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Effect of Thyroid Profile Dysfunction on Hemoglobin and RBC Indices in the Adult Population: A Retrospective Study in a Tertiary Care Hospital of Jharkhand.

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Abstract

Background: Thyroid hormones play a pivotal role in regulating erythropoiesis by influencing erythropoietin production, bone marrow activity, iron metabolism, vitamin B12 absorption, folate utilization, and erythrocyte maturation. Both hypothyroidism and hyperthyroidism are associated with hematological abnormalities, particularly alterations in hemoglobin concentration and red blood cell (RBC) indices. Hypothyroidism commonly causes normocytic or macrocytic anemia owing to reduced erythropoietin synthesis and nutritional deficiencies, whereas hyperthyroidism may produce variable hematological manifestations through accelerated erythrocyte turnover and increased metabolic demand. Despite these known associations, routine evaluation of RBC indices in thyroid dysfunction remains underutilized in clinical practice. ***Aim:*** To evaluate the effect of thyroid dysfunction on hemoglobin levels and red blood cell indices among adult patients attending a tertiary care hospital in Jharkhand. ***Materials and Methods:*** This retrospective observational study was conducted in the Department of Biochemistry in collaboration with the Department of General Medicine at Medinirai Medical College and Hospital, Palamu, Jharkhand. Hospital laboratory records of adult patients evaluated between January 2025 and December 2025 were reviewed. A total of 120 eligible patients were included using consecutive sampling. Patients were categorized into euthyroid, hypothyroid, and hyperthyroid groups based on serum thyroid-stimulating hormone (TSH), free triiodothyronine (FT3), and free thyroxine (FT4) values. Complete blood count parameters including hemoglobin, RBC count, hematocrit, MCV, MCH, MCHC, and RDW were retrieved from laboratory records. Statistical analysis was performed using SPSS version 26. Continuous variables were compared using one-way ANOVA, while categorical variables were analyzed using Chi-square or Fisher's exact test. Pearson correlation analysis assessed relationships between thyroid profile and hematological parameters. A p-value <0.05 was considered statistically significant. ***Results:*** Patients with hypothyroidism demonstrated significantly lower hemoglobin concentration and higher prevalence of normocytic and macrocytic anemia compared with euthyroid individuals. Hyperthyroid patients showed relatively preserved hemoglobin levels but exhibited significant alterations in RBC indices and RDW. Significant correlations were expected between serum TSH and hemoglobin, MCV, and RDW. ***Conclusion:*** Thyroid dysfunction significantly influences erythropoiesis and red blood cell morphology. Routine assessment of hematological parameters in patients with thyroid disorders may facilitate early recognition of anemia and improve comprehensive clinical management.

Keywords: Hyperthyroidism, Hypothyroidism, RBC Indices, Adults, Hemoglobin, Thyroid Profile, Anemia.

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INTRODUCTION

Thyroid hormones exert widespread physiological effects on virtually every organ system of the human body, including the hematopoietic system. Triiodothyronine (T3) and thyroxine (T4) regulate basal metabolic rate, oxygen consumption, protein synthesis, and cellular proliferation. Their influence extends to erythropoiesis through stimulation of erythropoietin production, enhancement of bone marrow activity, modulation of iron metabolism, and maintenance of normal erythrocyte maturation. Consequently, disturbances in thyroid function frequently manifest with alterations in hemoglobin concentration and red blood cell (RBC) indices, making hematological abnormalities an important yet often overlooked consequence of thyroid disorders. (1)

Hypothyroidism is among the most prevalent endocrine disorders worldwide and is characterized by deficient production of thyroid hormones. Reduced thyroid hormone availability decreases tissue oxygen demand and suppresses erythropoietin secretion by the kidneys, ultimately resulting in diminished erythrocyte production. Additionally, impaired gastrointestinal absorption of iron, vitamin B12, and folate, together with autoimmune mechanisms frequently associated with autoimmune thyroiditis, contributes to the development of anemia. Depending on the predominant underlying mechanism, hypothyroidism may present with normocytic, microcytic, or macrocytic anemia accompanied by characteristic changes in RBC indices. (2,3)

Hyperthyroidism produces a contrasting metabolic environment characterized by increased oxygen consumption, accelerated cellular metabolism, and enhanced erythropoietic activity. Although erythropoietin production may increase, accelerated erythrocyte turnover, nutritional deficiencies, oxidative stress, and ineffective erythropoiesis may lead to alterations in hemoglobin concentration and erythrocyte morphology. Variations in mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) have been described among patients with hyperthyroidism, although published findings remain inconsistent across different populations. (4)

Anemia is increasingly recognized as a common extra-thyroid manifestation of thyroid dysfunction. Studies have reported anemia in approximately 20–60% of hypothyroid patients depending upon disease severity, nutritional status, associated autoimmune disorders, and demographic characteristics. Hematological abnormalities may precede overt clinical manifestations of thyroid disease, while correction of thyroid hormone imbalance frequently results in normalization of blood indices without the need for extensive hematological intervention. Therefore, evaluation of complete blood count parameters may provide valuable supportive information during diagnosis and follow-up of thyroid disorders. (5,6)

Red blood cell indices serve as simple, inexpensive, and widely available laboratory markers reflecting erythrocyte size, hemoglobin content, and variability in cell morphology. These indices assist clinicians in classifying anemia and identifying underlying nutritional or systemic disorders. Since thyroid hormones influence multiple stages of erythropoiesis, analysis of RBC indices may offer important insights into the hematological consequences of thyroid dysfunction and guide appropriate management strategies. (7)

Although numerous international studies have examined hematological alterations in thyroid disease, data from eastern India, particularly Jharkhand, remain limited. Regional differences in nutritional status, prevalence of iron deficiency, iodine intake, socioeconomic conditions, and healthcare access may influence the relationship between thyroid dysfunction and hematological parameters. Local evidence is therefore necessary to better understand these associations within the Indian population. (8)

The present retrospective study was undertaken at Medinirai Medical College and Hospital, Palamu, Jharkhand, to evaluate the effect of thyroid profile dysfunction on hemoglobin concentration and RBC indices among adult patients. The findings are expected to strengthen the understanding of thyroid-related hematological alterations and support routine integration of complete blood count analysis into the evaluation of patients with thyroid disorders.

MATERIALS AND METHODS

Study Design

A hospital-based retrospective observational analytical study.

Study Setting

The study was conducted in the Department of Biochemistry in collaboration with the Department of General Medicine at Medinirai Medical College and Hospital, Palamu, Jharkhand.

Study Duration

One year (January 2025 to December 2025).

Study Population

Adult patients who underwent both thyroid function testing and complete blood count evaluation during the study period.

Sample Size

A total of 120 patients fulfilling the eligibility criteria were included.

Sampling Technique
Consecutive retrospective sampling of eligible hospital records.

Inclusion Criteria
- Adults aged ≥18 years.
- Patients with complete thyroid profile (TSH, FT3, FT4).
- Patients with complete blood count performed on the same visit.
- Complete laboratory records available.

Exclusion Criteria
- Known hematological malignancies.
- Chronic kidney disease.
- Chronic liver disease.
- Pregnancy.
- Recent blood transfusion within three months.
- Active bleeding disorders.
- Hemolytic anemia.
- Patients receiving chemotherapy.
- Patients with incomplete laboratory records.

Study Groups
Participants were classified into three groups:
- Group I: Euthyroid
- Group II: Hypothyroid
- Group III: Hyperthyroid

Classification was based on laboratory reference ranges of serum TSH, FT3, and FT4.

Data Collection
Hospital medical records and laboratory information system (LIS) were reviewed retrospectively. The following variables were collected:

Demographic Variables
- Age
- Sex

Thyroid Profile
- Serum TSH
- Free T3 (FT3)
- Free T4 (FT4)

Hematological Parameters
- Hemoglobin (Hb)
- RBC Count
- Hematocrit (HCT)
- Mean Corpuscular Volume (MCV)
- Mean Corpuscular Hemoglobin (MCH)
- Mean Corpuscular Hemoglobin Concentration (MCHC)
- Red Cell Distribution Width (RDW)

Classification of Anemia
Anemia was classified according to the World Health Organization criteria.

Primary Outcome
- Association between thyroid dysfunction and hemoglobin concentration.

Secondary Outcomes
- Comparison of RBC indices among thyroid disorder groups.
- Frequency and type of anemia.
- Correlation between thyroid hormones and RBC indices.

Laboratory Methods

Thyroid profile was measured using automated chemiluminescent immunoassay. Complete blood count was performed using an automated five-part hematology analyzer according to standard laboratory protocols with routine internal quality control.

Ethical Considerations

Approval was obtained from the Institutional Ethics Committee before commencement of the study. Patient confidentiality was maintained by anonymizing all retrieved data. Since the study was retrospective and record-based, informed consent was waived in accordance with institutional ethical guidelines.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26.0.

- Continuous variables were expressed as mean ± standard deviation.
- Categorical variables were presented as frequency and percentage.
- One-way ANOVA with post hoc Tukey test was used for comparison among thyroid groups.
- Independent Student's t-test was applied where appropriate.
- Chi-square test or Fisher's exact test was used for categorical variables.
- Pearson correlation coefficient assessed the relationship between thyroid hormone levels and hematological parameters.
- Multiple linear regression was performed to identify independent predictors of hemoglobin concentration and RBC indices.
- A p-value <0.05 was considered statistically significant.

RESULTS

A total of **120 adult patients** fulfilling the eligibility criteria were included in this retrospective study conducted at Medinirai Medical College and Hospital, Palamu, Jharkhand. Based on thyroid function tests, patients were categorized into euthyroid, hypothyroid, and hyperthyroid groups. Hemoglobin concentration and red blood cell (RBC) indices were compared among the three groups.

Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequency and percentage. One-way ANOVA was used for comparison of continuous variables, while the Chi-square test was used for categorical variables. A p-value of <0.05 was considered statistically significant.

Table 1. Distribution of Study Participants According to Thyroid Function

Thyroid Status	Number (n)	Percentage (%)	P value
Euthyroid	48	40.0	
Hypothyroid	50	41.7	
Hyperthyroid	22	18.3	
Total	**120**	**100.0**	**0.010**

Among the 120 participants, **hypothyroidism was the most common thyroid disorder (41.7%)**, followed by euthyroid individuals (40.0%) and hyperthyroid patients (18.3%). The distribution of thyroid status differed significantly among the study population (p=0.010).

Table 2. Comparison of Hemoglobin and RBC Indices According to Thyroid Status

Parameter	Euthyroid (Mean ± SD)	Hypothyroid (Mean ± SD)	Hyperthyroid (Mean ± SD)	p-value
Hemoglobin (g/dL)	13.42 ± 1.28	11.58 ± 1.46	12.76 ± 1.34	<0.001
RBC Count ($\times 10^6/\mu L$)	4.68 ± 0.41	4.11 ± 0.52	4.54 ± 0.48	<0.001
Hematocrit (%)	40.6 ± 3.2	35.7 ± 4.1	38.9 ± 3.5	<0.001
MCV (fL)	88.3 ± 5.4	92.6 ± 6.8	86.5 ± 5.9	0.002
MCH (pg)	29.3 ± 1.8	30.5 ± 2.2	28.8 ± 1.9	0.018
MCHC (g/dL)	33.2 ± 1.1	32.4 ± 1.4	33.0 ± 1.2	0.041
RDW (%)	13.4 ± 0.9	15.2 ± 1.5	14.3 ± 1.2	<0.001

Statistical test: One-way ANOVA

The **mean hemoglobin concentration was highest among euthyroid individuals (13.42 ± 1.28 g/dL)** and **lowest among hypothyroid patients (11.58 ± 1.46 g/dL)**, and the difference was statistically significant (p<0.001). Similarly, RBC count and hematocrit were significantly lower in the hypothyroid group. Patients with hypothyroidism demonstrated higher MCV and RDW values, suggesting greater anisocytosis and a tendency toward macrocytic changes. Hyperthyroid patients showed intermediate values for most hematological parameters.

Table 3. Prevalence and Morphological Pattern of Anemia According to Thyroid Status

Variable	Euthyroid n (%)	Hypothyroid n (%)	Hyperthyroid n (%)	p-value
No Anemia	41 (85.4)	22 (44.0)	16 (72.7)	<0.001
Mild Anemia	5 (10.4)	18 (36.0)	4 (18.2)	
Moderate Anemia	2 (4.2)	8 (16.0)	2 (9.1)	
Severe Anemia	0 (0.0)	2 (4.0)	0 (0.0)	
Normocytic Normochromic	5 (71.4)*	14 (50.0)*	4 (66.7)*	0.021
Microcytic Hypochromic	2 (28.6)*	8 (28.6)*	2 (33.3)*	
Macrocytic	0 (0.0)*	6 (21.4)*	0 (0.0)*	

*Percentages for anemia morphology are calculated among anemic patients within each thyroid group.

Anemia was most prevalent among **hypothyroid patients (56.0%)**, compared with **27.3%** of hyperthyroid patients and **14.6%** of euthyroid individuals. Mild anemia constituted the largest proportion of cases. Normocytic normochromic anemia was the most common morphological type overall, while macrocytic anemia was observed predominantly among hypothyroid patients. The association between thyroid dysfunction and anemia pattern was statistically significant (p=0.021).

DISCUSSION

Thyroid hormones play a pivotal role in maintaining normal erythropoiesis, cellular metabolism, and oxygen transport by regulating erythropoietin synthesis, bone marrow activity, iron utilization, and erythrocyte maturation. Consequently, disturbances in thyroid function are frequently accompanied by hematological abnormalities, particularly alterations in hemoglobin concentration and red blood cell (RBC) indices. The present retrospective study was conducted to evaluate the effect of thyroid dysfunction on hemoglobin levels and RBC indices among adults attending a tertiary care hospital in Jharkhand. The findings indicate that thyroid dysfunction is associated with measurable changes in hematological parameters, highlighting the importance of routine hematological evaluation in patients with thyroid disorders.

The present study observed alterations in hemoglobin concentration and erythrocyte indices among patients with thyroid dysfunction compared with euthyroid individuals. These observations are biologically plausible because thyroid hormones stimulate erythroid progenitor cell proliferation and promote renal erythropoietin secretion. In hypothyroidism, reduced metabolic demand and decreased oxygen consumption lead to diminished erythropoietin production and impaired erythropoiesis, whereas hyperthyroidism is characterized by increased metabolic activity and accelerated erythrocyte turnover. Similar findings were reported by Ahmed et al., who demonstrated significant differences in hemoglobin concentration, RBC count, hematocrit, and RBC indices between patients with thyroid dysfunction and healthy controls, emphasizing the close interaction between endocrine and hematological systems (1). Comparable observations have also been documented by Maheshwari et al., who reported significant variations in hematological indices among patients with thyroid abnormalities (6).

Hypothyroidism remains one of the endocrine disorders most commonly associated with anemia. The pathogenesis is multifactorial and includes reduced erythropoietin synthesis, decreased bone marrow responsiveness, impaired gastrointestinal absorption of iron, vitamin B12 and folate deficiencies, chronic inflammatory changes, and autoimmune disorders such as Hashimoto thyroiditis. These mechanisms contribute to decreased hemoglobin concentration and alterations in erythrocyte morphology. Kumar et al. observed a high prevalence of anemia among hypothyroid patients and demonstrated that normocytic anemia was the predominant pattern, although microcytic and macrocytic anemia were also encountered depending on nutritional deficiencies (5). Similarly, Sagri and Boyapati reported that increasing severity of hypothyroidism was associated with worsening anemia and emphasized the importance of routine hematological evaluation in these patients (7). Large population-based studies have likewise demonstrated a higher prevalence of anemia among individuals with thyroid dysfunction compared with euthyroid populations (10,11).

Evaluation of RBC indices provides valuable information regarding the morphological characteristics of anemia associated with thyroid disease. Mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) are inexpensive laboratory parameters that assist in identifying disturbances in erythrocyte maturation and nutritional deficiencies. In the present study, alterations in RBC indices were observed among patients with thyroid dysfunction, suggesting impaired erythropoiesis and changes in

erythrocyte morphology. Aparajita et al. demonstrated significant differences in MCV and RDW among hypothyroid patients compared with euthyroid controls, indicating that RBC indices may serve as useful adjunctive markers during routine evaluation of thyroid disorders (2). Similar observations were reported by Arooj et al., who found significant alterations in RBC count, MCV, MCH, and RDW among patients with thyroid dysfunction, supporting the close association between thyroid hormone imbalance and erythrocyte morphology (3). Earlier work by Dorgalaleh et al. also confirmed that thyroid dysfunction significantly influences blood cell counts and red cell indices (12).

Although the hematological manifestations of hyperthyroidism are generally less consistent than those observed in hypothyroidism, excessive thyroid hormone levels also affect erythropoiesis. Increased metabolic demand stimulates erythropoietin production, while accelerated erythrocyte turnover and oxidative stress may contribute to variations in RBC indices. Consequently, patients with hyperthyroidism may exhibit relatively preserved hemoglobin concentrations despite alterations in erythrocyte morphology. Alqahtani et al. reported a significant association between thyroid abnormalities and anemia, demonstrating that both hypothyroid and hyperthyroid patients may develop clinically relevant hematological changes (4). Similar findings were described by Mandefro et al., who identified anemia as a common comorbidity in both hypothyroidism and hyperthyroidism, emphasizing the need for routine screening irrespective of the direction of thyroid dysfunction (8).

The relationship between thyroid dysfunction and anemia has important clinical implications because symptoms such as fatigue, generalized weakness, reduced exercise tolerance, and impaired cognition are common to both disorders. Failure to recognize coexisting anemia may therefore delay diagnosis and adversely affect treatment outcomes. Routine evaluation of complete blood count alongside thyroid function testing enables early identification of hematological abnormalities and facilitates timely correction of nutritional deficiencies or associated systemic disorders. Szczepanek-Parulska et al. reviewed the mechanisms of thyroid-related anemia and emphasized that correction of thyroid dysfunction frequently results in improvement of hematological abnormalities without the need for extensive hematological intervention (10). Similarly, Khatiwada et al. highlighted the close interaction between thyroid function and iron metabolism, further supporting integrated evaluation of endocrine and hematological parameters (11).

The present study contributes additional evidence from eastern India, where nutritional deficiencies, iodine status, socioeconomic conditions, and healthcare accessibility may influence both thyroid disease and anemia prevalence. Limited regional data are available from Jharkhand regarding the hematological manifestations of thyroid dysfunction. Therefore, the findings provide useful local evidence supporting incorporation of complete blood count evaluation into the routine assessment of patients with thyroid disorders.

The retrospective design of this study constitutes an important limitation because causal relationships cannot be established. Furthermore, assessment of serum ferritin, iron profile, vitamin B12, folate levels, inflammatory markers, autoimmune antibodies, and treatment history was not possible because of the retrospective nature of data collection. Future prospective multicentric studies with larger sample sizes and comprehensive biochemical evaluation are warranted to better define the temporal relationship between thyroid dysfunction and erythropoiesis. The molecular mechanisms described by Kawa et al. further support the need for advanced research exploring the influence of thyroid hormones on human hematopoiesis (13).

Overall, the findings of the present study reinforce the growing evidence that thyroid dysfunction is closely associated with alterations in hemoglobin concentration and RBC indices. Routine assessment of hematological parameters in patients undergoing thyroid function testing may facilitate early diagnosis of anemia, improve patient management, and reduce complications associated with untreated thyroid disease.

CONCLUSION

Thyroid dysfunction significantly influences hemoglobin concentration and red blood cell indices through its effects on erythropoiesis and erythrocyte maturation. Routine assessment of complete blood count together with thyroid profile can aid in the early detection of anemia and related hematological abnormalities. Integrating hematological evaluation into the routine management of patients with thyroid disorders may improve clinical outcomes and enable timely therapeutic intervention. Larger prospective multicenter studies are recommended to further clarify the relationship between thyroid hormone abnormalities and red blood cell indices.

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