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Investigating the Relationship Between Insulin-Like Growth Factor -I and Thyroid Hormones in Thyroid Disorder Patients

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***Abstract*—The insulin-like growth factor I (IGF-I) system plays a pivotal role in endocrine regulation, metabolism, and cellular growth; however, its interaction with thyroid hormones in the context of thyroid dysfunction remains insufficiently understood. This study aimed to investigate the correlations between IGF-I and thyroid hormones, TSH, T3, and T4, in females diagnosed with thyroid disorders. After removing 15 women due to pregnancy or medication use, 160 women from the Koya district were assessed. Serum levels of IGF-I and thyroid hormones were measured using the COBAS e411 analyzer, and body mass index (BMI) was also recorded. Statistical analysis was conducted using SPSS 25, employing Kruskal-Wallis ANOVA and Spearman correlation for thyroid groups: hyperthyroid, hypothyroid, and euthyroid. The results demonstrated significant variation in IGF-I levels across thyroid conditions. IGF-I was markedly elevated in hyperthyroid individuals and showed a moderate inverse correlation with TSH, along with a positive correlation with T3 and T4. Hypothyroid individuals exhibited significantly lower IGF-I levels, suggesting a regulatory role of IGF-I in thyroid hormone dynamics. Additionally, BMI varied significantly across groups ($p < 0.001$), with the highest values are observed in hypothyroid participants, supporting the metabolic implications of thyroid dysfunction and its association with IGF-I. The study concludes that IGF-I could serve as a valuable adjunct biomarker in the assessment of thyroid disorders, particularly in ambiguous or subclinical cases. Incorporating IGF-I into routine thyroid evaluation may enhance early detection, risk stratification, and individualized management strategies, contributing to more precise and effective endocrine care.**

***Index Terms*— Endocrine regulation, Hormonal correlation, Insulin-like growth factor-I, Thyroid disorders.**

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I. Introduction

The system of insulin-like growth factor (IGF) bioregulation plays an essential role in thyroid gland growth and thyroid function (Karagiannis, et al., 2020). The IGF family consists of insulin and two endogenous growth hormones (GHs), IGF-I and IGF-II (Ławnicka, et al., 2020; Adamek and Kasprzak, 2018). IGF-I, a protein product of liver synthesis, acts primarily as an endocrine hormone secreted by the liver and transported to target tissue (Bailes and Soloviev, 2021). IGF-I also influences energy metabolism concerning GH and shows insulin-like actions (Tseng et al., 2019). Thyroid hormone synthesis is regulated by feedback mechanisms mediated by the hypothalamus-pituitary–thyroid axis, which ensures hormonal balance and metabolic stability (Babić Leko et al., 2021).

Thyroid cells have developed IGF-I receptors, and research has shown that the interaction between IGF-I and thyroid stimulating hormone (TSH) exerts a synergetic effect on the proliferation and growth of thyroid cells (Vargas-Ortega et al., 2021). Thyroid hormones are crucial for normal development, regulating growth, and necessary for the proper functioning of physiological systems.

IGF-I has a close interaction with thyroid hormones, with effects on multiple components of thyroid physiology and pathology (Smith, 2021a). Thyroid dysfunction may cause conditions, such as hypothyroidism and hyperthyroidism, each with certain clinical manifestations. Thyroid conditions are among the most prevalent endocrine conditions worldwide (Anandkumar, Chacko, and Usha, 2020). Recent studies have investigated the relationship between IGF-I and thyroid nodules, with emerging evidence showing that IGF-I itself may contribute to the development of different thyroid diseases. IGF-I is involved both in goiter pathogenesis and tumorigenesis, including the tumors occurring in the setting of acromegaly (Smith, 2021b).

Thyroid hormones significantly impact glucose metabolism in tissues responsive to insulin, including the skeletal muscle, liver, and adipose tissue (Al-bayati and Al-Khateeb, 2021; Sabatino and Vassalle, 2025; Chadt and Al-Hasani, 2020). IGF-I controls the growth, development, and function

of multiple human tissues, including the thyroid and its hormones. These hormones control glucose absorption, storage, and usage, thereby ensuring energy homeostasis as well as metabolic effectiveness (Chadt and Al-Hasani, 2020). Although T4 remains inactive until it becomes converted to its active form, T3 is the major hormone released by the thyroid gland (De Stefano et al., 2021).

T3 and IGF-I modulate GH production and pituitary cell secretion in various ways, and a deficit in GH can impair T3 production. Thyroid epithelial cell function also depends on crucial ingredients, such as TSH and IGF-I, necessary for thyroid hormone synthesis. The proper understanding of the complicated interconnectivity between IGF-I and thyroid hormones plays a vital role in explaining the mechanisms underlying thyroid diseases. IGF-I and thyroid hormones play a fundamental role in regulating endocrine function, growth, and metabolism. Their ability to interact with TSH, however, remains not fully understood, particularly when distinguishing between physiological and malignant changes.

The primary goal of this cross-sectional study is to examine the correlation between IGF-I levels and different thyroid dysfunctions; namely, hypothyroidism, hyperthyroidism, and euthyroid in female patients, that considers the elevated prevalence of thyroid disorders in women. The study focused on clarifying the underlying mechanisms of thyroid disease through the analysis of both clinical and biochemical information.

This study is the initial examination in the Koya District to investigate the correlation between IGF-I and thyroid hormones in the context of thyroid dysfunction. In contrast to other regional studies that primarily examined the prevalence and hormonal profiles, this research highlights a potential regulatory function of IGF-I.

II. Materials and Methods

A. Study Design and Patient Selection

This study was conducted as a cross-sectional study among thyroid disease patients visiting Shahid Dktor Khalid Hospital in the Koya region. Institutional ethical clearance was received by the Faculty of Science and Health, Koya University ethics committee, by ethics form (012 Bio) on December 23, 2024. Blood samples and questionnaires were collected from December 2024 to April 2025. Receiver operating characteristic (ROC) curve exploration was carried out to examine the diagnostic performance of IGF-I levels in diagnosing thyroid dysfunction in patients. ROC analysis was carried out among all thyroid status groups (hypothyroid, hyperthyroid, and euthyroid) to analyze the potentiality of IGF-I as a biomarker supplement in examining thyroid disease, using the area under the curve (AUC) to estimate the accuracy of IGF-I as an indicator of thyroid dysfunction.

B. Patient Population

The study population included 175 individuals. The candidates are required to be of particular ages from 20 to 60 years. The sample consists of 99 patients with specific thyroid pathology, including hypothyroidism and hyperthyroidism, and 61 euthyroid patients with complete biochemical and clinical information, including levels of TSH, T3, T4, and IGF-I. In the whole case, 15 patients with other endocrinopathies, pregnancy, or recent thyroid surgery or therapy were excluded from the total data set.

This research only had female participants because thyroid issues are more common among women. The primary purpose was to analyze the potential role of IGF-I as a biomarker of thyroid function in a female population. The thyroid's pathophysiology can differ between sexes; by focusing on females, we aimed to provide a better and more meaningful analysis of IGF-I levels.

Based on their clinical diagnostic and hormone profiles and known clinical thresholds, participants were put into one of three groups based on their thyroid status:

- Hyperthyroidism: Suppressed TSH levels (<0.27 IU/mL) accompanied by elevated T3 and/or T4 concentrations.
- Hypothyroidism: Elevated TSH levels (>4.2 IU/mL) with reduced T3 and/or T4 concentrations.
- Euthyroid: Normal TSH levels (0.27–4.2 IU/mL) with corresponding normal T3 and T4 levels.

C. Data Collection and Biochemical Analysis

Participants provided 5 mL blood samples while fasting, using simple (non-additive) collection tubes. The serum was separated from the samples by spinning them at 3000 rpm for 10 min. Then, the serum was divided into smaller amounts and kept at −20°C until more clinical tests could be done.

Blood samples were obtained under fasting conditions, specifically between 8 and 10 AM, and subsequently analyzed using the Cobas e411 immunoassay analyzer (Roche Diagnostics, Germany) to ascertain serum concentrations of TSH, T3, T4, and IGF-I. The hormonal reference ranges employed in this investigation were: T3 (1.3–3.1 nmol/L), T4 (66–181 nmol/L), and TSH (0.27–4.2 IU/mL). The normal range for IGF-I in adult women was 60–350 ng/mL.

A standardized questionnaire was used to gather demographic and clinical data, such as age, sex, height, and weight, during the study period. An Excel spreadsheet was used to record all of the data so that it could be analyzed later.

D. Statistical Analysis

The Statistical Package for the Social Sciences version 25 conducted a statistical analysis on the dataset entailed various tests to analyze differences and relationships between variables. Descriptive statistics, such as mean, standard deviation, minimum, and maximum values aggregated the fundamental characteristics of the population under study. Given the existence of large groups and non-parametric assessment based on the distribution of data, a one-way analysis of variance supplemented by the Kruskal–Walli's test was used to contrast IGF-I levels among Euthyroid, Hypo, and Hyperthyroid groups. Spearman's rank order test was used to analyze relations between IGF-I, TSH, T3, and

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T4, using correlation coefficients and p-values. The statistical analysis ascertains an overall assessment of endocrine and metabolic variables. ROC analyses were performed in each category of thyroid status (hypothyroid, hyperthyroid, and euthyroid), with the AUC used to evaluate the diagnostic accuracy of IGF-I as a marker of thyroid dysfunction.

III. Result

The study sample used in this study consists of 160 cases with an age range from 20 to 60 years (Mean = 39.01, standard deviation [SD] = 10.09). The participants weigh between 41 and 110 kg (Mean = 70.1 kg, SD = 14.23 kg. The height of the patients measures from 1.51 to 1.8 m (Mean = 1.6619, SD = 0.0623). IGF-I levels vary greatly with values ranging between 6.89 and 490.5 ng/mL (Mean = 94.65, SD = 67.35). The levels of TSH vary between 0.005 and 100 IU/mL (Mean = 5.78, SD = 11.10) with great variability. The levels of T3 vary between 1.1 and 10.36 nmol/L (Mean = 2.3, SD = 0.96), whereas those of T4 reveal a large variability between 34.68 and 230 nmol/L (Mean = 113.29, SD = 30.85), revealing a near-normal distribution. The data reveal a heterogeneous sample population, especially concerning metabolic and endocrinological parameters. Descriptive statistics yielding the characteristics of the population are described in Table I.

The Shapiro–Wilk test was employed to assess the normality of continuous variables. Most of the indicators, such as IGF-I, TSH, T3, and body mass index (BMI), were not normally distributed ($p < 0.05$). Conversely, T4 exhibited a distribution pattern aligned with normalcy ($p > 0.05$). Because most of the variables didn't follow a normal distribution, we used non-parametric statistical approaches throughout the investigation. These included the Kruskal–Wallis test for comparing groups and Spearman's rank correlation for looking at relationships.

Descriptive statistics among the groups of IGF-I levels show significant differences, as illustrated in Table II. The mean IGF-I level among the Hyper group (n = 32) was 126.13 (SD = 49.92), higher than those of all other groups. The mean IGF-I level was lower among the Hypothyroid group (n = 67), with higher variability (Mean = 78.40, SD = 56.67). The Euthyroid group (n = 61) has a mean IGF-I level of 95.99, with SD 79.83. The large standard deviations between the Euthyroid and Hypothyroid groups show significantly different IGF-I levels. The $p = 0.004$ was indicative of significance among the three groups. The variances observed show that significantly different levels of IGF-I are present among the groups. The participants had an average BMI of 25.39 ± 5.02 kg/m^2, with values ranging from 14.02 to 38.97 kg/m^2.

There are values between each pair of groups, as depicted in Table III. Whereas there is no significance between the hypo and hyper groups, the data shows that the euthyroid group plays a role when compared with the remaining two thyroid status groups.

To provide a graphical comparison of distributions of IGF-I levels in groups identified as having Hyper, Hypo, and Euthyroid thyroid status. The boxplot, from Fig. 1, describes central tendency (median), variability (interquartile range), and outliers in each group.

Table I
Baseline Characteristics of the Study Population

Parameter	N	Minimum	Maximum	Mean±standard deviation
Age (year)	160	20	60	39.01±10.09
Weight (Kgs)		41	110	70.10±14.23
Height (Cm)		1.51	1.8	1.66±0.06
Body mass index		14.02	38.97	25.394±5.02
IGF-I ng/mL		6.89	490.5	94.65±67.35
TSH IU/mL		0.005	100	5.78±11.10
T3 nmol/L		1.1	10.36	2.30±0.96
T4 nmol/L		34.68	230	113.29±30.85

TABLE II
Descriptive Statistics for IGF-I (ng/mL) across Thyroid Groups

Group	N	Mean±standard deviation	Standard error	Minimum	Maximum
Hyperthyroid	32	126.13±49.92	8.82	18.11	274.60
Hypothyroid	67	78.40±56.67	6.92	7.00	346.40
Euthyroid	61	95.99±79.83	10.22	6.89	490.50

IGF-I values were non-normally distributed across thyroid groups (Shapiro–Wilk $p<0.05$). Therefore, Kruskal–Walli's test was applied.

TABLE III
IGF-I Comparison Across Thyroid Groups

Groups	p-value	95% confidence interval	
		Lower	Upper
Hyper versus euthyroid	0.091	−3.64	63.92
Hyper versus hypo	0.002	14.47	80.98
Hypo versus euthyroid	0.285	−9.80	44.97

Pairwise differences were assessed using non-parametric *post hoc* tests due to non-normal IGF-I distribution.

The Hyper group, with its reduced spread and highest median IGF-I level, reflects more stability in this category. The hypo group has a wider spread and lower median IGF-I level, reflecting more variability. The euthyroid category has a broad range of IGF-I measurements with multiple extreme outliers. The euthyroid category shows the highest diversity, whereas the overall trend reflects IGF-I levels to be generally higher in the Hyper category and lower in the Hypo category.

Table IV shows mean IGF-I values by thyroid state category (Hypothyroid, Euthyroid, and Hyperthyroid) for participants aged 20–60 years. Although all individuals belong to the relevant study age group (20–60 years), statistical analysis reveals a significant effect of age on IGF-I levels ($p = 0.016$). It suggests that although participants were selected from the typical study age group, subtle age-specific differences in IGF-I levels are still evident in this group.

Even with overall uniformity in IGF-I normal ranges for individuals of this age category, the high p-value for age implies that physiological considerations can still influence IGF-I levels throughout this interval. They can include metabolic changes, lifestyle effects, or unapparent fluctuations in IGF-I production not easily captured by a normal adult's standard reference interval.

The Spearman correlation study has significant correlations between IGF-I, TSH, T3, and T4, reflecting

the interdependence of these hormones in their mechanisms of action. As illustrated in Table V and Fig. 2, a weak but statistically significant positive association between IGF-I and T3 ($r = 0.186$, $p = 0.019$) reflects a possible interdependency between their regulation. On the other hand, IGF-I has a moderate negative association with TSH ($r = -0.278$, $p < 0.001$), suggesting high levels of IGF-I are associated with low levels of TSH. IGF-I shows no significant relationship with T4 ($r = 0.046$, $p = 0.561$), reflecting a lack of meaningful relationship between IGF-I and T4.

TSH has a significantly negative relationship with both T3 ($r = -0.419$, $p < 0.001$) and T4 ($r = -0.453$, $p < 0.001$), demonstrating that a rise in TSH levels goes with a decrease in levels of T3 and T4. This reflects a negative association between thyroid hormones and TSH. T3 and T4 reveal a moderate positive association ($r = 0.497$, $p < 0.001$), reflecting a general increase in levels of T3 with an increase in levels of T4. Overall, IGF-I has a profound effect on TSH and T3 with no appreciable effect on T4. The study reflects a strong interaction between thyroid hormones, particularly the inverse relationship between TSH with T3 and T4. The findings illustrate that changes in thyroid hormone levels greatly influence each other, with TSH playing a central role in regulating levels of T3 and T4, although IGF-I may play a lesser role in regulating levels of T3 and TSH. Multiple relationships reflect the complexity of endocrine regulation and functional interrelationships of individual hormones in a metabolic process.

The 95% confidence intervals show the range of true mean IGF-I values for each group of thyroid status. The average IGF-I level for people with hypothyroidism is thought to be between 64.6 and 92.2 ng/mL, for people with euthyroid between 75.5 and 116.4 ng/mL, and for people with hyperthyroidism between 108.1 and 144.1 ng/mL. These intervals show how accurate the mean estimations are and demonstrate that IGF-I levels tend to rise from hypothyroid to hyperthyroid states, with not much overlap between groups. This suggests that IGF-I levels may vary depending on how well the thyroid is working.

ROC analysis was conducted using binary logistic regression, with IGF-I as the predictor variable and thyroid status; hyperthyroid versus euthyroid, or hypothyroid versus euthyroid as the binary outcome. Because IGF-I values don't follow a normal distribution, binary logistic regression was used because it works well for modeling binary outcomes with continuous, non-normally distributed predictors in clinical biomarker investigations.

Table VI and Figs. 3 and 4 show that IGF-I didn't do a good job of separating different groups. It was only somewhat good at telling the difference between hyperthyroidism and euthyroid, and it was very bad at telling the difference between hypothyroidism and euthyroid. The calculated AUC was 0.703, reflecting a moderate discriminative ability of the

TABLE IV
MEAN IGF-I LEVEL IN THE THYROID GROUP

Thyroid status	Age range (years)	Mean IGF-I (ng/mL)	Standard Deviation	95% confidence interval	p-value
Hypothyroid	20–60	78.404	56.674	64.6–92.2	0.016
Euthyroid	20–60	95.99	79.832	75.5–116.4	
Hyperthyroid	20–60	126.129	49.918	108.1–144.1	

TABLE V
SPEARMAN CORRELATION ANALYSIS OF IGF-I, TSH, T3, AND T4

Spearman's rho	IGF-I	TSH	T3	T4
IGF-I				
Correlation coefficient	1	−0.278	0.186*	0.046
p-value	.	<0.001	0.019	0.561
TSH				
Correlation coefficient	−0.278	1	−0.419	−0.453
p-value	0	.	0	0
T3				
Correlation coefficient	0.186*	−0.419	1	0.497**
p-value	0.019	<0.001	.	<0.001
T4				
Correlation coefficient	0.046	−0.453	0.497**	1
p-value	0.561	<0.001	<0.001	.

Note: Spearman's rho was used due to the non-normal distribution of IGF-I and thyroid parameters.
IGF-I: Insulin-like growth factor I, TSH: Thyroid stimulating hormone.
*: Indicates that the correlation is statistically significant ($p<0.05$).
**: Indicates that the correlation is statistically significant ($p<0.01$).

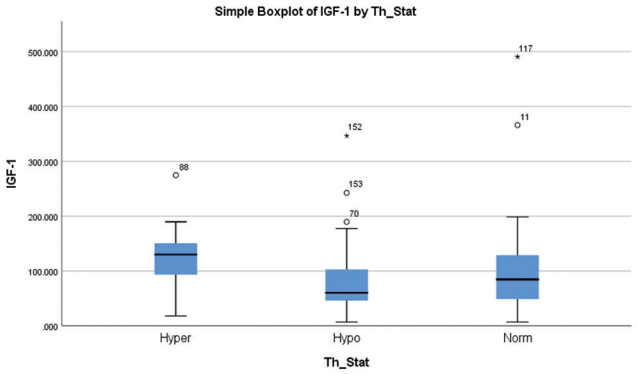

Fig. 1. Distribution of insulin-like growth factor-I (ng/mL) levels among thyroid status groups.

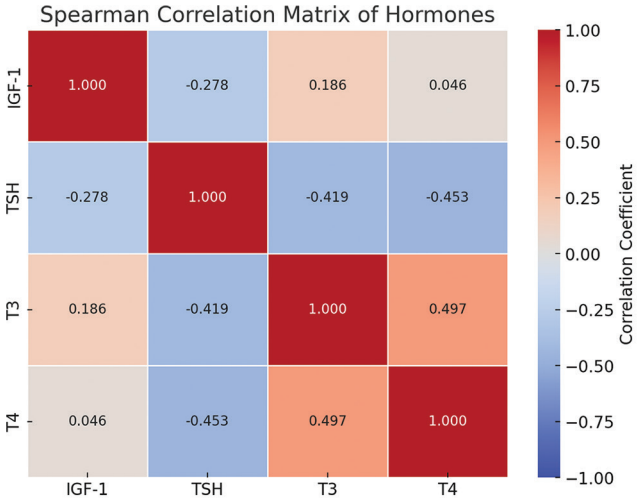

Fig. 2. Correlation Matrix between thyroid hormones with Insulin-like growth factor-I.

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model in distinguishing between hyperthyroid and euthyroid conditions. There were 93 instances accepted; 32 were due to hyperthyroidism (positive class) and 61 were due to euthyroid state (negative class). The performance of the model is represented by the ROC curve; even though the AUC was less than optimum 1.0, it shows that the model has a reasonable discriminative ability between the two conditions. The model holds a moderate discriminative ability with AUC = 0.703.

Following assessment of the ROC of hypothyroidism status, it was found to be 0.433, revealing the poor ability of the model to distinguish between euthyroid and hypothyroid conditions. There were 128 true instances identified, including 67 instances of hypothyroidism (positive class) and 61 instances of euthyroid condition (negative class). The AUC of 0.433 was far less than the desired optimum score of 1.0, revealing poor discriminative effectiveness of the IGF-I test variable to distinguish between both thyroid conditions. The IGF-I test variable is not a good marker of hypothyroidism because of its poor AUC score. The model lacks adequate discriminative ability.

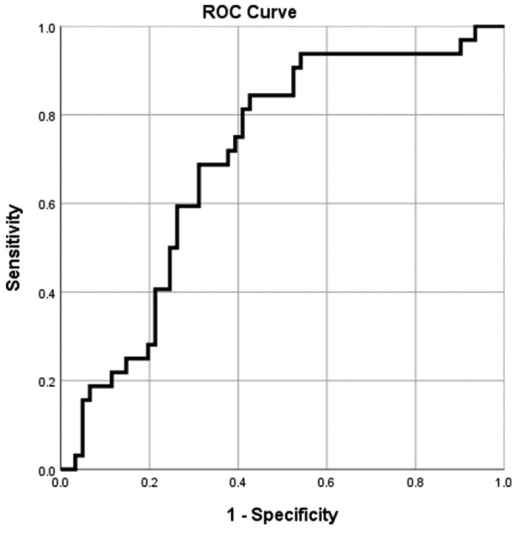

Fig. 3. Receiver operating characteristic of insulin-like growth factor-I with hypothyroidism.

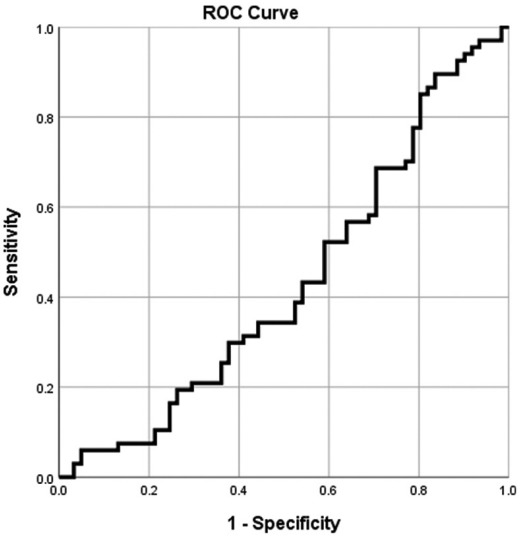

Fig. 4. Receiver operating characteristic of insulin-like growth factor-I with hyperthyroidism.

The AUC of IGF-I in hyperthyroidism was 0.703 (standard error: 0.055, p = 0.001), representing a moderate diagnostic performance. The AUC of hypothyroidism was 0.433 (standard error: 0.051, p = 0.189), meaning IGF-I was not significantly able to separate hypothyroid individuals from Euthyroid. The findings reveal that IGF-I can act as an extra biomarker in hyperthyroidism, but its diagnostic accuracy in hypothyroidism is limited.

Table VII demonstrates a significant variation in BMI across different thyroid function groups ($p < 0.001$). People with hypothyroidism had the highest BMI values (28.31 ± 4.09), which were much higher than those in the euthyroid group (23.15 ± 4.08; $p < 0.001$). Conversely, hyperthyroid patients exhibited a mean BMI of 23.56 ± 5.45, indicating no statistically significant difference when compared to euthyroid persons (p = not significant). These data indicate that the metabolic consequences of thyroid malfunction are more pronounced in hypothyroidism, wherein a diminished metabolic rate may lead to a rise in body weight.

IV. Discussion

This study was designed to explore possible correlations between thyroid function and blood IGF-I concentrations, as well as their potential association with thyroid disorders. The results provide evidence of a complex interaction between thyroid hormone and IGF-I levels, consistent with prior research and adding new insights into its mechanisms.

Hypothyroidism patients in this study showed significantly lower levels of blood IGF-I with an average of 78.40 ng/mL (SD = 56.67). The findings match those of earlier research, where it was concluded that low IGF-I levels in many individuals are commonly linked with hypothyroidism as well as with decreased growth regulation and reduced metabolic activity secondary to low thyroid

TABLE VI
AUC for IGF-I with Hyperthyroidism and Hypothyroidism

Status	Area	Standard error	p-value
Hyperthyroidism	0.703	0.055	0.001
Hypothyroidism	0.433	0.051	0.189

Note: IGF-I data were non-normally distributed. AUC analysis was conducted using ROC for binary classification.
ROC: Receiver operating characteristic, IGF-I: insulin-like growth factor I, AUC: Area under the curve.

TABLE VII
BMI Distribution by Thyroid Status

Group	N	Mean BMI±standard deviation	Median (IQR)	Range	p-value
Hyperthyroid	32	23.56±5.45	21.64 (7.24)	15.62–37.11	<0.001
Euthyroid	61	23.15±4.08	23.23 (5.66)	14.02–33.65	
Hypothyroid	67	28.31±4.09	28.70 (5.58)	18.51–38.97	

Note: BMI distribution was non-normal (Shapiro–Wilk $P<0.05$); Kruskal–Walli's test was used for group comparisons.
BMI: Body mass index.

hormone levels.

This supports the hypothesis that thyroid hormones play a major role in regulating IGF-I synthesis and secretion (Iglesias et al., 2001). Several studies examined the association between IGF-I and thyroid hormones in various thyroid pathologies. It has been demonstrated that thyroid hormones may modulate IGF-I levels in plasma independent of GH. In autoimmune thyroid disease, hyperthyroidism was associated with elevated IGF-I levels, whereas hypothyroidism was associated with low levels of IGF-I (Smith, 2021a).

Untreated hyperthyroid cases had normal IGF-I measurements averaging 126.13 ng/mL (SD = 49.92). These findings are consistent with other studies and imply that hyperthyroidism need not always yield IGF-I derangements. This can partly be due to hyperthyroidism not markedly changing growth factor levels to the extent similar to hypothyroidism due to excess thyroid hormones. The findings underscore the need for a greater appreciation of thyroid-IGF-I interaction across all phases of thyroid function (Iglesias et al., 2001).

In addition, in Graves' disease, a common cause of hyperthyroidism, IGF-I in serum showed a negative relationship with TSH levels. The reverse association suggests IGF-I may play a role in Graves' disease pathogenesis and modulate disease severity (Krieger et al., 2016; Krieger et al., 2015).

The relationship between IGF-I levels and thyroid disease remains insufficiently analyzed; however, some studies clarified this association. For example, Dogansen et al. (2019) identified that in acromegalic patients, increased IGF-I levels were associated with thyroid disorder development ($p = 0.01$). The results of this study endorse this concept, suggesting that not only in acromegaly but also in other thyroid function conditions, IGF-I can participate in thyroid disease.

In addition, Tseng et al. (2019) identified that both thyroid nodules and goiter were linked with high levels of serum IGF-I, thus verifying the hypothesis that IGF-I controls thyroid tissue growth and nodule development. It has been well documented that thyroid hormones and IGF-I are indeed in a bidirectional interaction with each other. Thyroid hormones regulate GH, and GH controls the production and discharge of IGF-I subsequently.

This relationship was investigated by Tseng et al. (2019) by focusing on the effects of thyroid hormones on GH levels and how these may impact IGF-I production. The evidence supports this hypothesis by illustrating how thyroid function and IGF-I interact in a bidirectional manner with complex feedback-regulatory mechanisms.

The highlight of our findings was the link between high levels of IGF-I and the incidence of thyroid disorders in adult females. The individuals of this study were only females, so all results apply only to females with thyroid disease Völzke et al. (2007) previously observed this correlation mostly in men; our data support that this link also shows itself in women. Our results suggest that IGF-I might be a useful biomarker for female thyroid problems; nonetheless, more research is needed to confirm the consistency of this relationship between sexes.

Although IGF-1 levels might not replace conventional thyroid hormone testing, the ROC curve analysis results show that they could operate as an auxiliary marker for evaluating thyroid malfunction. In cases when additional markers are needed to assess thyroid health or dysfunction, the usefulness of IGF-1 as an auxiliary biomarker is especially remarkable. Confirming the role of IGF-1 in thyroid illnesses and looking at its usefulness in clinical practice needs more study.

Furthermore, particularly concerning TSH, IGF-I is a crucial growth factor involved in the regulation of thyroid cell proliferation and differentiation. Ławnicka et al. (2020) emphasized the significance of IGF-I in thyroid tissue functionality by demonstrating its role in regulating the formation and differentiation of thyroid cells through TSH. The results of the present investigation enhance previous knowledge and further underscore the significance of IGF-I in thyroid development and growth.

The present study's analytical findings imply that IGF-I levels may inversely correlate with the degree of hyperthyroidism. Patients showing milder types of hyperthyroidism (Hyper group, mean IGF-I = 126.13 ng/mL, SD = 49.92) showed significantly higher IGF-I levels; those with more severe hyperthyroidism (Hypo group, mean IGF-I = 78.40, SD = 56.67) had notably lower IGF-I levels.

This result complements those of (Rochel et al., 2018), who said that as hyperthyroidism gets more severe, IGF-I levels could drop this adverse association is shown by the statistical relevance between the Hyper and Hypo groups ($p = 0.002$). This inverse relationship may indicate that IGF-I regulates the impact of thyroid hormones in hyperthyroid situations, influencing the severity of the ailment. In addition, the Circulation of IGF-I levels exhibits a negative correlation with TSH in both euthyroid and hyperthyroid individuals (Girnita et al., 2022).

Our results indicate that IGF-I may operate as an additional biomarker in the therapy of thyroid dysfunction. For example, the inverse relationship between IGF-I and TSH in hyperthyroidism and the decreased levels of IGF-I in hypothyroidism may guide the creation of IGF-I-based diagnostic instruments or risk stratification panels. Liu and Wang (2024), demonstrated the predictive value of the IGF-I/IGFBP-3 ratio in evaluating thyroid nodule risk in diabetic patients, underscoring the general relevance of IGF-I measures in endocrine disorders. Adding IGF-I tests to regular thyroid function panels (TSH, T3, T4) could help find hormonal problems earlier and help doctors come up with more personalized treatment plans.

Emerging evidence supports this connection; Girnita et al. (2022) reported direct crosstalk between TSH and IGF-I receptors in thyroid epithelial cells, where TSH enhances IGF-I signaling and co-activation of these receptors promotes thyroid cell proliferation. In an experimental hypothyroid model, Hasoon et al. (2022) found that co-administration of IGF-I with levothyroxine led to greater increases in TSH, T3, and T4 levels compared to levothyroxine alone, suggesting that IGF-I may potentiate thyroid hormone synthesis. These findings reinforce the concept that IGF-I is not merely a systemic growth factor but also a functional modulator of

thyroid-specific gene expression and endocrine regulation.

Furthermore, findings from a recent study indicated that persons with hypothyroidism displayed considerably increased BMI, but hyperthyroid patients had BMI levels similar to those of euthyroid controls, which is supported by recent epidemiological data. Mahdavi et al. (2021) observed that obese persons had around twice the incidence of overt hypothyroidism, but they did not find a strong connection between obesity and hyperthyroidism. A comprehensive meta-analysis corroborated a positive correlation between TSH and BMI, and a negative correlation between FT4 and BMI, thereby reinforcing the metabolic difference across thyroid functioning states identified in our study (Roa Dueñas et al., 2025).

This study provides new information about the link between IGF-I levels and thyroid dysfunction in a group of women, building on and improving on earlier studies. In contrast to previous studies with mixed-gender cohorts, our exclusive focus on women; who are more commonly affected by thyroid disorders, provides a more precise evaluation of IGF-I as a potential biomarker.

V. Conclusion

This study validates the association between IGF-I levels and thyroid dysfunction among females beyond adulthood in the Kurdistan Region. The major developments ought to show IGF-I concentration association with different thyroid states, while higher IGF-I levels are found in hyperthyroid patients than in hypothyroid patients. The negative correlation between IGF-I and TSH and the positive correlation with T3 would allow a hypothesis that there might be a regulatory balance present between the IGF-I system and thyroid hormone axis for further exploration.

Future studies may employ longitudinal designs to establish temporal associations and causal pathways and recruit males so potential sex differences can be explored. Further, we would encourage research that investigates the molecular mechanisms that are potentially responsible for the observed associations would also be beneficial for translatability and practice opportunities.

In conclusion, our work contributes to the expanding evidence on the involvement of IGF-I in both normal and pathological thyroid function. Thyroid hormones alone may not always yield a comprehensive diagnostic overview; however, the integration of IGF-I levels into clinical assessment could improve the evaluation of thyroid problems, particularly in intricate or ambiguous situations. These results indicate that IGF-I could function as a supporting biomarker, providing an enhanced understanding of the interactions across endocrine systems and aiding in the development of more tailored therapy approaches for thyroid disorders. If corroborated by more studies, the routine assessment of IGF-I may enhance diagnostic accuracy and facilitate treatment planning in endocrinology.

For future research, creating regression models could assist in quantifying the predicted link between IGF-I and thyroid hormones (TSH, T3, and T4). This method would help us better understand how strong and in what direction these links are across different types of thyroid problems, which could improve both diagnostic and prognostic uses.

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