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Effect of Iron Deficiency on Thyroid Hormone Function and Haematological Parameters in Malnourished Children.

Haroon Ur Rashid[1], Shafaq Saleem[2], Javaid Hassan[3], Mohammad Haroon[4], Bubrak Amin[5], Irshad Ahmed[6]

[1]Senior District Pathologist BPS-19, Benazir Bhutto Shaheed Teaching Hospital, Abbottabad, Pakistan

[2]Lecturer, Department of Pathology, Gomal Medical College, Dera Ismail Khan, Pakistan

[3]Associate Professor, Department of Physiology, Kabir Medical College Gandahara University, Peshawar, Pakistan

[4]Associate Professor, Department of Biochemistry, Mohammad College of Medicine, Peshawar, Pakistan

[5]Neonatal Registrar, University Hospital Galway, Ireland

[6]Principle Medical Officer, DHQ Hospital Lakki Marwat, Pakistan

Corresponding author:

Shafaq Saleem,

Lecturer, Department of Pathology, Gomal Medical College, Dera Ismail Khan, Pakistan

Email: drshafaqsaleem17@gmail.com

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ABSTRACT

Background: Malnutrition and iron deficiency are significant health issues in the developing world, which can result in a number of physiological dysfunctions. Recent studies have shown that iron is essential for thyroid hormone production and that iron deficiency may lead to thyroid dysfunction, especially in at-risk children.

Objective: To evaluate the effect of iron deficiency on thyroid hormone function and hematological parameters in malnourished children.

Methods: This cross-sectional, analytical study took place at Kabir Medical College between January 2024 and January 2025. Consecutive sampling of 72 malnourished children (1-10 years) was done. Hematological indices, iron indices (serum iron, TIBC, ferritin) and thyroid indices (TSH, FT3, FT4) were measured. SPSS version 25 was used for statistical analysis. Independent t-test, Pearson correlation and chi-square test were used and $p \leq 0.05$ was taken as significant.

Results: Iron deficiency was observed in 61.1% of children. Thyroid dysfunction was identified in 33.3% of cases, with subclinical hypothyroidism being the most common. Iron-deficient children had significantly higher TSH and lower FT3 and FT4 levels compared to non-deficient children ($p < 0.001$). A strong negative correlation was found between serum ferritin and TSH ($r = -0.61$, $p < 0.001$), while positive correlations were observed with FT3 and FT4. Severe malnutrition was significantly associated with thyroid dysfunction ($p = 0.002$).

Conclusion: Iron deficiency significantly affects thyroid hormone function and hematological parameters in malnourished children. Early identification and management of iron deficiency may help prevent thyroid dysfunction and improve overall health outcomes in this population....

Key Words: Iron Deficiency; Malnutrition; Thyroid Hormones; Child; Anemia; Ferritin.

INTRODUCTION

Malnutrition remains a critical public health issue in low- and middle-income countries, and is one of the major causes of childhood morbidity and mortality. In children, malnutrition impacts not only on growth but also multiple physiological processes, including hematological and endocrine systems. Iron-deficiency is the most common micronutrient deficiency and a major cause of anemia in children. It has extensive effects on cognitive, immune, and metabolic processes (1-3).

Recently, an association between iron status and thyroid hormone metabolism has emerged. Iron is a key constituent of thyroid peroxidase, a heme-containing enzyme that synthesises thyroid hormones. Iron deficiency can affect the enzyme's function, thereby decreasing the synthesis of triiodothyronine (T3) and thyroxine (T4) hormones, and increasing thyroid-

stimulating hormone (TSH) levels. This connection hints at the possibility that iron deficiency might play a role in thyroid dysfunction, especially in malnourished populations (4-8)..

Malnourished children are more likely to experience multiple micronutrient deficiencies, possibly compounding endocrine dysfunctions. Existing research has suggested individuals with iron deficiency may have abnormal thyroid hormone levels, such as an increase in TSH and decrease in thyroid hormones. But this link has been less investigated in malnourished children, particularly in low- and middle-income countries (9).

Understanding the combined impact of iron deficiency and malnutrition on thyroid function is crucial for early diagnosis and appropriate management. Identifying such associations may help in developing integrated intervention strategies aimed at improving both nutritional and endocrine health outcomes. Therefore, this study was designed to evaluate the effect of iron deficiency on thyroid hormone function and hematological parameters in malnourished children.

METHODOLOGY

This cross-sectional analytical study was conducted at Kabir Medical College from January 2024 to January 2025. The objective of the study was to evaluate the effect of iron deficiency on thyroid hormone function and hematological parameters in malnourished children. Prior to the commencement of the study, ethical approval was obtained from the Institutional Review Board of the respective institution. Written informed consent was taken from the parents or guardians of all participating children, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

The study used a non-probability consecutive sampling method to recruit 72 malnourished children aged between 1 to 10 years. Anthropometric indices such as weight-for-age, height-for-age and mid-upper arm circumference (MUAC) were used to define malnutrition, and children were classified as moderate acute malnutrition (MAM) and severe acute malnutrition (SAM) based on WHO criteria. To remove confounding factors, children with a known thyroid disease, chronic systemic diseases, congenital anomalies, or those already on iron or thyroid supplements were excluded from the study.

A 5 mL blood sample was drawn from each child under aseptic conditions. A hematology analyzer was used to measure various hematological indices such as hemoglobin (Hb), red blood cell count (RBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and red cell distribution width (RDW). Iron parameters, including serum ferritin, serum iron, total iron-binding capacity (TIBC) and transferrin saturation, were measured by biochemical techniques. Iron deficiency was determined based on low serum ferritin levels according to pediatric standards.

Thyroid hormones such as thyroid-stimulating hormone (TSH), free triiodothyronine (FT3) and free thyroxine (FT4) were assayed through enzyme-linked immunosorbent assay (ELISA). Using these measurements, patients were diagnosed as euthyroid, subclinical and overt hypothyroid according to established criteria.

Data were entered and analysed using IBM SPSS Statistics 25. Continuous variables were described as mean ± standard deviation, and categorical variables as N and percent. The means of the iron-deficient and non-deficient groups were compared using independent sample t-test. The correlation between iron status (serum ferritin and hemoglobin) and thyroid hormones was examined using Pearson correlation coefficient. Chi-square test was used to assess the relationships between categorical variables (such as severity of malnutrition and thyroid dysfunction). P-value of ≤ 0.05 was considered statistically significant.

RESULTS

The average age of malnourished children was 4.8 ± 1.9 years, with a higher proportion of males (55.6%). The majority of the children had severe acute malnutrition (SAM) (58.3%) rather than moderate acute malnutrition (MAM) (41.7%) suggesting that the population was severely malnourished.

Table 1: Demographic and Nutritional Characteristics

Variable	Value
Age (years, Mean ± SD)	4.8 ± 1.9
Gender (Male/Female)	40 (55.6%) / 32 (44.4%)
Weight (kg, Mean ± SD)	12.6 ± 2.8
Height (cm, Mean ± SD)	92.4 ± 8.5
MUAC (cm, Mean ± SD)	11.1 ± 1.2
Nutritional Status	SAM: 42 (58.3%), MAM: 30 (41.7%)

A total of 61.1% of the children had iron deficiency. Hematological parameters revealed microcytic hypochromic anemia, with low hemoglobin and MCV, suggesting iron deficiency as a key underlying cause of anemia in these malnourished children.

Table 2: Iron Status and Hematological Profile

Variable	Mean ± SD / n (%)
Serum Ferritin (ng/mL)	11.8 ± 4.6
Serum Iron (µg/dL)	38.5 ± 10.2
TIBC (µg/dL)	412.6 ± 48.3
Transferrin Saturation (%)	14.2 ± 4.8
Iron Deficiency	44 (61.1%)
Hemoglobin (g/dL)	8.9 ± 1.4
RBC Count (×10⁶/µL)	3.8 ± 0.7
MCV (fL)	72.5 ± 6.3
MCH (pg)	23.1 ± 3.2
RDW (%)	16.8 ± 2.5

A significant number of children had thyroid dysfunction, with subclinical hypothyroidism (22.2%) more prevalent than overt hypothyroidism (11.1%). Higher TSH levels with normal FT4 point to early thyroid dysfunction.

Table 3: Thyroid Function Parameters

Variable	Mean ± SD / n (%)
TSH (mIU/L)	5.8 ± 2.6
FT3 (pg/mL)	2.9 ± 0.7
FT4 (ng/dL)	0.98 ± 0.2
Euthyroid	48 (66.7%)
Subclinical Hypothyroidism	16 (22.2%)
Overt Hypothyroidism	8 (11.1%)

The group of iron deficient children had significantly higher TSH and lower FT3, FT4 and hemoglobin levels than the group without iron deficiency ($p < 0.001$). This suggests iron deficiency is strongly linked with thyroid dysfunction.

Table 4: Comparison of Iron Deficient vs Non-Iron Deficient Children

Variable	Iron Deficient (n=44)	Non-Deficient (n=28)	p-value	Effect Size
TSH (mIU/L)	6.9 ± 2.8	4.1 ± 1.6	<0.001	0.82
FT3 (pg/mL)	2.6 ± 0.6	3.4 ± 0.5	<0.001	0.91
FT4 (ng/dL)	0.89 ± 0.2	1.12 ± 0.2	<0.001	0.76
Hemoglobin (g/dL)	8.3 ± 1.2	9.8 ± 1.1	<0.001	0.88
MCV (fL)	69.8 ± 5.2	76.4 ± 4.9	<0.001	0.79

The serum ferritin level was strongly inversely correlated with TSH ($r = -0.61$, $p < 0.001$) and positively correlated with FT3 and FT4, showing that the decrease in iron stores is accompanied by a deterioration of thyroid function.

Table 5: Correlation Between Iron Status and Thyroid Hormones

Variables	r-value	p-value
Ferritin vs TSH	-0.61	<0.001
Ferritin vs FT3	0.58	<0.001
Ferritin vs FT4	0.49	<0.001
Hemoglobin vs TSH	-0.52	<0.001

Thyroid dysfunction was significantly more prevalent in children with severe acute malnutrition (SAM) than in children with mild acute malnutrition (MAM) ($p = 0.002$) with more hypothyroidism in SAM than MAM.

Table 6: Association of Malnutrition Severity with Thyroid Dysfunction

Nutritional Status	Euthyroid	Hypothyroid	p-value	Cramer's V
SAM (n=42)	22 (52.4%)	20 (47.6%)	0.002	0.34
MAM (n=30)	26 (86.7%)	4 (13.3%)		

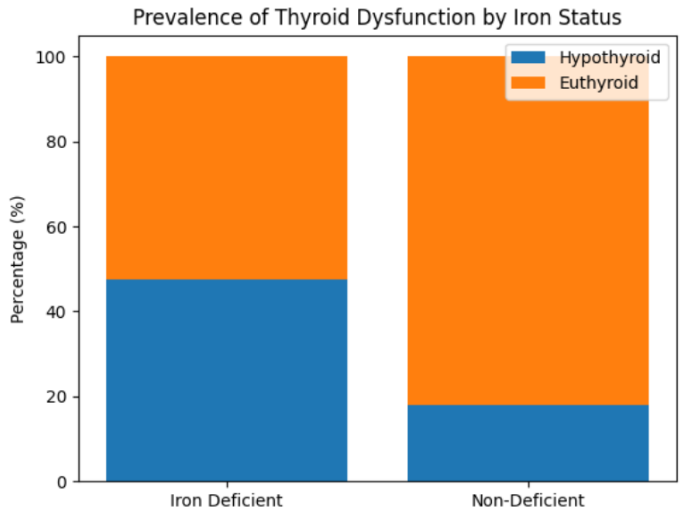

Figure 1: **Prevalence of thyroid dysfunction among iron-deficient and non-deficient malnourished children. A higher proportion of hypothyroidism is observed in iron-deficient children compared to non-deficient counterparts.**

DISCUSSION

This study demonstrates a significant association between iron deficiency and altered thyroid hormone function in malnourished children. A high prevalence of iron deficiency (61.1%) and anemia was observed, accompanied by notable thyroid dysfunction, particularly subclinical hypothyroidism. The elevated mean TSH levels alongside relatively reduced FT3 and FT4 levels indicate early impairment of thyroid function. These findings support the concept that iron plays a crucial role in thyroid hormone synthesis, as it is a cofactor for thyroid peroxidase, an essential enzyme in hormone production (10-12).

Comparing iron-deficient and non-deficient patients, children in the former category had significantly higher TSH and lower FT3 and FT4 ($p < 0.001$). This suggests an adverse influence of iron deficiency on thyroid function. This association has also been noted in recent pediatric studies and studies of nutritional factors, where iron-deficient children had lower thyroid hormone levels and increased TSH. The differences in hemoglobin and MCV also indicate that the anemia is most likely microcytic and iron-deficiency related, which adds to the plausibility of this effect (13-15).

A major strength of the present study is that we found a strong inverse association between serum ferritin and TSH ($r = -0.61$, $p < 0.001$) and a direct association between ferritin and FT3/FT4. This supports the notion that iron deficiency is associated with thyroid dysfunction. This is in line with recent research suggesting that iron deficiency can inhibit deiodinases and therefore peripheral conversion of T4 to T3. This may account for lower FT3 levels in our cohort (16-18).

The association between the degree of malnutrition and thyroid dysfunction also underscores the multiple effects of nutritional deficiency. The rate of hypothyroidism was significantly higher in children with severe acute malnutrition (SAM) than in those with moderate malnutrition ($p = 0.002$). This indicates that extended nutritional stress not only impacts blood indices but also the endocrine system. These findings are consistent with malnourished children, in whom adaptive metabolic responses initially maintain thyroid hormone levels, but ultimately result in dysfunction as malnutrition progresses (19, 20).

In a clinical context, these results highlight the need for a comprehensive approach to screening malnourished children. The presence of iron deficiency, anemia and thyroid dysfunction indicate the need for routine thyroid assessment in this high-risk group. Timely diagnosis and treatment of iron deficiency may not only address hematological issues but also resolve thyroid dysfunction, thus avoiding long-term metabolic and developmental complications.

CONCLUSION

Iron deficiency is highly prevalent among malnourished children and is significantly associated with impaired thyroid hormone function and abnormal hematological parameters. Elevated TSH levels and reduced FT3 and FT4 levels in iron-deficient children highlight the impact of iron status on thyroid physiology. Additionally, severe malnutrition further exacerbates thyroid dysfunction. These findings underscore the need for early detection and management of iron deficiency to improve both hematological health and endocrine function in malnourished pediatric populations

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