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Original Research Article.

Iron Deficiency Anemia in School-Going Children: Assessment of Prevalence, Severity and Gender-Based Correlation

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ABSTRACT

Background: Iron deficiency anemia (IDA) is a common nutritional disorder among school-going children and may adversely affect growth, cognition, physical performance, and academic functioning. Gender-related physiological and nutritional differences may influence its occurrence, particularly during later childhood and adolescence. Early identification is therefore important for preventing potentially avoidable developmental consequences.

Aim: To assess the prevalence and severity of iron deficiency anemia among school-going children and determine its correlation with gender.

Material and Methods: This hospital-based cross-sectional observational study included 105 school-going children aged 6–15 years attending Department of Paediatrics, Index Medical College, Hospital & Research Centre, Indore, Madhya Pradesh (India) or referred through school health screening. Demographic, dietary, nutritional, and clinical information was recorded. Hematological parameters included hemoglobin, hematocrit, RBC count, MCV, MCH, MCHC, and RDW. Iron status was assessed using serum ferritin, serum iron, total iron-binding capacity (TIBC), and transferrin saturation. Children were classified according to anemia severity. Gender-wise comparisons were performed using appropriate statistical tests, with $p<0.05$ considered statistically significant.

Results: Of 105 children, 56 (53.33%) were males and 49 (46.67%) were females. Overall, 59 (56.19%) had iron deficiency anemia. IDA was significantly more common among females than males (69.39% vs 44.64%; $p=0.011$). Mild, moderate, and severe anemia were observed in 24.76%, 25.71%, and 5.71% of children, respectively, with severity significantly associated with gender ($p = 0.030$). Females had significantly lower mean hemoglobin (10.91±1.47 vs 11.62±1.38 g/dL), PCV, MCV, MCH, serum ferritin, serum iron, and transferrin saturation, and significantly higher RDW and TIBC. IDA was significantly associated with pica ($p=0.019$), inadequate iron-rich food intake ($p=0.002$), underweight status ($p=0.016$), and irregular or absent deworming ($p=0.042$).

Conclusion: Iron deficiency anemia was highly prevalent among school-going children and showed a significant female predominance. Nutritional inadequacy, pica, underweight status, and poor deworming practices were important associated factors. Regular screening, dietary improvement, iron supplementation, and school-based preventive measures are warranted.

Keywords: Iron Deficiency Anemia; School-Going Children; Gender; Ferritin; Nutritional Status.

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INTRODUCTION

Iron deficiency anemia (IDA) is one of the most important nutritional disorders affecting children and adolescents and remains a major public health concern, particularly in low- and middle-income countries. Iron is an essential micronutrient required for hemoglobin synthesis, oxygen transport, cellular metabolism, immune function, and normal growth. When body iron stores become depleted, erythropoiesis is progressively impaired and hemoglobin production declines, resulting in iron deficiency anemia. In India, childhood anemia has a multifactorial background in which inadequate dietary iron intake, poor bioavailability, nutritional deficiencies, infections, socioeconomic disadvantage, and other biological factors may coexist.[1]

School-going children represent an important population for assessment because the school years encompass both middle childhood and the transition into adolescence. During these years, increases in body size, blood volume, muscle mass, and metabolic activity increase nutritional requirements. Iron requirements may become particularly high during accelerated growth. Dietary inadequacy, irregular meal patterns, limited consumption of iron-rich foods, and predominantly plant-based diets may further reduce bioavailable iron. Rural residence, poor sanitation, socioeconomic limitations, and inadequate access to preventive health services can also contribute to micronutrient deficiencies.[2]

Iron deficiency can exist before anemia becomes clinically apparent. Depletion of iron stores is followed by iron-restricted erythropoiesis and, with further progression, a fall in hemoglobin concentration. Consequently, hemoglobin estimation alone may not fully characterize iron status. Assessment may include red-cell indices and biochemical markers such as serum ferritin, serum iron, total iron-binding capacity, and transferrin saturation. Serum ferritin is useful for assessing stored iron, while interpretation alongside other hematological and biochemical parameters can improve recognition of iron deficiency. Combined hematological and biochemical assessment is therefore useful in schoolchildren.[3]

The relevance of IDA in school children extends beyond abnormalities in the complete blood count. Iron participates in brain energy metabolism, neurotransmitter synthesis, myelination, and other processes important for neurological function. Deficiency during childhood and adolescence may be associated with reduced attention, concentration, memory, learning capacity, and scholastic performance. These effects are particularly relevant during the school years, when cognitive development and academic demands are increasing. Research among school-going adolescent females has emphasized the relationship between iron status and cognitive functioning, supporting early identification of iron deficiency even before its consequences become clinically prominent.[4]

Gender is an important consideration when assessing anemia in school-going children. Before puberty, differences between boys and girls may be relatively small; however, with advancing age, physiological and nutritional requirements begin to diverge. Adolescent girls are particularly vulnerable because rapid growth is accompanied by the onset of menstruation and recurrent iron loss. Inadequate dietary replacement can progressively reduce iron stores. Boys also have increased iron requirements during growth because of expansion of lean body mass and blood volume, but the pattern of risk may differ between genders. School-based research among adolescent girls has therefore emphasized early detection, iron-folic acid supplementation, dietary improvement, and supervised preventive strategies.[5]

Clinical and nutritional factors may further modify the risk of iron deficiency anemia. Poor intake of iron-rich foods, undernutrition, pica, recurrent infections, and parasitic infestation can contribute directly or indirectly to deficient iron status. The bioavailability of dietary iron is influenced by its source and by substances that enhance or inhibit intestinal absorption. Children consuming diets with limited heme iron may depend predominantly on non-heme iron, whose absorption is more variable. Because iron deficiency can affect both physical capacity and intellectual functioning, assessment of school children should consider dietary, anthropometric, clinical, and laboratory characteristics rather than hemoglobin concentration alone. Studies in primary school populations have reinforced the importance of examining iron deficiency in relation to learning and development.[6]

MATERIALS AND METHODS

The present study was designed as a hospital-based cross-sectional observational study to assess the prevalence and severity of iron deficiency anemia among school-going children and to determine its correlation with gender. A total of 105 school-going children fulfilling the eligibility criteria were enrolled. Children were evaluated according to a predefined protocol including demographic assessment, clinical examination, hematological investigations, and iron profile. A total of 105 children of school-going age, 6–15 years, attending Department of Paediatrics, Index Medical College, Hospital & Research Centre, Indore, Madhya Pradesh (India) or referred through school health screening were included. Participants were enrolled consecutively until the required sample size was achieved. Children were categorized according to gender as male and female, and appropriate age groups were formed for comparative analysis. The principal outcome was the presence and severity of iron deficiency anemia, while gender-wise differences in hematological and iron parameters were evaluated as secondary outcomes.

Inclusion Criteria

School-going children aged 6–15 years whose parents or legal guardians provided written informed consent were eligible for participation. Children who were willing to undergo clinical examination and blood investigations and for whom adequate demographic, clinical, and laboratory information was available were included in the study.

Exclusion Criteria

Children with a known history of hemoglobinopathies, aplastic or hemolytic anemia, chronic kidney disease, chronic liver disease, malignancy, major congenital disorders, or other chronic systemic illnesses known to affect hemoglobin concentration were excluded. Children with recent blood transfusion, active significant bleeding, or currently receiving therapeutic doses of iron were also excluded. Children with incomplete laboratory investigations or inadequate blood samples were not considered for final analysis.

Methodology

A structured data collection proforma was used for each participant. Information regarding age, gender, residence, dietary pattern, socioeconomic background, history of pica, appetite, recurrent infections, deworming, previous iron supplementation, and relevant medical history was recorded. Dietary history particularly assessed the consumption of iron-rich foods, green leafy vegetables, pulses, fruits, milk, and animal-source foods. Clinical examination included general condition and assessment for pallor, fatigue, weakness, irritability, koilonychia, glossitis, angular cheilitis, and other manifestations suggestive of anemia. Height and weight were measured using standardized techniques, and body mass index was calculated.

Hematological Assessment

Under aseptic precautions, venous blood was collected from each participant. Complete blood count was performed using an automated hematology analyzer. The parameters evaluated included hemoglobin (Hb), hematocrit/packed cell volume (PCV), red blood cell count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW). Peripheral blood smear examination was performed where required to assess red cell morphology, including microcytosis, hypochromia, anisocytosis, and poikilocytosis.

Iron Profile and Biochemical Assessment

Iron status was assessed using serum ferritin, serum iron, total iron-binding capacity (TIBC), and transferrin saturation (TSAT). Transferrin saturation was calculated as serum iron divided by TIBC multiplied by 100. Serum ferritin was considered the primary marker of depleted iron stores. C-reactive protein (CRP) was assessed when clinically indicated because ferritin may be falsely elevated in the presence of inflammation. The combined interpretation of hemoglobin, red cell indices, ferritin, serum iron, TIBC, and transferrin saturation was used to improve the identification of iron deficiency anemia.

Definition and Classification of Anemia

Anemia was defined on the basis of age-appropriate hemoglobin cut-off values recommended for children. According to hemoglobin concentration, anemic children were further categorized as having mild, moderate, or severe anemia. Iron deficiency anemia was identified by low hemoglobin accompanied by biochemical evidence of reduced iron stores, particularly reduced serum ferritin and/or reduced transferrin saturation, together with supportive findings such as low serum iron, increased TIBC, low MCV, low MCH, and increased RDW. The frequency and severity of iron deficiency anemia were compared between male and female participants.

Gender-wise Correlation and Outcome Measures

The primary outcome measure was the proportion of children with iron deficiency anemia. Additional outcomes included severity of anemia, mean hemoglobin concentration, MCV, MCH, MCHC, RDW, serum ferritin, serum iron, TIBC, and transferrin saturation. These parameters were compared between male and female children to determine whether gender was significantly associated with the occurrence or severity of iron deficiency anemia. Associations with age group, dietary pattern, nutritional status, pica, and other relevant clinical factors were also evaluated.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS). Continuous variables were expressed as mean ± standard deviation or median with interquartile range according to data distribution, while categorical variables were presented as frequency and percentage. The independent-samples t-test or Mann–Whitney U test was used for comparison of continuous parameters between genders. The Chi-square test or Fisher's exact test was used to assess the association between gender and anemia categories. Pearson's or Spearman's correlation was applied where appropriate for relationships between quantitative variables. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1. Demographic and Baseline Characteristics of the Study Participants According to Gender

A total of 105 school-going children were included in the study, comprising 56 males (53.33%) and 49 females (46.67%). With regard to age distribution, 28 (26.67%) children belonged to the 6–8-year age group, including 15 (26.79%) males and 13 (26.53%) females. A total of 36 (34.29%) children were aged 9–11 years, of whom 20 (35.71%) were males and 16 (32.65%) were females. The largest proportion, 41 (39.05%), belonged to the 12–15-year age group, comprising 21 (37.50%) males and 20 (40.82%) females. The difference in age-group distribution between males and females was not statistically significant (p=0.930). Regarding residence, 64 (60.95%) children were from rural areas, including 33 (58.93%) males and 31 (63.27%) females, whereas 41 (39.05%) children were from urban areas, comprising 23 (41.07%) males and 18 (36.73%) females. There was no statistically significant difference in residence according to gender (p=0.650). With respect to dietary pattern, 61 (58.10%) children were vegetarian, including 35 (62.50%) males and 26 (53.06%) females, while 44 (41.90%) consumed a mixed diet, comprising 21 (37.50%) males and 23 (46.94%) females. The gender-wise difference in dietary pattern was not statistically significant (p=0.328). Assessment of nutritional status showed that 31 (29.52%) children were underweight, including 15 (26.79%) males and 16 (32.65%) females. The remaining 74 (70.48%) children were not underweight, comprising 41 (73.21%) males and 33 (67.35%) females. The distribution of nutritional status was comparable between male and female children, with no statistically significant difference (p=0.511).

Table 2. Prevalence and Severity of Iron Deficiency Anemia According to Gender

Among the 105 children studied, 46 (43.81%) had no anemia, whereas 59 (56.19%) had iron deficiency anemia. Among males, 31 of 56 (55.36%) had no anemia, compared with 15 of 49 (30.61%) females. Mild anemia was observed in 26 (24.76%) children overall, including 14 (25.00%) males and 12 (24.49%) females. Moderate anemia was present in 27 (25.71%) children, comprising 9 (16.07%) males and 18 (36.73%) females. Severe anemia was identified in 6 (5.71%) children, including 2 (3.57%) males and 4 (8.16%) females. The overall distribution of anemia severity differed significantly according to gender (p=0.030). Overall iron deficiency anemia was present in 25 of 56 males (44.64%) and 34 of 49 females (69.39%). Thus, the proportion of children with iron deficiency anemia was higher among females than males. The association between gender and the presence of iron deficiency anemia was statistically significant (p=0.011).

Table 3. Comparison of Hematological Parameters Between Male and Female Children

The mean hemoglobin concentration was 11.62±1.38 g/dL in males and 10.91±1.47 g/dL in females, with a statistically significant difference between the two groups (p=0.012). Similarly, mean PCV/hematocrit was 35.40±4.20% among males compared with 33.10±4.60% among females, and the difference was statistically significant (p=0.009). The mean RBC count was $4.36\pm0.52\times10^6/\mu L$ in males and $4.18\pm0.49\times10^6/\mu L$ in females. Although the mean RBC count was numerically lower among females, this difference was not statistically significant (p=0.072). The mean MCV was 77.80±8.50 fL in males and 73.90±9.10 fL in females, showing a statistically significant gender-wise difference (p=0.025). Mean MCH was also significantly higher among males at 25.50±3.20 pg compared with 23.90±3.40 pg among females (p=0.015). Mean MCHC was 31.80±2.10 g/dL in males and 31.10±2.30 g/dL in females; however, the difference was not statistically significant (p=0.106). In contrast, mean RDW was 14.90±2.10% among males and 16.20±2.40% among females, with females showing a significantly higher mean value (p=0.004). Therefore, statistically significant gender differences were observed for hemoglobin, PCV, MCV, MCH, and RDW, whereas RBC count and MCHC did not differ significantly between the two groups.

Table 4. Comparison of Iron Profile Parameters Between Male and Female Children

The iron profile demonstrated significant differences between male and female children. Mean serum ferritin concentration was 24.80±16.30 ng/mL in males compared with 16.90±12.70 ng/mL in females, and this difference was statistically significant (p=0.007). Mean serum iron was 61.40±22.60 µg/dL among males and 49.80±20.70 µg/dL among females, with a statistically significant difference between the two genders (p=0.007). Mean total iron-binding capacity was 365.00±58.00 µg/dL in males and 394.00±64.00 µg/dL in females. TIBC was significantly higher among females than males (p=0.017). Mean transferrin saturation was 17.60±7.50% among males compared with 13.10±6.80% among females, and this difference was also statistically significant (p=0.002). Thus, all four iron profile parameters evaluated—serum ferritin, serum iron, TIBC, and transferrin saturation—showed statistically significant differences between male and female children.

Table 5. Association of Selected Clinical and Nutritional Factors With Iron Deficiency Anemia

A history of pica was reported in 28 children, of whom 21 (75.00%) had iron deficiency anemia and 7 (25.00%) did not have iron deficiency anemia. Among the 77 children without a history of pica, 38 (49.35%) had iron deficiency anemia and 39 (50.65%) did not. The association between a history of pica and iron deficiency anemia was statistically significant (p=0.019). Regarding iron-rich food consumption, 57 children had low or inadequate intake. Among these, 40 (70.18%) had iron deficiency anemia, while 17 (29.82%) did not. Of the 48 children with adequate intake of iron-rich foods, 19 (39.58%) had iron deficiency anemia and 29 (60.42%) did not. The association between adequacy of iron-rich food intake and iron deficiency anemia was statistically significant (p=0.002). Among 31 underweight children, 23 (74.19%) had iron deficiency anemia and 8 (25.81%) had no iron deficiency anemia. Among the 74 children who were not underweight, 36 (48.65%) had iron deficiency anemia and 38 (51.35%) did not. Nutritional status showed a statistically significant association with iron deficiency anemia (p=0.016). With regard to deworming status, 64 children had irregular or no deworming, of whom 41 (64.06%) had iron deficiency anemia and 23 (35.94%) did not. Among 41 children receiving regular deworming, 18 (43.90%) had iron deficiency anemia and 23 (56.10%) had no iron deficiency anemia. The association between deworming status and iron deficiency anemia was statistically significant (p=0.042). Among the 61 children following a vegetarian diet, 39 (63.93%) had iron deficiency anemia and 22 (36.07%) did not. Among 44 children consuming a mixed diet, 20 (45.45%) had iron deficiency anemia and 24 (54.55%) did not. Although the proportion of iron deficiency anemia differed between the two dietary groups, the association did not reach statistical significance (p=0.060).

Table 1. Demographic and baseline characteristics of the study participants according to gender

Parameter	Male (n=56) n (%)	Female (n=49) n (%)	Total (n=105) n (%)	p-value
Age group (years)				**0.930**
6–8 years	15 (26.79%)	13 (26.53%)	28 (26.67%)	
9–11 years	20 (35.71%)	16 (32.65%)	36 (34.29%)	
12–15 years	21 (37.50%)	20 (40.82%)	41 (39.05%)	
Residence				**0.650**
Rural	33 (58.93%)	31 (63.27%)	64 (60.95%)	
Urban	23 (41.07%)	18 (36.73%)	41 (39.05%)	
Dietary pattern				**0.328**
Vegetarian	35 (62.50%)	26 (53.06%)	61 (58.10%)	
Mixed diet	21 (37.50%)	23 (46.94%)	44 (41.90%)	
Nutritional status				**0.511**
Underweight	15 (26.79%)	16 (32.65%)	31 (29.52%)	
Not underweight	41 (73.21%)	33 (67.35%)	74 (70.48%)	

Table 2. Prevalence and severity of iron deficiency anemia according to gender

Anemia status	Male (n=56) n (%)	Female (n=49) n (%)	Total (n=105) n (%)	p-value
No anemia	31 (55.36%)	15 (30.61%)	46 (43.81%)	
Mild anemia	14 (25.00%)	12 (24.49%)	26 (24.76%)	
Moderate anemia	9 (16.07%)	18 (36.73%)	27 (25.71%)	
Severe anemia	2 (3.57%)	4 (8.16%)	6 (5.71%)	**0.030**
Overall iron deficiency anemia	**25 (44.64%)**	**34 (69.39%)**	**59 (56.19%)**	**0.011**

Table 3. Comparison of hematological parameters between male and female children

Hematological parameter	Male (n=56), Mean ± SD	Female (n=49), Mean ± SD	p-value
Hemoglobin (g/dL)	11.62 ± 1.38	10.91 ± 1.47	**0.012**
PCV/Hematocrit (%)	35.40 ± 4.20	33.10 ± 4.60	**0.009**
RBC count (×10^6/µL)	4.36 ± 0.52	4.18 ± 0.49	0.072
MCV (fL)	77.80 ± 8.50	73.90 ± 9.10	**0.025**
MCH (pg)	25.50 ± 3.20	23.90 ± 3.40	**0.015**
MCHC (g/dL)	31.80 ± 2.10	31.10 ± 2.30	0.106
RDW (%)	14.90 ± 2.10	16.20 ± 2.40	**0.004**

Table 4. Comparison of iron profile parameters between male and female children

Iron profile parameter	Male (n=56), Mean ± SD	Female (n=49), Mean ± SD	p-value
Serum ferritin (ng/mL)	24.80 ± 16.30	16.90 ± 12.70	**0.007**
Serum iron (µg/dL)	61.40 ± 22.60	49.80 ± 20.70	**0.007**
TIBC (µg/dL)	365.00 ± 58.00	394.00 ± 64.00	**0.017**
Transferrin saturation (%)	17.60 ± 7.50	13.10 ± 6.80	**0.002**

Table 5. Association of selected clinical and nutritional factors with iron deficiency anemia

Factor	Total n	Iron deficiency anemia n (%)	No iron deficiency anemia n (%)	p-value
History of pica				**0.019**
Present	28	21 (75.00%)	7 (25.00%)	
Absent	77	38 (49.35%)	39 (50.65%)	
Iron-rich food intake				**0.002**
Low/inadequate	57	40 (70.18%)	17 (29.82%)	
Adequate	48	19 (39.58%)	29 (60.42%)	
Nutritional status				**0.016**
Underweight	31	23 (74.19%)	8 (25.81%)	
Not underweight	74	36 (48.65%)	38 (51.35%)	
Deworming status				**0.042**
Irregular/no deworming	64	41 (64.06%)	23 (35.94%)	
Regular deworming	41	18 (43.90%)	23 (56.10%)	
Dietary pattern				**0.060**
Vegetarian	61	39 (63.93%)	22 (36.07%)	
Mixed diet	44	20 (45.45%)	24 (54.55%)	

DISCUSSION

The present study included 105 school-going children aged 6–15 years, with 56 (53.33%) males and 49 (46.67%) females. The largest proportion belonged to the 12–15-year age group (39.05%), followed by 9–11 years (34.29%) and 6–8 years (26.67%), with no significant gender-wise difference in age distribution (p=0.930). Rural children constituted 60.95% of the study population, while 39.05% were urban; similarly, 58.10% were vegetarian and 29.52% were underweight, with none of these baseline characteristics differing significantly according to gender. Muthayya et al. (2007) evaluated 2,030 school-going children aged 5–15 years in Bangalore, with a mean age of 9.5±2.6 years. They reported an overall anemia prevalence of 13.6% and found no significant difference between urban and rural children, with prevalence rates of 14.6% and 12.3%, respectively. Thus, although the population characteristics and anemia burden differed, both studies included a broad school-age population and did not demonstrate a marked residence-related difference in anemia distribution.[7] In the present study, iron deficiency anemia was detected in 59 of 105 children, giving an overall prevalence of 56.19%. A marked gender difference was observed, with iron deficiency anemia occurring in 69.39% of females compared with 44.64% of males (p=0.011). Basu et al. (2005) studied 1,120 school-going adolescents in Chandigarh and reported an overall anemia prevalence of 16.25%. Anemia was significantly more common among girls than boys (23.9% vs 7.7%, p<0.01), while depleted iron stores were found in 81.7% of girls compared with 41.6% of boys among those assessed for ferritin. Iron deficiency anemia was documented in 11.4% of the evaluated girls and none of the boys. Although the prevalence in the present study was considerably higher, the clear female predominance was comparable with their findings.[8]

Regarding severity, the present study showed mild anemia in 24.76%, moderate anemia in 25.71%, and severe anemia in 5.71% of all children. Moderate anemia was substantially more frequent among females than males (36.73% vs 16.07%), as was severe anemia (8.16% vs 3.57%), and the overall gender-wise distribution of severity was significant (p=0.030). Goyle et al. (2009) assessed 109 adolescent girls aged 10–15 years attending a government school in Jaipur and reported a much higher anemia prevalence of 96.3%. Among their participants, 31.2% had mild anemia and 65.1% had moderate anemia; anemia was also reported to be more frequent in the older age groups. Therefore, moderate anemia constituted an important component of the anemia burden in both studies, although its magnitude was substantially greater in the Jaipur population.[9]

Significant gender differences were also observed in hematological indices in the present study. Mean hemoglobin was 11.62±1.38 g/dL in males and 10.91±1.47 g/dL in females (p=0.012), while PCV was 35.40±4.20% and 33.10±4.60%, respectively (p=0.009). Females also had significantly lower MCV (73.90±9.10 vs 77.80±8.50 fL; p=0.025) and MCH (23.90±3.40 vs 25.50±3.20 pg; p=0.015), whereas RDW was significantly higher in females (16.20±2.40% vs 14.90±2.10%; p=0.004). RBC count and MCHC did not differ significantly. Ramzi et al. (2011) evaluated 363 adolescent schoolgirls and reported considerably higher mean values of hemoglobin 13.89±1.19 g/dL, hematocrit 40.38±3.01%, RBC count 4.85±0.50×10^6/µL, MCV 83.87±8.88 fL, MCH 28.85±3.58 pg, and MCHC 34.33±1.12 g/dL. Their MCV showed a significant positive relationship with hemoglobin (p<0.001). Compared with these values, females in the present study had lower hemoglobin and red-cell indices, corresponding with their greater burden of iron deficiency anemia.[10]

The iron profile in the present study further demonstrated significant gender differences. Mean serum ferritin was 24.80±16.30 ng/mL in males compared with 16.90±12.70 ng/mL in females (p=0.007), while serum iron was 61.40±22.60 versus 49.80±20.70 µg/dL (p=0.007). Females had a higher TIBC of 394.00±64.00 µg/dL compared with 365.00±58.00 µg/dL in males (p=0.017), whereas transferrin saturation was lower at

13.10±6.80% versus 17.60±7.50% (p=0.002). Ahmed et al. (2000) studied 548 adolescent schoolgirls in Bangladesh and found anemia in 27%, depleted serum ferritin stores in 17%, and iron deficiency anemia in 32% of anemic girls. They demonstrated significant positive relationships of hemoglobin with serum iron, transferrin saturation, and ferritin, whereas TIBC was negatively related to hemoglobin. They further observed that each 1 µg/L change in ferritin was associated with a 0.046 g/L change in hemoglobin after adjustment for other variables. These biochemical relationships correspond with the lower ferritin, serum iron, and transferrin saturation and higher TIBC observed among females in the present study.[11]

Pica showed a significant association with iron deficiency anemia in the present study. Among 28 children with pica, 21 (75.00%) had iron deficiency anemia, compared with 38 of 77 (49.35%) children without pica (p=0.019). Singhi et al. (2003) compared 31 children with pica with 60 age-, sex-, and nutrition-matched controls and found that mean plasma iron was significantly lower among children with pica (42.7±9.2 µg/dL) than controls (51.5±10.0 µg/dL, p<0.001), representing an approximately 20% reduction. Mean hemoglobin was also lower in the pica group (8.5±1.3 g/dL) than in controls (9.4±1.1 g/dL). These findings are consistent with the present observation that pica was substantially more frequent in association with iron deficiency anemia.[12]

Nutritional status was another significant correlate in the present study. Overall, 31 children (29.52%) were underweight, and iron deficiency anemia was found in 74.19% of underweight children compared with 48.65% of children who were not underweight (p=0.016). In contrast, Gupta et al. (2012) studied 1,596 school-going adolescent girls aged 10–19 years in Shimla and reported an anemia prevalence of 21.4%, but body mass index did not show a statistically significant association with anemia. Thus, the present finding of a significant association between underweight status and iron deficiency anemia differs from their observation, indicating that the relationship between anthropometric nutritional status and anemia may vary across different school populations.[13]

Dietary intake and deworming status also showed important associations in the present study. Iron deficiency anemia was present in 70.18% of children with low or inadequate iron-rich food intake compared with 39.58% of those with adequate intake (p=0.002). Similarly, anemia occurred in 64.06% of children with irregular or no deworming compared with 43.90% receiving regular deworming (p=0.042). Among vegetarians, 63.93% had iron deficiency anemia compared with 45.45% of children consuming a mixed diet, although this difference did not reach statistical significance (p=0.060). Kaur et al. (2006) studied 630 adolescent girls in rural Wardha and reported an overall anemia prevalence of 59.8%. Anemia was present in 85.8% of vegetarians compared with 41.5% of non-vegetarians, in 73.2% of girls consuming <14 mg iron/day compared with 34.9% consuming 20–27 mg/day, and in 87.7% of girls with a history of worm infestation compared with 56.6% without infestation. On multivariate analysis, vegetarian diet (OR=5.83), iron intake <14 mg/day (OR=4.16), and worm infestation (OR=4.11) remained significant determinants. These results closely correspond with the present findings for inadequate iron intake and irregular deworming, while the dietary-pattern association in the present study showed the same numerical direction without achieving statistical significance.[14]

CONCLUSION

The study demonstrated a high prevalence of iron deficiency anemia among school-going children, with female children being significantly more affected than males. Females also showed lower hemoglobin, serum ferritin, serum iron, and transferrin saturation levels. Iron deficiency anemia was significantly associated with pica, inadequate iron-rich food intake, underweight status, and irregular deworming. These findings emphasize the need for regular screening, nutritional education, iron supplementation, and preventive school health measures, particularly among girls.

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