EFFECT OF IRON DEFICIENCY ANEMIA ON INTELLIGENCE QUOTIENT IN SCHOOL GOING CHILDREN OF PESHAWAR KHYBER PAKHTUNKHWA, PAKISTAN

Nida Khan[1,2✉], Zahid Khan[1], Rubina Nazli[2], Saima Arzeen[3], Naeema Arzeen[3], Tasleem Akhtar[4]

ABSTRACT

OBJECTIVE: To find the effect of iron deficiency anemia (IDA) on intelligence quotient (IQ) in school going children of Peshawar, Pakistan.

METHODS: In this cross-sectional study a total of 153 children (male and female) of age 7-11 years were included. Socio-demographic questionnaire was designed for the collection of data. Blood specimens were collected in ethylenediaminetetraacetic acid (EDTA) and gel tubes. Complete blood count (CBC) was analyzed using fully automatic hematology analyzer (Model Sysmex XP-100, serial no.B2444) in EDTA blood. Ferritin levels were analyzed using chemistry analyzer (Model: Cobas e-6000), by Electrochemiluminescence immunoassay (ECLIA) in serum. Raven Colored Progressive Matrices (RCPM) was used for finding IQ of children. Statistical analysis was done using SPSS-22.

RESULTS: Out of 153 children 66 (43.1%) were females and 87 (56.9%) were males. The prevalence of IDA was 11.7%. The mean IQ of nuclear family (57.3±37.33) was significantly higher than joint family children (34.8±34.53). The mean IQ of male (41.7±35.0) is bit higher than female (39.0±38.62). In 153 children, 66 (43.1%) were normal, 33 (21.6%) were obese and 54 (35.3%) were underweight. IQ of below average children with the average ones shows significant difference with hemoglobin and hematocrit (HCT). IQ of iron deficient anemic children was significantly lower than the normal children. The mean IQ, hemoglobin and ferritin levels for children having IDA were 9.1±8.01 (percentile), 11.2±0.33 (g/dl), and 9.6±1.2 (ng/ml) respectively.

CONCLUSION: Intelligence of school going children is significantly affected with IDA and they have low IQ values as compared to normal children.

KEY WORDS: Anemia, Iron Deficiency (MeSH); Intelligence quotient (Non-MeSH); Anemia (MeSH); Hemoglobins (MeSH); School going children (Non-MeSH); Raven Colored Progressive Matrices (Non-MeSH); Ferritins (MeSH).

INTRODUCTION

Iron deficiency anemia (IDA) is defined as, hemoglobin less than 11.5 g/dL and ferritin of less than 12 ng/mL.[1,2] IDA is one of the most wide-ranging health problem especially in children, around 40% of children in Asia and Africa are anemic.[3] IDA causes weakness, poor physical growth and a weak immune system. It also affects cognition, interrupt psychomotor development and has many negative effects on academic performance of school going children.[4] Iron is required during periods of rapid growth and development of children, so mostly infants, children and adolescence are affected.[5]

According to the global prevalence of anemia "the highest prevalence of anemia in children was 42.6%".[6] Similarly, according to WHO estimation, the people suffering from anemia are more than 2 billion and approximately half of it are due to iron deficiency.[7] Another study shows that the incidence of anemia in children of age 5-12 years was 46% in developing countries. Highest rates were seen in Asia (50%) and Africa (49%).[8]

Prevalence of IDA in Thailand is 4.2% in all children and 19.4% among the anemic children.[9] In US the prevalence is less than 3% in children age: 6-11 years. In Iran (age < 17 years) prevalence is 29.5%, while in India prevalence is 63%[10] and 50%[11] and Nepal 16%.[12]

In Islamabad prevalence of IDA is 70.2% in children age 7-9 years, of low income families[13.] Karachi 70%[14,15] and Lahore 68.8%.[16] A research study from District Karak, Khyber Pakhtunkhwa Province reported IDA in school going children age 6-12 years as 34%.[17] Similarly in Dera Ismail Khan a survey was conducted, which shows that at the age of six years, 58.58% boys and 70% girls were anemic.[13]

Some studies shows that children with IDA and iron deficiency have no significant difference with cognitive function,[18,19] while some studies have reported significant decrease in cognitive and motor function with IDA.[20,21] An evidence from Islamabad (Pakistan) found that the intelligence quotient (IQ) scores of children having IDA are lower than non-IDA children.[13] A study in Karak (Khyber Pakhtunkhwa- Pakistan) also reported that mental and motor function in children reduced with iron deficiency.[22] In Pakistan many studies have been conducted on IDA children but very few

TABLE I: DEMOGRAPHIC PARAMETERS OF CHILDREN

Demographics		n	%	IQ (Percentile)	Hb (g/dl)	Ferritin (ng/ml)
Age (years)	7	30	19.60	45±43.07	11.9±1.02	43.3±32.34
	8	21	13.72	45±38.62	12.3±0.65	68.0±15.09
	9	24	15.6	36.8±32.5	12.2±0.52	67.8±23.65
	10	30	19.60	38.5±38.6	12.5±0.75	68.5±22.1
	11	48	31.37	39±35.31	12.5±1.15	70.9±16.32
School grades	≤ 3	90	58.82	39.8±36.96	12.2±0.8	60.8±26.13
	>3	63	41.17	41.6±36.1	12.5±1.04	68.9±19.97
Family System	Nuclear	39	25.49	57.3±37.33*	12.6±0.8	70.9±19.71
	Joint	114	74.51	34.8±34.53*	12.2±0.94	61.8±25.0
Siblings	≤ 4	87	56.9	40.3±37.5	12.2±1.09	63.1±26.34
	>4	66	43.13	40.9±35.4	12.4±0.62	65.5±20.79
Child Ordinal Position	≤ 2	81	52.94	35.1±35.8	12.3±1.06	62.7±26.02
	>2	72	47.05	46.6±36.5	12.2±0.72	65.8±21.72
Father Occupation	Government Job	33	21.56	28.1±31.56	12.0±0.87	63.0±23.71
	Private Job	57	37.25	43.94±37.21	12.3±0.69	67.8±22.97
	Self-Business	63	41.17	44.0±37.86	12.4±1.10	61.4±25.52
Family Income (PKR)	≤10000	57	37.25	42.36±38.0	12.3±1.04	60.8±24.94
	>10000	96	62.74	39.5±35.74	12.3±0.84	66.1±23.44
Mother Education	Educated	63	41.17	41.9±37.89	12.1±0.92	60.7±27.18
	Uneducated	90	58.82	39.6±35.69	12.4±0.90	66.6±21.47
Father Education	Educated	108	70.58	43.1±36.68	12.3±0.96	64.3±24.51
	Uneducated	45	29.41	34.3±35.65	12.2±0.79	63.8±23.20

P<0.05* is considered as significant, n= total number of samples, %= percentage, IQ= intelligence quotient, Hb= Hemoglobin.

studies have been done on IQ of iron deficient anemic children. In Peshawar, no study has been conducted on effect of IDA on intelligence of school going children; therefore this study was designed to find the effect of IDA on intelligence of school going children related to our community. This was done by taking IQ test from children and by measuring hematological parameters and serum ferritin levels.

METHODS

This cross-sectional study was conducted in different colonies (Ahmadabad, Qaziabad, Shah-G abad, Bukhari colony, Yaqoob quarters and Madina colony) of Peshawar city from November 2, 2017 to April 30, 2018. One hundred and fifty-three school going healthy children (male and female) of grade 1-5, age

ranged between 7-11 years were included randomly in this study.

Study was approved from ethical review board of Khyber Medical University, Peshawar, Pakistan. Participants in the community were approached and aims of the study were clearly explained to them. Consents and assents were signed from parents and children. Socio-demographic questionnaire and anthropometric data regarding age, weight and height etc. were taken from children. Body Mass Index (BMI) was calculated by using formula weight/height^2 in Kg/m^2. By using BMI chart for boys and girls (age 2-20 years) they were divided in to three categories i.e underweight, normal and obese.

Blood samples (3ml) were collected aseptically in vacutainers (EDTA and Gel tubes). The serum was separated by

centrifugation at 4000 rpm for 10 minutes and stored at -40° in deep freezer of Pakistan Health Research Council (PHRC). Complete blood count (CBC) was measured in EDTA blood using fully automatic hematology analyzer (Model Sysmex XP-100, serial no. B2444) in PHRC. In serum, ferritin levels were measured using chemistry analyzer (Model: Cobas e-6000), Electrochemiluminescence immunoassay (ECLIA) in Hayatabad Medical Complex (HMC) Peshawar.

Raven's Colored Progressive Matrices (RCPM) was used as psychometric tool for finding intelligence quotient. This is a culture-fair test and designed to assess non-verbal intelligence. This test is used for children of ages 5.5 to 11.5 years.[23] IQ scores were divided into three categories as below average (5-10 percentile), average (25-50 percentile) and above average (75-95 percentile).

Data was analysed using mean/ standard deviation and different parameters were compared using SPSS version 22. For normally distributed data student t test was used while for skewed data means were compared using Mann Whitney U test. P <0.05 was considered as significant.

RESULTS

There were 153 children in study, out of which 66 (43.1%) were females and 87

TABLE II: COMPARISON OF IQ AND BLOOD PARAMETER AMONGST MALE AND FEMALE IN STUDY POPULATION

Parameters	Female (n=66)	Male (n=87)	P-value
Intelligence Quotient (Percentile)	39.0±38.62	41.7±35.0	0.79
Hemoglobin (g/dl)	12.2±0.93	12.3±0.91	0.70
Ferritin (ng/ml)	60.4±26.12	67.0±22.13	0.33
Hematocrit (%)	36.0±1.79	35.4±2.28	0.31
Mean Corpuscular Volume (fl)	79.3±3.64	78.4±4.70	0.46
Mean corpuscular hemoglobin (pg)	26.9±2.01	27.3±2.34	0.0005
Mean corpuscular hemoglobin concentration (g/dl)	34.0±1.99	34.8±1.57	0.11

TABLE III: COMPARISON OF NORMAL CHILDREN WITH UNDERWEIGHT AND OBESE CHILDREN

Parameters	Underweight n=54 (35.5%)		Normal Weight n=66 (43.1%)	Obese n=33 (21.6%)	
	Mean±SD	P-value	Mean±SD	Mean±SD	P-value
Intelligence Quotient (Percentile)	21.3±28.48	0.002	53.4±34.27	46.3±40.80	0.60
Hemoglobin (g/dl)	12.0±0.82	0.03	12.6±0.86	12.2±1.01	0.24
Ferritin (ng/ml)	56.2±28.25	0.02	73.0±15.83	59.6±25.80	0.07
Hematocrit (%)	35.0±1.34	0.04	36.3±2.38	35.7±2.28	0.49
Mean Corpuscular Volume (fl)	78.4±3.68	0.07	80.4±3.23	76.3±5.76	0.01
Mean corpuscular hemoglobin (pg)	26.8±2.09	0.04	28.0±1.64	26.1±2.83	0.02
Mean corpuscular hemoglobin concentration (g/dl)	34.2±1.85	0.28	34.8±1.67	34.1±2.01	0.29

(56.9%) were males. The socio-economic and socio-demographic data given in Table-I shows that only IQ of nuclear family children is significantly higher than joint family children. Other parameters, including family income, parent's education, number of siblings, child ordinal position, were not significant.

The comparison of IQ, hemoglobin (Hb), Ferritin (reference value: 12-150 ng/ml)[16] and other blood parameters in both genders are not significant except for Mean corpuscular hemoglobin (MCH) which is significant (P<0.05) (Table II). However, the mean IQ of male is bit higher than female.

The BMI data shows that in a total of 153 children, 66 (43.1%) were normal, 33 (21.6%) obese and 54 (35.3%) were underweight. Comparison of underweight children with normal shows that IQ, Hb, Ferritin, Hematocrit (HCT), MCH are decreasing significantly with BMI in underweight children (P<0.05), While the comparison of obese with normal children shows that only Mean Corpuscular Volume (MCV) and MCH are decreasing significantly in obese children (Table III).

The comparison of IQ of below average children with the average ones shows significant difference with Hb and HCT, while the difference for ferritin, MCV, MCH, Mean corpuscular hemoglobin concentration (MCHCl) are not significant. On the other hand, comparison of above average children with average ones shows no significant difference with Hb, instead IQ is significantly increasing with increase in MCV, MCH, MCHC (Table IV).

The comparison between IDA and normal children (non-iron deficient anemic) shows that the IQ of iron deficient anemic children is significantly lower than the normal children. The mean IQ, Hb and ferritin levels for children having IDA are found to be 9.1±8.01 (percentile), 11.2±0.33 (g/dl), and 9.6±1.2 (ng/ml) respectively (Table V).

DISCUSSION

In this study we tried to explore the effects of IDA on IQ of school going children in Peshawar. Our study revealed that IQ of below average children with the average ones shows significant difference with hemoglobin and HCT. IQ of children having IDA was significantly lower than the normal children.

It is estimated that 25% of the world population is affected by iron deficiency. The age groups most affected are infants between 4 and 24 months, school age children, female adolescents, pregnant women, and nursing mothers.[22]

In this research study the prevalence of IDA in children aged 7-11 years was found to be 11.7%. Different studies reported different prevalence of IDA. In some countries the prevalence is low as in Thailand (4.2%)[9], United states (3%)[24], in Nepal (16%)[25], Iran (29.5%)[19], while in some areas IDA prevalence is high, Africa (60%), Latin America (46%), Eastern Mediterranean (63%), Southeast Asia (66%).[26] In Pakistan the prevalence of IDA is high as in Karak (34%)[22], Lahore (68.8%)[16] and Karachi (70%).[14] In Peshawar city, the prevalence is low as compared with other studies.

As the IQ of males was found bit higher than females, similar study has been reported by Rassamee Sungthong et.al in Thailand in which male IQ is slightly higher as compare to female.[9]

The IQ of children is decreasing with hemoglobin. The reason may be that the areas of brain involved in coordination and motor control needs iron. Moreover, the prefrontal part of the brain which is involved in attention and memory require dopamine. Dopamine is a neurotransmitter and show decrease activity with decreasing iron concentration.[27,28]

In this study the IQ of IDA children are lower as compared to normal children. Similar studies have been reported significant decrease in cognitive and motor function with IDA.[29,30] Evidence from Islamabad found that the IQ scores

TABLE IV: COMPARISON OF IQ WITH BLOOD PARAMETERS

Blood Parameters	Below Average (5-10 percentile) n=66 (43.1%)		Average (25-50 Percentile) n=30 (19.6%)	Above Average (75-95 Percentile) n=57 (37.3%)	
	Mean±SD	P-value	Mean±SD	Mean±SD	P-value
Hemoglobin (g/dl)	11.7±0.67	0.01	12.4±0.73	12.9±0.81	0.11
Ferritin (ng/ml)	52.5±28.77	0.13	68.4±21.73	75.4±8.61	0.22
Hematocrit (%)	34.8±1.69	0.05	36.0±1.21	36.5±2.51	0.55
Mean Corpuscular Volume (fl)	78.1±4.80	0.47	76.9±3.03	80.7±3.53	0.007
Mean corpuscular hemoglobin (pg)	26.2±2.16	0.71	26.5±2.02	28.6±1.56	0.004
Mean corpuscular hemoglobin concentration (g/dl)	33.6±1.79	0.25	34.4±1.87	35.4±1.29	0.05

TABLE V: COMPARISON OF IRON DEFICIENCY ANEMIA WITH NORMAL CHILDREN

Parameters	Iron Deficiency Anemia (n=18)	Normal (n=135)	P-value
IQ (Percentile)	9.1±8.01	44.7±36.52	0.02
Hemoglobin (g/dl)	11.2±0.33	12.4±0.87	0.001
Ferritin (ng/ml)	9.6±1.2	71.4±13.79	0.000
Hematocrit (%)	34.2±1.77	35.9±2.06	0.06
Mean Corpuscular Volume (fl)	75.5±7.35	79.3±3.56	0.03
Mean corpuscular hemoglobin (pg)	24.9±2.79	27.5±1.94	0.005
Mean corpuscular hemoglobin concentration (g/dl)	33±1.40	34.6±1.77	0.03

of children having IDA are lower than non-IDA children. Another study also shows that mental and motor function in children are reduced with iron deficiency.[13]

IQ of children in nuclear family was significantly high as compare to children in joint family. The reason may be that the children of joint family are residing in very small houses where most of the families occupy only one room with several children, and the parents can't give proper attention to their children, while the difference between hemoglobin and serum ferritin levels were found non-significant.

LIMITATIONS AND RECOMMENDATIONS

The sample size was small and collected only from one community, so we can't generalize it. For diagnosing IDA, only Hb, MCV and ferritin levels were considered. The other blood parameters like total iron binding capacity (TIBC), transferrin saturation, serum Iron, and peripheral blood smear must be examined in blood sample.

CONCLUSION

The study concluded that the intelligence of school going children is affected with iron deficiency anemia and they have low IQ values as compared to normal children.

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AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

NK: Conception and study design, acquisition of data, drafting the manuscript, critical review, approval of the final version to be published.

ZK & SA: Analysis and interpretation of data, drafting the manuscript, approval of the final version to be published.

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NA: Analysis and interpretation of data, critical revision, approval of the final version to be published.

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Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

DATA SHARING STATEMENT
The data that support the findings of this study are available from the corresponding author upon reasonable request.