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Correlation between haematological and cognitive profile of anaemic and non anaemic school age girls.

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Abstract

Iron deficiency anaemia in infants can cause developmental problems. However, the relationship between iron status and cognitive achievement in older children is less clear. This study was undertaken to investigate the relationship between iron deficiency and cognitive test scores among school aged girls. Quasi random experimental research design was used. School girls aged 8 to 11 years from Banasthali residential school were selected purposively. Haematological assessment included estimation of haemoglobin (Hb), red cell indices, serum iron, total iron binding capacity (TIBC), serum transferrin saturation and serum ferritin. Psychological assessment was conducted to determine intelligence quotient (IQ), intellectual capacity, educational achievement. Among 111 children in the sample, 77% were anaemic. Serum iron, TIBC, transferrin saturation and serum ferritin were significantly lower in anaemic girls when compared with non anaemics. The former had lower IQ, intellectual capacity and educational achievement than those of their non anaemic counterparts. These three parameters had significant correlation ($p<0.05$) with Hb and serum iron. We demonstrated lower cognitive test scores among iron-deficient anaemic school age girls.

Keywords: Anaemia, Iron deficiency, Cognition, Intelligence Quotient, Educational achievement

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Introduction

Iron status can be considered as a continuum from iron deficiency with anaemia, to iron deficiency with no anaemia, to normal iron status with varying amounts of stored iron, and finally to iron overload- which again proves detrimental by causing organ damage in severe cases. Iron deficiency affects both physical and mental health of humans. The functional consequences transgress physical domain to intrude and erode mental faculties and jolt the well being thereafter, all the more so in the fairer sex. Thus the nutrition and health vulnerabilities of women in developing countries get compounded owing to the physiological perils of menarche and motherhood (when a sudden iron overload wreaks havoc to precipitate cardiovascular and malignant diseases) with respect to iron nutriture.

The pallor of anaemia was associated with weakness and tiredness long before its cause was known. Now it is recognized that even without anaemia, mild to moderate iron deficiency has adverse functional consequences on- (i) the use of energy sources by muscles and thus the physical capacity and work performance of adolescents and adults alike, (ii) the immune status and morbidity from infections in all age groups, (iii) the cognitive performance, behaviour and physical growth of infants, preschool and school aged children. In addition, iron deficient humans have improved gastro intestinal functions and altered patterns of hormone production and metabolism. The latter include those for neurotransmitters and thyroid hormones which are associated with neurological, muscular and temperature regulatory altercations. Iron deficiency anaemia 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.

Anaemia prevalence in the world is estimated to be 1.32 billion people or about 25% of the world's population [1]. Asia has the highest number of cases of anaemia with about half of the world's anaemic women living in the Indian subcontinent, the majority of whom develop anaemia during pregnancies [2]. Nutritional anaemia is one of India's major public health problems. The prevalence of anaemia ranges from 33% to 89% among preg-

nant women and is more than 60% among adolescent girls. Among adolescent girls from 16 districts, the overall prevalence of anaemia (defined as Hb < 120 g/L) was 90.1%, with 7.1% having severe anaemia (Hb < 70 g/L) [3]. Anaemia prevalence among children (< 3 years) (Hb < 11g/dl), pregnant women (Hb < 11g/dl), and women of reproductive age (Hb < 12g/dl) was high at 79%, 59% and 56% respectively and appears to have increased overall since the last National Family Health Survey (1998-1999) [4], though more so in rural than urban areas [5].

The importance of widespread iron deficiency and anaemia among Indian girls has to be viewed in the context of these functional consequences. The present study was undertaken to study the correlation between anaemia and certain cognitive abilities in school age girls. The work was taken up as this aspect has been least researched upon, as also this age group in females.

Material and Methods

The participants of the study were 8 to 11 year old school age girls residing in the hostels of *Banasthali Vidyapith*, a residential educational institution for girls. The study was delimited to the girls studying and residing in a single institution so as to have a group homogeneous with respect to living conditions, eating pattern, intellectual environment and exposure to information and knowledge; factors which can have a confounding effect on the results. After getting the consent from the authorities and the parents of the children, they were screened for haemoglobin (Hb) level and intelligence quotient (IQ). Those having severe anaemia or IQ < 75 or having suffered a recent episode of malaria or having attained menarche were excluded. The complete data was thus obtained from 111 girls.

Data collection included estimation of Hb (cyanmethaemoglobin method), red cell indices namely, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) (using automated haemo analyser), serum iron and total iron binding capacity (TIBC) (using reagent kits based on Ramsay's method) and serum ferritin in one fourth of the subjects using enzyme linked fluorescent assay (ELFA) technique. Psychological testing included assessment of cognition through determination of IQ (General mental ability test for children), intellectual capacity {Raven's standard progressive matrices (RSPM)} and scholastic performance (based on general classroom ability test).

Minitab® 15.1.0.0 (Minitab Inc.) was used for the statistical analysis of the data. A Pearson correlation coefficient was used to measure the extent to which two continuous variables are linearly related. The student's t test procedure was used to make inferences about the difference between two population means, based on data from two random samples.

Results

The prevalence of anaemia (Hb < 11.5 g/dl) was 77.5% in the study population; 46.0% subjects had mild anaemia (n=51) and 31.5% had moderate anaemia (n=35). Mean Hb of mildly and moderately anaemics was 10.4 and 9.3 g/dl respectively (table 1). Non anaemic subjects' (n=25) mean was 12.1 g/dl. Mean MCV, MCH and MCHC of anaemic subjects were 73.0 fl, 27.6 pg and 31.3% respectively. The means of same indices in non anaemic group were 88.0 fl, 28.8 pg and 32.8% respectively. Serum iron and TIBC mean values were 55.5 and 776.9 µg/dl in moderately anaemic subjects; 86.8 and 663.9 µg/dl in mildly anaemic subjects; 151.5 and 594.2 µg/dl in non anaemic subjects. Per cent transferrin saturation means were 7.2, 13.2 and 26.2 in moderately anaemic, mildly anaemic and non anaemic groups respectively. Mean serum ferritin was 17.1 µg/l in those suffering from moderate anaemia, 18.8 µg/l in mildly anaemics and 50.2 µg/l in those who were not anaemic. There was a significant difference ($p < 0.05$) between anaemic and non anaemic group in all the haematological parameters.

School age girls having IQ of ≥75 were enrolled for the study. The IQ of the study population was between 75 and 150. It ranged from 75 to 150 in anaemic group and from 100 to 148 in non anaemic group. Most of the children (n=45) had average IQ, followed by superior (n=20), genius (n=18), very superior (n=17) and dull (n=11) IQ, respectively. Highest proportion of genius subjects was in the non anaemic group (table 2). The highest frequency of anaemic subjects was in average IQ category. None of the subjects who had moderate anaemia crossed 125 in IQ where as 10 subjects who had mild anaemia had IQ ≥140. The χ^2 statistics showed that degree of anaemia and categories of IQ are associated. Pearson correlations between IQ and Hb (r=0.697; p=0.000), IQ and serum iron (r=0.662; p=0.000) were positive and statistically significant.

RSPM is a culture free test and primarily is used as a measure of general intelligence. The median score for children between 8 to 9 years is expected to be 31, that for 9 to 10 years is 36 and for 10 to 11 years is 39. On the basis of the raw scores obtained, percentile point is derived. Sixty three per cent of the subjects were found to be having raw scores at median or above it for their respective ages Only 55% of anaemic subjects had median or above median scores vis-à-vis 92% non anaemic subjects. Moderately anaemic subjects failed to touch the 95th percentile (intellectually superior) but 8 subjects from mildly anaemic group and 5 non anaemic subjects were intellectually superior. The highest frequency of mildly

anaemics was between 90 to 94th percentile (category II+, definitely above the average in intellectual capacity). Thirteen out of 35 moderately anaemic subjects were in III- category (25th to 49th percentile), the frequency being highest in this category. The highest frequency (8) of non anaemic subjects was in II+ category. The difference between the raw scores of anaemics and non anaemics was statistically significant (p=0.023) (table 3). RSPM raw scores had positive correlation with Hb (r=0.416; p=0.000) as well as serum iron (r=0.391; p=0.000) and the correlations were statistically significant

The maximum possible score in the educational achievement was 30. All the subjects who had superior educational achievement were non anaemics. Among the mildly anaemic subjects highest frequency (32) was in above average category whereas it was in below average category in case of moderately anaemics (27 out of 35). Nineteen non anaemic subjects had above average educational achievement. The χ^2 test demonstrated association between degree of anaemia and categories of educational achievement. Mean scores for educational achievement (table 4) were highest for non anaemic group followed by mildly and moderately anaemic groups. Statistically significant difference was observed between the educational achievement of anaemic and non anaemic groups. A positive and statistically significant correlation existed between educational achievement test scores and Hb (r=0.871; p=0.000) as well as serum iron (r=0.819; p=0.000).

Table 1. *Categorisation of study population on the basis of haemoglobin levels*

Haemoglobin levels (g/dl)	Category	Number	Haemoglobin (g/dl)
			(Mean±SD)
< 11.5	Anaemics	86	10.0* ±0.70
10.0 to < 11.5	*Mild*	51	10.4 ±0.40
7.0 to < 10.0 l	*Moderate*	35	9.3 ±0.55
≥ 11.5	Non anaemics	25	12.1* ±0.37
	Total subjects	111	10.4 ±1.09

* p<0.05 at 5% level (Anaemics Vs Non anaemics)

Table 2. *Inter group intelligence quotient*

Groups	n	IQ		
		Mean	Median	SD
Total subjects	111	111.0	106.0	21.00
Mildly anaemic	51	115.7	115.0	20.34
Moderately anaemic	35	92.2	92.0	8.53
Total anaemics	86	106.1*	102.5	20.20
Total non anaemics	25	127.6*	128.0	14.21

* p<0.05 at 5% level (Anaemics Vs Non anaemics)

Table 3. *Inter group RSPM raw scores*

Groups	Raw scores on Raven's Standard Progressive Matrices			
	n	Mean	Median	SD
Total subjects	111	38.0	39.0	8.1
Hb wise-				
Total anaemics	86	37.1*	38.0	8.3
Total non anaemics	25	41.0*	42.0	7.0
Age wise-				
8 years	17	36.4	37.0	5.7
9 years	32	35.8	37.0	7.9
10 years	62	39.6	40.5	8.5

** p=0.023 at 5% level (Anaemics Vs Non anaemics)*

Table 4. *Inter group educational achievement test scores*

Groups	n	Scores		
		Mean	Median	SD
Total subjects	111	17.7	18.0	2.90
Mildly anaemic	51	18.2	18.0	1.62
Moderately anaemic	35	14.5	15.0	1.37
Total anaemics	86	16.7*	16.5	2.38
Total non anaemics	25	20.9*	21.0	2.12

** p<0.05 at 5% level (Anaemics Vs Non anaemics)*

Discussion

The prevalence of anaemia in the study population was 77%. Prevalence of this magnitude has been reported in other surveys from various parts of the country. National Family Health Survey [4] reports prevalence of anaemia to be 70 to 80% in Indian children. At the baseline survey of 3000 school children in Gujarat, 84% had Hb < 12g/dl. No differences were observed in the prevalence of IDA according to sex, but significantly more rural than urban children had IDA (92% versus 78%) [6].

Several biological mechanisms potentially link iron deficiency with impaired cognitive performance. Iron deficiency results in decreased body iron stores, including decreased iron in the central nervous system, even before red blood cell production is affected [7]. Disordered cerebral oxidative metabolism attributable to low levels of haeme-containing and iron-dependent enzymes results in behavioural abnormalities in animals [8]. Furthermore, alterations of the metabolism of several putative neurotransmitters have been described in both iron-deficient animals and humans [9].

Iron deficiency anaemia is associated with developmental difficulties in infancy and early childhood. Specifically, infants with iron deficiency anemia have lower scores on the Bayley Scale of Mental Development compared with iron-sufficient infants. Furthermore, behavioural and cognitive symptoms often improve with iron-replacement therapy, in many instances before an increase in the Hb concentration [10].

Only a few studies have considered the effect of iron deficiency on cognitive performance among older children and adolescents. Initially, Webb and Oski observed lower achievement test scores (including a math component) among school-aged children in Philadelphia who had a microcytic anaemia [11]. Although this study raised the possibility that iron deficiency affected academic performance, iron deficiency was not established as the cause of the microcytic anemia and potential confounding variables, such as poverty and race, were not considered.

After this observation, 3 trials in non-Western countries (Egypt, Indonesia, and Thailand) assessed the effect of iron supplementation on cognitive performance among school-aged children and adolescents [12, 13, 14]. Although the specific findings of these studies varied somewhat, each showed lower test scores among children with iron deficiency, compared with their iron-replete peers, thus providing reasonable evidence of an association between iron deficiency and some measures of cognition among children in these countries. One of these studies [12] found lower scores on achievement tests that included a math component.

School performance was compromised in the anaemic in comparison to the non anaemic children in this study, more so in moderately anaemics. Educational achievement had a high correlation with Hb as well as serum iron as deduced through the data of this study which is in conformity with the findings of Pollitt. The study design in this research project was that of a pre test, post test intervention trial with random allocation of subjects into experimental and control groups. The potential confounding effect of many environmental factors was controlled by undertaking the study on subjects exposed to same living conditions of a residential school.

It is time to attend to the needs of school age children and prevent them from the scourge of hidden hunger. Mounting scientific evidence indicates that iron deficiency has intergenerational effects that significantly increase its economic and other social costs. Investments in children's health are, therefore, investments in future well being and productivity and in future generations. Preschools and schools offer many opportunities to promote healthy diets and physical activity for children and are also a potential access point for engaging parents and community members in preventing child malnutrition in all its forms (i.e., undernutrition, micronutrient deficiencies, and obesity and other nutrition-related chronic diseases). The universality of the school setting for gaining access to children makes it highly relevant to global efforts to combat the increasing public health problems of nutrition related ill health.

The study concludes that the anaemic subjects are at a disadvantage when it comes to performance in the school and intellectual capacity. The haemoglobin and serum iron levels are correlated to intelligence quotient, intellectual capacity and educational achievement in the school aged girls. It is high time that we look beyond targeting at the meagre manifest symptoms at a particular stage or condition and aim at the holistic nutrition of women, beginning at childhood and spanning school age, menarche, middle age and post menopausal years.

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