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CORRELATION BETWEEN THYROID PARENCHYMAL ECHOGENICITY AND THYROID FUNCTION TESTS AMONG ADOLESCENTS

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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. In terms of thyroid echogenicity, participants were categorized into isoechoic, hyperechoic, and hypoechoic groups, with no statistically significant differences observed in thyroid function tests across these echogenicity types.*

Conclusion*: Particularly with TSH levels, thyroid function tests and thyroid parenchymal echogenicity show a strong association among teenagers, this implies that evaluating thyroid condition in this age range can benefit much from ultrasonic imaging.*

INTRODUCTION

A thyroid ultrasound 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.(1) A thyroid US can easily identify the heterogeneous parenchyma observed in subjects with diffuse thyroid diseases, including Graves' disease and Hashimoto's thyroiditis.(2) The relationship between TG echogenicity and thyroid function parameters has been described in adults.(3)

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).(4) Ultrasound imaging is a non-invasive and widely used diagnostic modality to evaluate the structural integrity and functional implications of the thyroid gland.(5) 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.(6)

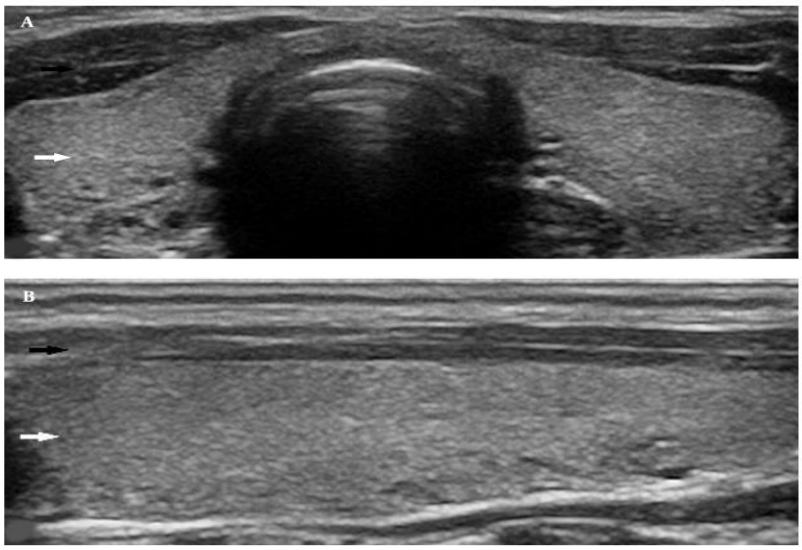

Figure 1 A, Transverse; and B, Sagittal gray-scale ultrasound images of thyroid gland showing homogeneous echogenicity of normal thyroid parenchyma (white arrow) (3)

Adolescence is a critical period marked by rapid physical, hormonal, and psychological changes.(7) During this phase, thyroid dysfunction can have profound implications, potentially affecting growth, development, and quality of life.(8) Understanding the relationship between thyroid parenchymal echogenicity and thyroid function tests (TFTs) among adolescents is vital for early detection and management of thyroid disorders.(9) 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.(10)

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.(11) 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 (a\nti-thyroglobulin and anti-thyroid peroxidase), are used to evaluate autoimmune thyroid diseases.(12) These tests are particularly relevant in adolescents, where autoimmune etiologies are a common cause of thyroid dysfunction.(13)

Combining TFTs with imaging findings, such as echogenicity, enhances diagnostic accuracy and informs treatment strategies.(13) 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.(14) Additionally, the psychological impact of these disorders, including mood changes and reduced academic performance, underscores the importance of timely diagnosis and management.(15)

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.

Objective

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

Methodology

Following the approval of the research briefly, the cross-sectional analytical study carried out at the Radiology Department of Allied Hospital Faisalabad over nine months Using a typical prevalence-based calculation, the sample size of the study was computed at a 96% level of significance and a 5% margin of error; 217 patients in all were included.(3) The target population was guaranteed a thorough representation by use of the sequential sampling method. .

The inclusion criteria necessitated that adolescents aged 10 to 19 years, regardless of gender, have undertaken thyroid function tests (TSH, Free T4, and Free T3) within the past week and have endured a thyroid ultrasound for parenchymal echogenicity assessment.(16, 17) Excluded were those with clinical suspicion of thyroid nodules, a history of thyroid surgery, medication influencing thyroid function, acute illnesses, pregnancy, or inadequate medical records.(16-18)

To guarantee accuracy and repeatability in evaluating thyroid echogenicity, the ultrasonic study used a set procedure. Patients were advised to reduce picture artifacts by wearing loose-fitting clothes and taking off any jewelry around the neck. They were positioned supine with a cushion under the shoulders throughout the operation to help the neck to hyperextension for best thyroid gland view. Swallowing motions were done to improve the evaluation of related nodules and retrosternal thyroid sections. While anteroposterior and lateral scanning guarantees complete vision, a superficial linear probe (7–11 MHz) was employed to generate high-resolution gray-scale ultrasonic pictures of the thyroid gland.(19, 20)

The ultrasonic probe was used with low pressure to avoid compression artifacts, which can compromise echogenicity interpretation. Thyroid echogenicity was categorized in three terms based on the sonographic assessment: isoechoic, in which the echogenicity was similar to adjacent muscles, indicating a normal thyroid structure; hyperechoic, in which the thyroid appeared brighter than surrounding tissues or benign hyperplasia; and hypoechoic, in which reduced echogenicity, usually associated with chronic inflammation, nodular disease, or cancer. To evaluate vascularity patterns, doppler imaging helped differentiate benign from worrisome thyroid lesions.(6) Given the elevated malignancy risk, fine-needle aspiration biopsy (FNAB) was advised if the nodules showed irregular borders or enhanced vascularity.(21-23)

Strict adherence to ethical standards was maintained; written informed permission was obtained from every participant guaranteeing anonymity, confidentiality, and voluntary involvement all through the study. Patients were checked in a supine posture with neck hyperextension to improve vision using a typical thyroid ultrasonic technique. Retrosternal thyroid areas were evaluated using several procedures including swallowing.

SPSS version 25 was used for data analysis whereby categorical variables were expressed as percentages and continuous variables as mean and standard deviation (SD). While diagnostic accuracy was ascertained by sensitivity, specificity, positive

predictive value, negative predictive value, and general diagnosis accuracy, statistical tests—including Chi-square and ANOVA—were used to evaluate dependent and independent variables. Considered statistically significant was a p-value of under 0.05.

Results

The study included 118 males (54.4%) and 99 females (45.6%), with 43.3% of participants having a family history of thyroid disease. The most common symptoms reported were weight gain (22.6%) and fatigue (19.8%), while 23.5% had no symptoms. Symptom severity was moderate in 41.5% of cases, and 59.9% of participants were smokers. Vascularity was present in 52.5% of cases, and thyroid echogenicity was categorized as isoechoic (37.3%), hyperechoic (28.1%), and hypoechoic (34.6%). 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.

Table 1: Discriptive statistics f daa

Category	Mean	Standard Deviation
Age	14.45	2.87
BMI	21.4	1.71
Duration of Symptoms	5.88	3.76
Thyroid Volume	9.78	2.85
TSH Levels	0.95	0.34
Free T4 Levels	0.99	0.14
Free T3 Levels	2.5	0.34

Table 2: Echogenicity and Thyroid Hormone Levels (TSH, Free T4, Free T3)

Variable	Echogenicity	N	Mean	Std. Deviation	Std. Error	F-Statistic	p-Value
TSH (mIU/L)	Isoechoic	81	0.8852	0.35253	0.03917	2.303	0.102
	Hyperechoic	61	0.977	0.32114	0.04112		
	Hypoechoic	75	0.992	0.32581	0.03762		
	Total	217	0.9479	0.3368	0.02286		
Free_T4 (ng/dL)	Isoechoic	81	1.0136	0.14031	0.01559	0.739	0.479
	Hyperechoic	61	0.9869	0.1565	0.02004		
	Hypoechoic	75	0.992	0.13127	0.01516		
	Total	217	0.9986	0.1419	0.00963		
Free_T3 (pg/mL)	Isoechoic	81	2.4642	0.35472	0.03941	0.662	0.517
	Hyperechoic	61	2.5279	0.3163	0.0405		
	Hypoechoic	75	2.5093	0.35305	0.04077		
	Total	217	2.4977	0.34325	0.0233		

Table 3: Cross tabulation of TSH Levels by Gender and Smoking Status

Category	TSH (mIU/L)	Male/Non-Smoker	Female/Smoker	Total	p-value
Gender	0.5	55	0	55	.000
	0.8	5	49	54	
	1.1	54	0	54	
	1.4	4	50	54	
	Total	118	99	217	
Smoking Status	0.5	23	32	55	0.429

	0.8	26	28	54	
	1.1	20	34	54	
	1.4	18	36	54	
	Total	87	130	217	

Females have significantly higher TSH levels than males and there is no significant difference in TSH levels based on smoking status

Table 34:T-Test Results for TSH Levels by Gender and Smoking Status

	Category	Gender	N	Mean	Std. Deviation	Std. Error Mean	p-value
TSH (mIU/L)	**Gender**	**Male**	118	0.8178	0.30957	0.0285	.000
		Female	99	1.103	0.30151	0.0303	.000
	Smoking Status	**Non-Smoker**	87	0.9138	0.32749	0.03511	.223
		Smoker	130	0.9708	0.34223	0.03002	.219

The t-test confirms a significant difference in TSH levels between genders and shows no significant difference in TSH levels based on smoking status.

Discussion

Thyroid parenchymal echogenicity has been investigated as a possible indicator of thyroid function, particularly in the setting of autoimmune thyroid illnesses and other thyroid-related disorders. The absence of statistical significance in TSH levels among isoechoic, hyperechoic, and hypoechoic thyroid groups (p = 0.102) suggests that differences in thyroid echogenicity alone may not be a consistent indication of thyroid dysfunction. Likewise, levels of Free T4 (p = 0.479) and Free T3 (p = 0.517) revealed no appreciable variation between echogenicity levels. These findings coincide with other studies showing that thyroid function status should be evaluated using additional clinical and biochemical indicators in addition to ultrasonic-based echogenicity evaluation.

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.(24) 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. (25)

Çolak and Özkan (2022) 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.(3) 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.

Park et al. (2021) found that changed thyroid function—including higher TSH levels and lower Free T4—was highly linked with differences in heterogeneity and echogenicity. Though we did not find the same strong correlation with Free T4 or Free T3 levels as observed in Park et al.'s cohort, in our investigation we identified a substantial association between thyroid paredchymal echogenicity and TSH levels.(26) This difference might be the result of our study's more diverse sample—a mix of clinical presentations including individuals with autoimmune illnesses and other thyroid problems. This variation implies that, in some subgroups of teenagers, thyroid echogenicity might be a more accurate indicator of TSH malfunction.

Januś et al. (2018) underlined the importance of thyroid ultrasonic tests in identifying early parenchymal alterations that can indicate papillary thyroid carcinoma or other thyroid malignancies.(27) Although our study did not specifically address cancer, by looking at the relationship between thyroid parenchymal echogenicity and thyroid function tests, it resembles work by Januś et al. One

important difference, though, is that whereas our work focused more on understanding instantaneous functional correlations, Januś et al. stressed the possibility for ultrasonography data to predict long-term thyroid health problems, including cancer.

Rostami et al. (2024) found that thyroid ultrasonography, namely echogenicity and vascularity, was substantially linked with abnormal thyroid function tests, such as high TSH and thyroid autoantibodies.(28) Our work also finds a strong association between echogenicity and TSH levels, however with a clear absence of correlation with autoantibody presence. This contrast implies that whereas ultrasonic imaging may consistently identify thyroid function issues, the importance of autoantibodies may change depending on age group or existence of certain thyroid diseases.

Conclusion

This study finds, especially with TSH levels, a notable association between thyroid parenchymal echogenicity and thyroid function tests among teenagers. This implies that evaluating thyroid condition in this age range can benefit much from ultrasonicography. The results underline the need of include echogenicity measures into clinical assessments for early thyroid problem treatment and identification. This strategy could improve patient outcomes and diagnostic accuracy.

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