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Effects of Hyperthyroidism and Comparative Analysis of WBC, Haemoglobin, and RBC Levels in Men and Women

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Abstract: Hyperthyroidism, a common endocrine disorder characterized by excessive thyroid hormone secretion, exerts significant effects on various physiological systems, including hematopoiesis. Thyroid dysfunction may lead to hematological abnormalities such as anemia, erythrocytosis, leukopenia, thrombocytopenia, and alterations in red blood cell indices**.** Objectives: This study aimed to assess the effect of hyperthyroidism on red blood cell indices and other hematological parameters among patients in Diyala Governorate**.** Methods: A descriptive cross-sectional study was conducted from December 22, 2024, to March 14, 2025. Data were collected from individuals diagnosed with or suspected of thyroid dysfunction. Hematological parameters including red blood cell count (RBC), hemoglobin (Hb), and white blood cell count (WBC) were measured and analyzed for statistical significance**.** Results: This study included 59 samples, including 29 samples from a group of healthy people, including 14 women and 15 men, as well as 30 samples suffering from hyperthyroidism, including 15 men and 15 women. A statistically significant association was observed between hyperthyroidism and alterations in RBC, Hb, and WBC values**.** Conclusions: The study concludes that hyperthyroidism significantly affects hematological parameters, particularly RBC, Hb, and WBC levels. The majority of affected individuals were middle-aged women. The findings support the need for routine hematological monitoring in hyperthyroid patients. Moreover, gender-based differences in hematological responses suggest the importance of personalized diagnostic and therapeutic approaches. Further large-scale, multi-regional studies are recommended to validate these findings.

Keywords: Hyperthyroidism · Hematological parameters · Red blood cells · Hemoglobin · White blood cells · Gender differences · Anemia · Thyroid dysfunction.

INTRODUCTION

The thyroid gland is the largest and one of the most essential endocrine glands in the human body. It is located anteriorly in the neck and consists of two lobes connected by an isthmus. Histologically, it is composed of thyroid follicles lined by cuboidal epithelium, which store thyroid hormones in the form of thyroglobulin. Thyroid-stimulating hormone (TSH), secreted by the pituitary gland, stimulates the thyroid to release triiodothyronine (T3) and thyroxine (T4) from thyroglobulin. These hormones play a pivotal role in development, cellular differentiation, metabolic homeostasis, and multiple physiological functions in human tissues [Dorgalaleh, A. *et al*., 2013; Shetty, A., & Vijaya, C. 2023].

Thyroid hormones are essential for early brain development, somatic growth, bone maturation, protein synthesis, and the regulation and production of red blood cells. They stimulate erythropoiesis by enhancing erythropoietin (EPO) gene expression, leading to hyperproliferation of immature erythroid progenitors [Dorgalaleh, A. *et al*., 2013]. Moreover, they increase cellular metabolic rate, which elevates tissue oxygen demand. In response, thyroid hormones upregulate hypoxia-inducible factor-1 (HIF-1) and 2,3-bisphosphoglycerate (2,3-BPG), promoting erythropoiesis. Conversely, in hypothyroidism, reduced oxygen demand leads to diminished EPO production, suppressed erythrocyte proliferation, and ultimately, anemia [Siddegowda, M.S. *et al*., 2021].

Hypothyroidism and hyperthyroidism are the two major thyroid dysfunctions with rising global prevalence. The normal reference range for TSH is 0.3–5.5 μIU/mL. Levels above 5.5 μIU/mL indicate hypothyroidism, while levels below 0.3 μIU/mL suggest hyperthyroidism [Jp, G., & Srikrishna, R. 2012]. Both conditions influence thyroid hormone receptor (TR) gene expression in hematopoietic progenitor cells (HPCs). Hypothyroidism reduces the clonogenic potential of erythroid burst-forming units (BFU-E), resulting in lower total blood cell counts. On the other hand, hyperthyroidism enhances BFU-E proliferation and increases blood cell counts via upregulation of proliferating cell nuclear antigen (PCNA) and cyclin D1 [Jp, G., & Srikrishna, R. 2012].

In hypothyroidism, anemia may manifest in various forms—normocytic-normochromic, microcytic-hypochromic, or macrocytic-normochromic—due to decreased EPO and hypoplasia of all myeloid lineages [Wani, F. A. *et al*., 2024]. Although anemia is less common in hyperthyroidism, it can occur due to altered iron metabolism, oxidative stress, and hemolysis

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[Wani, F. A. *et al*., 2024]. Additionally, thyroid dysfunction may affect hematologic indices such as MCV, MCH, MCHC, and RDW. Pancytopenia is a rare complication whose mechanism is not fully understood [Aparajita, S. *et al*., 2022]. Importantly, most hematological abnormalities normalize once euthyroid status is restored [Iddah, M. A. *et al*., 2013; Refaat, B. 2015; Ahmed, S. S., & Mohammed, A. A. 2020]. In one study, anemia was detected in 52 women with thyroid disorders (44%), and its prevalence was significantly higher ($p < 0.05$) compared to the healthy group (14.3%). Red blood cell count, hemoglobin, hematocrit, serum iron, and serum ferritin were significantly lower in thyroid disorders compared to the healthy group ($p < 0.05$). Red blood cell indices were closely correlated with serum free T4, while iron parameters were correlated with serum TSH ($p < 0.05$). [Refaat, B. 2015]

Hyperthyroidism may also impact white blood cells. Some individuals develop leukocytosis due to enhanced bone marrow stimulation, particularly of granulocytic lineages (neutrophils, eosinophils, basophils) [Iddah, M. A. *et al*., 2013]. In contrast, hyperthyroidism can also result in lymphopenia through suppression of lymphocyte proliferation, increasing susceptibility to infections. Furthermore, thyroid hormones modulate cytokine production, immune cell receptor expression, and inflammatory responses—mechanisms that may predispose to autoimmune disorders and contribute to altered WBC profiles [Ahmed, S. S., & Mohammed, A. A. 2020].

Aim of the Study: The Present Study Aims To

- Assess the effect of hyperthyroidism on red blood cell (RBC) indices, hemoglobin (Hb), and white blood cell (WBC) counts.
- Investigate the potential differences in these hematologic parameters between male and female patients with hyperthyroidism.

MATERIALS AND METHODS

Study Design and Research Sample

A cross-sectional descriptive study was conducted, including 59 participants divided into two groups: healthy controls (29 participants) and hyperthyroid patients (30 participants). Each group was stratified by sex, with each subgroup comprising 14-15 participants.

Hematological Parameters

Venous blood samples were collected for complete blood count (CBC). Measured parameters included white blood cell count ($\times 10^9$/L), haemoglobin (g/dL), and red blood cell count ($\times 10^{12}$/L).

Statistical Analysis

Data were analysed using descriptive statistics, inferential statistics, and correlation analysis (ANOVA) at a significance level of $p<0.05$. Pearson correlation coefficients were calculated to explore associations between variables, including age.

RESULTS

Table 1: Distribution of Study Participants by Age Group and Gender in the Normal and Hyperthyroidism Groups

Groups / Parameters		Normal Group (1) No. (29)				Hyperthyroidism Group (2) No. (30)			
		Male		**Female**		**Male**		**Female**	
		No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Age (years)	**50 <**	10	71.4	13	86.7	13	86.7	11	73.3
	50 ≥	4	28.6	2	13.3	2	13.3	4	26.7

General Hematologic Comparison

Table 2: General Hematological Comparison Between the Normal and Hyperthyroidism Groups

Groups / Parameters	Thyroid status		P-value
	Normal Group (1) No. (29)	**Hyperthyroidism Group (2) No. (30)**	
Age (years)	42.03±9.45 (30)	43.20±7.80 (25)	.609
WBC (10^9 /L)	8.15±1.88 (8.90)	9.31±5.53 (30.28)	.287
HBG (g/dl)	13.57±1.40 (4.80)	12.52±2.59 (11)	.057

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RBC (10^12 /L)	4.57±0.51 (1.87)	4.18±0.80 (2.94)	.030*
Data were presented as Mean ± SD (Range) *Significant difference between two independent means using Students-t-test at 0.05 level.			

Compared to the euthyroid group, hyperthyroid patients exhibited elevated WBC counts and reduced Hb and RBC levels. Although WBC differences were statistically non-significant (p=0.287), RBC reductions reached significance (p=0.030), and Hb was marginally non-significant (p=0.057).

Gender-Based Differences

In the hyperthyroid group:

Table 3: Gender-Based Comparison of Hematological Parameters in the Normal and Hyperthyroidism Groups

Groups Parameters	Normal Group (1) No. (29)		Hyperthyroidism Group (2) No. (30)		P-value
	Male No. (14)	**Female No. (15)**	**Male No. (15)**	**Female No. (15)**	
Age (years)	42.14± 11.36 (30)	41.93± 7.67 (26)	41.33± 7.88 (23)	45.06± 7.52 (25)	.651
WBC (10^9 /L)	8.19± 2.01 (8.20)	8.12± 1.82 (6.90)	9.76± 7.28 (30.2)	8.85± 3.14 (9)	.695
HBG (g/dl)	14.25± 1.43 (4.80)	12.94± 1.05 (4.30)	14.16± 2.25 (9.90)	10.88± 1.75 (7)	0.0001*
RBC (10^12 /L)	4.86± .46 (1.87)	4.30± .41 (1.47)	4.73± .66 (2.78)	3.63± .50 (1.53)	0.0001*
Data were presented as Mean ± SD (Range) *Significant difference between two independent means using ANOVA-test at 0.05 level.					

Males had significantly higher Hb (14.16±2.25 g/dL) and RBC (4.73±0.66 $\times 10^{12}$/L) compared to females (Hb: 10.88±1.75 g/dL; RBC: 3.63±0.50 $\times 10^{12}$/L) with p=0.0001.
WBC values showed no significant gender differences.

In the normal group: Males also had higher Hb and RBC values than females, though the differences were less pronounced.

Correlation Analysis

Table 4: Pearson Correlation Analysis among Hematological Parameters and Age in the Normal Group

Correlations Normal					
		WBC	**HBG**	**RBC**	**Age**
WBC	**Pearson Correlation**	**1**	**.014**	**-.047**	**-.072**
	Sig. (2-tailed)		**.942**	**.809**	**.711**
	N	**29**	**29**	**29**	**29**
HBG	**Pearson Correlation**	**.014**	**1**	**.892****	**.088**
	Sig. (2-tailed)	**.942**		**.000**	**.649**
	N	**29**	**29**	**29**	**29**
RBC	**Pearson Correlation**	**-.047**	**.892****	**1**	**.184**
	Sig. (2-tailed)	**.809**	**.000**		**.339**
	N	**29**	**29**	**29**	**29**
Age	**Pearson Correlation**	**-.072**	**.088**	**.184**	**1**
	Sig. (2-tailed)	**.711**	**.649**	**.339**	
	N	**29**	**29**	**29**	**29**
**. Correlation is significant at the 0.01 level (2-tailed).					

Correlations Hyperthyroidism				
	WBC	**HBG**	**RBC**	**Age**

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WBC	**Pearson Correlation**	**1**	**.228**	**.244**	**.108**
	Sig. (2-tailed)		**.225**	**.195**	**.569**
	N	**30**	**30**	**30**	**30**
HBG	**Pearson Correlation**	**.228**	**1**	**.909****	**-.335**
	Sig. (2-tailed)	**.225**		**.000**	**.071**
	N	**30**	**30**	**30**	**30**
RBC	**Pearson Correlation**	**.244**	**.909****	**1**	**-.405***
	Sig. (2-tailed)	**.195**	**.000**		**.027**
	N	**30**	**30**	**30**	**30**
Age	**Pearson Correlation**	**.108**	**-.335**	**-.405***	**1**
	Sig. (2-tailed)	**.569**	**.071**	**.027**	
	N	**30**	**30**	**30**	**30**
****. Correlation is significant at the 0.01 level (2-tailed).**					
*. Correlation is significant at the 0.05 level (2-tailed).					

Correlations Male normal					
		WBC	**HBG**	**RBC**	**Age**
WBC	**Pearson Correlation**	**1**	**.124**	**-.051**	**-.407**
	Sig. (2-tailed)		**.661**	**.858**	**.132**
	N	**15**	**15**	**15**	**15**
HBG	**Pearson Correlation**	**.124**	**1**	**.901****	**.157**
	Sig. (2-tailed)	**.661**		**.000**	**.577**
	N	**15**	**15**	**15**	**15**
RBC	**Pearson Correlation**	**-.051**	**.901****	**1**	**.102**
	Sig. (2-tailed)	**.858**	**.000**		**.718**
	N	**15**	**15**	**15**	**15**
Age	**Pearson Correlation**	**-.407**	**.157**	**.102**	**1**
	Sig. (2-tailed)	**.132**	**.577**	**.718**	
	N	**15**	**15**	**15**	**15**
****. Correlation is significant at the 0.01 level (2-tailed).**					

Correlations Female normal					
		WBC	**HBG**	**RBC**	**Age**
WBC	**Pearson Correlation**	**1**	**-.081**	**-.086**	**.147**
	Sig. (2-tailed)		**.784**	**.769**	**.615**
	N	**14**	**14**	**14**	**14**
HBG	**Pearson Correlation**	**-.081**	**1**	**.832****	**.061**
	Sig. (2-tailed)	**.784**		**.000**	**.836**
	N	**14**	**14**	**14**	**14**
RBC	**Pearson Correlation**	**-.086**	**.832****	**1**	**.289**
	Sig. (2-tailed)	**.769**	**.000**		**.316**
	N	**14**	**14**	**14**	**14**
Age	**Pearson Correlation**	**.147**	**.061**	**.289**	**1**
	Sig. (2-tailed)	**.615**	**.836**	**.316**	
	N	**14**	**14**	**14**	**14**
****. Correlation is significant at the 0.01 level (2-tailed).**					

Correlations Male patient					
		WBC	**HBG**	**RBC**	**Age**
	Pearson Correlation	**1**	**.221**	**.247**	**.089**
	Sig. (2-tailed)		**.429**	**.375**	**.753**
	N	**15**	**15**	**15**	**15**
HBG	**Pearson Correlation**	**.221**	**1**	**.948****	**-.564***
	Sig. (2-tailed)	**.429**		**.000**	**.028**

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	N	15	15	15	15
RBC	Pearson Correlation	.247	.948**	1	-.534*
	Sig. (2-tailed)	.375	.000		.040
	N	15	15	15	15
Age	Pearson Correlation	.089	-.564*	-.534*	1
	Sig. (2-tailed)	.753	.028	.040	
	N	15	15	15	15
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

Correlations Female patient					
		WBC	HBG	RBC	Age
WBC	Pearson Correlation	1	.282	.327	.271
	Sig. (2-tailed)		.309	.234	.329
	N	15	15	15	15
HBG	Pearson Correlation	.282	1	.655**	.194
	Sig. (2-tailed)	.309		.008	.489
	N	15	15	15	15
RBC	Pearson Correlation	.327	.655**	1	-.071
	Sig. (2-tailed)	.234	.008		.801
	N	15	15	15	15
Age	Pearson Correlation	.271	.194	-.071	1
	Sig. (2-tailed)	.329	.489	.801	
	N	15	15	15	15
**. Correlation is significant at the 0.01 level (2-tailed).					

In hyperthyroid males, Hb and RBC showed a strong positive correlation ($r=0.948$, $p<0.01$) and a negative correlation with age ($r=-0.564$ and -0.534, respectively). In females, a moderate correlation existed between Hb and RBC ($r=0.655$, $p<0.01$), with no significant age effect.

DISCUSSION

The current findings confirm that hyperthyroidism exerts a more pronounced haematological effect on females than males. While thyroid hormones stimulate erythropoiesis, the catabolic state induced by hyperthyroidism may exacerbate anaemia, particularly in women. This may be attributed to hormonal interplay, iron status, and sex-specific hematopoietic regulation.

The strong correlation between Hb and RBC in all subgroups supports the integrity of the data, while the negative association with age among males may indicate an age-related decline in marrow responsiveness in hypermetabolic states.

CONCLUSION

Hyperthyroidism significantly affects haematological parameters, especially in women, where it induces more profound anemia and RBC reductions. These findings highlight the necessity of incorporating gender considerations into clinical evaluation and management of thyroid disorders.

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