Presence of Iron Deficiency Anemia in Adolescent Girls of Jammu District and its Effect in their Physical Performance

Anjali Nadir Bhat[1,*], Sabita Yograj[2], Manisha Sahi[3]

[1]Professor,[3]Demonstrator, Postgraduate Department of Physiology, Government Medical College, Jammu
[2]Associate Professor; Department of Physiology, ASCOMS, Sidhra, Jammu

***Corresponding Author:**
E-mail: anjalinadirbhat@hotmail.com

ABSTRACT

Iron deficiency is the commonest cause of anemia in Indian adolescent girls and women and it impairs their work performance and work capacity. The study was carried out on 210 adolescent girls in the age group of 10 to 19 years, selected randomly from schools of Jammu district. Samples of blood were collected from the subjects and analyzed for parameters like haemoglobin concentration, total erythrocyte count, packed cell volume, serum iron and total iron binding capacity. From TEC, PCV and haemoglobin were calculated the blood indices MCV and MCHC. From serum iron and TIBC was calculated the transferrin saturation index.Our findings show that 71.42% adolescent girls were anemic, and they showed significant decrease in physical performance. Hematological parameters and biochemical parameters were significantly lower in moderately anemic adolescent girls as compared to mild anemic adolescent girls.Also the physical fitness index was poor in girls with moderate anemia as compared to mild anemic and non anemic adolescent girls.

Keywords: *Total Erythrocyte Count,Haemoglobin,Serum Iron, Physical Fitness Index, Mild Anemic, Moderately Anemic.*

Access this article online	
Quick Response Code:	**Website:** www.innovativepublication.com
	DOI: 10.5958/2394-2126.2015.00013.4

INTRODUCTION

Iron deficiency is the most common cause of anemia and is one of the leading risk factors for disability and death worldwide, affecting an estimated 2 billion people (1). It is a state in which the content of iron in body is decreased, which manifests as decreased serum iron, decreased transferrin saturation, low hemoglobin and low hematocrit. It occurs in varying degrees of severity, which merge imperceptibly into one another(2,3).

Iron deficiency impairs work performance both during intense short-lived exercise and longer intervals. The decrease in work capacity is proportional to blood hemoglobin concentration. Low hemoglobin concentration in blood results in decreased oxygen capacity of hemoglobin with the parallel effect on blood carbon dioxide transport (4). Iron deficiency also results in decreased iron containing enzymes of mitochondrial respiratory chain in skeletal muscles with a concomitant decline in muscle respiratory capacity to utilize oxygen. This reduction in aerobic metabolism is associated with an increased susceptibility to fatigue (5).

Iron deficiency anemia is a formidable health challenge in developing countries and remains persistently high despite national programmes to control this deficiency(6). In a study conducted separately in eleven Asian countries including India, more than 40% of adolescents were anemic (hemoglobin <115 g/L). A review of Indian studies on anemia revealed that >70% of adolescent girls in low income communities had hemoglobin levels <110 g/L.When the WHO cut-off of 120 g/L was applied, the prevalence was even higher *i.e.* 80-90%(7).Iron requirements are increased during adolescence, reaching a maximum at peak growth, and remaining almost as high in girls after menarche to replace menstrual losses (8).

Besides being a major threat to safe motherhood, iron deficiency anemia (IDA) in adolescent girls contributes to poor growth, lowered resistance to infections, poor cognitive development and most importantly, decreased physical work capacity (6). Iron deficiency is associated with an inability to perform normal physical activities such as walking various distances, climbing stairs, carrying groceries, etc. Concentration and short-term memory loss are the most common presenting symptoms in day to day routine activity in iron deficiency Anaemia. Chronic tiredness or fatigue is a non-specific symptom often attributed to iron deficiency(9).

In this context, the present study was undertaken to evaluate the effect of iron deficiency on physical performance in adolescent girls, iron deficiency being the most common cause of anemia. It is one of the leading risk factors for disability and death worldwide, affecting an estimated two billion people. Anemic girls are at a risk of compromised physical performance, but may also be at increased obstetric risk once they become pregnant.

MATERIAL AND METHODS

The prospective randomized study was carried out on 210 subjects in the age group of 10 to 19 years of age, in the Postgraduate Department of Physiology in collaboration with the Department of Biochemistry, Government Medical College, Jammu. The subjects were selected randomly fromvarious schools of Jammu district. The blood samples were taken after proper counseling and consent and were analyzed for parameters like hemoglobin estimation, total erythrocyte count, packed cell volume, serum iron, total iron binding capacity. The adolescent girls were subjected to detailed evaluation regarding history, socio-economic status and general physical examination. The subjects were classified prospectively into three groups on the basis of their hemoglobin levels as per National Institute of Nutrition (NIN) Classification of Anemia (10). Group A (n=60): non-anemics with hemoglobin levels >12 gm% (as control group), Group B (n=75): mild anemics with hemoglobin levels 10 to 11.9 gm%, Group C (n=75): moderate anemics with hemoglobin levels 8 to 9.9 gm%.Under all aseptic precautions, venous blood was collected for the study and the girls were subjected to detailed evaluation including: (i) Biodata of subjects; (ii) Detailed investigative work-up in the form of hemoglobin estimation, total erythrocyte count (TEC), packed cell volume (PCV), serum iron and total iron binding capacity (TIBC); (iii) From TEC, PCV and hemoglobin, blood indices were calculated *i.e.* mean corpuscular hemoglobin concentration (MCHC) and mean corpuscular volume (MCV); (iv) From serum iron and TIBC, transferrin saturation index (TSI) was calculated (11).

The blood samples were taken in the morning from 8 to 11 a.m., as there is diurnal variation in serum iron levels, being highest in the morning and lowest in the evening (12, 13). It was made sure that the subjects were not taking any iron or vitamin preparation for one week prior to the test. Exclusion criteria for the subjects included: hemoglobin <8 gm%, respiratory disorders, cardiovascular disorders and any chronic systemic disease.Hemoglobin estimation was done using acid hematin method which employs Sahli's hemoglobinometer. For TEC, hemocytometer was used for counting of cells in the blood. For determining the presence or absence of anemia and measuring its degrees, measurement of PCV/hematocrit was done by using Wintrobe's tube after centrifugation of blood. From the above estimation, two blood indices MCV (in cubic micron) and MCHC (in percentage) were derived. TSI was measured by ‘The Iron Method’ based on direct iron assay, using chromophore ferene. It was done in Auto Analyzer (SIMENS) Dimension X pand clinical chemistry. TIBC was measured by TIBC method which is a direct iron procedure using a surfactant to prevent protein precipitation. From serum iron and TIBC, TSI was calculated.

The physical performance of the subjects was assessed by Harvard Step Test.This test exposes the subject to a standard exercise that no one can perform in a ‘steady state’ for more than a few minutes. It takes into account two factors – the length of time the exercise can be sustained and deceleration of heart rate after exercise. It consists of measuring the endurance in stepping up and down on a bench of standard height and the pulse rate in response to the exercise (10). The exercise was performed for as many minutes as subject could sustain,not exceeding 5 minutes in any case. After the cessation of exercise, pulse was recorded from 1 minute to 1.5 minutes for a period of 30 seconds. Thereafter, the index of fitness or physical fitness index (PFI) was calculated.

STATISTICAL ANALYSIS

Arithmetic mean, standard deviation, mean square and sum of squares of each parameter were calculated. Statistical analysis of each set of variants in all the three groups was carried out by the method of analysis of variance (ANOVA). The value of ‘F’ obtained from ANOVA was tested for significance from the ‘F’-table at 5% level of significance. Further comparison between the means of each variable in different groups was done with one another using Bonferroni-‘t’ procedure and critical values obtained. ‘Z’ transformation of Bonferroni-‘t’ was done. The critical values so obtained were compared with the table value of ‘Z’ and were considered significant if ‘p’ was <0.0.

RESULTS

The mean baseline characteristics of 210 subjects and their mean physical fitness index (PFI) are depicted in Table 1. The mean age and mean weight of all the three groups was in close proximity to each other. The mean values of variables among Group A, B and C were comparedand it was observed thatthe mean differences in hemoglobin (p=0.00), PCV (p=0.00), TEC (p=0.00), MCHC (p=0.04), MCV (p=0.00), serum iron (p=0.00), TIBC (p=0.00), TSI (p=0.00) and PFI (p=0.00) were all found to be statistically significant by the method of ANOVA.Further comparison of mean values of variables of individual groups with one another was done using Bonferroni-‘t’ method with ‘Z’ transformation. The mean values of all the variables *i.e.*, hemoglobin, PCV, TEC, MCHC, MCV, serum iron, TIBC, TSI and PFI were significant when compared between Group A and Group B, Group B and Group C and also Group A and Group C (p<0.05) (Table 2).

Table 1: Mean baseline characteristics of Group A, B and C

Variables	Group A (n=60) Mean ± SD	Group B (n=75) Mean ± SD	Group C (n=75) Mean ± SD
Age (years)	13.66 ± 1.38	14.17 ± 1.75	14.42 ± 1.75
Weight (kg)	38.46 ± 5.99	40.76 ± 5.72	40.41 ± 6.52
Haemoglobin (gm/dL)	12.33 ± 0.38	10.55 ± 0.45	8.90 ± 0.53
PCV (%)	42.65 ± 1.69	37.61 ± 2.26	32.04 ± 2.00
TEC (millons/mm^3)	5.25 ± 0.15	5.22 ± 5.00	4.29 ± 0.20
MCHC (%)	28.94 ± 1.14	31.28 ± 2.78	27.27 ± 2.16
MCV (μ/mm^3)	81.22 ± 3.25	80.85 ± 4.92	74.62 ± 4.97
Serum iron (μg/dL)	101.51 ± 10.46	82.57 ± 12.60	42.13 ± 12.03
TIBC (μg/dL)	291.23 ± 25.47	313.62 ± 26.35	457.6 ± 27.37
TSI (%)	35.10 ± 5.14	26.52 ± 5.26	9.24 ± 2.95
PFI	76.42 ± 7.65	53.48 ± 8.63	44.67 ± 6.69

Table 2: Comparison of individual groups with one another using Bonferroni procedure with 'Z' transformation

Variables	Group A vs Group B	Group A vs Group C	Group B vs Group C
Haemoglobin	p<0.05	p<0.05	p<0.05
PCV	p<0.05	p<0.05	p<0.05
TEC	p>0.05	p<0.05	p<0.05
MCHC	p<0.05	p<0.05	p<0.05
MCV	p>0.05	p<0.05	p<0.05
Serum iron	p<0.05	p<0.05	p<0.05
TIBC	p<0.05	p<0.05	p<0.05
TSI	p<0.05	p<0.05	p<0.05
PFI	p<0.05	p<0.05	p<0.05

DISCUSSION

The present study was conducted on 210 adolescent girls with an aim to study the effect of iron deficiency anemia on their physical performance. Blood samples were taken from the subjects and were analyzed for different parameters to evaluate iron status. Adolescent girls with hemoglobin levels of12 gm% or more, formed Group A or non-anemic group and included 60 girls. Group B or mild anemic group with hemoglobin levels 10-11.9 gm% consisted of 75 girls. Group C or moderate anemic group had hemoglobin levels 8-9.9 gm% and included 75 girls.

The term 'anemia' refers to a reduction below normal in the concentration of hemoglobin or red blood cells in the blood. Any of the three measures of concentration *i.e.* hemoglobin, hematocrit or number of red cells may be used to establish the presence of anemia. The manifestations of anemia depend on five factors *i.e.* the reduction in oxygen carrying capacity of the blood, the degree of change in total blood volume, the rate at which the previous two factors developed, the capacity of the cardiovascular and pulmonary systems to compensate for anemia and the associated manifestations of the underlying disorder that resulted in the development of anemia (14).

Hematological parameters estimated in the present study were hemoglobin, total erythrocyte count (TEC) and packed cell volume (PCV). From these parameters, mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) were calculated. All these parameters gave evidence of iron deficiency anemia and its severity (15).

Iron deficiency anemia has been defined as a microcytic hypochromic anemia secondary to a total body iron deficiency. A more sensitive definition of iron deficiency is a negative iron balance and iron deficient erythropoiesis. Iron deficiency with microcytic hypochromic red blood cell morphology indicates a prolonged period of negative iron balance and production of poorly hemoglobinized cells. In iron deficiency anemia, there is fall in hemoglobin level and also there is fall in packed cell volume. MCV and MCHC are also decreased. In iron deficiency anemia, serum iron falls with an increase in total iron binding capacity (TIBC). The transferrin saturation index (TSI) falls and if it is less than 16%, it is diagnostic of iron deficiency anemia (10, 16, 17).

The fall in mean hemoglobin values in the present study was statistically significant when compared between Group A and Group B, Group B and Group C, and Group A and Group C (for all, $p<0.05$).The fall in hemoglobin levels occurs in iron deficiency anemia because iron is an important component required for hemoglobin synthesis and when there is negative iron balance with reduced iron availability for hemoglobin synthesis, hemoglobin levels start to fall (3, 11, 17).

In the present study, the mean PCV in Group A was 42.65% with a range of 39 to 45%. In

Group B, mean PCV was 37.61% with a range of 34-42% and in Group C, mean PCV was 32.04% with a range of 28-36%. The values were statistically significant between all the three groups, *i.e.* between Group A and Group B, Group B and Group C and Group A and Group C (for all, $p<0.05$).

The significant fall in hematocrit in subjects with mild anemia as compared to non-anemic group and more low values in moderate anemic subjects are in accordance with observations of LaManca and Haymes (13), Lukaski*et al.* (18) and Ballin*et al.* (19). Similar findings were reported by Bainton and Finch (20) in the anemic subjects in their study.The mean TEC values were found statistically insignificant when compared between Group A and Group B ($p >0.05$) but statistically significant between Group B and Group C and also between Group A and Group C ($p<0.05$).

Similar results have been quoted by Benjamin *et al.* (21). Nagi*et al.* (10) did not find any statistical significant co-relationship among their three groups. Smith (22) mentioned that as iron deficiency primarily affects hemoglobin synthesis and red cell synthesis is affected to a lesser extent so erythropoiesis may be normal or moderately reduced.

In the present study, the MCV values were statistically insignificant when compared between Group A and Group B ($p>0.05$) but statistical comparison between Group B and Group C and Group A and Group C was significant ($p<0.05$).Similar findings were found by Nagi*et al.* (10) where they also found low MCV in anemic subjects. Bainton and Finch (20) also found MCV to be decreased in anemic subjects. A decrease in MCV in iron deficiency anemia was also observed by Ballin*et al.* (19).The mean values of MCHC were found to be statistically significant in the present study when compared between Group A and Group B, Group B and Group C and Group A and Group C ($p<0.05$).

An MCHC of 28% in anemic subjects was observed by Bainton and Finch (20). Findings of present study are also in agreement with findings of Ballin*et al.* (19).The mean values for serum iron were statistically significant ($p<0.05$), when compared between all the three groups *i.e.* between Group A and Group B, Group B and Group C and Group A and Group C.The present study findings are in accordance with those reported by Finch (2), Rapaport (16), Ballin*et al.* (19) and Bainton and Finch (20). Impaired iron absorption, increased RBC destruction, abnormally high excretion, chronic blood loss or other reasons of iron loss, lead to depletion of iron stores (23).

The mean TIBC was raised in Group B and Group C in the present study. The mean TIBC in the three groups was compared the difference among the mean TIBC values in the three groups was statistically significant ($p<0.05$).The above observations show that the fall in serum iron levels in body is associated with an increase in TIBC levels. Similar findings were also reported by Bainton and Finch (20) and Peter and Wang (23).

In the present study, the statistical comparison of TSI was significant when compared between Group A and Group B, Group B and Group C and between Group A and Group C with $p<0.05$.Patients with iron deficiency anemia have a decreased concentration of serum iron, increased TIBC and a low degree of transferrin saturation index (23). Dallman (24) reported that analysis of hemoglobin concentration, TSI and blood smear are not reliable for the diagnosis of mild iron deficiency anemia, whereas Tumbi*et al.* (25) have proposed TSI as a better indicator of iron status than serum iron or TIBC alone.Physical performance in the present study was assessed by Harvard Step test and expressed by physical fitness index (PFI) or rapid fitness index (RFI). There was statistically significant co-relationship of PFI when compared between Group A and Group B, Group B and Group C and between Group A and Group C ($p<0.05$). A significantly high score of Harvard Step test in non-anemic subjects as compared to the anemic subjects was observed. These results are in agreement with those reported by Nagi*et al.* (10) and Tumbi*et al.* (25).

Decreased oxygen carrying capacity of blood in iron deficiency anemia is due to decreased iron and hemoglobin in the blood resulting in decreased physical performance (13, 24).

CONCLUSION

Out of 210 adolescent girls tested, 71.42% were anemic. Hematological parameters were significantly lower in moderately anemic adolescent girls as compared to mild anemic adolescent girls. Biochemical parameters were also significantly lower in moderately anemic adolescent girls as compared to mild anemic adolescent girls. There was significant decrease in physical performance in anemic adolescent girls as compared to non-anemic adolescent girls. The physical fitness index was poor in moderately anemic adolescent girls as compared to an average score in mild anemic adolescent girls and non anemic adolescent girls.

REFERENCES

1. WHO. Iron deficiency anemia: assessment, prevention and control. A Guide for Programme Managers. WHO Publications, Geneva 2001: 132 (WHO/NHD/01.3).
2. Finch CA. Iron deficiency in United States. JAMA 1968; 203: 407-10.
3. Beutlar E, Virgil FF. Iron deficiency. Hematology. Williams WJ, Beutlar E, Erslev AJ and Lichtman

MA (editors), McGraw Hill Book Company, 3rd edition 1983; 468-88.
4. Sproule BJ, Mitchell JH, Miller CF. Cardiopulmonary physiological responses to heavy exercise in patients with anemia. J Clin Invest 1960; 39: 378-81.
5. McLane JA, Fell RD, McKay RH et al. Physiology and biochemical effects of iron deficiency on rat skeletal muscle. Am J Physiol 1981; 10 (1): C47-C53.
6. Sen A,Kanani S. Deleterious functional impact of anemia on young adolescent school girls. Indian Pediatr 2006; 43: 219-26.
7. Kanani S,Ghanekar J. Anemia and the adolescent girl: A review of some research evidence and intervention strategies. Department of Foods and Nutrition, MS University of Baroda and UNICEF, India 1997.
8. Kanani S,Poojara R. Supplementation with iron folic acid enhance growth in adolescent Indian girls. J Nutr 2000; 130: 452S-55S.
9. Patterson AJ, Brown WJ, Powers JR, Roberts DCK. Iron deficiency, general health and fatigue: Results from the Australian Longitudinal Study on Women's Health. In: Quality of Life Research. Kluwer Academic Publishers, 2000; 9: 491-97.
10. Nagi MK, Kour V, Mann SK. A study of iron status and its impact on physical performance of rural adult women. Indian J Physiol Allied Sci 1995; 49: 203-07.
11. Boggs DR, Richard G, Bithal CT and Athen JW. Production of erythrocyte. Clinical Hematology, 7th edition. KM Varghese Company 1975: 179-94.
12. Wintrobe MM, Richard G, Boggs RD et al. Iron deficiency and iron deficiency anemia. Clinical Hematology, 7th edition. KM Varghese Company 1975: 635-699.
13. LaManca JJ,Haymes EM.Effects of iron repletion on VO_{2max} endurance and blood lactate in women. Med Sci Sports Exercise 1993; 25 (12): 1386-392.
14. Lee GR. Anemia general aspects. Wintrobe's Clinical Hematology, 10th edition, 1998: vol. 1: pp. 897-907.
15. Hillman RS. Hematological alterations in anemia. Harrison's Principles of Internal Medicine, 4th edition. McGraw Hill Inc., 1997; 1: 334-38.
16. Rapaport SI. Blood. Best and Taylor's Physiological Basis of Medical Practice, 12th edition. BI Waverly Pvt Ltd, 1996; pp. 336-37.
17. Fauci B, Hillman RS. Iron deficiency and other hypoproliferative anemia. Harrison's Principles of Internal Medicine, 4th edition. McGraw Hill Inc., 1997; 1: 638-44.
18. Lukaski HC, Hall CB, Siders WA. Altered metabolic response of iron deficient women during graded maximal exercise. J ApplPhysiol 1991; 63: 140-145.
19. BallinA, Berar M, Rubinstein U et al. Iron status in female adolescents. Am J Dis Child 1992; 146: 803-05.
20. Bainton DF, Finch CA. The diagnosis of iron deficiency anemia.Am J Med 1964; 37: 62-70.
21. Benjamin F, Barsen FA, Meyer LM. Serum levels of folic and vitamin B_{12} and iron in anemia of pregnancy. Am J ObstGyne 1966; 96 (3): 310-15.
22. Smith CN. In: Blood Diseases of Infancy and Childhood. CV Mosby St. Louis, 1960: 243-98.
23. Peter F, Wang S. Serum iron and total iron binding capacity compared with serum ferritin in assessment of iron deficiency. ClinChem 1981; 27 (2): 276-79.
24. Dallman PR. New approaches to screening for iron deficiency. J Pediatr 1972; 4: 678-81.
25. Tumbi Z, Dodd S, Nina G. Effect of ferrous fumarate on the iron status and physical work capacity of women. Nutr Res 1990; 10: 1375-384.