



Original Research Article

A Study of Iron Status and Its Effects on Physical Performance in Young Adult Females

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Received: 31/08/2015

Revised: 22/09/2015

Accepted: 24/09/2015

ABSTRACT

Occurrence of iron deficiency in women of reproductive age group is very common in India. Invariably it is associated with reduced physical work performance. There is decrease time to exhaustion during sub maximal and maximal work in iron deficient women. The present study involved evaluation of 140 subjects for anemia and their physical efficiency. There was statistically significant decrease in the physical efficiency of young females with anemia.

Keywords: Anemia, Harvard step test, Rapid fitness index, Iron deficiency anemia IDA, Iron binding capacity, Transferrin saturation index.

INTRODUCTION

Iron is an essential element of all living cells and a participant in many metabolic pathways. Total body iron is 3-5 grams and is divided into different compartments. The functional compartment is the iron involved in cellular metabolism. (1)

The storage compartment consists of iron sequestered in relatively safe and nontoxic form as ferritin and hemosiderin. These two compartments are linked by a small transport compartment, largely in the form of the carrier molecule transferrin. Its iron is normally replaced or 'turned over' at least ten times every twenty-four hours. (1,2)

Anemia is a significant reduction in red cell mass and causes corresponding decrease in oxygen carrying capacity of

blood with a parallel effect on carbon dioxide transport. (3)

The incidence of IDA is more in the females of reproductive age group when the mobilization of reticuloendothelial iron and enhanced absorption of iron are inadequate to meet the needs of erythroid marrow, the plasma iron tends to fall and serum transferrin increases. The transferrin saturation index (TSI) decreases & is one of the best measures to indicate iron deficiency and if it is less than 16 it is diagnostic. (4)

Iron deficiency also results in decreased iron containing enzymes of the 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. (5-7)

MATERIALS AND METHODS

The present study was conducted in the Department of Physiology Govt. Medical College Jammu. Subjects chosen were 140 healthy women in the age group of 18-35 yrs. The subjects were classified prospectively into three groups on the basis of their hemoglobin levels as per NIN (National Institute of Nutrition) Classification of anemia. (7)

Group A Non-Anemics with Hb levels 12 gm% or more (control group)

Group B Mild anemia with Hb levels 10 to 11.9 gm%

Group C Moderate anemia with Hb levels 8 to 9.9 gms%

Weight and height were taken to exclude obese women. Seventeen subjects were excluded after Hb estimation only because it was less than 8gm% & this group does not form the part of our study. The subjects were advised not to take any iron or vitamin preparation one month prior to the test.

5 ml of venous blood sample was drawn. Hemoglobin estimation (Hb) by acid hematin method with Sahli's Haemoglobinometer; total erythrocyte count (TEC) with Hemocytometer using hayme's fluid; Pack Cell Volume (PCV) using wintrobe's tube, were estimated.

From TEC, Hb and PVC, blood indices were calculated i.e. Mean Corpuscular.

Total serum iron was measured by the Iron Method based on direct iron assay developed by Smith et al., using chromophoreferrene. It was done in Auto Analyser (Dade Behring-Dimension (AR) using TIBC Flex™ reagent Cartridge No. DF 49A.

Total iron binding capacity (TIBC) was measured by TIBC method which is a direct iron procedure using a surfactant to prevent precipitation. It was done in Auto Analyser (Dade Behring-Dimension (AR)

using TIBC Flex™ reagent cartridge no. DF 83.

From serum iron and TIBC, Transferrin Saturation Index (TSI) was calculated.

$$TSI = \frac{S. Iron \times 100}{TIBC}$$

The physical efficiency was assessed by Harvard step test. The index of Fitness or physical Fitness index (PFI) was calculated from given formula.

$$PFI = \frac{\text{Time of stepping in second} \times 100}{5.5 \times \text{Pulse Rate 1 to 1.5 seconds after exercise.}}$$

Airthmatic mean, standard deviation, mean square and sum of squares of each parameter was calculated. Stastical analysis of each set of variants in all the three groups was carried out by the method of Analysis of Variance (ANOVA). Further comparison between the mean of each variable in different groups was done with one another by using Bonferrani procedure. (8)

OBSERVATIONS

Anemia is one of the most common manifestations of diseases on the world. Iron deficiency anemia is the commonest cause of nutritional deficiency. It is more prevalent in women of reproductive age group. (9,10) In India and other developing countries 60-70% of women & young children suffer from iron deficiency anemia. (11)

7.1% in this study are anemic. The statistical correlation of various parameters taken in this study amongst group A, B & C is found significant (p value <0.05)

The intergroup comparison of Hb, PCV & RFI is found statistically significant when compared between group A & B, B & C and C&A .Mean values of TEC, MCHC & TIBC are found statistically insignificant when compared between group A & B and B & C but significant between A and C (p value < 0.0025). Whereas mean MCV, & S. iron value were found statistically

insignificant when compared between A & B but significant when compared between B & C and A & C (p value <0.0025).

The presence and severity of anemia can be easily described based on deviation of patients' hemoglobin from a normal set of values. When iron deficiency develops, the hematocrit often falls before MCV becomes subnormal. (9)

The iron deficiency primarily affects Hb synthesis and only to a lesser degree the red cell formation, the later may be normal or only moderately reduced. (10)

MCHC is important in the diagnosis of mild iron deficiency. They have stressed on the diagnostic importance of MCV even if the treatment with iron has already been started, since abnormalities are not reversed

until the old cells are gradually replaced by the newly produced RBC. MCV has been labelled as much more sensitive index for detecting changes in iron deficiency than MCHC. MCV is normal in mild iron deficiency anemia of shorter duration. When MCV is reduced, the cell is microcytic. (18)

The finding of microcytosis gives greater significance to a border line value of Hb or one that is in the lower part of normal range.

The degree of change in the severity of red cell indices is associated with development of anemia. There occurs simultaneous decrease in MCV & MCHC that may actually represent a greater relative deviation from normal than occurs in concentration of Hb.

Table 1: comparative tabulation of various observations in each group.

	GROUP A		GROUP B		GROUP C		P VALUE			
	MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.	A:B:C	A:B	B:C	A:C
AGE (Yrs)	24.4	5.96	24.16	5.91	25.3	5.29				
Wt. (Kgs)	51.85	5.356	51.68	5.047	50.3	4.67				
Hb (gm/dl)	12.39	0.47	11.09	0.476	9.15	0.423	<0.005	<0.0025	<0.0025	<0.0025
PCV (%)	41.6	1.97	39.21	1.58	33.4	2.905	<0.005	<0.0025	<0.0025	<0.0025
TEC(Mil/cumm)	4.925	0.284	4.72	0.26	4.4	0.297	<0.005	>0.0025	>0.0025	<0.0025
MCHC (%)	29.98	1.003	28.3	1.12	27.8	2.385	<0.005	>0.0025	>0.0025	<0.0025
MCV Cub.mic.	84.38	3.597	83.01	3.856	76.1	6.78	<0.005	>0.0025	<0.0025	<0.0025
S IRON	89.82	11.273	74.1	12.91	46.3	15.25	<0.005	>0.0025	<0.0025	<0.0025
Micgm/dl	294	27.869	322.6	42.11	36.0	57.26	<0.005	>0.0025	>0.0025	<0.0025
TSI (%)	30.83	4.8	23.35	4.981	13.3	5.214	<0.005	>0.0025	>0.0025	>0.0025
RFI (%)	71.98	10.94	59.79	9.98	47.6	9.02	<0.005	<0.0025	<0.0025	<0.0025

ENDURANCE

Table 2: Showing comparative duration of exercise in each group.

Group	Duration of Exercise 5 minutes	Duration of exercise 4 minutes	Duration of exercise 3 minutes
A	16 Subjects 40%	21 Subjects 52.5%	3 Subjects (7.5%)
B	13 Subject (19.4%)	27 Subject (40.3%)	27 Subjects (40.3%)
C	2 Subjects (6.06%)	12 Subjects (30%)	19 Subjects (57.58%)

The levels of serum iron are decreased I group B and C and intergroup comparison is statistically significant between group B & C and A & C. The TIBC levels are increased in anemic but intergroup comparison is statically significant only between A & C (p value <0.0025). TSI is reduced in anaemics but not statically significant in intergroup comparison.

There is reduced RFI in anaemics as compared to non anaemics and intergroup comparison is statically significant when compared between groups A & B, B & C and A & C.

DISCUSSION

The anemia is associated with reduced physical performance.

In anemia, the decrease in iron levels is compensated by the iron stores, which maintain the serum iron levels; when the iron stores are exhausted then the serum iron levels fall. ⁽¹²⁾ When iron is lost continuously owing to an impaired absorption, increased destruction, abnormally high excretion, chronic blood loss or other reasons, the depletion of iron stores is the first stage of this process. Depending upon the amount of iron lost and the amount of dietary iron absorbed, a period of time varying from a few months to several years may be required before the iron deficit becomes evident as iron deficiency anemia. ⁽¹³⁾

High levels of TIBC in anemics associated with decreased serum iron are due to stimulation of erythropoiesis which increases number of immature red cells in circulation. ⁽¹⁴⁾ As immature cells have greater amount of transferrin in them, so that amount of transferrin in blood will lead to raised TIBC. Also raised TIBC is the first sign of iron depletion. Fall in serum iron occurs very late. ⁽¹⁵⁾

Decreased TIBC with decreased serum iron is found in hypoproteinemia and decreased TIBC with normal iron is seen in chronic disorders. ⁽¹⁶⁾ So relationship of serum iron and TIBC serves as means of evaluating the diagnostic value of iron deficiency. The validity of percentage saturation (TSI) for assessing iron status is important because it usually reflects depressed levels early in course of iron deficiency at a time when peripheral criteria are unreliable. ⁽¹⁷⁾ Patients with iron deficiency anemia have decreased concentration of serum iron and increased TIBC and accordingly a low degree of transferrin saturations. ⁽¹⁸⁾ Iron uptake by reticulocytes is not only a function of iron present in the plasma but also its relation to the iron binding protein. ⁽¹⁹⁾

When the mobilization of reticuloendothelial iron and enhanced absorption of iron is inadequate to meet the needs of the erythroid marrow, plasma iron levels fall and the amount for transferrin usually increase. ⁽²⁰⁾ The fall in percent saturation of transferrin serves the purpose of more completely directing all available iron to the marrow. When TSI is depressed, the erythroid cells obtain insufficient iron to develop normally. ⁽²¹⁾ TSI has been proposed as a better indicator of iron status than serum iron or TIBC alone by Tumbi & Dodd. In their study they have obtained the data which showed a mean TSI value of only 11.7% as against 23.8% in non anemic; indicating iron deficiency erythropoiesis. ⁽²²⁾

The decreased physical performance in the deficiency anemia is because of reduction in oxygen carrying capacity of blood with a parallel effect on blood CO₂ transport. It is also because of changes in muscle iron containing proteins and in the oxidative work capacity of muscle tissue. ^(23,24)

The iron deficiency can seriously impair the work performance in adults both during intense short lived exercise and during longer endurance work. ⁽²⁴⁾ Mild anemia is easily compensated for by the innate ability of Hb oxygen dissociation curve to maintain oxygen delivery to the tissues as Hb levels fall. However, the shift in the curve will progressively reduce the capacity of red cell to respond to a situation of increased demand as exercise. The subject will have loss of stamina, shortness of breath and a rapid heart rate with exercise because VO_{2max} is more dependent on blood oxygen carrying capacity than on tissue oxidative capacity. ^(25,26)

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The finding of microcytosis gives greater significance to a border line value of Hb or one that is in lower part of normal range. The degree of change in red cell indices is associated with development of anemia. Simultaneous decrease in MCV and MCHC may actually represent a greater relative deviation from normal than occurs in concentration of Hb. (29,30)

There is decreased time to exhaustion during submaximal and maximal work for iron deficient groups. Increase in submaximal endurance was associated with improvement in iron dependent oxidative enzyme capacity within the muscle. The enzymes increase in co-relation with improved iron stores. Both endurance time to exhaustion and enzymes activity continued to improve with iron repletion after Hb concentration and maximum oxygen consumption returned to normal in iron depleted subject.

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How to cite this article: Sharma V, Shazia, Padha L. A study of iron status and its effects on physical performance in young adult females. *Int J Health Sci Res*. 2015; 5(10):118-123.
