engaged in different sports (2). In another study, focuses the anaemia and iron deficiency in female have reported that female athletes and reference groups had similar blood indices for iron status (22).

The prevalence of iron deficiency among the working women was also found high and are related to low socio economic status (23). It was observed that anemia and iron deficiency may limit physical fitness index (PFI) in women. Anemia and ID reduces the oxygen supply to the tissues which may decrease the VO_{2max} and thus have impact on the physical activity. An investigation conducted physical work capacity and cognition of anemic schoolgirls and in early adolescence non-anemic schoolgirls, reported that anemia affect physical work capacity and cognition (24). They suggested that iron deficiency anemia during adolescence may reduce physical work capacity and cognitive function. Another investigation showed high prevalence of non-vegetarianism in Indian National sports women than lacto, ovolacto vegetarianism. It was observed that the haemoglobin level and endurance time was better in non-vegetarians than lacto or ovolacto vegetarians (25). Dietary iron supplementation is used for prevention iron deficiency. A study on iron supplementation on iron-depleted female athletes has reported that oral supplementation of 100-mg FeSO4Idj1 (20 mg elemental iron) can improve iron status and may enhance sports performance (26). However, iron toxicity may occur due to supplementation (27). Therefore, dietary modification is being emphasised rather than supplementation to increase iron status of athletes. Dietary modification include an iron-rich diet, or/and haem iron-based diet, dietary counselling and inclusion of new iron-rich food in the diet (27). It can be recommended the iron deficiency of the female athletes should be screened at the initial stage of the training programme by assessing hemoglobin and serum ferritin level, and dietary modification and/or supplementation be made to those with compromised iron status (26). There are different approaches for management of iron deficiency in female athletes, the supplementation of iron and dietary intake iron reach foods. Both of these have advantages and disadvantages which should be taken into consideration when managing iron deficiency in female athletes (28).

Iron is an important mineral for optimal athletic performance, due to its oxygen carrying capacity and role in energy production (1). Iron deficiency is one of the most common deficiencies among female athletes and leads to impaired muscle function and reduced work capacity (7, 12). Endurance athletes' iron needs are particularly high and have been reported to be up to ~70% higher than requirements among non-athletes (1). Endurance athletes that consume a plant based diet and therefore primarily non-heme iron, which is absorbed much less efficiently than heme iron, may have even higher requirements (7, 12). Female athletes at risk of consuming low iron levels are endurance runners, vegetarians, adolescents, and athletes that frequently donate blood (7, 12). Thus inadequate nutritional intake in highly active females can bring about menstrual abnormalities and anemia. Proper training, physical activity and iron reach diet in female may increase performance of the athletes and reduce the risk for chronic diseases (11). Sport scientists recognized iron deficiency in female athletes, and suggested regular monitoring of iron status during training. It is better to monitor iron status of female athletes at an interval of four months. However, in case of male athletes it can be checked at an interval of six months. In addition to blood indicators, history of iron deficiency, menstrual cycle, and nutritional status should be considered (13).

CONCLUSION

Iron is an essential part of haemoglobin and myoglobin and helps in the oxygen transport and energy production. Low iron level in the body may cause iron deficiency anemia. Iron is an important micronutrient required for sport performance. Iron deficiency is frequently noted in female athletes, particularly who are participating in endurance sport, are at high risk of depleted iron status. Iron deficiency in female may occur due to dietary iron deficiency and menstrual bleeding. In addition, exercise induced haemolysis, foot strike haemolysis, plasma expansion and increase perspiration may aggravate the situation in the female athletes. All these factors may lead to iron deficiency anaemia. Iron deficiency may hinder sports performance. In the present study a lower total red blood cells count, haematocrit, mean corpuscular volume, mean corpuscular hemoglobin, haemoglobin, serum ferritin and soluble transferrin receptor were observed among the tribal female athletes than the non-tribal female athletes. As the age progresses higher levels of TRBC, Htc, MCV, MCH, Hb, SF and sTfR were noted among the all the athletes. The tribal female athletes performed extensive physical wok for their livelihood apart from the athletic activities. This might cause haemolysis as indicated by decrease in red blood cells count, MCV, haemoglobin and haematocrit. In addition, low socio-economic and nutritional status of the tribal female athletes may be the possible cause of low iron status. The low iron status may limit the performance of the tribal female athletes. Iron deficiency may be overcome through nutritional modification with iron-rich diet. Regular monitoring of iron status of female athletes during training programme is required to assess their iron status.

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Table 1: Haematological variables of Tribal and Non-Tribal female athletes

Age Groups (yr)	Tribal female athletes				Non-Tribal female athletes			
	TRBC (x 10^{12}/l)	Htc (%)	MCV (fl)	MCH (pg)	TRBC (x 10^{12}/l)	Htc (%)	MCV (fl)	MCH (pg)
12	4.0[NS] ± 0.2	35.6[NS] ±2.1	71.3[NS] ± 4.5	26.3[NS] ±2.3	4.2[*] ± 0.3	36.6[NS] ±2.2	79.4[*] ± 2.9	27.4[NS] ±2.5
13	4.1[a] ± 0.1	36.4[NS] ±2.3	74.2[a] ± 3.6	27.1[NS] ± 2.1	4.4[a*] ± 0.4	37.7[a*] ±1.3	81.2[a*] ± 3.2	28.4[*] ± 2.2
14	4.2[a] ± 0.4	37.1[a] ±1.5	78.6[a,b] ±3.4	27.4[NS] ±2.3	4.4[a*] ± 0.2	38.1[a*] ±1.7	84.2[a,b*] ± 3.1	28.6[*] ±2.2
15	4.3[a,b] ± 0.3	38.2[a-c] ±2.3	82.1[a-c] ±3.1	28.3[a] ±4.1	4.5[a*] ± 0.4	38.8[a,b] ±2.0	86.4[a-c*] ±2.4	29.2[a,b] ±2.1
16	4.4[a-c] ± 0.1	39.1[a-c] ±2.4	84.6[a-d] ±4.8	29.1[a-c] ±3.1	4.6[a-c*] ± 0.2	39.9[a-d] ±2.1	88.3[a-d*] ±2.7	29.8[a-c] ±2.4
17	4.4[a-c] ± 0.2	39.7[a-d] ±2.1	88.6[a-e] ±4.7	29.4[a-c] ±2.4	4.7[a-e*] ± 0.1	41.1[a-e*] ±2.3	90.5[a-e] ±2.6	30.2[a-c] ±2.1
18	4.6[a-f] ± 0.3	41.3[a-f] ±2.2	90.5[a-e] ±3.8	30.1[a-d] ±2.2	4.8[a-e*] ± 0.3	41.7[a-e] ±2.2	91.2[a-e] ±3.1	30.8[a-d] ±2.2

All the values were expressed as mean and standard deviation (SD), n=50; [a] When compare to 12 yrs, [b] When compare to 13 yrs, [c] When compare to 14 yrs, [d] When compare to 15 yrs, [e] When compare to 16 yrs, [f] When compare to 17 yrs, [*] When compare to Tribal athletes; NS= not significant; TRBC = total red blood cells count, Htc = hematocrit, MCV = mean corpuscular volume, MCH=Mean corpuscular hemoglobin.

Table 2: Iron status of Tribal and Non-Tribal female athletes

Age Groups (yr)	Tribal female athletes			Non-Tribal female athletes		
	Hemoglobin (gm/dl)	Serum ferritin (μg/dl)	sTfR (mg/l)	Hemoglobin (gm/dl)	Serum ferritin (μg/dl)	sTfR (mg/l)
12	10.6[NS] ± 1.1	22.1[NS] ± 1.5	4.1[NS] ± 0.2	11.2[NS] ± 1.6	24.1[*] ± 1.4	4.2[NS] ± 0.7
13	10.9[NS] ± 1.3	24.3[a] ± 1.7	4.3[a] ± 0.5	11.5[NS] ± 1.1	26.3[a*] ± 1.2	4.4[NS] ± 0.6
14	11.3[a,b] ± 1.5	26.4[a,b] ± 2.1	4.7[a,b] ± 0.3	11.7[NS *] ± 1.6	28.4[a,b*] ± 2.5	4.9[a,b*] ± 0.4
15	11.6[a,b] ± 1.3	27.2[a,b] ± 1.2	4.9[a-c] ± 0.4	11.9[a *] ± 1.4	29.4[a,b*] ± 1.7	5.1[a-c*] ± 0.2
16	11.7[a,b] ± 1.4	28.4[a-d] ± 2.8	5.3[a-d] ± 0.4	12.0[a,b*] ± 1.7	30.5[a-d*] ± 2.2	5.4[a-c] ± 0.8

17	11.9[a-c] ± 1.1	30.1[a-e] ± 2.2	5.5[a-e] ± 0.4	12.2[a,b] ± 1.5	31.1[a-d] ± 2.1	5.7[a-d*] ± 0.3
18	12.1[a-c] ± 1.5	31.6[a-f] ± 3.1	5.6[a-e] ± 0.5	12.6[a,b] ± 1.5	33.2[a-e] ± 2.3	5.9[a-f*] ± 0.4

All the values were expressed as mean and standard deviation (SD), n=50; [a] When compare to 12 yrs, [b] When compare to 13 yrs, [c] When compare to 14 yrs, [d] When compare to 15 yrs, [e] When compare to 16 yrs, [f] When compare to 17 yrs, [*] When compare to Tribal athletes; NS= not significant; sTfR = soluble transferrin receptor.