Int J Adv Life Sci Res. Volume 8(1) 140-153
https://doi.org/10.31632/ijalsr.2025.v08i01.013

International Journal of Advancement in Life Sciences Research
Online ISSN: 2581-4877
Journal homepage http://ijalsr.org

Original Article

Correlation Between Thyroid Hormones and Haematological Profiles in Patients with Thyroid Dysfunction

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Abstract

Background: Irregularities in blood cells are recurrently connected with thyroid hormone dysfunction, thyroid hormones such as T3 and T4, play a vital role in blood formation and cellular differentiation and dysregulation that can lead to noteworthy modifications in blood parameters. **Aim:** Present study aimed to examine the correlation between thyroid dysfunctions, predominantly hyperthyroidism and hypothyroidism, and their impression on haematological parameters. **Methods:** A cross-sectional study was performed among the 210 individuals from the tertiary care hospital in Dermatology department at Shimoga, Karnataka. Blood samples from individuals were analysed to evaluate thyroid hormone levels along with the haematological parameters. Chemiluminescent immunoassays were used to quantity T3, T4 and TSH levels, while CBC analyser analyse RBC, WBC, haemoglobin (Hb) and other blood indices. Based on the analysis the participants are categorised with Hyperthyroidism group, Hypothyroidism group and Control group. **Results:** In the study, significant variations were observed in haematological parameters across thyroid conditions. RBC levels were lower in hyperthyroid compared to normal (mean difference: -0.4495, $p < 0.01$) and higher in hypothyroid compared to hyperthyroid (mean difference: 0.797, $p < 0.01$). Hb levels were reduced in hyperthyroid (mean difference: -1.4691, $p < 0.01$) and hypothyroid patients (mean difference: -2.0434, $p < 0.01$). MCV and MCH were significantly higher in hypothyroid than hyperthyroid groups ($p < 0.01$). WBC and polymorph counts increased in hyperthyroid but decreased in hypothyroid patients ($p < 0.01$). Similarly, eosinophils, monocytes, and basophils were higher in hyperthyroid patients ($p < 0.01$), while lymphocytes were lower ($p < 0.01$). Platelet counts were meaningfully reduced in hyperthyroid compared to normal ($p < 0.01$). These findings reflect significant hematological alterations due to thyroid dysfunction. The results established that T3 and T4 levels were maximum in patients with hyperthyroidism group and lowermost with hypothyroidism group, with TSH levels increased in hypothyroid patients' group. Haematological aberrations were found to correlate with thyroid hormone levels: hyperthyroid individuals displayed down regulated RBC, Hb and platelets, however hypothyroid individuals presented increased MCV,

Received on :3rd October 2024; Revised version received on :28th November 2024; Accepted: 4th January 2025

MCH and platelet counts. Furthermore, disparities in immune cell parameters were detected; hyperthyroid individuals had raised WBC counts, whereas hypothyroid patients exposed with increased monocytes and eosinophils. **Conclusion:** These outcomes indicate that thyroid dysfunction meaningfully affects haematological profiles, with hyperthyroidism related to lower blood cell indications and hypothyroidism related with higher blood cell indications. Understanding these relationships might enable the early detection and management of blood-related problems in thyroid disorders, possibly modifying related morbidity and mortality.

Keywords: *Haematological Parameters, Thyroid Hormone, Thyroid Disorder*

Introduction

Thyroid hormones play a significant biotic role in human biological system. It regulates human blood production in bone marrow cells. The connotation of thyroid disorders and irregularities in haematological parameters is well established (Iddah *et al.,* 2013). Disorders in blood are frequently observed in individuals with thyroid disorders, as these hormones play an important role in the red blood cells production and metabolism, as well the other blood components (Chandel, Chatterjee & Abichandani, 2015; Jafarzadeh *et al.,* 2010). This master gland produces TSH which inturn stimulates secretion of hormones likeT3 (triiodothyronine) and T4 (tetraiodothyronine or thyroxine) which plays a vital role in the human body tissues development, propagation, biological functions and its balance (Siddegowda, Chaithra, Shivakumar, 2021; Maheshwari, Rajagopalan & Samuel 2020). Aberrations of thyroid function have varied clinical scale, which is an usual medical problem, numerous patients existing with subclinical imbalances of functioning thyroid and are identified on the base of thyroid evaluation with subsequent investigations which includes lipid imbalance and alteration in blood parameters, cardiovascular dysfunction and other medical incorporation (Cinemre *et al.,*2009; Qasim *et al.,* 2018; Qasim *et al.,* 2021). Hypothyroidism, results from thyroid hormone dysfunction, that disturbs 4.1% of women and 0.6% of men in 1,000 individuals every year (Kawa & Machaliński 2014). Likewise, thyroid dysregulation is observed in around 18% of elderly individual, but above half of the individuals aware of this disease condition. In haematopoiesis stage, thyroid hormones control the cell proliferation, cell cycle and production of components like platelets, erythrocytes and leucocytes. Conditions like hypothyroidism and hyperthyroidism disturbs the synthesis, differentiation of biological functions of all blood cells (Tata, 2013; Chiovato, Magri & Carlé, 2019). Hypothyroidism is a long-term state categorised by the inadequate thyroid hormone production by thyroid gland, that subsequently resultant in insufficient body's requirements for metabolism. Haematological aberrations such as anaemia, thrombocytopenia and leucopoenia are normally experiential in individuals with hypothyroidism (Alqahtani 2021; Das *et al.,* 2012). Though, the extent of haematological irregularities and its related risk factors for hypothyroidism might differ from one location to another (World Health Organization 2011).

Anaemia is a widespread clinical issue, with its incidence in the wide-ranging population possibly reaching as high as 10% in certain provinces of the world. It is predominantly dominant among married females, specifically in elderly women. Anaemia is categorised by a reduction in the red blood cells (RBC) quantity and down regulation in Hb (Haemoglobin), that leads to a reduced volume of blood to transfer oxygen to all the tissues in the human body. The World Health Organization (WHO) describes anaemia as a condition characterized by a haemoglobin level of less than 12g/dL in women and less than 13g/dL in men. Normocytic anaemia is specified by MCV (Mean Corpuscular Volume) extending from 80 to 100 femtoliters (fl), whereas microcytic anaemia is ruled out when the MCV is less than 80fl. On the other hand, macrocytic anaemia is resolved by an exceeding value of 100fl (Szczepanek*et* Parulska, Hernik & Ruchała 2017; Soliman *et al.,* 2017).

Thyroid hormones exert a direct effect on blood parameters by stimulating the predecessors of erythrocytes and indirectly by endorsing the erythropoietin production. Individuals with thyroid disorders might experience down regulated iron levels, which could impact concentration of haemoglobin. Moreover, decreased levels of Vitamin B12and folate have been detected approximately 25% of these individuals, further persuading blood crucial parameters like RBC and Hb. Other possible contributors to anaemia might include bone marrow destruction and numerous related circumstances (Cinemre *et al.,*2009; Soliman *et al.,* 2017). Numerous studies have documented the correlation between anaemia and thyroid dysfunction, assessing that over 50% of patients display blood abnormalities. A substantial number of these individuals involve subclinical hypothyroidism, which might indicate as abnormalities in blood components especially anaemia (Schindhelm *et al.,* 2013). Anaemia in individuals with thyroid dysfunction is not exclusively related to deficiency of nutrition, it is also an outcome of thyroid hormone down regulation. This decreasing process results in inadequate initiation of erythrocyte inside the bone marrow, sequentially bring out a deterioration in transport of oxygen to different tissues in the body as well as down regulation in the levels of erythropoietin (Schindhelm *et al.,* 2013; Sugimoto & Mori, 2012).Therefore, the aim of present study was to assess haematological irregularities and related factors in patients diagnosed with hypothyroidism, hyperthyroidism with the goal of simplifying early recognition of these irregularities to decrease morbidity and mortality rates.

Methodology

Study Population

The study involved a cross-sectional analysis of patients diagnosed with thyroid disorders, including hyper and hypothyroidism, as well as a control group with normal thyroid function. A total of 210 individuals were selected based on thyroid conditions, such as hyperthyroid, hypothyroid and normal. Participants were recruited from a tertiary care hospital, Shimoga, Karnataka, and informed consent was obtained from all individuals. Ethical approval was granted by the Institutional Ethical Committee Reference (VMKVMC&H/IEC/22/85) dated 18/09/2022.

Inclusion and Exclusion Criteria

Individuals aged 18 years and above, with confirmed diagnoses of hyperthyroidism or hypothyroidism based on clinical assessment and laboratory tests, were included in the present study. For control groups, healthy individuals scrutinised without any diagnosed systematic diseases and their thyroid hormones levels were within limit. Further, individuals with other endocrine disorders, haematological conditions, or chronic illnesses affecting thyroid or haematological parameters were excluded in the present study.

Sample Collection and Preparation

Venous blood samples, around 5mL in volume, were collected from each participant by retaining standard sterilised procedures. The samples were assigned into two isolated tubes: one chosen for thyroid hormone assays and the other comprising EDTA as an anticoagulant for haematological parameters analysis. All samples were analysed within 2hours of sample collection to confirm their integrity was maintained.

Thyroid Hormone Measurement

The serum concentrations of T3 (triiodothyronine), T4 (thyroxine) and TSH (thyroid-stimulating hormone) were evaluated by means of Chemi Luminescent Immuno Assay (CLIA) kits (Mitra Private Corporation Ltd, New Delhi). Standardization was directed according to the protocols confirmed by the manufacturer and internal controls were applied to assure the consistency of the assay.

Haematological Assessment

Haematological parameters were evaluated by using CBC analyser, which conducted a CBC (complete blood count). This investigation includes the measurement of RBC, WBC count, Hb concentration, Platelets, Polymorphs, Esinophil, Basoplil, monocyte, lymphocyte, MCV, MCH (Mean Corpuscular Haemoglobin), MCHC (Mean Corpuscular Haemoglobin Concentration) etc.

Statistical Analysis

Data analysis was conducted utilizing SPSS version 30.0 (IBM, Statistics, USA). Expressive statistics, includes means and standard deviations, were calculated for every parameter within the control, hyper and hypothyroid cohorts. One-way ANOVA was used to estimate mean variances amongst the groups regarding both thyroid levels and haematological specification. To identify substantial differences among exact groups, HSD (Tukey's Honest Significant Difference) post hoc test was applied. p-value of less than 0.05 was estimated with significant statistics.

Results

Comparison of T3 Levels among Normal, Hyperthyroid, and Hypothyroid Groups

The T3 levels among the normal, hyperthyroid, and hypothyroid cohorts confirmed notable variations in T3 concentrations across the three thyroid conditions. The hyperthyroid group displayed the highest mean T3 levels at 213.37ng/dL, followed by the normal group at 108.21ng/dL, while the hypothyroid group recorded the lowest mean at 49.19 ng/dL. The *F*-value for this comparison was 17295.23 ($p < 0.01$), indicating highly statistically significant differences in T3 levels among the groups (Fig1 &Table 1).

X`Subsequently post hoc analysis showed that the differences among all group pairs were statistically significant. In specific, T3 levels in the hypothyroid group were significantly lower than those in the normal group (MD, mean difference = 59.03ng/dL, $p < 0.01$) and the hyperthyroid group displayed significantly higher levels when compared to normal group (MD = -105.16ng/dL, $p < 0.01$). Moreover, T3 levels in the hyperthyroid group were significantly raised compared to the hypothyroid group (MD = 164.19ng/dL, $p < 0.01$) (Table 2).

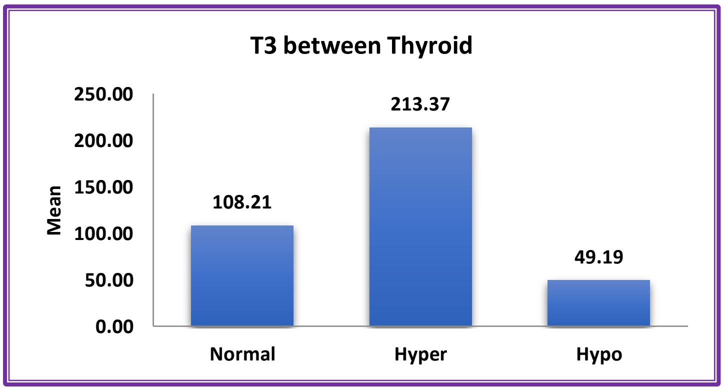

Figure 1: *Comparison of T3 Levels among Normal, Hyperthyroid, and Hypothyroid Groups*

Assessment of T3 levels among normal, hyperthyroid and hypothyroid groups. The graph shows the mean T3 levels (ng/dL) among the three groups, demonstrating significant differences in T3 concentration.

Table 1: Comparison of T3 levels among normal, hyperthyroid, and hypothyroid groups

Variable	Thyroid	N	Mean	SD	*F*-value	*p*-value
T3	Normal	70	108.21	4.50	17295.23	0.0005 **
	Hyper	70	213.37	6.90		
	Hypo	70	49.19	4.02		

*** Statistically Significant at p < 0.01 level*

Values illustrate the T3 levels vary significantly across thyroid conditions ($p < 0.01$), indicating T3 as a sensitive indicator for distinguishing between thyroid states.

Table 2: T3 levels post hoc assessment - Tukey hsd – manifold assessments

Conditional Variable			MD	Standard Error	*p*-value	95% C. I	
						LB	UB
T3	Normal	Hyper	105.1571*	0.8943	0.0005 **	107.268	103.046
		Hypo	59.0286*	0.8943	0.0005 **	56.917	61.140
	Hyper	Hypo	164.1857*	0.8943	0.0005 **	162.074	166.297

*** Significant Statistics at p < 0.01 level*

This table displays significant differences ($p < 0.01$) between all pairs of thyroids conditions reinforce T3's effectiveness as a differentiating factor.

Outcome of T4 Levels in three Different Groups

The estimation of T4 levels among normal, hyper and hypothyroid groups exposed considerable differences in T4 concentration. The mean T4 levels were maximum in the hyperthyroid group (17.11µg/dL), shadowed by the normal group (8.25µg/dL) and hypothyroid group showed lowest (3.29µg/dL). The *F*-value for the comparison was 23267.95 ($p < 0.01$), representing highly significant differences in T4 levels among all the groups (Figure 2 &Table 3).

Tukey's HSD test further confirmed substantial differences among all pairs of groups. Precisely, T4 levels in the hyperthyroid group were meaningfully higher than in the normal group (MD = -8.87µg/dL, $p < 0.01$) and pointedly higher than in the hypothyroid group (MD = 13.83µg/dL, $p < 0.01$). In addition, T4 levels in the hypothyroid group were suggestively lower than in the normal (MD = 4.96µg/dL, $p < 0.01$) (Table 4).

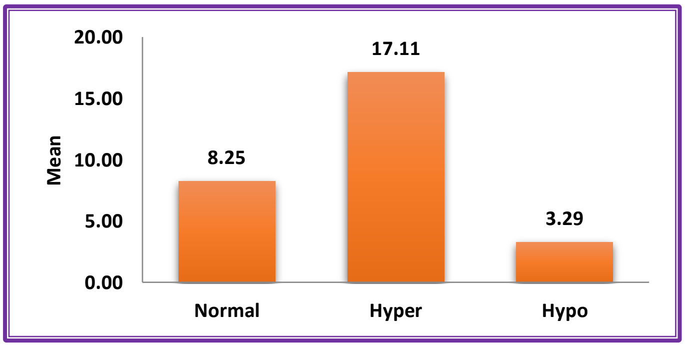

Figure 2: *Evaluation of T4 Levels among Normal, Hyperthyroid, and Hypothyroid Groups*

Estimation of T4 levels in normal control, hyper and hypothyroid groups. The graph shows the mean T4 levels (µg/dL) for every group, specifying substantial variations in T4 concentration among the 3 groups.

Table 3: Evaluation of T4 Levels among Normal, Hyperthyroid, and Hypothyroid Groups

Variable	Thyroid	N	Mean	SD	F-value	*p*-value
T4	Normal	70	8.25	0.47	23267.95	0.0005 **
	Hyper	70	17.11	0.43		
	Hypo	70	3.29	0.19		

*** High Significance in Statistics at p < 0.01 level*

Table 3 shows that T4 levels fluctuate evidently by thyroid ($p < 0.01$), describing T4 as another consistent biomarker for assessment of thyroid.

Table 4: T4 levels post hoc trials - Tukey HSD comparisons

Conditional Shifting			MD (I-J)	Std. Error	*p*-value	95% C. I	
						LB	UB
T4	Normal	Hyper	-8.8671*	0.0649	0.0005 **	-9.020	-8.714
		Hypo	4.9600*	0.0649	0.0005 **	4.807	5.113
	Hyper	Hypo	13.8271*	0.0649	0.0005 **	13.674	13.980

** Significance with Statistics at $p < 0.01$ level

Values demonstrates strong statistical significance ($p < 0.01$) in T4 levels among all thyroid states emphasizes T4's diagnostic value.

Consequence of TSH Levels in all three Groups

The assessment of TSH levels among all three groups revealed distinguished variations in TSH concentrations. The hypothyroid group showed the maximum mean TSH level at 11.92 µIU/mL, normal group at 2.22µIU/mL, whereas the hyperthyroid group documented the lowest level at 0.07µIU/mL. The F-value for this examination was 10915.11 (p < 0.01), which indicates a high degree of significant statistics in TSH levels in different groups (Fig 3 &Table 5).

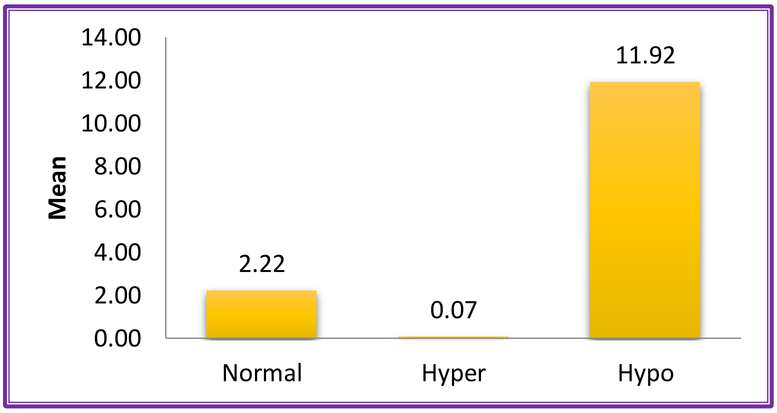

Figure 3: *TSH Levels among Normal, Hyperthyroid, and Hypothyroid Groups*

TSH levels in all experimental groups. The graph explains the mean TSH levels (µIU/mL) in the three groups, displaying significant variances in TSH concentration.

Table 5: TSH levels among normal, Hyperthyroid, and Hypothyroid groups

Variable	Thyroid	N	Mean	SD	*F*-value	*p*-value
TSH	Normal	70	2.22	0.19	10915.11	0.0005 **
	Hyper	70	0.07	0.02		
	Hypo	70	11.92	0.86		

** Substantial Significance at $p < 0.01$ level

Values illustrates effective statistical significance ($p < 0.01$) in TSH levels among all thyroid states highlights TSH diagnostic value. Data are expressed as mean ± standard deviation.

Tukey's HSD test specified momentous differences among all group combinations. Markedly, TSH levels in the hyper group were pointedly lower than normal group (MD = 2.15 µIU/mL, $p < 0.01$) and further lower than hypothyroid group (MD = -11.85µIU/mL, $p < 0.01$). Furthermore, TSH levels in the hypothyroid group were meaningfully raised in comparison to normal (MD = -9.70µIU/mL, $p < 0.01$) (Table 6).

Table 6: TSH Levels Tukey HSD - Post Hoc

Variables			MD	Error	Significant Value	95% C. I	
						LB	UB
TSH	Normal	Hyper	2.15043*	0.08545	0.0005 **	1.9487	2.3521
		Hypo	-9.69857*	0.08545	0.0005 **	-9.9003	-9.4969
	Hyper	Hypo	-11.8490*	0.08545	0.0005 **	-12.051	-11.6473

*** Significance Statistically at p < 0.01 level*

This table shows pair wise assessments of TSH levels among three groups, classifying statistically significant differences. This is done by HSD (Tukey's Honestly Significant Difference) test, with *p*-values representing the level of significance for every comparison.

Haematological Parameters Outcome in Experimental Groups

The evaluation of haematological parameters, such as RBC, Hb, MCV, and MCH, among control and experimental groups verified distinguished differences across the groups (Fig 4). The average values for these parameters were distinct and connected to thyroid function. In hyperthyroid group, RBC, Hb, MCV and MCH were characteristically lower than normal group. In contrary, the hypothyroid group presented up regulated levels of above parameters in comparable to normal and hyperthyroid groups. This outcome suggest that thyroid level has influence on haematological parameters, with hyperthyroidism linked with down regulated values, whereas hypothyroidism associated with increased values.

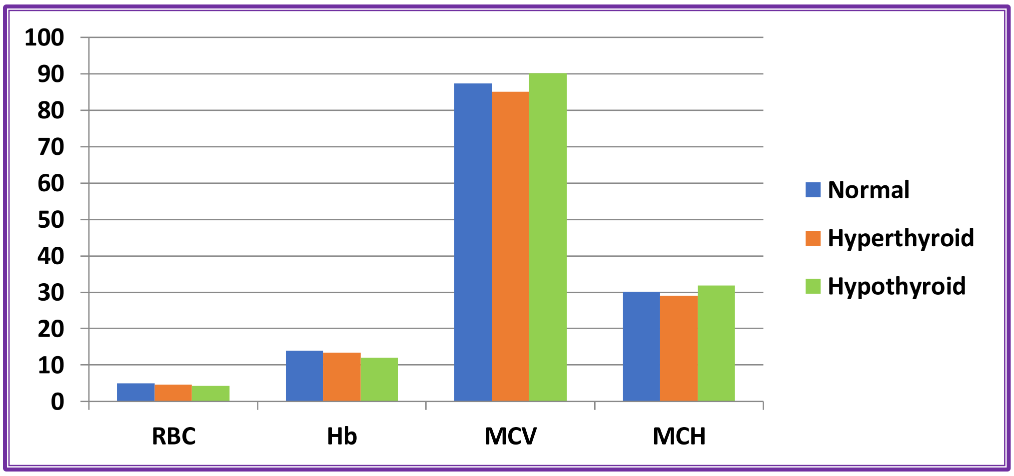

Figure 4: *Haematological parameters among Normal, Hyperthyroid, and Hypothyroid groups*

Haematological parameters such as RBC, Hb, MCV (mean corpuscular volume) and MCH (mean corpuscular haemoglobin) in all groups. The graph shows mean values for each parameter in the three groups, exposing dissimilarities related with thyroid levels.

Analysis of Immune Cell Parameters in the Groups

The estimation of further parameters, such as WBC count, polymorph nuclear cells, lymphocytes, eosinophils and monocytes, among different experimental cohorts illustrates noteworthy variations in immune cell distribution. In the hyperthyroid cohort, the above said parameters were suggestively up regulated in comparison to normal, signifying a possible immune response in the immune system due to surplus thyroid hormones. Equally, eosinophils and monocytes displayed lower values in the hyperthyroid group, representing a conceivable suppression of these cells. In contrast, the hypothyroid group displayed a noteworthy increase in monocytes and eosinophils comparative to normal and hyperthyroid, although lymphocytes and polymorphs were evidently reduced (Fig 5). These observations emphasize a compensatory immune response in hypothyroidism, categorised by modifications in specific immune cell production.

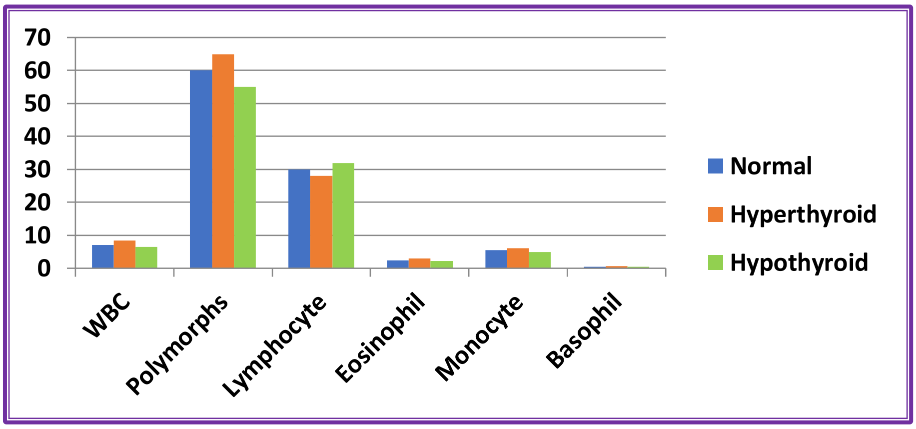

Figure 5: *Haematological parameters normal, Hyperthyroid, and Hypothyroid groups*

Haematological parameters such as WBC count, polymorphs, lymphocytes, eosinophils, and monocytes in all 3 groups. The graph displays the mean values for each parameter in the three groups, demonstrating alterations in immune cell depiction related with thyroid function.

Evaluation of Platelet Count in the Groups

The assessment of platelet counts in all three groups exposed significant differences in platelet levels. The mean platelet count was found to be lowermost in the hyperthyroid group, followed by the normal group, and uppermost in the hypothyroid group. In the hyperthyroid group, platelet counts were suggestively reduced compared to normal and hypothyroid groups, signifying a potential destruction of platelet production. Instead, the hypothyroid group showed significantly increased platelet counts, probably due to abridged platelet clearance or redeeming response to reformed thyroid hormone levels (Fig 6). These outcomes point the influence of thyroid dysfunction on platelet parameter, with hyperthyroidism being linked with low platelet count and hypothyroidism connected to raised platelet levels.

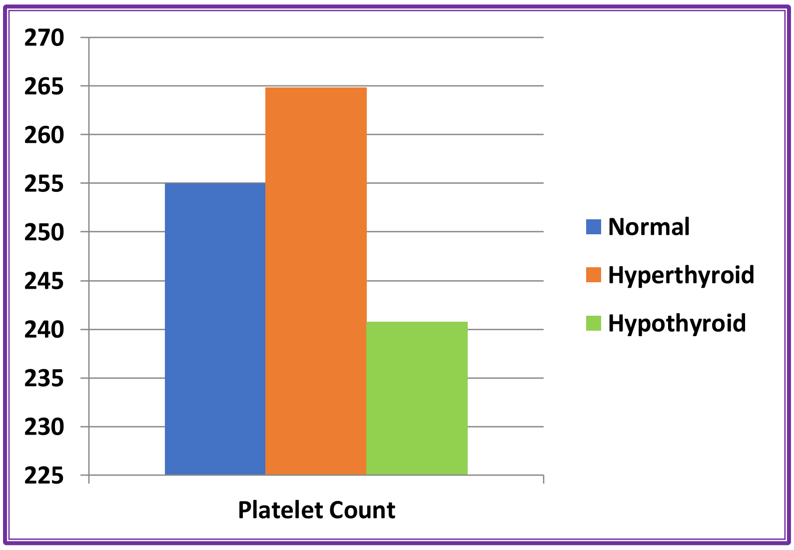

Figure 6: *Platelet count among Normal, Hyperthyroid, and Hypothyroid groups*

Platelet count in normal, hyper and hypothyroid groups. Graph proves the mean platelet count ($10^3/\mu L$) in all three groups, illustrating variations in platelet levels connected with thyroid function.

Haematological Parameters Differences in the Groups: Tukey HSD Analysis

Tukey's HSD test conducted on haematological parameters indicated notable differences in experimental groups. The normal group showed the highest RBC count at 4.99 ± 0.31million/µL and Hb concentration at 14.01 ± 0.87g/dL, followed by the hyperthyroid group, whereas the hypothyroid group documented the low values. Equally, patients with hypothyroidism confirmed the maximum MCV at 90.13 ± 3.59fL and MCH at 31.93 ± 1.40pg, while the hyperthyroid group offered the lowest MCV and MCH extents. Mean corpuscular haemoglobin concentration (MCHC) continued comparatively constant across the groups, with the maximum levels in hypothyroidism. WBC counts were uppermost in the hyperthyroid group at 8.50 ± 1.50 × $10^3/\mu L$, which as well displayed up regulated levels of monocytes, polymorphs and eosinophils. In contrary, lymphocyte counts were more predominant in the hypothyroid group.

Haematological Parameters Correlation

The RBC levels were found to be up regulated in normal, showing a mean difference of -0.4495 when related to hyperthyroid (p = 0.01) and a difference of 0.3475 relative to hypothyroid individuals (p = 0.01) (Table 7 & 8). Likewise, haemoglobin levels were raised in the normal group, with a mean difference of -1.4691 in comparable to hyperthyroid subjects (p = 0.01) and a difference of 0.5743 when compared to hypothyroid individuals (p = 0.004). Additionally, MCV) and MCH were maximum in hypothyroid group, with MCV display a significant increase in hyperthyroid individuals, replicated by a mean difference of -2.8187 (p = 0.01). MCH was meaningfully low in hyperthyroid compared to normal, with a mean difference of -24.0839 (p = 0.01).

Table 7: Haematological parameters

Parameter	Normal (Mean ± SD)	Hyperthyroid (Mean ± SD)	Hypothyroid (Mean ± SD)	*F*-value	*p*-value
RBC	4.99 ± 0.31	4.65 ± 0.32	4.20 ± 0.27	142.27	< 0.001
Hb	14.01 ± 0.87	13.44 ± 1.06	11.97 ± 1.21	78.69	< 0.001
MCV	87.31 ± 4.26	85.15 ± 3.95	90.13 ± 3.59	23.57	< 0.001
MCH	30.02 ± 1.27	28.98 ± 1.22	31.93 ± 1.40	101.3	< 0.001
MCHC	33.98 ± 0.99	33.80 ± 1.02	34.95 ± 1.02	33.21	< 0.001
WBC	7.00 ± 1.50	8.50 ± 1.50	6.50 ± 1.50	50.69	< 0.001
Polymorphs	60.00 ± 5.00	65.00 ± 5.00	55.00 ± 5.00	67.71	< 0.001
Lymphocyte	30.00 ± 5.00	28.00 ± 5.00	32.00 ± 5.00	7.95	< 0.001
Eosinophil	2.43 ± 0.35	2.99 ± 0.46	2.23 ± 0.43	64.68	< 0.001
Monocyte	5.50 ± 0.92	6.06 ± 0.92	4.95 ± 0.99	42.57	< 0.001
Basophil	0.51 ± 0.10	0.59 ± 0.10	0.39 ± 0.10	97.99	< 0.001
Platelet Count	254.9 ± 30.5	264.82 ± 29.6	240.7 ± 31.7	17.3	< 0.001

Table 7 explains the haematological parameters (RBC count, haemoglobin, MCV, MCH, MCHC, and WBC) among different groups. This table describes pair wise evaluations of these haematological parameters in all 3 groups. The F-values specify the variance among groups, whereas the p-values expose the significance of modifications.

Table 8: *Haematological parameters Tukey HSD - Post Hoc comparison*

Variables			Mean Difference	Significant Value	95% C. I (Confidence Interval)	
					LB	UB
RBC	Normal	Hyper	-0.4495	0.01	-0.57	-0.3291
		Hypo	0.3475	0.01	0.2271	0.4679
	Hyper	Hypo	0.797	0.01	0.6766	0.9174
HB	Normal	Hyper	-1.4691	0.01	-1.8905	-1.0476
		Hypo	0.5743	0.004	0.1529	0.9958
	Hyper	Hypo	2.0434	0.01	1.622	2.4648
MCV	Normal	Hyper	4.9781	0.01	3.4055	6.5507
		Hypo	2.1594	0.004	0.5868	3.732
	Hyper	Hypo	-2.8187	0.01	-4.3913	-1.2461
MCH	Normal	Hyper	2.9494	0.01	2.4318	3.4671
		Hypo	1.039	0.01	0.5213	1.5566
	Hyper	Hypo	-1.9105	0.01	-2.4281	-1.3928
MCHC	Normal	Hyper	1.1451	0.01	0.7419	1.5483
		Hypo	0.1775	0.553	-0.2257	0.5807
	Hyper	Hypo	-0.9676	0.01	-1.3708	-0.5644
WBC	Normal	Hyper	-1.4713	0.01	-2.0871	-0.8554
		Hypo	-1.3618	0.01	-1.9776	-0.7459
	Hyper	Hypo	0.1095	0.908	-0.5064	0.7254
Polymorphs	Normal	Hyper	-8.7272	0.01	-10.6016	-6.8527
		Hypo	-4.8543	0.01	-6.7287	-2.9799
	Hyper	Hypo	3.8729	0.01	1.9984	5.7473
Lymphocyte	Normal	Hyper	3.4081	0.01	1.5168	5.2994
		Hypo	0.9941	0.431	-0.8972	2.8854
	Hyper	Hypo	-2.4141	0.008	-4.3053	-0.5228
Eosinophil	Normal	Hyper	-0.7559	0.01	-0.9216	-0.5902
		Hypo	-0.5552	0.01	-0.7208	-0.3895
	Hyper	Hypo	0.2007	0.013	0.0351	0.3664
Monocyte	Normal	Hyper	-1.1123	0.01	-1.4879	-0.7367
		Hypo	-0.5617	0.002	-0.9373	-0.1861
	Hyper	Hypo	0.5506	0.002	0.175	0.9262
Basophil	Normal	Hyper	-0.1945	0.01	-0.2338	-0.1553
		Hypo	-0.0804	0.01	-0.1197	-0.0411
	Hyper	Hypo	0.1141	0.01	0.0749	0.1534
Platelet Count	Normal	Hyper	-24.0839	0.01	-36.3069	-11.8609
		Hypo	-9.838	0.141	-22.061	2.385
	Hyper	Hypo	14.2459	0.018	2.0229	26.469

Table 8 presents the results of the Tukey HSD post hoc analysis concerning haematological parameters, including RBC, Hb, MCV, and MCH. It details the mean difference values, significance levels and 95% confidence intervals. This table facilitates pair wise comparisons of these parameters across normal, hyperthyroid, and hypothyroid groups, highlighting the mean deviations, p-values that denote statistical significance, and the corresponding 95% confidence intervals for each comparison.

Discussion

The present study demonstrates the significant variations in thyroid hormone levels like T3, T4, TSH and general haematological parameters such as RBC, WBC, Hb, MCV, MCH, MCHC and platel*et al* l experimental groups. The present findings support the central role of thyroid hormones in regulating numerous physiological processes, like blood components and immune function, which provides an understanding of how dysfunction of thyroid could impact overall health. The outcome of this study validates noticeable differences in T3, T4 and TSH levels across the conditions (hyperthyroid, hypothyroid and normal). T3 levels were suggestively high in hyperthyroid group, normal group and low in hypothyroid group, present finding correlates with previous findings that increased T3 levels in hyperthyroidism and decreased levels in hypothyroidism (Qassim & Ibrahim, 2024; Nakova *et al.,* 2022; Bahn*et al.,* 2011). Likewise, T4 levels observed the same results with hyperthyroid group expressing maximum level and hypothyroid group express low level, further highlighting the connection between thyroid hormone formation and function. The differences in TSH levels across the groups, with the minimum values in hyperthyroidism and the maximum in hypothyroidism, the comprehension of the negative response loop that controls thyroid hormone levels runs alongside with this consideration (Ashraf *et al.,* 2024). These results strengthen the role of TSH, T3 and T4 as a reliable biomarker for the analysis of thyroid disorders, with statistically significant alterations found in experimental groups.

Thyroid hormones employ a significant impact on haematological parameters, as showed by the dis similar variations in RBC, Hb, MCV and MCH across the thyroid conditions. The present findings disclose that the normal had the maximum RBC and Hb, whereas the hyperthyroid group showed the minimum values for these parameters. These results are constant with the identified properties of thyroid hormones on erythropoiesis. In hyperthyroidism, up regulated metabolic action might result indrop of RBC due to up regulated oxygen consumption and maximum turnover of red blood cells. On the other hand, hypothyroidism was related with increased RBC and Hb, which might be associated to reduced oxygen demand and abridged erythropoietic suppression (Miliutin*e et al.,* 2021).

MCV and MCH were also pointedly disturbed by thyroid dysfunction. The hypothyroid group displayed the increased MCV and MCH values, signifying the occurrence of macrocytic anaemia. This finding coincides with previous outcome that have stated up regulated MCV in hypothyroid individuals due to changed RBC maturation process (Effraimidis & Wiersinga, 2014). Hyperthyroidism, was associated with decreased MCV and MCH, which could emulate a microcytic anaemia because of increased demand for RBC without adequate time for complete maturation (Tsai *et al.,* 2019).

MCHC, also displays significant changes. The hypothyroid and normal group showed the maximum MCHC, but the hyperthyroid group displayed lower values. MCHC is degree of the haemoglobin concentration within RBC and might impact modifications in the oxygen-carrying possibility of erythrocytes (Miyagaki, Fujimoto, Sato, 2015). These differences in MCHC further reinforce the theory that thyroid hormone control erythropoiesis and haemoglobin formation. The Mean Corpuscular Hemoglobin Concentration (MCHC) values demonstrate significant differences across thyroid conditions. Compared to normal individuals, hyperthyroid patients exhibit slightly reduced MCHC levels, while hypothyroid patients show an increase in MCHC. The significant differences between hyperthyroid and hypothyroid groups (mean difference: -0.9676, $p < 0.01$) suggest that thyroid dysfunction affects hemoglobin concentration within erythrocytes, likely reflecting altered erythropoiesis or red cell metabolism due to thyroid hormone imbalance. The immune system is as well influenced by thyroid hormones, as established by the noteworthy variations in distribution of immune cells in all three groups. The hyperthyroid group showed increased WBC, mostly increased polymorphs and lymphocytes count, that could be indication of active immune response related with excess thyroid. Numerous studies have stated that hyperthyroidism could result in up regulated immune responses, perhaps due to thyroid hormones immuno modulatory outcomes (Wenzek *et al.,* 2022). Quite the opposite, hypothyroidism was linked with up regulation in eosinophils and monocytes, signifying altered immune profile due to deficiency of thyroid. This result was consistent with outcomes that hypothyroidism can modify the balance of immune cell environment, which includes a switch to elevated eosinophils and monocytes (Ca *et al.,* 2022). Furthermore, the lesser lymphocyte and polymorph counts in hypothyroid group may impact immune shift and function in specific cell subsets. These results summit the intricate relationship among thyroid and immune cell distribution and propose that thyroid deterioration can suggestively impact the immune system.

Platelet count investigation produced remarkable observations, representing that the maximum platelet count was in hypothyroid group, although the hyperthyroid group showed the lower count. Supporting evidence has established a correlation between hyperthyroidism and reduced platelet formation, as well as maximum platelet turnover (Arooj *et al.,* 2022), which may interpret for the condensed platelet count in this cohort. In contrast, hypothyroidism seems to relate with increased platelet, potentially due to decreased platelet clearance and altered response intended at sustaining production levels of platelet (Babhina & Papaiah, 2023; Hassan *et al., 2023*). These results suggest that thyroid disorder directly affects platelet regulation, requiring deliberation of thyroid levels when assessing platelet function and its count. The dissimilar variations in haematological and immune variations reported in this study indicates the crucial role of thyroid hormones in the blood component regulation. The distinguished differences in T3, T4, and TSH levels among the groups, along with the related changes in haematological parameters, indicated that thyroid function can deeply disturb many physiological processes. These finding carry significance, predominantly in diagnosis and management of thyroid disorders. Measuring thyroid hormones in combination with a wide-ranging analysis of haematology may simplify the difference between normal, hyperthyroid, and hypothyroid conditions (Vekic *et al., 2024;* Montagnana & Lippi*, 2023)*, thus clinicians can understand the systemic inferences of thyroid disorders. Moreover, the observed alterations in immune cell distribution, platelet counts, and other haematological parameters might assist as useful diagnostic indications for sensing thyroid disorders. Clinicians can correlate the potential effects of thyroid dysfunction when interpreting haematological and immune cell profiles, as imbalances in thyroid hormones can obscure or resemble other underlying health issues.

This study provides novel insights into the correlation between thyroid dysfunction and hematological profiles by comprehensively analyzing the impact of hyperthyroidism and hypothyroidism on various blood parameters, including RBC, WBC, Hb, MCV, MCH, and platelet counts. It highlights unique immune alterations, such as increased WBC and polymorphs in hyperthyroid patients and elevated eosinophils and monocytes in hypothyroid patients, shedding light on thyroid-mediated immune modulation. By integrating thyroid hormone levels (T3, T4, TSH) with hematological indices, the research emphasizes their combined diagnostic value for early detection and differentiation of thyroid disorders. This study bridges a critical gap by providing region-specific data from the Indian population and proposes practical applications for improving clinical management and reducing morbidity associated with thyroid dysfunction.

Limitations

The present study is a cross-sectional design with limited sample size for certain age groups, it also lacks of in-depth molecular analysis, absence of detailed diet and lifestyle factors, study participants were from single-geographic location, potential sampling bias exist in gender distribution and reliance on self-reported medical histories are the limitations of the present study.

Conclusion

This presents research gives strong indication representing that thyroid dysfunction suggestively influences haematological and immune parameters. The variations in T3, T4 and TSH levels in all groups highlight the indispensable role of thyroid hormones in the metabolism, erythropoiesis, immune response and platelet formation. The alterations observed in RBC, Hb, MCV, MCH, WBC and platelet counts exemplify the strong relationship between thyroid function and blood components. MCHC levels are influenced by thyroid disorders, with hyperthyroid patients exhibiting lower levels and hypothyroid patients showing higher levels compared to normal. These findings underline the importance of monitoring hematological parameters as part of the evaluation of thyroid dysfunction, as they provide insight into the systemic effects of altered thyroid hormone levels. These findings signify the diagnostic standing of measuring thyroid hormones along with haematological parameters to distinguish among various thyroid abnormal conditions and stress the requirement for detailed assessments of thyroid function in medical settings, for diagnosis and appropriate treatment.

Conflict of Interest

There are no conflicts of interest.

Acknowledgement

The authors are thankful to all contributors for their participation in this study.

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