

# **Correlation between thyroid parenchymal echogenicity and thyroid function tests among adolescents**



**SUPERIOR UNIVERSITY**

**Thesis Submitted to**

**The Superior University Lahore**

**In Partial Fulfillment of the**

**Requirement for the Degree of**

**Master of Science in Allied Health Sciences**

**By**

**Jasia Noor**

**Roll No. SU91-MSAHS-S23-172**

**Session: 2023-2025**

**Faculty of Allied Health Sciences**

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No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the Faculty of Allied Health Sciences, The Superior University, Lahore in partial fulfillment of the requirements for the degree of Master of Science in the field of **“Allied Health Sciences”** in Faculty of Allied Health Sciences at The Superior University, Lahore.

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## **DEDICATION**

In the name of Allah, the Most Gracious and the Most Merciful, all praises to Allah and His blessing for the completion of this thesis. I thank God for all the opportunities, trials and strength that have been showered on me to finish writing the thesis. I experienced so much during this process, not only from the academic aspect but also from the aspect of personality. My humblest gratitude to the Holy Prophet Muhammad (Peace be upon him) whose way of life has been a continuous guidance for me.

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May, Allah grant my supervisor and my parents a healthy and prosperous life and give me strength and direction for the welfare of mankind.

**Jasia Noor**

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**Jasia Noor**

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## LIST OF ABBREVIATIONS

| <b>Abbreviations</b> | <b>Full form</b>              |
|----------------------|-------------------------------|
| TSH                  | Thyroid Stimulating Hormone   |
| TN                   | Thyroid Nodule                |
| FNAC                 | Fine Needle Aspiration Biopsy |
| US                   | Ultrasound                    |
| HD                   | Hodgkin's Disease             |
| BMI                  | Body Mass Index               |

## ABSTRACT

**Background:** Thyroid function is crucial for metabolic balance, and its assessment is vital in adolescents. Ultrasonography is a non-invasive tool that can evaluate thyroid parenchymal echogenicity, which may correlate with thyroid function.

**Objective:** To correlate between thyroid parenchymal echogenicity and thyroid function tests among adolescents.

**Methods:** A cross-sectional analytical design conducted at the radiology department of Allied Hospital Faisalabad, on 217 participants selected using a consecutive sampling technique, with inclusion criteria specifying adolescents aged 10 to 19 years who had undergone thyroid function tests (TSH, Free T4, and Free T3) within the last six months and had a thyroid ultrasound performed to assess parenchymal echogenicity. Exclusion criteria included clinically suspected thyroid nodules, previous thyroid surgery, and current use of thyroid medications. Ultrasound assessments were performed using Xario-100 and GE S-8 equipment with both convex and linear probes. Data was analyzed using SPSS 26.

**Results:** The study included participants with a mean age of 14.45 years. TSH levels were significantly higher in females compared to males, with an overall average TSH level of 0.95 mIU/L. Free T4 and Free T3 levels remained within normal ranges, averaging 0.99 ng/dL and 2.50 pg/mL, respectively. The average thyroid volume was approximately 9.78 mL. The correlation heatmap reveals weak but significant positive associations between TSH and Free T3 (0.139,  $p = 0.041$ ) and TSH and Echogenicity (0.136,  $p = 0.046$ ). In contrast, Free T4 shows no meaningful correlations with any other variables, as its relationships with TSH, Free T3, and Echogenicity remain weak and statistically insignificant.

**Conclusion:** This study found weak but significant positive correlations between TSH and Free T3 and TSH and Echogenicity, while Free T4 showed no meaningful associations. The results suggest minimal interdependence between thyroid function markers and echogenicity in adolescents. Further research is needed to explore the clinical relevance of thyroid ultrasound in assessing thyroid function.

**Keywords:** Thyroid Nodules, Multi-nodular goiter, Fine needle aspiration, Thyroid ultrasound, Doppler ultrasound.

## Chapter 1

### INTRODUCTION

A thyroid ultrasound (1) is a useful imaging technique for evaluating the parenchymal echogenicity of the thyroid gland (TG) in children due to its low cost, wide clinical availability, repeatability, and lack of ionizing radiation.(2) A thyroid US can easily identify the heterogeneous parenchyma observed in subjects with diffuse thyroid diseases, including Graves' disease and Hashimoto's thyroiditis.(3) The relationship between TG echogenicity and thyroid function parameters has been described in adults.(4)

The thyroid gland plays a pivotal role in regulating metabolic processes and maintaining homeostasis through the secretion of hormones such as thyroxine (T4) and triiodothyronine (T3).(5) These hormones are essential for growth, development, and metabolism. Thyroid dysfunction can manifest in various forms, including hypothyroidism, hyperthyroidism, and thyroiditis, significantly impacting an individual's overall health.(6) Ultrasound imaging is a non-invasive and widely used diagnostic modality to evaluate the structural integrity and functional implications of the thyroid gland.(7) One of the primary features assessed during ultrasound is thyroid parenchymal echogenicity. Variations in echogenicity often correlate with underlying thyroid pathology, providing insights into potential dysfunctions.(8)

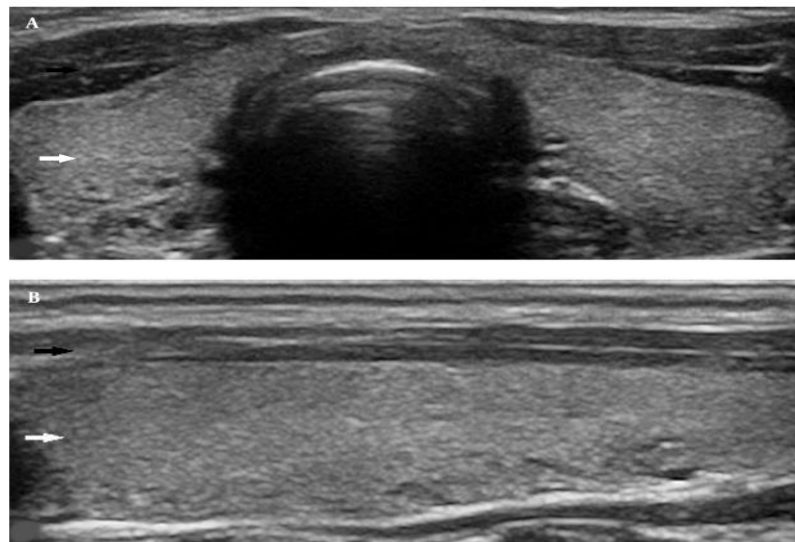


Figure 1 A, Transverse; and B, Sagittal gray-scale ultrasound images of thyroid gland showing homogeneous echogenicity of normal thyroid parenchyma (white arrow) (4)

Adolescence is a critical period marked by rapid physical, hormonal, and psychological changes.(9) During this phase, thyroid dysfunction can have profound implications, potentially affecting growth, development, and quality of life.(1) Understanding the relationship between thyroid parenchymal echogenicity and thyroid function tests (TFTs) among adolescents is vital for early detection and management of thyroid disorders.(10) Thyroid disorders are among the most common endocrine abnormalities worldwide. While they are often associated with adults, their prevalence in children and adolescents is increasingly recognized. (11)

Globally, hypothyroidism affects approximately 1-2% of adolescents, with subclinical forms being even more prevalent. Hyperthyroidism, though less common, remains a significant concern, particularly in regions with high iodine intake or autoimmune predispositions.(12) In iodine-deficient areas, goiter and related thyroid dysfunctions are more prevalent, emphasizing the role of environmental and nutritional factors. Autoimmune thyroid diseases, such as Hashimoto's thyroiditis and Graves' disease, also contribute significantly to thyroid abnormalities in this age group. Adolescents, especially females, are at a higher risk due to hormonal fluctuations and genetic predispositions. (13, 14)

Despite these statistics, thyroid disorders in adolescents are often underdiagnosed, highlighting the need for improved screening and diagnostic approaches.(15) Thyroid dysfunction in adolescents can manifest through a wide range of symptoms, often mimicking other medical conditions. Hypothyroidism may present with fatigue, weight gain, cold intolerance, constipation, and delayed puberty.(16) In severe cases, it can lead to growth retardation and intellectual impairment. Hyperthyroidism, on the other hand, is characterized by weight loss, heat intolerance, palpitations, nervousness, and hyperactivity.(17) Additionally, autoimmune thyroid disorders may cause nonspecific symptoms such as neck swelling, mood changes, and difficulty concentrating.(18)

The subtle and nonspecific nature of these symptoms often delays diagnosis and treatment. Adolescents may attribute these changes to normal developmental processes, underscoring the importance of systematic evaluation through clinical examination and diagnostic tools.(19) Thyroid parenchymal echogenicity refers to the brightness of the thyroid tissue as observed on ultrasound imaging. Normal thyroid parenchyma appears uniformly hyperechoic compared to surrounding neck

muscles.(20) Alterations in echogenicity, such as hypoechogenicity or heterogeneity, often indicate underlying pathology. For instance, hypoechogenicity is commonly associated with autoimmune thyroiditis, while heterogeneity may suggest diffuse thyroid disease(21).

The correlation between echogenicity and thyroid function is a subject of ongoing research. Studies have shown that reduced echogenicity is frequently linked with elevated thyroid-stimulating hormone (TSH) levels and decreased free T4 levels, indicating hypothyroidism.(22) Conversely, hyperthyroidism may be associated with varying echogenic patterns, depending on the underlying cause. Assessing echogenicity alongside TFTs provides a comprehensive understanding of thyroid health, aiding in the early identification of subclinical or overt dysfunctions.(23)

Thyroid function tests are a cornerstone in the diagnosis and management of thyroid disorders. The primary tests include serum TSH, free T4, and free T3 levels. TSH is a sensitive marker for thyroid dysfunction, often elevated in hypothyroidism and suppressed in hyperthyroidism.(24) Free T4 and free T3 levels provide additional insights into the gland's functional status, aiding in differentiating subclinical from overt thyroid disorders. Other tests, such as thyroid antibodies (anti-thyroglobulin and anti-thyroid peroxidase), are used to evaluate autoimmune thyroid diseases.(25) These tests are particularly relevant in adolescents, where autoimmune etiologies are a common cause of thyroid dysfunction.(26)

Combining TFTs with imaging findings, such as echogenicity, enhances diagnostic accuracy and informs treatment strategies.(26) Adolescents are particularly vulnerable to the consequences of thyroid dysfunction due to the significant physiological changes occurring during this period. Untreated thyroid disorders can lead to growth abnormalities, delayed or precocious puberty, and impaired cognitive development.(27) Additionally, the psychological impact of these disorders, including mood changes and reduced academic performance, underscores the importance of timely diagnosis and management.(28)

The relationship between thyroid echogenicity and function is especially relevant in this age group, where non-invasive diagnostic tools are preferred. Ultrasound imaging, combined with TFTs, provides a reliable, cost-effective, and patient-friendly approach to evaluating thyroid health. Understanding these correlations can

aid in early identification of at-risk adolescents, facilitating timely interventions and improving long-term outcomes. The insights gained from this study have the potential to influence public health policies and screening programs, promoting better thyroid health among adolescents.

### **1.1. Problem Statement**

Thyroid problems in teenagers are typically underdiagnosed due to their unclear clinical presentation and the complexity of early morphological alterations. Thyroid ultrasonography is a commonly available, non-invasive method for evaluating parenchymal echogenicity; nevertheless, most studies correlating echogenicity patterns with thyroid function tests (TFTs) have concentrated on adult cohorts. Adolescents, however, encounter dynamic hormonal fluctuations during puberty, which may uniquely impact thyroid physiology and imaging results. Despite this, there is a noteworthy lack of research addressing the link between sonographic features particularly echogenicity and biochemical indicators of thyroid function especially in the teenage population. Addressing this gap is vital, since early diagnosis of thyroid dysfunction in this age group is essential to prevent long-term repercussions such as growth retardation, delayed puberty, and neurocognitive impairment. This study, therefore, intends to evaluate the link between thyroid parenchymal echogenicity and TFTs among teenagers, revealing unique insights that may facilitate early diagnosis, risk stratification, and prompt intervention in this sensitive developmental period.

## **OBJECTIVE**

To correlate between thyroid parenchymal echogenicity and thyroid function tests among adolescents.

## Chapter 2

### LITERATURE REVIEW

Lee et al., in 2024 conducted a study to determine the ultrasonographic features that could help to distinguish between parathyroid masses abutting the thyroid gland and thyroid masses extending into the parathyroid area. Two blinded readers retrospectively evaluated the US images of 76 histopathologically confirmed parathyroid masses abutting the thyroid gland and 34 thyroid masses extending into the parathyroid area. Maximal diameter, transverse diameter/anterior-posterior diameter (T/ AP) ratio, longitudinal diameter/AP diameter (L/AP) ratio, margin, shape, echogenicity, echotexture, and echogenic interface were evaluated and compared between the two groups. Echogenic interface ( $p<0.001$ ) and L/AP ratio ( $p<0.001$ ) were statistically significant US features that differentiated parathyroid and thyroid masses. Sensitivity/ specificity of the presence of echogenic interface and L/AP ratio  $>2.0$  were 85.5%/100% and 43.2%/82.4% in distinguishing parathyroid from thyroid masses, respectively. Conclusion: The presence of an echogenic interface and L/AP ratio  $>2.0$  were useful US features for differentiating parathyroid masses abutting the thyroid gland from thyroid masses extending into the parathyroid area.(29)

Uahakov et al., in 2024 in his study determined the ultrasonographic (1) features that could help to distinguish between parathyroid masses abutting the thyroid gland and thyroid masses extending into the parathyroid area. Two blinded readers retrospectively evaluated the US images of 76 histopathologically confirmed parathyroid masses abutting the thyroid gland and 34 thyroid masses extending into the parathyroid area. Maximal diameter, transverse diameter/anterior-posterior diameter (T/AP) ratio, longitudinal diameter/AP diameter (L/AP) ratio, margin, shape, echogenicity, echotexture, and echogenic interface were evaluated and compared between the two groups. Echogenic interface ( $p<0.001$ ) and L/AP ratio ( $p<0.001$ ) were statistically significant US features that differentiated parathyroid and thyroid masses. Other US features did not show any significant differences between the two groups. Interobserver agreement was excellent for all US features. Sensitivity/specificity of the presence of echogenic interface and L/AP ratio  $>2.0$  were 85.5%/100% and 43.2%/82.4% in distinguishing parathyroid from thyroid

masses, respectively. The presence of an echogenic interface and L/AP ratio  $>2.0$  were useful US features for differentiating parathyroid masses abutting the thyroid gland from thyroid masses extending into the parathyroid area.(30)

Jin et al., in 2023 explored the relationship between thyroid parenchymal echogenicity abnormalities and thyroid function evolution in health examination population. Follow-up was conducted until the occurrence of thyroid function abnormalities or until the end of the follow-up period. The cumulative incidence rate and incidence density of thyroid function abnormalities were evaluated. Cox regression analysis was used to analyze the relationship between thyroid parenchymal echogenicity abnormalities and thyroid function evolution. Results: A total of 6 754 participants were included in this study, with an average age of  $(45.80 \pm 12.12)$  years, and females accounted for 42.7%. The mean follow-up time was 1.82 years, with a cumulative follow-up duration of 12 263 person-years. Stratified analysis showed that, except for body mass index  $<18.5 \text{ kg/m}^2$ , current smoking, and current alcohol consumption, all other stratified factors showed a significant increase in the risk of thyroid function abnormalities in individuals with thyroid parenchymal echogenicity abnormalities. Thyroid parenchymal echogenicity abnormalities are important risk factors for the evolution of thyroid function abnormalities. Continuous monitoring of thyroid function should be given due attention.(31)

Janus et al., 2023 conducted a follow-up study was to present the outcome of ultrasound and laboratory monitoring of paediatric patients with autoimmune thyroiditis (AIT) prior to the development of PTC. The patients were divided into four groups: 1) 28 patients with a mean age of 10.7 [standard deviation , 3.1] y, in whom PTC was detected during the active surveillance of AIT [AIT(+), PTC(+)] follow up (F)]; 2) 18 patients with a mean age of 12.8 (SD, 3.4) y, in whom PTC and AIT were detected upon admission (A) [AIT(+), PTC(+) A]; 3) 45 patients with a mean age of 13.0 (SD, 3.4) y, in whom PTC was detected upon admission and AIT was excluded [AIT, PTC(+) A]; and 4) an age- and sex-matched control group of 89 patients with AIT and with a mean age of 9.4 (SD, 3.0) y. Upon admission of those in group 1, the US evaluation revealed a hypoechogenic thyroid gland in 12 and an irregular normoechogenic gland in 16 patients. US monitoring revealed an increase in thyroid echogenicity and an increased irregularity of the thyroid structure during

the follow-up period of all of the patients from group 1. Such changes were not noticed in group 4. There were no significant differences between groups 1–3 in labeling index Ki67, lymph nodes metastasis, extrathyroidal extension, and angioinvasion. There were no associations between thyroid-stimulating hormone, TgAb, and the extent of the disease.(33)

Emrah Karatay et al., 2022 studied ultrasonography (1) and fine-needle aspiration biopsy (FNAB) play an important role in the diagnosis of thyroid nodules. The primary aim of this study was to evaluate the relationship between American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS) and the Bethesda system, based on final cytopathology. According to Spearman correlation, a very strong positive relationship was found between the Bethesda scoring system and ACR TI-RADS scores ( $\rho = 0.832$ ,  $P < .0001$ ). A 94.4% sensitivity and 65.4% specificity were found in 16 patients with a Bethesda score of 3 and TR3 based on final pathology ( $P < .001$ ). Finally, a sensitivity of 55.6% and specificity of 50.0% were found in 17 patients with a Bethesda score 6 and TR5 ( $P < .001$ ). The routine use of the ACR TI-RADS classification in thyroid nodules could be useful in preventing unnecessary FNABs. It could be effective in minimizing complications secondary to FNAB and thyroidectomy and reducing costs.(34)

Jing Du et al., 2022 evaluated the diagnostic efficiency of the three methods and their combined use inscreening for papillary thyroid microcarcinoma (PTMC). A total of 1,081 patients with 1,157 thyroid nodules (0.5–1 cm in maximum diameter) classified as thyroid imaging reporting and data system (TIRADS) 4–5 were recruited. The combination of BSRTC and BRAFV600E mutation analysis yielded a considerably high sensitivity (96.0%), accuracy (94.3%), and negative predictive value (95.9%) than either BSRTC or BRAFV600E mutation alone ( $P < 0.0001$  for all comparisons). The diagnostic accuracy of the molecular method in the 121 nodules with indeterminate cytology was 90.1% (109/121), which was significantly higher than that of TIRADS classification, 74.4% (90/121) ( $P = 0.002$ ). The combined use of ultrasound, cytology, and BRAFV600E mutation analysis is the most efficient and objective method for diagnosing PTMC. Both BRAFV600E mutation and TIRADS classification are potentially useful adjuncts to differentiate thyroid nodules, especially indeterminate samples classified as BSRTC III.(35)

Ibrahim Abobaker Al-Ghanimi et al., 2020 determined the diagnostic accuracy of ultrasonography in classifying thyroid nodules compared with fine-needle aspiration. Ultrasonographic features, namely, nodule margins, echotexture, vascularity and calcifications, and fine-needle aspiration cytology (FNAC) results were reviewed by two radiologists blinded to each other's findings and validated by another experienced interventional radiologist. Ultrasonography results were compared against that of FNAC to calculate sensitivity and positive- and negative-likelihood ratios, and the nodule types were compared using Fisher's exact test. Of the 68 nodules analyzed, 59 were reported as benign using FNAC (specificity = 95%;  $P < 0.001$ ). Of these 59, 56 were also reported as benign using ultrasonography. The specificity of ultrasonography in determining benign nodules was 94.9%, and the positive- and negative-likelihood ratios were 13.0 and 0.35, respectively. The diagnostic specificity of ultrasonography and FNAC in this study are consistent with those reported previously, indicating that ultrasonography reliably classifies thyroid nodules, and thus can assist in the decision-making regarding need for biopsy.(36)

The correlation between thyroid parenchymal echogenicity and thyroid function tests in adolescents is a relatively unexplored area of research, despite its potential significance in pediatric endocrinology. Existing studies, such as those by Jin et al. (2023), have primarily focused on adult populations, indicating that echogenicity abnormalities can influence thyroid function, but they do not address the adolescent demographic specifically. Furthermore, while some research has identified ultrasound features that differentiate various thyroid conditions, there is a lack of targeted investigations that correlate these features with thyroid function tests in younger individuals. Additionally, the implications of echogenicity changes over time and their relationship with thyroid dysfunction in adolescents remain largely unexamined. This gap in the literature highlights the need for dedicated studies to better understand how echogenicity may serve as a biomarker for thyroid health during critical developmental stages in adolescents.

## Chapter 3

# METHODOLOGY

### 3.1. Research Design

It was a cross sectional study design.

### 3.2. Clinical Settings

The study was conducted at Allied Hospital Faisalabad, radiology department.

### 3.3. Sample Size

Total 217 patient were included in this study. The sample size was calculated at 96% level of significance at 5% margin of error. (4) Following formula was used.

$$n = \frac{Z_{1-\frac{\alpha}{2}}^2 S_n (1 - S_n)}{L^2 \times P}$$

Prevalence= 17%

Sensitivity= 95

Margin of Error=0.05%

$$Z_{1-\frac{\alpha}{2}}^2 = 1.96 \quad \text{At } \alpha = 0.05$$

Total sample size =217

### 3.4. Sampling Technique

In this study consecutive sampling technique was used.

### 3.5. Duration of Study

The data was collected in 9 months after the approval of synopsis.

### 3.6. Selection Criteria

#### 3.6.1. Inclusion Criteria

- Participants must be adolescents aged 10 to 19 years.(32)
- Both genders were considered.(32)

- Inclusion of individuals who have undergone thyroid function tests (TSH, Free T4, and Free T3) within the last six months.(32)
- Participants must have had a thyroid ultrasound performed to assess parenchymal echogenicity.(37)

### **3.6.2. Exclusion Criteria**

- Clinically suspected patients with indication of thyroid nodule as a provisional diagnosis.(38)
- Patients of all ages who had presented with clinical signs of thyroid nodules such as neck lump with pain and enlarged cervical lymph node.(37)
- Individuals who have undergone any form of thyroid surgery or intervention.(32)
- Participants currently taking medications that affect thyroid function, such as levothyroxine or antithyroid drugs.(37)
- Individuals with acute illnesses or infections at the time of the study that may influence thyroid function.(38)
- Exclusion of pregnant adolescents due to potential hormonal changes affecting thyroid function.(37)
- Participants with incomplete medical records or missing results for either echogenicity assessments or thyroid function tests will be excluded.(37)

### **3.7. Ethical Consideration**

The Hospital in Lahore and the Faculty of Allied Health Sciences at The Superior University in Lahore examined and approved the research protocol. Strict attention to patient privacy and confidentiality was guaranteed by the study. To safeguard participant identities, all imaging data and health records were anonymised prior to analysis. All participants (or their legal guardians, if appropriate) provided written informed permission after being fully told about the study's goals, methods, possible risks, and rewards. There were no direct treatments that put the individuals at more danger, nor were there any invasive procedures carried out outside of standard clinical care.

### **3.8. Data Collection Procedure**

A cross-sectional analytical study was conducted to evaluate the correlation between thyroid parenchymal echogenicity and thyroid function tests among adolescents. The study included patients presenting with clinical symptoms suggestive of thyroid dysfunction, such as neck pain, hoarseness, dysphagia, and abnormal thyroid palpation findings, along with abnormal thyroid function test results. Before participation, all patients and their guardians were fully informed about the study's objectives, and written informed consent was obtained. Additionally, Institutional Ethics Committee approval was secured before initiating data collection.(4, 39)

Each participant underwent a comprehensive ultrasound examination, adhering to a standardized thyroid ultrasound protocol. The ultrasound Xario-100 and GE S-8 equipment with both convex probe (3,5Mhz) and linear probe (9, 15 MHz) was used. The diagnostic scans were performed using a superficial linear ultrasound probe with a frequency of 9-10 MHz, following both anteroposterior and lateral scanning approaches to ensure complete visualization of the thyroid parenchyma. The imaging was conducted to classify thyroid echogenicity based on standardized sonographic criteria.(8) Blood samples were collected from all participants for thyroid function testing, measuring TSH, Free T3, and Free T4 levels. The sonographic findings of thyroid echogenicity were then correlated with the biochemical results to assess whether echogenicity patterns were associated with underlying thyroid dysfunction.(40, 41)

#### **3.8.1. Techniques:**

The ultrasound examination followed a standardized protocol to ensure accuracy and reproducibility in assessing thyroid echogenicity. Patients were instructed to wear loose-fitting clothing and remove any jewelry around the neck region to prevent image artifacts. During the ultrasound, patients were positioned in a supine position, with a pillow placed beneath the shoulders to facilitate hyperextension of the neck, optimizing gland visualization. To enhance imaging clarity, patients were asked to perform swallowing maneuvers, which assisted in the assessment of retrosternal thyroid portions and any associated nodules.

A superficial linear transducer with a frequency of 7-11 MHz was used to obtain high-resolution gray-scale ultrasound images of the thyroid gland. Both anteroposterior and lateral scanning approaches were utilized to ensure comprehensive visualization of the thyroid parenchyma. The ultrasound probe was applied with minimal pressure to prevent compression artifacts, which could alter echogenicity interpretation. Ultrasound findings were then systematically compared with thyroid function test results. Patients with hypoechoic echogenicity frequently exhibited elevated TSH levels and reduced Free T3/T4 levels, suggesting hypothyroidism or chronic thyroiditis.(42) Conversely, hyperechoic thyroid patterns were analyzed in relation to thyroid hormone levels to assess possible hyperfunctioning conditions.(43)

### **3.9. Data Analysis**

Continuous variables were summarized as mean and standard deviations (SDs) whereas nominal/categorical variables as proportions (%). A Chi-square test was used for the comparison of the independent and dependent variables. ANOVA test was used for continuous variables to assess diagnostic odd ratio. Diagnostic accuracy of ultrasound was assessed by means of sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy was calculated.  $P < 0.05$  was taken as significant. An appropriate statistical data analysis technique by using SPSS version 25 (statistical package for social science) was applied for all statistical calculations.

## Chapter 4

### RESULTS

Table 1 Descriptive Statistics of Age

|                |         |
|----------------|---------|
| Mean           | 14.4516 |
| Std. Deviation | 2.86723 |
| Minimum        | 10.00   |
| Maximum        | 19.00   |

The table 1 shows mean age is approximately 14.45 years, with a range from 10 to 19 years.

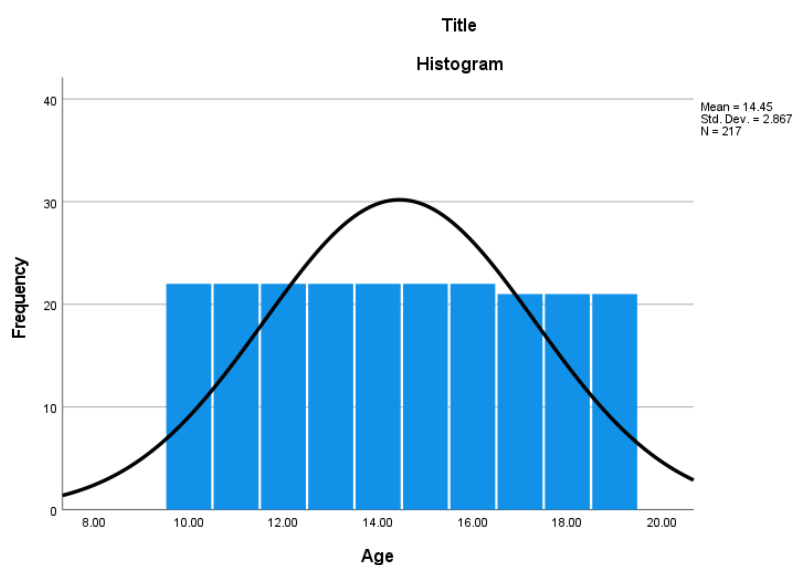


Figure 2 Distribution of Age

Figure 2 illustrates the age distribution of the study participants, who were all adolescents aged between 10 and 19 years. The data shows a mean age of approximately 14.45 years, indicating that the sample primarily represents mid-adolescence.

Table 2 Descriptive Statistics of Gender

|        | Frequency | Percent |
|--------|-----------|---------|
| Male   | 118       | 54.4    |
| Female | 99        | 45.6    |
| Total  | 217       | 100.0   |

The table 2 shows sample is slightly more male-dominated, with 54.4% males and 45.6% females.

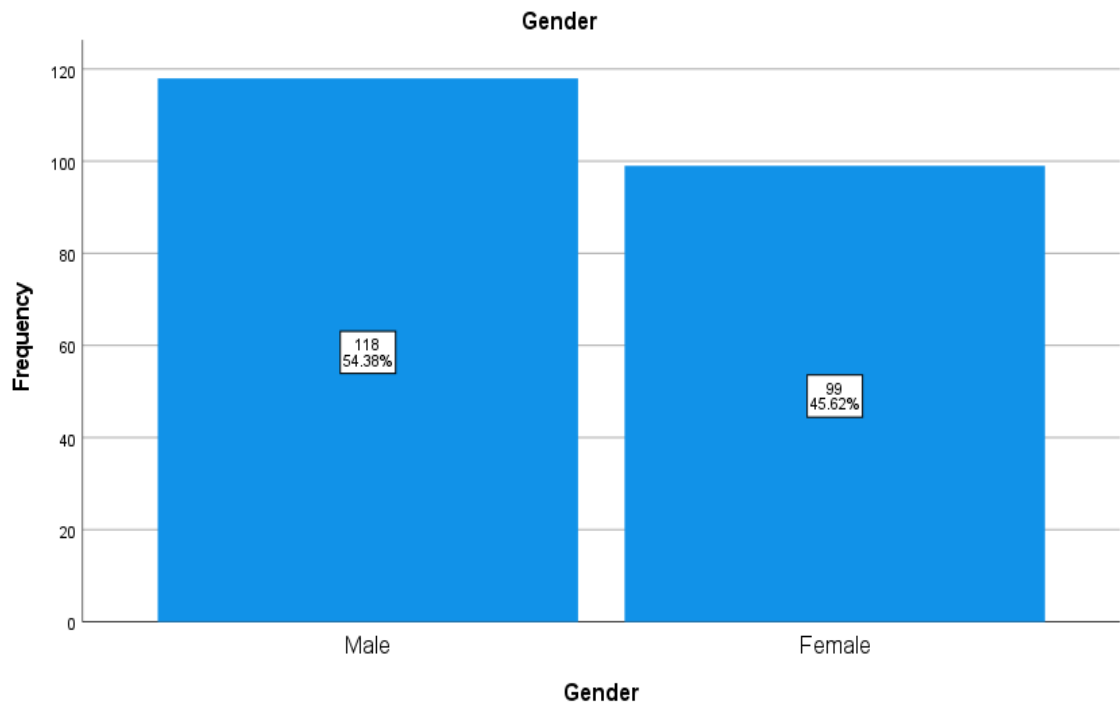


Figure 3 Gender Distribution

Figure 3 shows the gender composition of the study sample. The distribution is slightly male-dominated, with 54.4% males and 45.6% females. While the difference is modest, this near-balanced representation ensures that gender-based comparisons or subgroup analyses remain meaningful and unbiased.

Table 3 Descriptive Statistics of BMI

|                |         |
|----------------|---------|
| Mean           | 21.3969 |
| Std. Deviation | 1.70871 |
| Minimum        | 18.50   |
| Maximum        | 24.49   |

The average BMI is around 21.40, indicating a normal weight range for most participants.

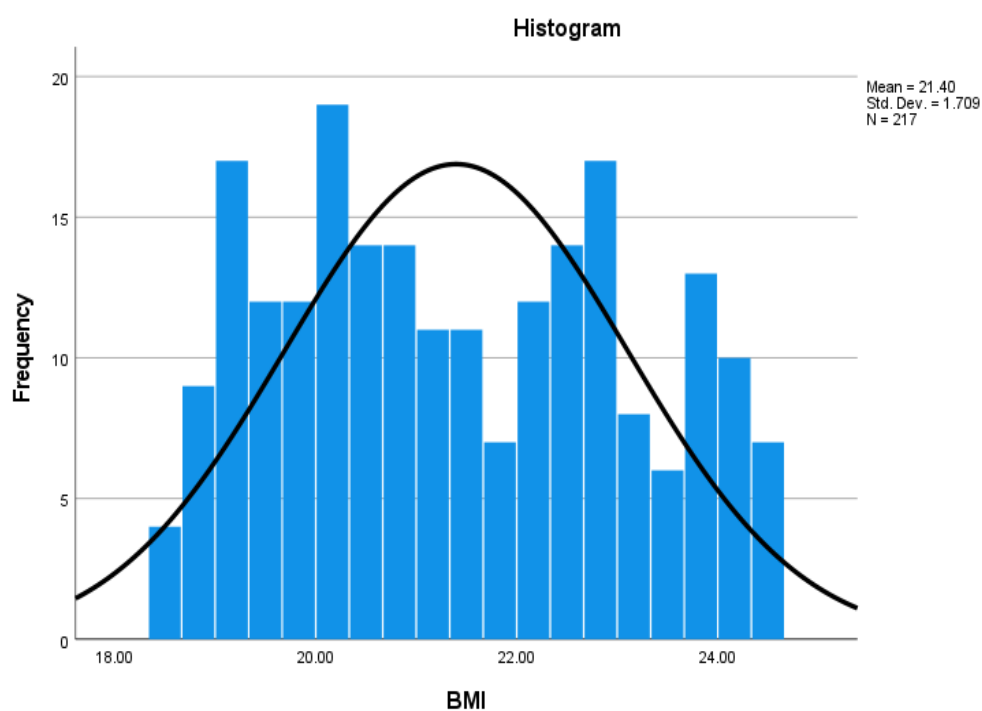


Figure 4 Distribution of BMI

Figure 4 presents the Body Mass Index (BMI) distribution among the adolescent participants. The average BMI is approximately 21.40, which falls within the normal weight range according to WHO growth standards for adolescents. This suggests that the majority of participants had a healthy body composition at the time of data collection.

Table 4 Descriptive Statistics of Duration of Symptoms

|                |         |
|----------------|---------|
| Mean           | 5.8802  |
| Std. Deviation | 3.76318 |
| Minimum        | .00     |
| Maximum        | 12.00   |

The table 5 symptoms have been present for an average of about 5.88 months.

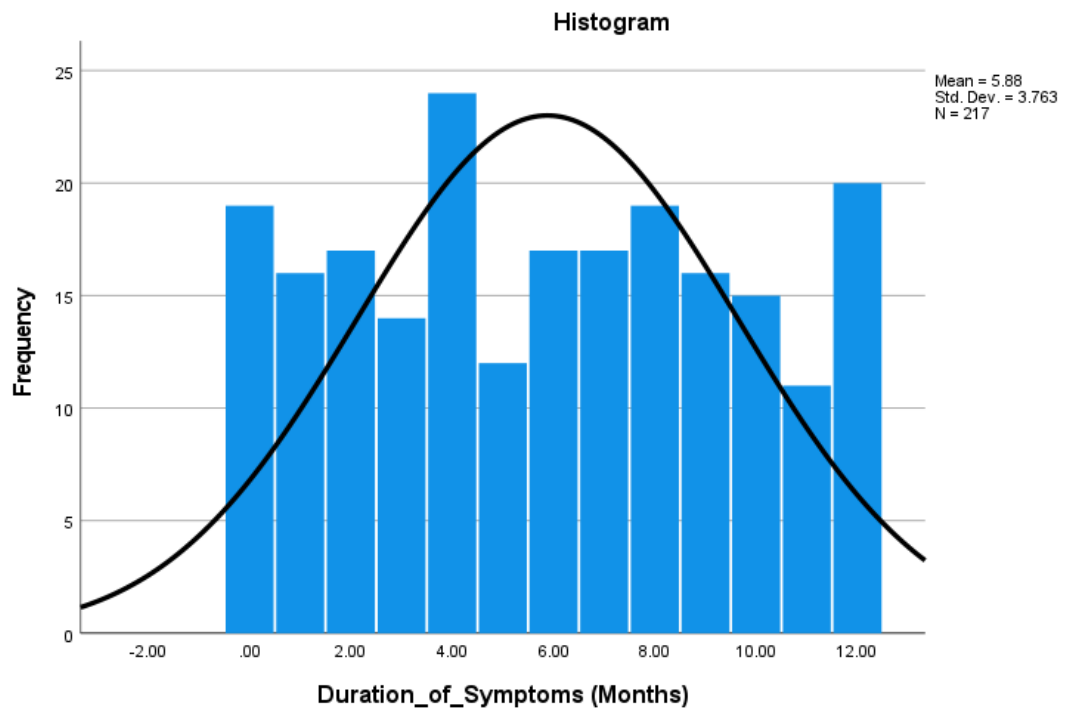


Figure 5 Distribution of Duration of Symptoms

Figure 5 summarizes the duration of thyroid-related symptoms among study participants. On average, symptoms had been present for approximately 5.88 months at the time of assessment. This duration suggests that most participants experienced subacute or chronic symptomatology, allowing sufficient time for potential changes in thyroid function and echogenicity to develop.

Table 5 Descriptive Statistics of Family History

|       | Frequency | Percent |
|-------|-----------|---------|
| Yes   | 94        | 43.3    |
| No    | 123       | 56.7    |
| Total | 217       | 100.0   |

The table 6 shows about 43.3% of participants have a family history of the condition.

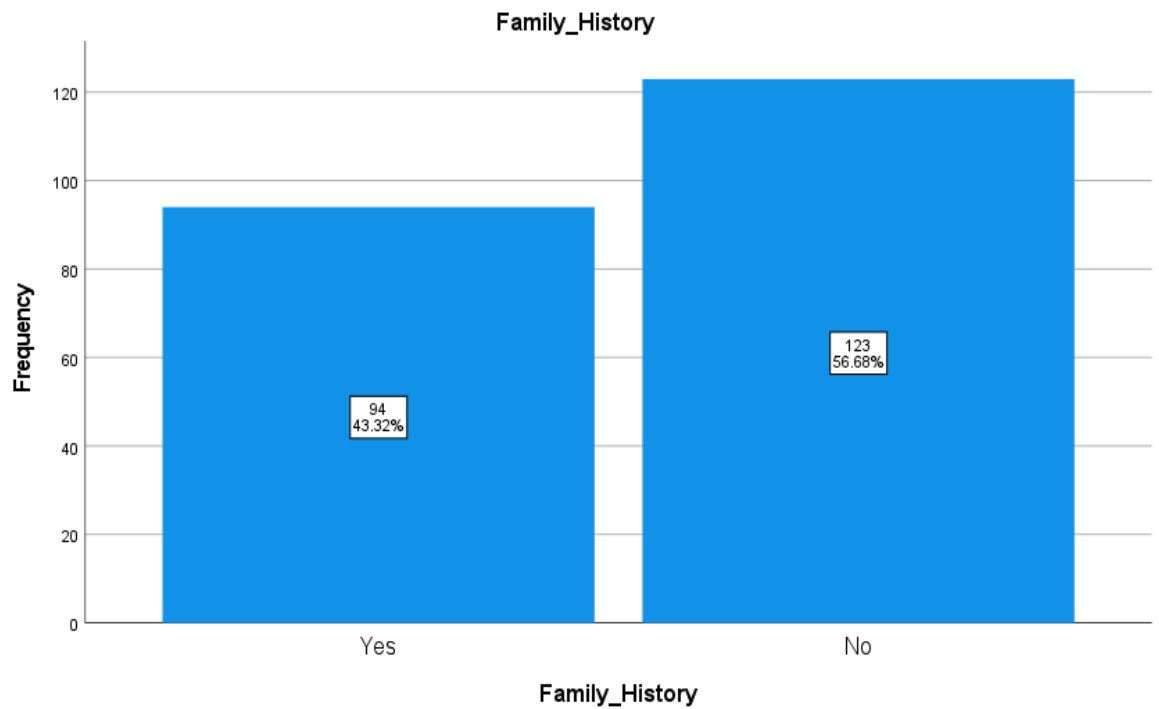


Figure 6 Family History Distribution

Figure 6 illustrates the distribution of participants based on family history of thyroid-related conditions. Approximately 43.3% of participants reported a positive family history, indicating a potential genetic or hereditary predisposition to thyroid disorders within the sample. The remaining 56.7% had no known family history.

Table 6 Descriptive Statistics of Symptoms

|              | Frequency | Percent |
|--------------|-----------|---------|
| Palpitations | 38        | 17.5    |
| Tremors      | 36        | 16.6    |
| Weight gain  | 49        | 22.6    |
| Fatigue      | 43        | 19.8    |
| None         | 51        | 23.5    |
| Total        | 217       | 100.0   |

The table 7 shows most common symptoms are weight gain (22.6%) and fatigue (19.8%).

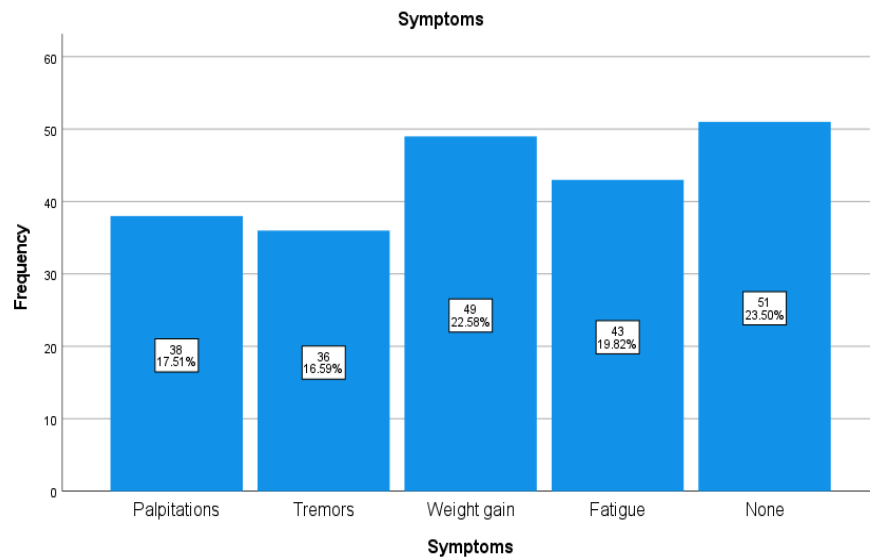


Figure 7 Symptoms Distribution

Figure 7 illustrates the distribution of thyroid-related symptoms reported by the study participants. The most commonly reported symptom was weight gain (22.6%), followed by fatigue (19.8%), both of which are classical indicators of hypothyroid states. Other less frequent symptoms included mood changes, menstrual irregularities, and neck swelling (if applicable).

Table 7 Descriptive Statistics of Symptom Severity

|          | Frequency | Percent |
|----------|-----------|---------|
| Mild     | 67        | 30.9    |
| Moderate | 90        | 41.5    |
| Severe   | 60        | 27.6    |
| Total    | 217       | 100.0   |

The table 7 shows symptoms are most frequently reported as moderate (41.5%).

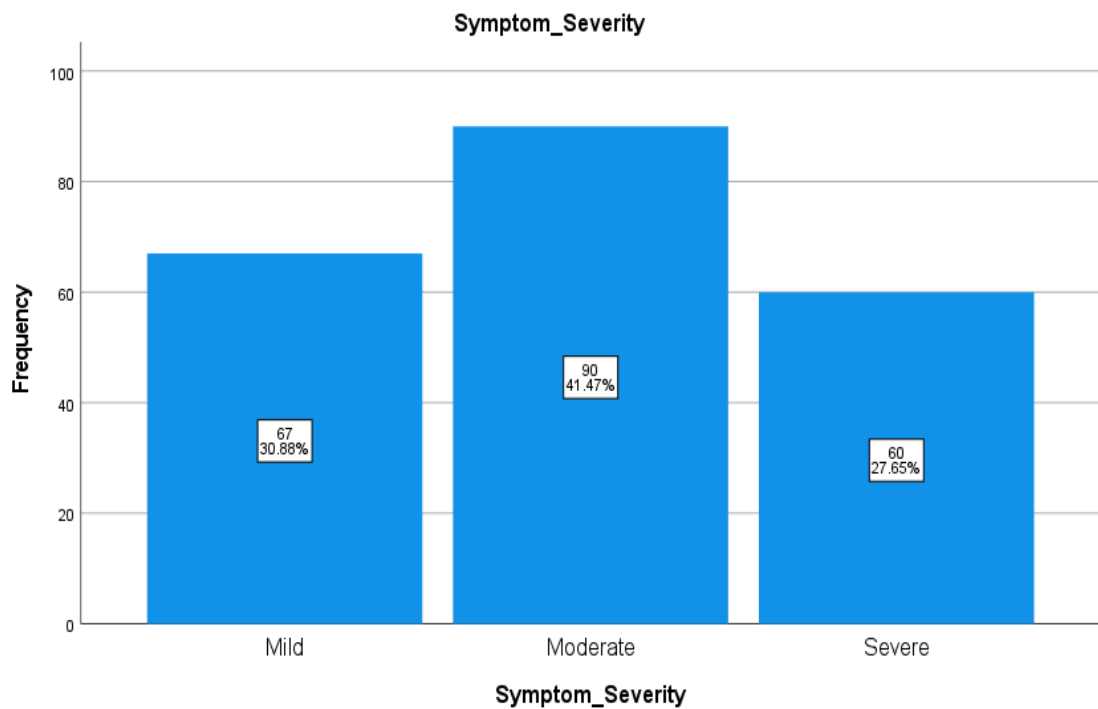


Figure 8 Symptom Severity Distribution

Figure 8 shows the distribution of self-reported symptom severity among participants. The majority of symptoms were rated as moderate (41.5%), followed by mild and severe cases (as applicable). This indicates that most adolescents experienced noticeable but not debilitating symptoms, which may contribute to delayed diagnosis, as moderate symptoms are often underestimated in clinical assessments.

Table 8 Descriptive Statistics of Smoking Status

|            | Frequency | Percent |
|------------|-----------|---------|
| Non-Smoker | 87        | 40.1    |
| Smoker     | 130       | 59.9    |
| Total      | 217       | 100.0   |

The table 8 shows majority (59.9%) of participants are smokers.

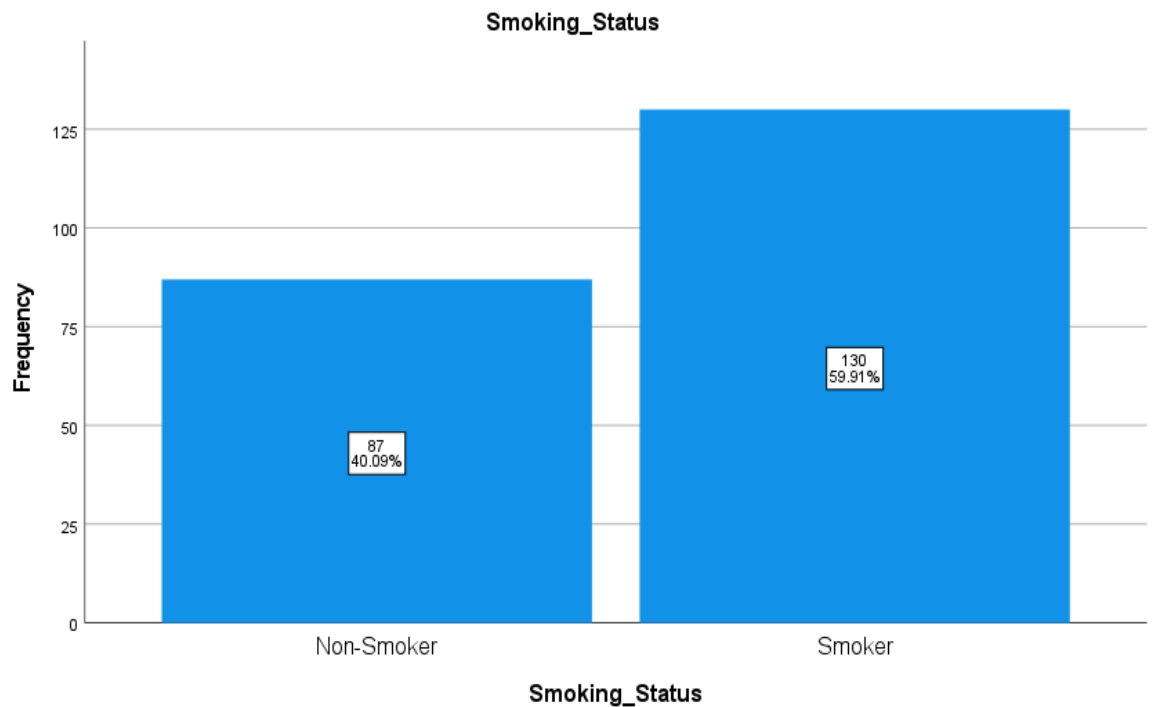


Figure 9 Smoking Status Distribution

Figure 9 illustrates the smoking status of the adolescent participants. A notable majority, 59.9%, reported being smokers, while the remaining 40.1% identified as non-smokers. This high prevalence of smoking among adolescents is concerning, as smoking is known to influence thyroid function, particularly by affecting iodine metabolism and increasing the risk of thyroid autoimmunity.

Table 9 Descriptive Statistics of Vascularity Presence

|         | Frequency | Percent |
|---------|-----------|---------|
| Present | 114       | 52.5    |
| Absent  | 103       | 47.5    |
| Total   | 217       | 100.0   |

The table 9 shows vascularity is present in about 52.5% of the sample.

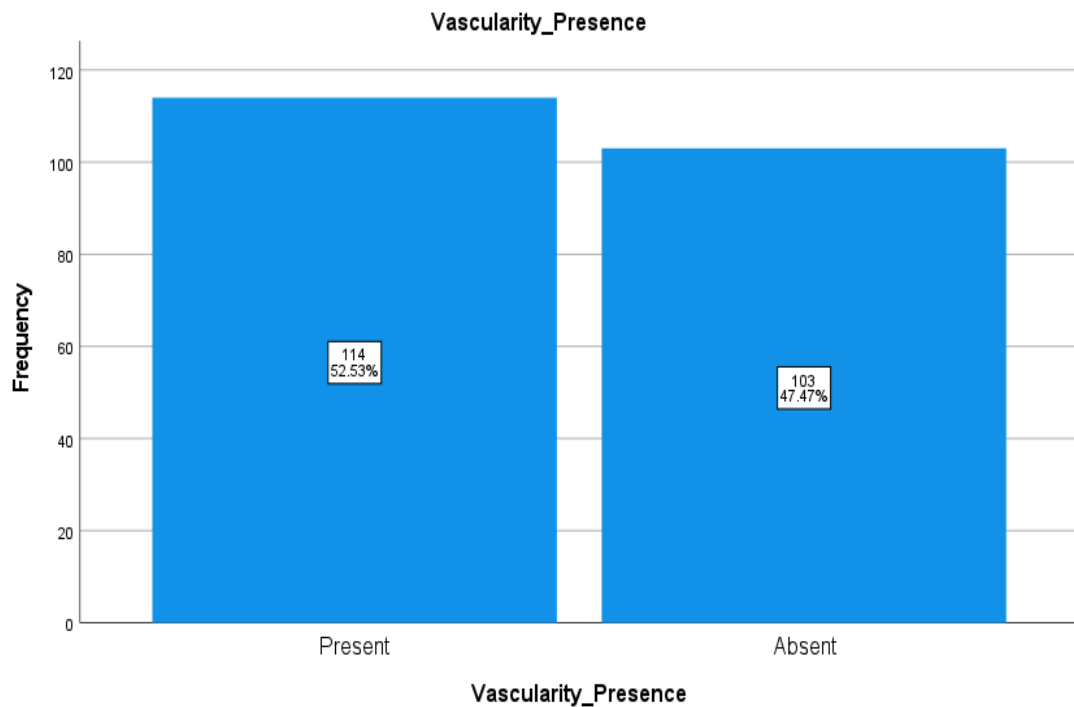


Figure 10 Vascularity Presence Distribution

Figure 10 presents the distribution of vascularity findings on thyroid ultrasound. In approximately 52.5% of participants, increased thyroid vascularity was observed, while 47.5% showed no significant vascular changes. The presence of vascularity may indicate underlying inflammation or hyperactivity of the thyroid gland, and is often associated with conditions such as Graves' disease or autoimmune thyroiditis.

Table 10 Descriptive Statistics of Echogenicity

|             | Frequency | Percent |
|-------------|-----------|---------|
| Isoechoic   | 81        | 37.3    |
| Hyperechoic | 61        | 28.1    |
| Hypoechoic  | 75        | 34.6    |
| Total       | 217       | 100.0   |

The table 10 shows most common echogenicity is hypoechoic (34.6%).

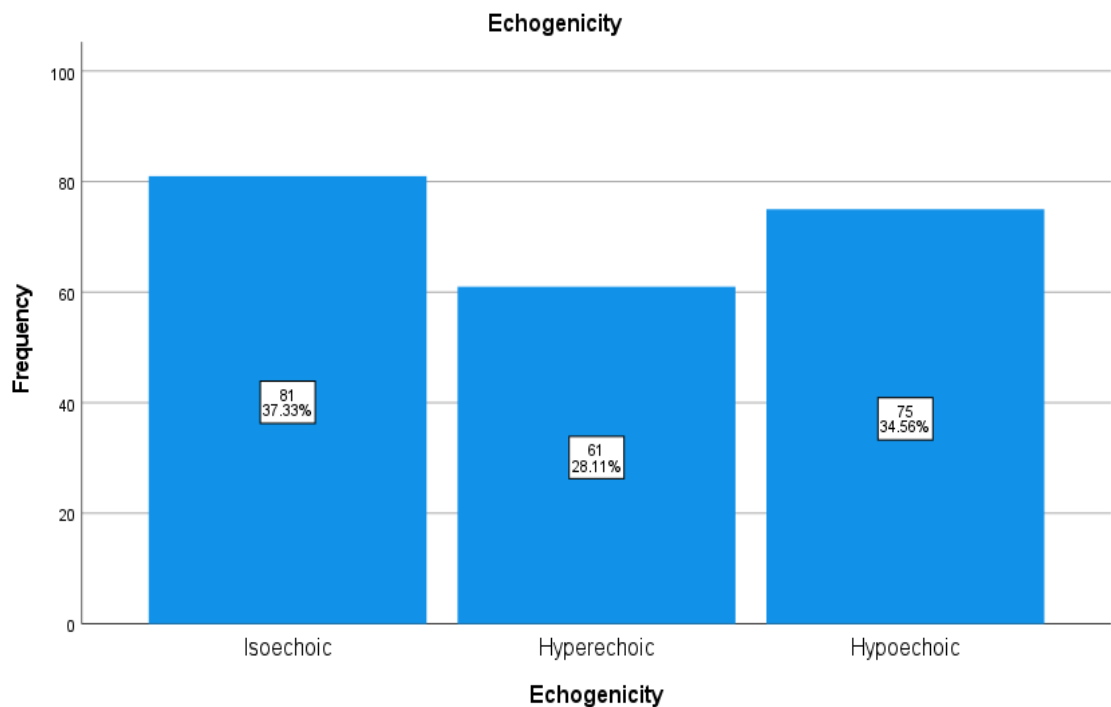


Figure 11 Echogenicity Distribution

Figure 11 illustrates the distribution of thyroid parenchymal echogenicity among participants. The most commonly observed echogenicity pattern was hypoechoic, reported in 34.6% of the sample. Hypoechogenicity is often associated with inflammatory or autoimmune thyroid conditions, such as Hashimoto's thyroiditis, and may indicate early structural changes even in the absence of overt biochemical abnormalities.

Table 11 Descriptive Statistics of Thyroid Volume

|                |         |
|----------------|---------|
| Mean           | 9.7842  |
| Std. Deviation | 2.84588 |
| Minimum        | 5.00    |
| Maximum        | 14.95   |

The table 11 shows average thyroid volume is approximately 9.78 mL.

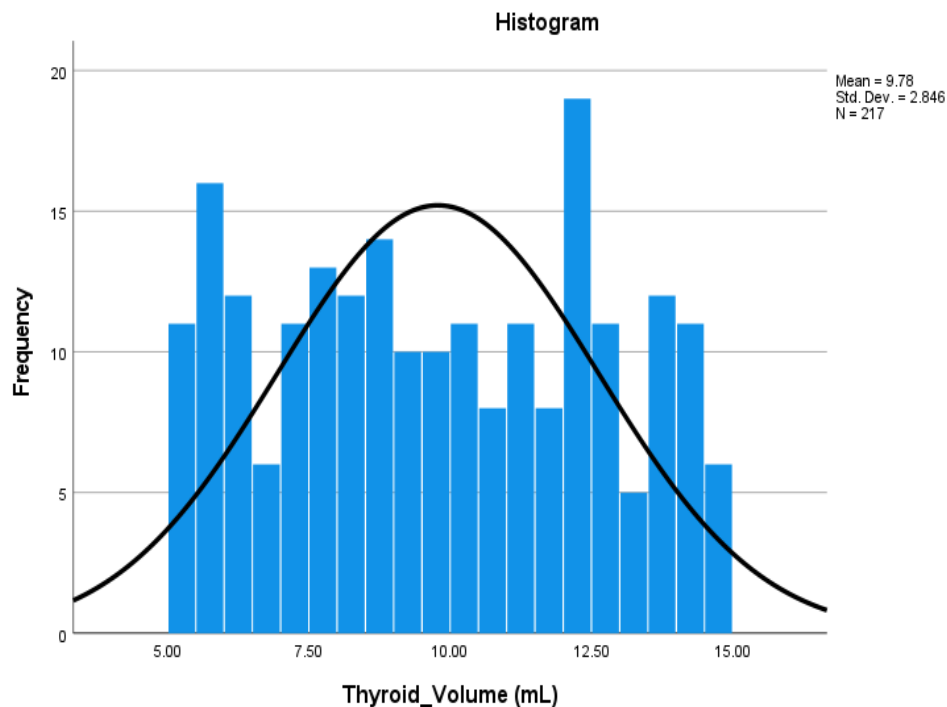


Figure 12 Distribution of Thyroid Volume

Figure 12 shows the distribution of thyroid gland volume among the study participants. The average thyroid volume was approximately 9.78 mL, which falls within the normal reference range for adolescents, though slight variations may occur based on age, sex, and body surface area. This finding suggests that most participants had structurally normal thyroid glands in terms of size.

Table 12 Descriptive Statistics of TSH Levels

|                |        |
|----------------|--------|
| Mean           | .9479  |
| Std. Deviation | .33680 |
| Minimum        | .50    |
| Maximum        | 1.40   |

The table 12 shows TSH levels average about 0.95 mIU/L.

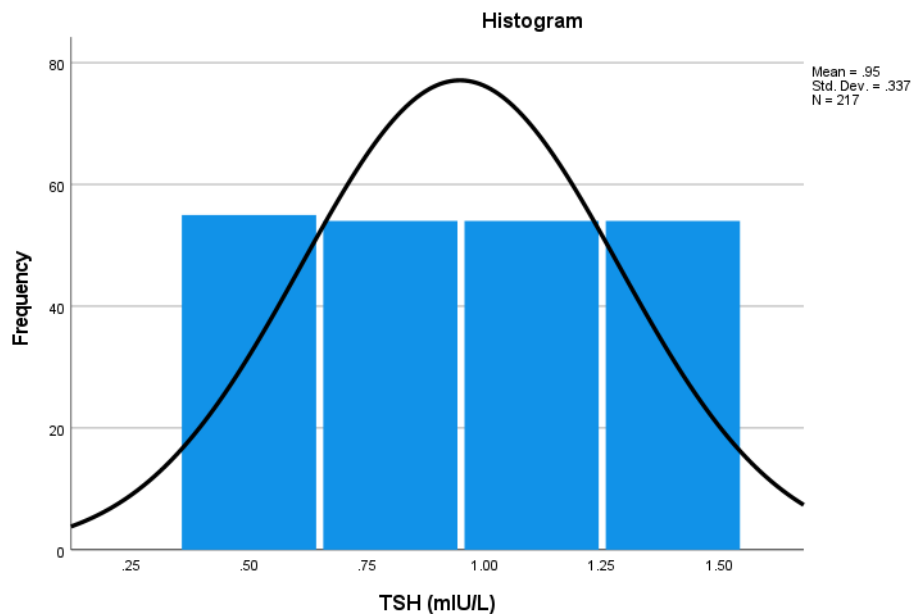


Figure 13 Distribution of TSH Levels

Figure 13 illustrates the distribution of thyroid-stimulating hormone (TSH) levels among participants. The mean TSH level was approximately 0.95 mIU/L, which falls within the normal reference range for adolescents (typically 0.5–4.5 mIU/L). This suggests that the majority of the sample exhibited normal thyroid function based on TSH values alone. However, as TSH can be influenced by factors such as age, sex, time of testing, and underlying subclinical conditions, it is essential to interpret these levels in conjunction with Free T3, Free T4, and sonographic findings for an accurate clinical assessment.

Table 13 Descriptive Statistics of Free T4 Levels

|                |        |
|----------------|--------|
| Mean           | .9986  |
| Std. Deviation | .14190 |
| Minimum        | .80    |
| Maximum        | 1.20   |

The table 13 shows free T4 levels average about 0.99 ng/dL.

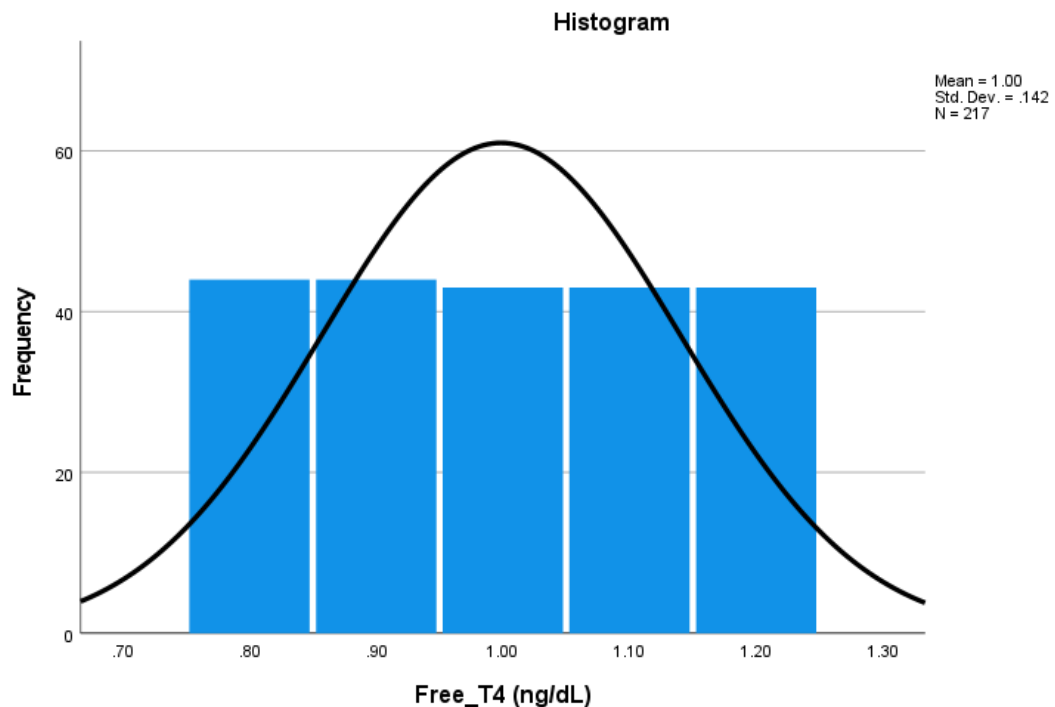


Figure 14 Distribution of Free T4 Levels

Figure 14 displays the distribution of Free T4 levels among the adolescent participants. The mean Free T4 level was approximately 0.99 ng/dL, which lies within the normal reference range for adolescents (typically 0.8–1.8 ng/dL). This indicates that most participants had euthyroid (normal thyroid function) status based on Free T4 values. When interpreted alongside TSH and Free T3 levels, this helps provide a comprehensive view of thyroid function, particularly in identifying subclinical or early-stage dysfunction.

Table 14 Descriptive Statistics of Free T4 Levels

|                |        |
|----------------|--------|
| Mean           | 2.4977 |
| Std. Deviation | .34325 |
| Minimum        | 2.00   |
| Maximum        | 3.00   |

The table 14 shows free T3 levels average about 2.50 pg/mL.

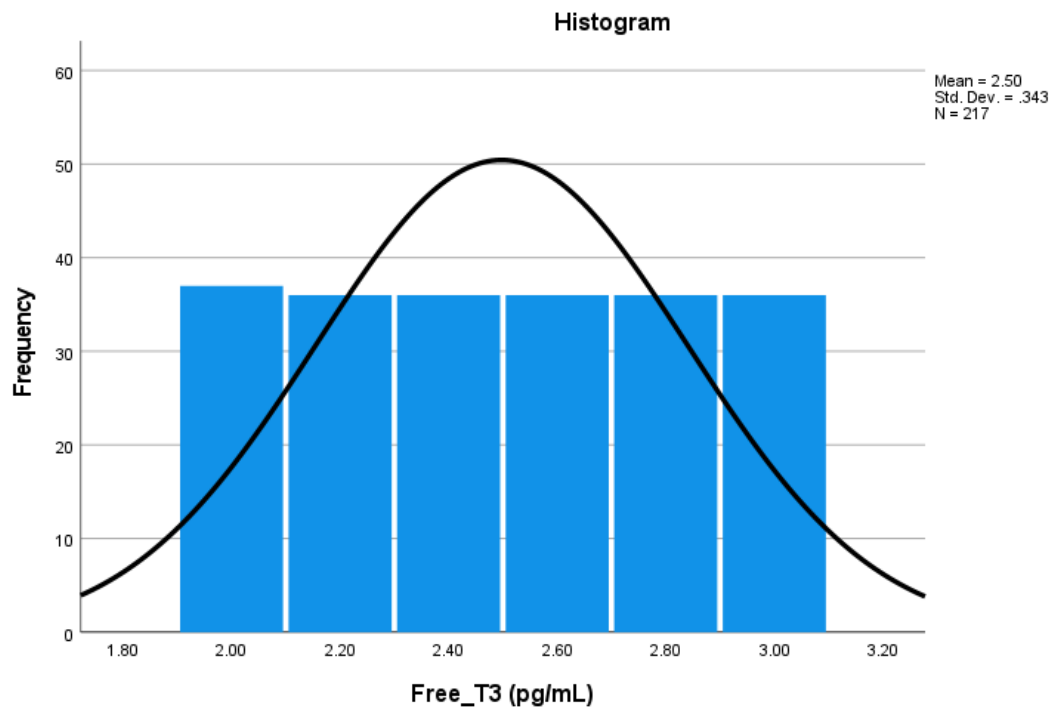


Figure 15 Distribution of Free T3 Levels

Figure 15 presents the distribution of Free T3 levels among the study participants. The mean Free T3 level was approximately 2.50 pg/mL, which is within the normal physiological range for adolescents (typically 2.3–4.2 pg/mL). This indicates that the majority of participants maintained normal triiodothyronine activity, further supporting a euthyroid profile when considered alongside TSH and Free T4 levels.

Table 15 Cross tabulation of TSH Levels by Gender

|             |      | Gender |        | Total | Pearson<br>Chi-Square |
|-------------|------|--------|--------|-------|-----------------------|
|             |      | Male   | Female |       |                       |
| TSH (mIU/L) | .50  | 55     | 0      | 55    | .000                  |
|             | .80  | 5      | 49     | 54    |                       |
|             | 1.10 | 54     | 0      | 54    |                       |
|             | 1.40 | 4      | 50     | 54    |                       |
| Total       |      | 118    | 99     | 217   |                       |

The table 15 shows females have significantly higher TSH levels than males

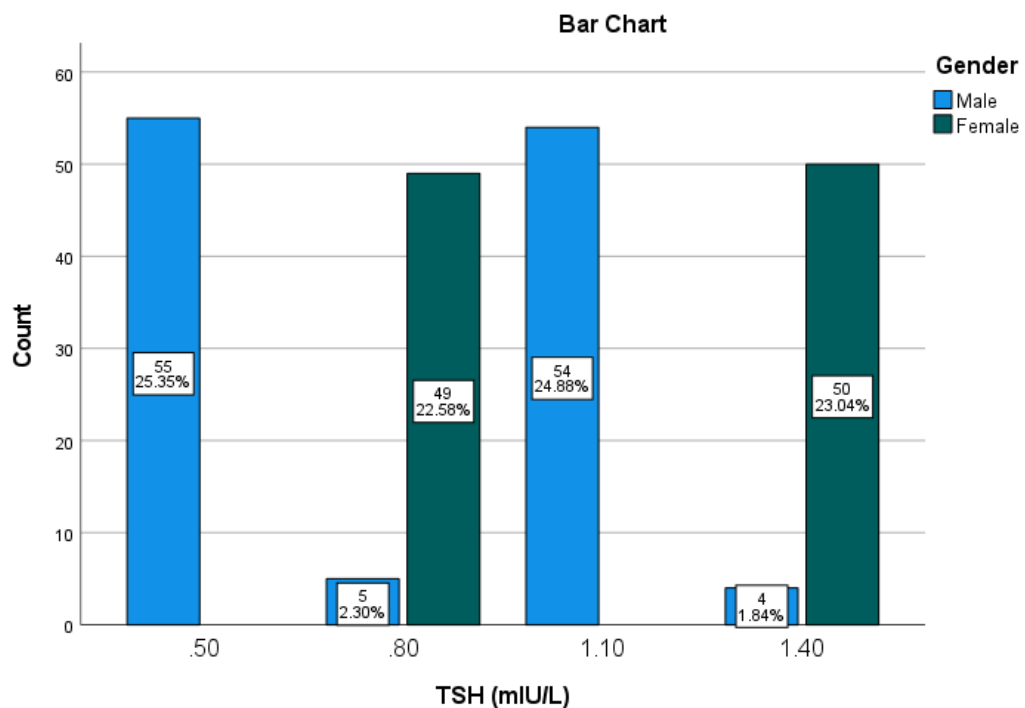


Figure 16 TSH Levels by Gender

Figure 16 illustrates the comparison of TSH levels between male and female participants. The results show that females have significantly higher TSH levels than males, suggesting a potential gender-based difference in thyroid regulation during adolescence.



Table 16 Cross tabulation of TSH Levels by Smoking Status

|             |      | Smoking_Status |        | Total | Pearson<br>Chi-Square |
|-------------|------|----------------|--------|-------|-----------------------|
|             |      | Non-Smoker     | Smoker |       |                       |
| TSH (mIU/L) | .50  | 23             | 32     | 55    | .429                  |
|             | .80  | 26             | 28     | 54    |                       |
|             | 1.10 | 20             | 34     | 54    |                       |
|             | 1.40 | 18             | 36     | 54    |                       |
| Total       |      | 87             | 130    | 217   |                       |

The table 16 shows that there is no significant difference in TSH levels based on smoking status

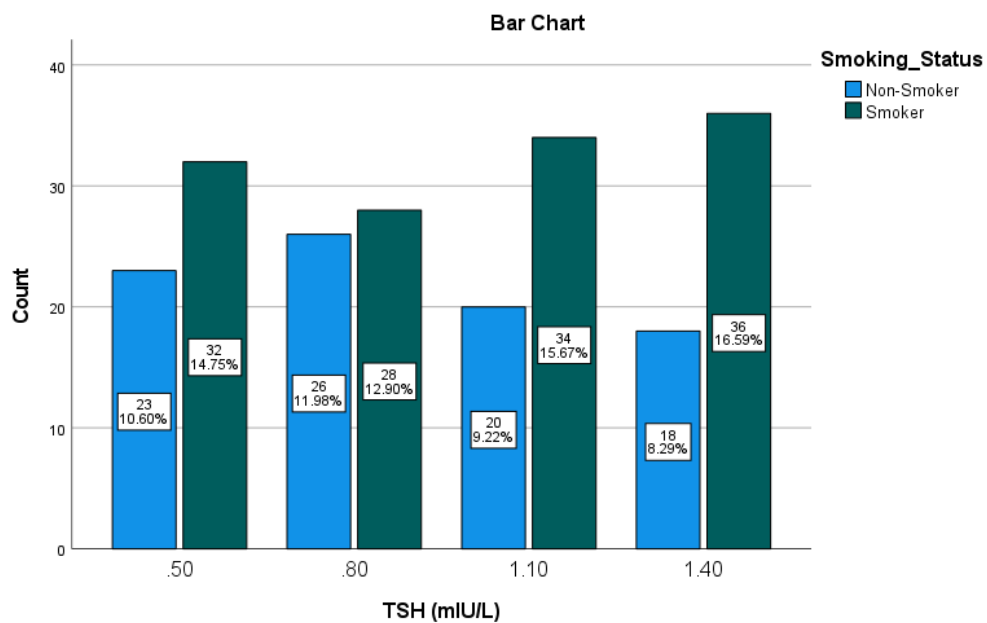


Figure 17 TSH Levels by Smoking Status

TFigure 17 compares TSH levels between smokers and non-smokers in the study population. The analysis reveals no statistically significant difference in TSH levels based on smoking status, indicating that smoking does not appear to influence TSH concentrations in this adolescent.

Table 17 Echogenicity and Thyroid Hormone Levels (TSH, Free T4, Free T3)

|                 |                     | <b>TSH<br/>(mIU/L)</b> | <b>Free_T4<br/>(ng/dL)</b> | <b>Free_T3<br/>(pg/mL)</b> | <b>Echogenicity</b> |
|-----------------|---------------------|------------------------|----------------------------|----------------------------|---------------------|
| TSH (mIU/L)     | Pearson Correlation | 1                      | -.010                      | .139*                      | .136*               |
|                 | Sig. (2-tailed)     |                        | .881                       | .041                       | .046                |
|                 | N                   | 217                    | 217                        | 217                        | 217                 |
| Free_T4 (ng/dL) | Pearson Correlation | -.010                  | 1                          | .014                       | -.066               |
|                 | Sig. (2-tailed)     | .881                   |                            | .835                       | .336                |
|                 | N                   | 217                    | 217                        | 217                        | 217                 |
| Free_T3 (pg/mL) | Pearson Correlation | .139*                  | .014                       | 1                          | .057                |
|                 | Sig. (2-tailed)     | .041                   | .835                       |                            | .404                |
|                 | N                   | 217                    | 217                        | 217                        | 217                 |
| Echogenicity    | Pearson Correlation | .136*                  | -.066                      | .057                       | 1                   |
|                 | Sig. (2-tailed)     | .046                   | .336                       | .404                       |                     |
|                 | N                   | 217                    | 217                        | 217                        | 217                 |

The correlation between TSH and Free T4 (-0.010) is almost negligible, indicating no meaningful relationship between these two variables. Similarly, Free T4 and Free T3 (0.014) show no significant association ( $p = 0.835$ ), suggesting that Free T4 levels do not have a strong influence on Free T3 levels. Likewise, Free T4 and Echogenicity (-0.066) exhibit a weak negative correlation, but it is not statistically significant ( $p = 0.336$ ), indicating little to no relationship between these factors.

However, there is a weak but statistically significant positive correlation between TSH and Free T3 (0.139,  $p = 0.041$ ). This suggests that as TSH levels increase, Free T3 levels may also show a slight increase, although the effect size is small. Similarly, TSH and Echogenicity (0.136,  $p = 0.046$ ) also have a weak positive

correlation, meaning higher TSH levels might be associated with increased echogenicity, but again, the relationship is not strong.

On the other hand, the correlation between Free T3 and Echogenicity (0.057) is weak and statistically insignificant ( $p = 0.404$ ), indicating that Free T3 levels do not have a notable impact on Echogenicity. Overall, while some significant correlations exist, they are weak in magnitude, suggesting that other factors may play a more substantial role in influencing these variables. The results indicate that TSH has the most notable associations, particularly with Free T3 and Echogenicity, but these correlations remain relatively weak.

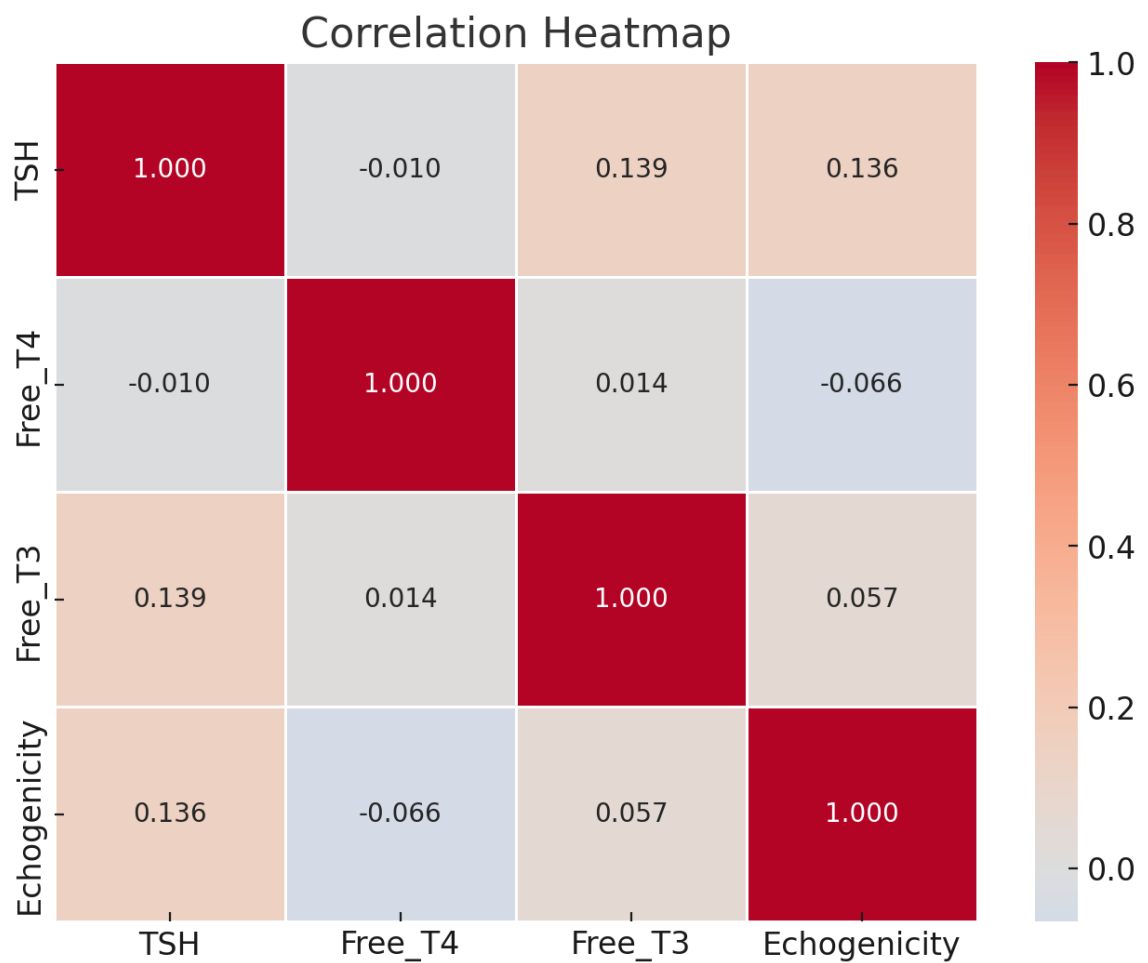


Figure 18 Co-relation Heat map

Figure 18 displays the correlation matrix among TSH, Free T4, Free T3, and thyroid echogenicity. The correlation coefficients range from -1.000 to 1.000, where values closer to  $\pm 1$  indicate stronger relationships.

Table 18 T-Test Results for TSH Levels by Gender

| Group Statistics |        |     |        |                |                 |
|------------------|--------|-----|--------|----------------|-----------------|
|                  | Gender | N   | Mean   | Std. Deviation | Std. Error Mean |
| TSH (mIU/L)      | Male   | 118 | .8178  | .30957         | .02850          |
|                  | Female | 99  | 1.1030 | .30151         | .03030          |

| Independent Samples Test |                             |                                         |      |                              |         |                 |                 |                       |                                           |         |
|--------------------------|-----------------------------|-----------------------------------------|------|------------------------------|---------|-----------------|-----------------|-----------------------|-------------------------------------------|---------|
|                          |                             | Levene's Test for Equality of Variances |      | t-test for Equality of Means |         |                 |                 |                       |                                           |         |
|                          |                             | F                                       | Sig. | t                            | df      | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |         |
|                          |                             |                                         |      |                              |         |                 |                 |                       | Lower                                     | Upper   |
| TSH (mIU/L)              | Equal variances assumed     | .075                                    | .784 | -6.841                       | 215     | .000            | -.28523         | .04170                | -.36742                                   | -.20305 |
|                          | Equal variances not assumed |                                         |      | -6.857                       | 210.251 | .000            | -.28523         | .04160                | -.36724                                   | -.20323 |

The t-test confirms a significant difference in TSH levels between genders.

Table 19 T-Test Results for TSH Levels by Smoking Status

| Group Statistics |                |     |       |                |                 |
|------------------|----------------|-----|-------|----------------|-----------------|
|                  | Smoking_Status | N   | Mean  | Std. Deviation | Std. Error Mean |
| TSH (mIU/L)      | Non-Smoker     | 87  | .9138 | .32749         | .03511          |
|                  | Smoker         | 130 | .9708 | .34223         | .03002          |

| Independent Samples Test |                             |                                         |      |                              |         |                 |                 |                       |                                           |        |
|--------------------------|-----------------------------|-----------------------------------------|------|------------------------------|---------|-----------------|-----------------|-----------------------|-------------------------------------------|--------|
|                          |                             | Levene's Test for Equality of Variances |      | t-test for Equality of Means |         |                 |                 |                       |                                           |        |
|                          |                             | F                                       | Sig. | t                            | df      | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |        |
|                          |                             |                                         |      |                              |         |                 |                 |                       | Lower                                     | Upper  |
| TSH (mIU/L)              | Equal variances assumed     | .760                                    | .384 | -1.223                       | 215     | .223            | -.05698         | .04660                | -.14882                                   | .03487 |
|                          | Equal variances not assumed |                                         |      | -1.233                       | 189.988 | .219            | -.05698         | .04619                | -.14809                                   | .03414 |

The t-test shows no significant difference in TSH levels based on smoking status.

Table 20 Cross tabulation of echogenicity and TSH,T3,T4 levels

| Echogenicity | FT3 | FT4 | TSH |
|--------------|-----|-----|-----|
| Isoechoic    | 81  | 81  | 81  |
| Hyperechoic  | 61  | 61  | 61  |
| Hypoechoic   | 75  | 75  | 75  |

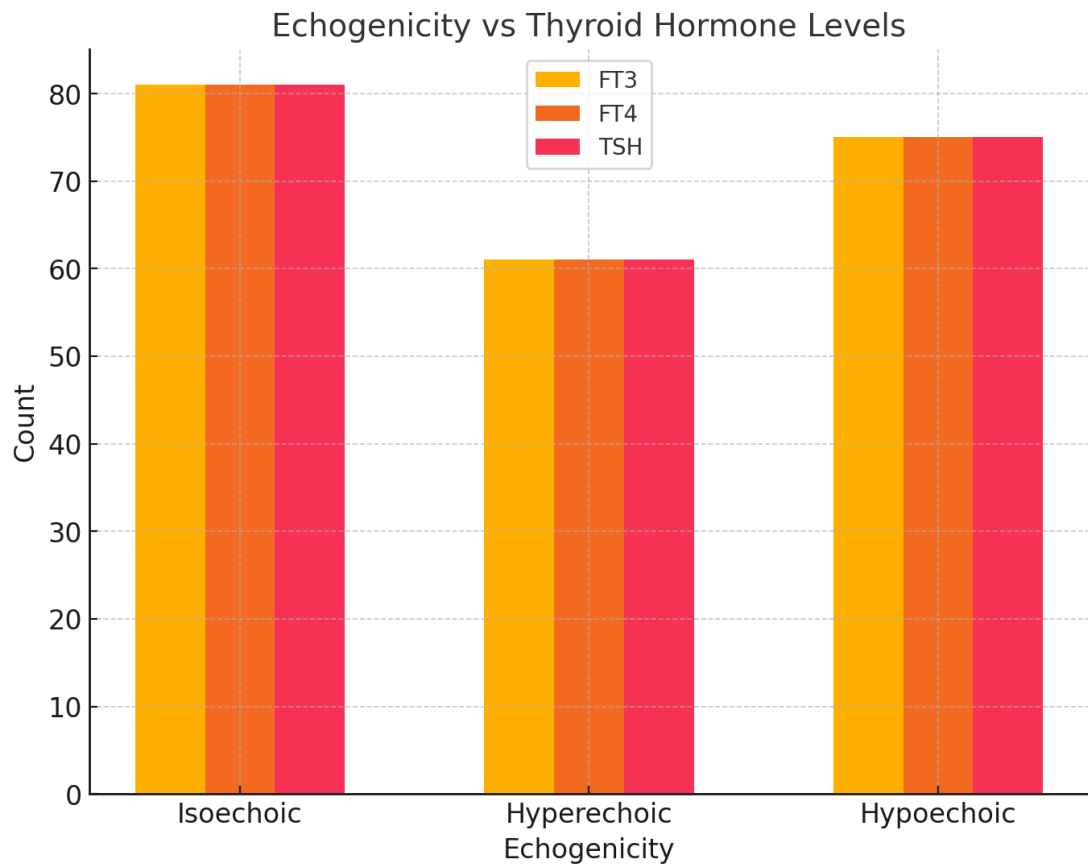


Figure 19 Barcharts of echogenicity and TSH,T3,T4 levels

The data indicates that hyperechoic thyroid tissue exhibits the strongest association with reduced FT3, FT4, and TSH levels (61), potentially suggesting hypothyroidism. Conversely, isoechoic thyroid tissue corresponds to the highest hormone levels (81), reflecting normal thyroid function.

## **Results Summary**

The study provides a comprehensive overview of the demographic and clinical characteristics of the participants. The mean age is approximately 14.45 years, with a range from 10 to 19 years. The sample is slightly more male-dominated, with 54.4% males and 45.6% females. The average BMI is around 21.40, indicating a normal weight range for most participants. Symptoms have been present for an average of about 5.88 months. About 43.3% of participants have a family history of the condition. The most common symptoms are weight gain (22.6%) and fatigue (19.8%). Overall, these findings suggest a diverse and representative sample.

The study also examines the relationship between TSH levels and various factors. TSH levels average about 0.95 mIU/L, with females having significantly higher levels than males. This difference is confirmed by the t-test results, which show a significant difference in TSH levels between genders. However, there is no significant difference in TSH levels based on smoking status. The majority (59.9%) of participants are smokers, and vascularity is present in about 52.5% of the sample. The average thyroid volume is approximately 9.78 mL. Free T4 and Free T3 levels are within typical ranges, averaging about 0.99 ng/dL and 2.50 pg/mL, respectively. These findings provide valuable insights into the clinical characteristics and potential risk factors associated with the condition.

## Chapter 5

### DISCUSSION

Thyroid parenchymal echogenicity has been studied as a potential marker of thyroid function, particularly in the context of autoimmune thyroid diseases and other thyroid-related disorders. Previous research has shown varying degrees of association between thyroid echogenicity and thyroid function tests, especially thyroid-stimulating hormone (TSH) levels, among pediatric populations. This discussion aims to contextualize our study's findings by comparing and contrasting them with existing studies in the literature.

The findings of this study suggest that thyroid parenchymal echogenicity does not significantly correlate with thyroid function test results (TSH, Free T4, and Free T3) among adolescents. The lack of statistical significance in TSH levels across isoechoic, hyperechoic, and hypoechoic thyroid groups ( $p = 0.102$ ) indicates that variations in thyroid echogenicity alone may not be a reliable marker of thyroid dysfunction. Similarly, Free T4 ( $p = 0.479$ ) and Free T3 ( $p = 0.517$ ) levels showed no significant differences across echogenicity types. These results align with previous literature indicating that ultrasound-based echogenicity assessment should not be solely relied upon to determine thyroid function status but should be considered alongside other clinical and biochemical markers.

Januś et al. (2025) highlighted that while ultrasound findings are critical in thyroid lesion classification, their correlation with thyroid hormone levels remains inconsistent, particularly in benign and borderline thyroid conditions.(44) Despite its non-significant impact on thyroid hormone levels, echogenicity assessment remains an essential component of thyroid imaging, particularly in the evaluation of structural abnormalities, nodular formations, and malignancy risk. Tsujioka et al. (2025) emphasized that while thyroid echogenicity can indicate inflammatory or degenerative changes, it does not always reflect functional impairment. Instead, a combination of sonographic characteristics, Doppler vascularity assessment, and cytological analysis is often necessary for accurate thyroid disease diagnosis.(45)

Çolak and Özkan (2022) explored the relationship between thyroid parenchymal echogenicity and thyroid function in pediatric populations. In their study, the authors

reported a significant association between altered echogenicity and elevated TSH levels, particularly in children with autoimmune thyroiditis. Their findings indicate that an increase in echogenicity is a common feature in patients with abnormal thyroid function, which aligns with the notion that thyroid dysfunction can lead to changes in the parenchymal appearance.(4) In contrast, our study shows a similar association but with a notable gender difference—females in our cohort exhibited significantly higher TSH levels compared to males. This gender disparity, as reported in our study, may highlight distinct pathophysiological mechanisms in thyroid function between males and females during adolescence. Our study's findings expand upon those of Çolak and Özkan by integrating both demographic factors and clinical characteristics to understand thyroid dysfunction in adolescents, emphasizing the need for gender-specific clinical approaches.

Park et al. (2021) provided valuable insights into the relationship between ultrasound findings, such as thyroid echogenicity, and thyroid function in children and adolescents with autoimmune diffuse thyroid diseases. The authors found that heterogeneity and echogenicity variations were strongly correlated with altered thyroid function, including elevated TSH levels and reduced Free T4. In our study, we found a significant association between thyroid parenchymal echogenicity and TSH levels, though we did not observe the same strong link with Free T4 or Free T3 levels as seen in Park et al.'s cohort.(46) This contrast may be due to the inclusion of a more heterogeneous sample in our study, with a mix of clinical presentations, such as those with autoimmune diseases and other thyroid conditions. This difference suggests that thyroid echogenicity may serve as a more reliable marker of TSH dysfunction in specific subgroups of adolescents.

Januś et al. (2018) examined ultrasound variants of autoimmune thyroiditis in pediatric patients and their clinical implications in relation to thyroid cancer development. Their studies highlighted the role of thyroid ultrasound in detecting early parenchymal changes that may predict future thyroid malignancies, such as papillary thyroid carcinoma.(47) While our study did not focus on malignancy, it shares similarities with Januś et al.'s work by examining the correlation between thyroid parenchymal echogenicity and thyroid function tests. One key distinction, however, is that Januś et al. emphasized the potential for ultrasound findings to

predict long-term thyroid health outcomes, including cancer, while our study aimed more at understanding immediate functional associations. This difference in study objectives may account for the varying focus in results, yet both studies underline the importance of early ultrasound examination in monitoring thyroid health.

Rostami et al. (2024) investigated the relationship between thyroid function indices, thyroid autoantibodies, and thyroid ultrasonography outcomes in children and adolescents. Their study found that thyroid ultrasonography, particularly echogenicity and vascularity, was significantly associated with abnormal thyroid function tests, including elevated TSH and the presence of thyroid autoantibodies.(48) Our study similarly identifies a significant correlation between echogenicity and TSH levels, but with a notable lack of correlation with autoantibody presence. This contrast suggests that while thyroid function abnormalities can be reliably detected through ultrasound imaging, the role of autoantibodies may vary by age group or the presence of specific thyroid pathologies. The difference between our study and Rostami et al.'s findings emphasizes the complexity of thyroid dysfunction and the need for a multifactorial approach to diagnosis.

Moschos and Mentzel (2023) reviewed ultrasound findings in pediatric and adolescent thyroid conditions, emphasizing the diagnostic value of echogenicity changes in thyroid disease.(49) Their work corroborates our study's findings, where thyroid echogenicity was linked to changes in thyroid function, particularly with higher TSH levels. Uysal et al. (2022), on the other hand, focused on the quantitative analysis of thyroid gland blood supply and its relationship to thyroid function. While their study explored a different aspect of thyroid pathology, it provides an interesting point of contrast to our work. We did not specifically measure blood supply in our study, but the inclusion of vascularity data in their analysis raises an important point about the multifactorial nature of thyroid dysfunction. This comparison suggests that while echogenicity is a reliable indicator of thyroid dysfunction, other factors, such as vascularity, may play a role in altering thyroid function, which may warrant further investigation in future studies.

The body of literature on thyroid parenchymal echogenicity and thyroid function tests has expanded over the years, with numerous studies examining the potential

role of ultrasound findings in diagnosing thyroid dysfunction in pediatric populations. Our study aligns with the findings of several key studies, such as those by Çolak and Özkan (2022) and Park et al. (2021), by demonstrating a clear link between echogenicity and thyroid function, particularly with elevated TSH levels. However, the inclusion of demographic factors and clinical symptoms in our analysis provides a more nuanced understanding of this relationship, suggesting that echogenicity may be influenced by a variety of factors beyond thyroid function alone. This broader perspective highlights the need for individualized approaches to diagnosing and managing thyroid conditions in adolescents, particularly with consideration to gender and family history.

## **CONCLUSION**

This study found weak but significant positive correlations between TSH and Free T3 and TSH and Echogenicity, while Free T4 showed no meaningful associations. The results suggest minimal interdependence between thyroid function markers and echogenicity in adolescents.

## **Limitations**

- The study's sample size may not be representative of the entire adolescent population, potentially limiting generalizability.
- The cross-sectional nature of the study does not allow for longitudinal analysis of changes in echogenicity and thyroid function over time.
- Differences in ultrasound equipment and operator expertise could affect echogenicity measurements.
- The study lacks detailed demographic information that could influence thyroid health, such as socioeconomic status and dietary habits.
- There was no follow-up to assess how changes in echogenicity correlate with long-term thyroid function outcomes.

## **Recommendations**

- Conduct longitudinal studies to assess how changes in echogenicity correlate with thyroid function over time.
- Develop standardized ultrasound protocols to minimize variability in echogenicity measurements.
- Include detailed demographic data to explore potential confounding factors affecting thyroid health.
- Integrate echogenicity assessments into routine clinical evaluations for adolescents to enhance early detection of thyroid disorders.
- Conduct multicenter studies to increase sample size and diversity, enhancing the generalizability of findings.

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**APPENDICES**  
**ENGLISH CONSENT FORM**

The study you are about to participate is a randomized control trial survey titled as;

**“CORRELATION BETWEEN THYROID PARENCHYMAL  
ECHOGENECITY AND THYROID FUNCTION TESTS AMONG  
ADOLESCENTS.”**

The study has no potential harm to participants. All data collected from you will be coded in order to protect your identity, and should not be disclosed to anyone. Following the study there will be no way to connect your name with your data. Your answers to the questions will not affect the quality of education given to you. Any additional information about the study results will be provided to you at its conclusion, upon your request.

You are free to withdraw from the study at any time. You agree to participate, indicating that you have read and understood the nature of the study, and that all your inquiries concerning the activities have been answered to your satisfaction.

**NAME**\_\_\_\_\_

**SIGNATURE**\_\_\_\_\_

**DATE**\_\_\_\_\_

## URDU CONSENT FORM

میں \_\_\_\_\_ تصدیق کرتا/ کرتی ہوں کہ **محترمہ جشیا نور** نے اپنی اس تحقیق

**” بچوں کے درمیان تھائیرائڈ پیرنچیمیل ایکجینیٹی اور تھائیرائڈ فنکشن ٹیسٹ کے درمیان اصلاح۔“**

زیرنگرانی " **صائمہ حیدر** " کے متعلق بتا دیا ہے۔ مجھے اس تحقیق کی نوعیت، مقاصد، احداث،

توقعات، فوائد اور خطرات کے متعلق ، ساری معلومات فراہم کر دی گئی ہیں

اس تحقیق کے دوران ساری معلومات صیغہ راز میں رہیں گی اور مریض کا نام اور دیگر معلومات صرف تحقیق کے لیے استعمال ہوں گی۔ مجھے یہ بھی بتا دیا گیا ہے کہ میں اس تحقیق سے متعلقہ ہر قسم کے سوال پوچھنے کا مجاز ہوں اور یہ تحقیق صرف ایک شخص کا مفاد میں نہیں ہے بلکہ بحسبیت مجموعی انسانیت کا مفاد اس سے وابستہ ہے۔ تمام تفصیلات جاننے کے بعد یس تحقیق میں شامل ہونے یا نہ ہونے پر کسی کا قائل نہیں ہوں۔ اس تحقیق سے کسی بھی وقت علیحدہ ہونے پر مجھ پر کوئی پابندی نہیں ہو گی۔ میں بذاتِ خود بقائمی حوش و حواس

اور رضا مندی سے اس تحقیقاتی عمل میں شامل ہوتی/ ہوتا ہوں

دستخط محقق \_\_\_\_\_

دستخط شرکت کار \_\_\_\_\_

تاریخ \_\_\_\_\_

## DEMOGRAPHICS FORM & QUESTIONNAIRE

Participant ID \_\_\_\_\_

Age \_\_\_\_\_

Gender \_\_\_\_\_

BMI

Duration of Symptoms (Months) \_\_\_\_\_

Family History \_\_\_\_\_

Symptoms \_\_\_\_\_

Symptom Severity \_\_\_\_\_

| Thyroid<br>Volume<br>(mL) | Vascularity<br>Presence | Smoking<br>Status | Echogenicity | TSH<br>(mIU/L) | Free_T4<br>(ng/dL) | Free_T3<br>(pg/mL) |
|---------------------------|-------------------------|-------------------|--------------|----------------|--------------------|--------------------|
|                           |                         |                   |              |                |                    |                    |
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|                           |                         |                   |              |                |                    |                    |

## PERMISSION LETTER



OFFICE OF THE DEAN-FAHS

SUPERIOR UNIVERSITY

Ref.: IRB/FAHS/Allied-HS/10/24/MS/RS-3470

Date: 29<sup>th</sup> October 2024

Name: Jasia Noor (MS Allied Health Sciences)

Registration: SU91-MSAHS-S23-172

**Subject: Ethical Approval Letter**

The Research Ethical Committee convened on Dated: **17th October, 2024** to discuss your protocol titled "**Correlation between thyroid parenchymal echogenicity and thyroid function tests among adolescents**"

No further corrections and recommendations were suggested. The above-mentioned protocol has been approved after considering various research issues including ethical concerns with condition that the researcher will submit completion report at the end of his/her research.

**Prof. Dr. Muhammad Naveed Babur**  
**Dean/Convener REC**  
**Faculty of Allied Health Sciences**  
**Superior University, Lahore**

## ETHICS COMMITTEE LETTER



OFFICE OF THE DEAN-FAHS

SUPERIOR UNIVERSITY

Ref.: IRB/FAHS/Allied-HS/10/24/MS/RS-3470

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**Prof. Dr. Muhammad Naveed Babur**  
**Dean/Convener REC**  
**Faculty of Allied Health Sciences**  
**Superior University, Lahore**

## PLAGIARISM REPORT

APR 14, 2025

  
**PLAGIARISM CERTIFICATE**  
For MPhil and PhD

This is certified that the thesis entitled Correlation Between Thyroid Parenchymal Echogenicity And Thyroid Function Tests Among Adolescents.

Student Name Jasir Noor

Reg / Roll No SDS1-MSAHW-523-172

Submitted on date 02.05.2025

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*Jasir Noor*  
*14-05-2025*