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Original Research Article

The Association between Iron Deficiency Anaemia and Intellectual Capacity in Adolescent School Students

Jitendra P. Sah[1], Anuradha B. Patil[2], Nirdhan Yadav[1], Kasturi Hunskatti[3], Aarati Sharma[4]

[1]Postgraduate Student, [2]Professor & HOD,
Department of Biochemistry, Jawaharlal Nehru Medical College, Belgaum, Karnataka, India
[3]Professor, Department of Physiology, Belgaum Institute of Medical Sciences, Belgaum, Karnataka, India
[4]Child Psychologist, Department of Paediatrics, Belgaum Institute of Medical Sciences, Belgaum, Karnataka, India

Corresponding Author: Jitendra P. Sah

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ABSTRACT

Background: Anaemia is currently one of the most common and intractable nutritional problems globally, estimated to be 1.32 billion people or about 25% of the world's population with approximately 50% of all anaemia attributable to iron deficiency. Adolescence is a vulnerable period in the human life cycle for the development of nutritional anaemia like iron deficiency anaemia when requirements are at peak. Iron deficiency has been seen to delay psychomotor development and impair cognitive performance of infants. Likewise, neurological malfunction in young children and adolescents has also been seen to be associated with iron deficiency.
Aims: To explore association between iron deficiency anaemia and intellectual capacity in adolescents.
Materials and Methods: Total 100 government school students of age group 12 – 15 years were included in the study. Blood samples collected from participants were tested for haemoglobin level, serum iron, TIBC, Transferrin saturation and Ferritin, and intellectual capacity was measured by Raven's Standard Progressive Matrices. Independent sample t-Test and one way ANOVA test were used to compare mean IQ percentile in different groups.
Results: We found that that mean IQ percentile (16.0) of Anaemic Iron deficient subjects was very low compare to mean IQ percentile (43.14) of Non-anaemic Non-iron deficient subjects and difference in the mean IQ percentile between two groups was statistically significant.
Conclusion: Iron deficiency anaemia affects intellectual capacity, so this has to be seriously looked upon and preventable measures like supplementation of iron to school students should be taken as early as possible.

Key-words: Iron deficiency anaemia, Adolescents, Intellectual capacity.

INTRODUCTION

Anaemia is currently one of the most common and intractable nutritional problems globally. It is a global public health problem that affects both developing and developed countries with major consequences for human health as well as social and economic development. Anaemia prevalence in the world is estimated to be 1.32 billion people or about 25% of the world's population with approximately 50%

of all anaemia attributable to iron deficiency. [1]

Adolescence (10-19 years) [2] is a vulnerable period in the human life cycle for the development of nutritional anaemia. [3] Iron deficiency and iron deficiency anaemia (IDA) in adolescence is a major public health problem. Studies indicate that the incidence of anaemia in adolescents tends to increase with age and corresponds with the highest acceleration of growth during adolescence. The highest prevalence is between the ages of 12-15 years when requirements are at peak. [4-6]

Iron deficiency is a systemic condition which mild to moderate iron deficiency has adverse functional consequences on cognitive function, behaviour and physical development of infants, preschool and school aged children. [7]

There is no obstacle for plasma transferrin to cross the blood-brain barrier, and thus it is at a higher concentration in the CSF than in the blood plasma. [8] It has been shown that iron is required for several neurological metabolic processes, including neurotransmitter synthesis, myelin formation, and brain growth. [9,10] It has also been demonstrated that iron distribution in adult brains is heterogeneous and different from iron distribution in developing brains. This observation suggests that iron plays a significant role for growing central nervous system. Thus consequences of iron depletion during neurological development could significantly affect a wide variety of behavioral and cognitive functions. [10,11]

Therefore, the present study was undertaken to explore association between iron deficiency anaemia and intellectual capacity in adolescents.

MATERIALS AND METHODS

The study was carried out in the Department of Biochemistry, JNMC, Belgaum, India and the ethical clearance was taken from institutional ethical committee. The participants were students of 6th, 7th and 8th standards of government school, Belgaum, Karnatka. The age group 12-15 years was included and those having acute or chronic blood loss or female students who were menstruating at the time of study were excluded from study. There were 105 students in all the three classes, out of this 101 students included in the study as per inclusion and exclusion criteria. Thus, a written informed consent was taken from parents or guardian of every students participating in this study and also from principal of school and blood samples were collected from 100 students as one student refused to give blood. Thus, total 100 students (54 male + 46 female) were tested for hemoglobin level (Cyanmethemoglobin method), serum iron and Total Iron Binding Capacity (Reagent kit based on Ferrozine method), Transferrin saturation (Calculated from iron and TIBC value), Ferritin (ELISA kit). Intellectual capacity was measured by RSPM (Raven's Standard Progressive Matrices) test.

Participants were divided in to three groups after screening;

Group I: Anaemic (Hb <12 gm%) [1] and Iron deficient (serum Ferritin <15 μg/L) [7]

Group II: Anaemic (Hb <12 gm%) and Non-iron deficient (serum Ferritin ≥15 μg/L)

Group III: Non-anaemic (Hb ≥12 gm%) and Non-iron deficient (serum Ferritin ≥15 μg/L)

All statistical calculations were done by using SPSS software version 16 and Microsoft office excel 2007. Independent sample t-Test was used to compare mean value of iron indices in anaemic and non-anaemic subjects and one way ANOVA test to compare mean IQ percentile in three groups.

RESULT

Out of 100 students 70 had hemoglobin level less than 12 g/dl and 30 had hemoglobin level more than or equal to 12 g/dl. Thus, anaemic subjects in adolescent school students were 70%. Anaemic subjects' (n=70) mean hemoglobin level was 10.13 ± 1.11, non-anaemic subjects' (n=30) mean hemoglobin level was 12.52 ± 0.52 and the total study subjects' (n=100) mean hemoglobin level was 10.85 ± 1.46 (Table 1, 2).

Mean serum iron, TIBC, Transferrin saturation and Ferritin of anaemic subjects were 58.87 µg/dl, 404.44 µg/dl, 18.57 % and 19.58 µg/L respectively. The mean of same indices in non-anaemic subjects were 83.56 µg/dl, 293.50 µg/dl, 30.67 % and 40.08 µg/L respectively. The correlation of iron indices between anaemic and non-anaemic subjects was statically significant (P < 0.001)(Table 3).

Out of 100 students, 43 had Serum Ferritin level <15µg/L. So the iron deficient subjects were 43%. Out of 70 anaemic subjects, 40 had Serum Ferritin level <15µg/L, thus iron deficient anaemic subjects were 40% which were placed in Group I and remaining 30 anaemic subjects had Serum Ferritin level ≥15µg/L, were placed in Group II. Out of 30 non-anaemic subjects, 27 had Serum Ferritin level ≥15µg/L and were placed in Group III (Table 4).

Table 1: Anaemic* and non-anaemic subjects in study population

Hemoglobin level	No. of subjects	(%)	Minimum	Maximum	Mean	SD
<12 g/dl	70	70	6.2	11.5	10.13	1.11
≥12 g/dl	30	30	12	14.2	12.52	0.52

*Hb level <12 g/dl

Table 2: Hemoglobin and iron indices in total subjects (N=100)

Variables	Minimum	Maximum	Mean	SD
Hb (g/dl)	6.2	14.2	10.85	1.46
Iron (µg/dl)	15.38	130.73	66.28	24.30
TIBC (µg/dl)	161.56	761.64	371.15	160.55
Transferrin saturation(%)	2.01	58.30	22.20	13.61
Serum Ferritin	0.06	87.26	25.73	20.90

Table 3: Mean value of Iron, TIBC and % Transferrin saturation in anaemic and non-anaemic subjects

Group	N	Iron (µg/dl) Mean±SD	TIBC (µg/dl) Mean±SD	% Transferrin saturation Mean±SD	Ferritin(µg/L) Mean±SD
Anaemic	70	58.87 ±21.80	404.44±172.60	18.57±12.68	19.58±17.50
Non-anaemic	30	83.56±21.05	293.50±90.59	30.67±11.98	40.08±21.41
t_{98}		5.242	4.195	4.443	5.012
P-value		<0.001	<0.001	<0.001	<0.001

Table 4: No. of students and mean value of Iron, TIBC, % Transferrin saturation and Ferritin in different groups

Groups	No. of students	Hb(gm%) Mean±SD	Iron(µg/dl) Mean±SD	TIBC(µg/dl) Mean±SD	%T. sat. Mean±SD	Ferritin Mean±SD
I	40	9.73±1.17	52.85±23.91	458.71±189.11	15.95±13.66	7.97±5.2
II	30	10.67±0.74	66.90±15.66	332.07±115.36	22.06±10.46	35.05±16.10
III	27	12.56±0.52	85.16±21.21	289.36±92.48	31.63±12.07	43.86±19.00

For assessing the Intellectual capacity RSPM test was used. On the basis of the raw score obtained by students, percentile points were derived. The mean percentile was calculated for three groups (Table 5).

Table 5: Mean IQ percentile points in different groups

Groups	Mean IQ percentile
Group I: Anaemic Iron deficient (n=40)	16.00
Group II: Anaemic Non-iron deficient (n=30)	27.16
Group III: Non-anaemic Non-iron deficient (n=27)	43.14

One way ANOVA test showed significant difference in mean IQ percentile among three groups (df = 2, F = 10.696, p value <0.001). The difference in mean IQ percentile were highly significant (df = 1, F = 22.369, p value <0.001) between Group I (Anaemic Iron deficient) and Group III (Non-anaemic Non-iron deficient). It was also significant (df = 1, F = 5.049, p value <0.029) between Group II (Anaemic Non-iron deficient) and Group III (Non-anaemic Non-iron deficient).

DISCUSSION

In the present study, the anaemic iron deficient and non-anaemic non-iron deficient subjects were compared with their IQ level. It was observed that mean IQ percentile of Group I (Anaemic Iron deficient) was very low compare to Group III (Non-anaemic Non-iron deficient) and difference in the mean IQ percentile between two groups was statistically significant.

Cognitive function is affected by anaemia by its direct neurochemical effect and ultimately it affects on behaviour, where children become less responsive and less attentive. Iron is present throughout the white matter in the brain but the highest concentration is seen in the basal ganglia. [12] After a number of significant work studies, direct neurochemical effect by which anaemia affects cognition has been explained. Iron concentration in the brain is decreased in iron deficiency anaemia which causes a reduction in the neurotransmitter levels and affects cognition. [13] Ultimately this causes delayed neuromaturation, leading to hypomyelination and impaired transmitter functions. Animal studies have shown that a deficiency of iron concentration in the brain of rats in the early developmental stages, causes decrease in the number of dopaminergic D2 receptors and altered neurotransmitter functions which leads to persistent behavioral changes. [14]

Only a few studies have considered the effect of iron deficiency on cognitive performance among older children and adolescents. A positive correlation of IDA with cognitive function and school performance was found in Morocco, in children aged 6-16 years using the RCPM as a psychometric test. Low ferritin level was associated with low IQ, poor mathematics scores and poor average annual scores. [15] In Indonesia, children (8-13 years) were assessed using the RCPM at baseline and after treatment of both controls and cases. At baseline, the non-anaemic children scored better but after intervention the IDA group showed the improvement in scores. A positive correlation between serum ferritin and poor scores in the RCPM was also found in another study conducted in Guatemala. [16] Present study also has similar findings, anaemic iron deficient subjects scored low IQ percentile in RSPM compare to non-anaemic non-iron deficient.

Sungthong and colleagues studied school children in Thailand for the effects of haemoglobin and serum ferritin concentrations on cognitive function. The sample size was 427 school children from two schools in socio-economically deprived communities of southern Thailand. Cognitive function was measured by an IQ test and school performance by Thai language and mathematics scores. Linear regression models were used to investigate the effects of anaemia and iron deficiency on cognition and school performance. Results showed that children with IDA consistently had poor cognitive scores and below average scores for mathematics and Thai language. [17]

Webb and Oski also observed lower achievement test scores (including a math component) among school-aged children in Philadelphia who had a microcytic anaemia.

[18] This is in accordance with present study findings.

The two studies by Pollitt (1997) were done in Egypt and Thailand. The Egyptian study tested effects of iron deficient anaemia on cognitive function of primary school children and findings showed no significant difference between the iron deficient anaemic and the control group on Continuous Performance Test and the Peabody Picture Vocabulary Test. The Thailand study assessed the effects of iron treatment on psycho-educational performance, following sixteen weeks of iron therapy. The IQ scores and educational achievement in mathematics and Thai language did not improve following therapy. [16]

A more recent study reported contradictory results to most of the studies. Dissanayake and colleagues studied the relationship between iron status and cognitive function among adolescents aged 13-15 years in Sri Lanka. Their results showed no significant relationship between intelligence and iron status. [19]

However few study showed no association of iron deficiency, iron deficiency anaemia with cognitive function, present study found iron deficiency anaemia affects intellectual capacity which is similar to most of the previous study.

CONCLUSION

In our study, anaemic iron deficient, anaemic non-iron deficient and non-anaemic non iron deficient in adolescent school student was 40%, 30%, and 27% respectively. The purpose of the study was to explore the association between iron deficiency anaemia and intellectual capacity. We found highly significant difference in IQ percentile measured by RSPM between anaemic iron deficient and non-anaemic non-iron deficient subjects. Thus iron deficiency anaemia affects intellectual capacity. So this has to be seriously looked upon and preventable measures should be taken as early as possible, such as supplementation of iron to adolescent school students.

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Declarations

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