

Ultrasonographic Assessment of Thyroid Morphometry with Emphasis on Sexual Dimorphism in Kashmiri Population

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ABSTRACT

Background: The thyroid gland is a vital endocrine organ regulating metabolism, growth, and development. Ultrasonographic assessment of thyroid morphometry provides important insights into gland size and structure, helping distinguish physiological variation from pathological enlargement. Sex-based differences and population-specific reference values are important for accurate evaluation. This study aimed to assess the ultrasonographic dimensions and volumes of the thyroid lobes and isthmus in a healthy Kashmiri adult population and evaluate sex-based differences.

Methods: A cross-sectional study was conducted on 300 healthy adults (150 males, 150 females) at the Post Graduate Department of Radiodiagnosis in collaboration with the Post Graduate Department of Anatomy, GMC Srinagar. Length, width, and depth of both thyroid lobes and the isthmus were measured using high-resolution ultrasonography. Volumes were calculated using the ellipsoid formula ($\text{Length} \times \text{Width} \times \text{Depth} \times 0.524$). Sex-based differences were analyzed statistically, with significance set at $p < 0.05$.

Results: Males exhibited consistently larger thyroid dimensions and volumes compared to females. The mean right lobe measured 5.2 ± 0.5 cm in length, 1.8 ± 0.3 cm in width, and 2.0 ± 0.2 cm in depth in males, versus 4.8 ± 0.4 cm, 1.6 ± 0.3 cm, and 1.8 ± 0.2 cm in females. The left lobe in males measured 5.0 ± 0.5 cm $\times$ 1.7 ± 0.2 cm $\times$ 1.9 ± 0.2 cm, compared to 4.6 ± 0.4 cm $\times$ 1.5 ± 0.2 cm $\times$ 1.7 ± 0.2 cm in females. The isthmus length and thickness were 1.4 ± 0.3 cm and 0.40 ± 0.07 cm in males, versus 1.3 ± 0.2 cm and 0.35 ± 0.06 cm in females. Calculated volumes of the right lobe (9.3 ± 1.5 mL vs 7.6 ± 1.2 mL), left lobe (8.5 ± 1.3 mL vs 6.7 ± 1.0 mL), and total thyroid (17.8 ± 2.5 mL vs 14.3 ± 2.0 mL) were all significantly higher in males than females ($p \leq 0.003$), reflecting clear sexual dimorphism.

Conclusion: Thyroid dimensions and volumes are significantly larger in males, reflecting clear sexual dimorphism. These findings provide population-specific ultrasonographic reference values for the Kashmiri adult population, useful for clinical and diagnostic evaluation.

Keywords: Thyroid gland, Ultrasonography, Thyroid volume, Thyroid morphometry, Sexual dimorphism,

INTRODUCTION

The thyroid gland, situated in the anterior aspect of the neck, is a vital endocrine organ responsible for the synthesis and secretion of hormones that regulate metabolism, growth, and development. The size and morphology of the gland exhibit considerable interindividual variation, influenced by factors such as age, sex, geographic location, and iodine status. [1,2] Each lobe of the thyroid is cone-shaped, measuring approximately 5 cm in length, 3 cm in width, and 2 cm in depth, while the isthmus averages about 1.25 cm in both width and height, though its size and position may vary among individuals. [3] The isthmus thickness, typically ranging from 3 to 5 mm, has also been reported to relate with certain demographic parameters. [4] Overall, variations in thyroid morphometry, including differences in volume, shape, and size, are primarily influenced by age and gender. Therefore, accurate evaluation of thyroid morphometry is essential for distinguishing physiological variations from pathological enlargement and for facilitating the early detection of thyroid abnormalities. Ultrasonography (USG) has become the imaging modality of choice for thyroid assessment due to its non-invasive nature, accessibility, high sensitivity, and real-time imaging capability. [5] It allows precise measurement of thyroid lobes and isthmus dimensions, as well as detailed evaluation of glandular echotexture and focal lesions. The sonographic estimation of thyroid volume serves as an important diagnostic adjunct in conditions such as diffuse goiter, thyroiditis, and nodular disease, and it provides valuable information for surgical planning and postoperative follow-up. [6] Globally, thyroid disorders remain among the most prevalent endocrine diseases, with regional variations related to dietary iodine intake and environmental influences. The Himalayan region, including the Kashmir Valley, has historically been recognized as an area of relative iodine deficiency and increased prevalence of thyroid enlargement and dysfunction. [7] Studies from this region

have reported a significant burden of both goiter and subclinical hypothyroidism, reflecting the continuing impact of environmental and nutritional factors on thyroid health. [7] Despite this high prevalence, there is a paucity of region-specific ultrasonographic data defining normal thyroid dimensions in the Kashmiri population. Most reference values used in clinical practice are extrapolated from studies conducted in other ethnic or geographic groups, which may not accurately reflect local anatomical characteristics. Establishing population-specific normative values is essential for improving diagnostic accuracy and minimizing over- or under-diagnosis of thyroid pathology. The present study was therefore undertaken to evaluate thyroid morphometry in the Kashmiri population using high-resolution ultrasonography and to establish baseline reference values for thyroid dimensions and volume.

MATERIAL AND METHODS

This cross-sectional observational study was conducted in the Department of Anatomy in collaboration with the Department of Radiodiagnosis, Government Medical College, Srinagar, J&K, India. The study aimed to evaluate thyroid morphometry using high-resolution ultrasonography in the Kashmiri population and to analyze gender-based variations. The study was carried out over a period of 12 months after obtaining approval from the Institutional Ethics Committee (IEC) vide Ref. No: IRBGMC-SGR/ Anat / 1113, dated: June 24, 2025. A total of 300 clinically Euthyroid subjects (150 males and 150 females), aged between 18 and 70 years, were included in the study. All participants were residents of the Kashmir Valley and were recruited from individuals referred for ultrasonographic evaluation of the neck region for non-thyroid-related complaints.

Inclusion Criteria

- Adults (18 years and above)
- Individuals with no clinical evidence of thyroid disease.
- Normal thyroid function test (T3, T4, and TSH within reference range).
- No prior history of thyroid surgery or neck irradiation.

Exclusion Criteria

- Presence of palpable goiter or nodules.
- History of thyroid dysfunction (hypo- or hyperthyroidism).
- Pregnancy or lactation.
- Patients on medications known to affect thyroid size (e.g., thyroxine, antithyroid drugs).
- Structural deformities of the neck or previous cervical surgeries.

Ultrasonographic Examination

All ultrasonographic examinations were performed using a high-resolution B-mode ultrasound machine (e.g., GE Logiq P5 or equivalent) equipped with a 7.5–12 MHz linear transducer. Participants were examined in the supine position with the neck extended and a pillow placed under the shoulders to optimize visualization of the thyroid gland. A thin layer of acoustic gel was applied to ensure optimal probe contact. Each thyroid lobe was examined in both longitudinal and transverse planes. The following parameters were measured:

- Length (cm): Maximum longitudinal extent of the lobe.
- Width (cm): Maximum transverse dimension.
- Depth (cm): Maximum anteroposterior diameter.
- Isthmus thickness (cm): Measured in the midline at the narrowest anteroposterior dimension.
- Isthmus length (cm): Measured between the points of attachment of the two lobes.

All measurements were taken with the patient in quiet respiration and by a single

experienced radiologist to minimize inter-observer variability. Each measurement was recorded to the nearest 0.1 cm.

Calculation of Thyroid Volume

The volume of each thyroid lobe was estimated using the conventional ellipsoid formula, $\text{volume} = \text{length} \times \text{width} \times \text{depth} \times \pi/6$ (0.524). The total thyroid volume was calculated as the sum of the right and left lobe volumes, excluding the isthmus. This approach is consistent with established ultrasonographic methods for thyroid-volume estimation [9].

Data Recording and Quality Control

All data were recorded in structured case record forms. To reduce measurement bias, each observation was repeated twice and the average value was used for statistical analysis. Calibration of the ultrasound machine was verified daily before use.

Statistical Analysis

Data were entered and analyzed using IBM SPSS Statistics version 26.0. Results were expressed as mean $\pm$ standard deviation (SD). The independent samples t-test was used to compare thyroid morphometric parameters between males and females. A p-value < 0.05 was considered statistically significant. Descriptive statistics were used to summarize demographic characteristics.

Ethical Considerations

Ethical clearance for the study was obtained from the Institutional Ethics Committee of Government Medical College, Srinagar, vide Ref. No: IRBGMC-SGR/ Anat / 1113, Dated: June 24, 2025. Written informed consent was obtained from all participants after explaining the purpose and procedure of the study. Confidentiality and anonymity were strictly maintained throughout the research process.

RESULTS

Table 1: Ultrasonographic Dimensions of Thyroid Lobes and Isthmus by Gender

Parameter	Male (n=150) Mean $\pm$ SD	Female (n=150) Mean $\pm$ SD	p-value
Right lobe length (cm)	5.2 $\pm$ 0.5	4.8 $\pm$ 0.4	0.001
Right lobe width (cm)	1.8 $\pm$ 0.3	1.6 $\pm$ 0.3	0.003
Right lobe depth (cm)	2.0 $\pm$ 0.2	1.8 $\pm$ 0.2	0.002
Left lobe length (cm)	5.0 $\pm$ 0.5	4.6 $\pm$ 0.4	0.004
Left lobe width (cm)	1.7 $\pm$ 0.2	1.5 $\pm$ 0.2	0.005
Left lobe depth (cm)	1.9 $\pm$ 0.2	1.7 $\pm$ 0.2	0.006
Isthmus length (cm)	1.4 $\pm$ 0.3	1.3 $\pm$ 0.2	0.008
Isthmus thickness (cm)	0.40 $\pm$ 0.07	0.35 $\pm$ 0.06	0.009

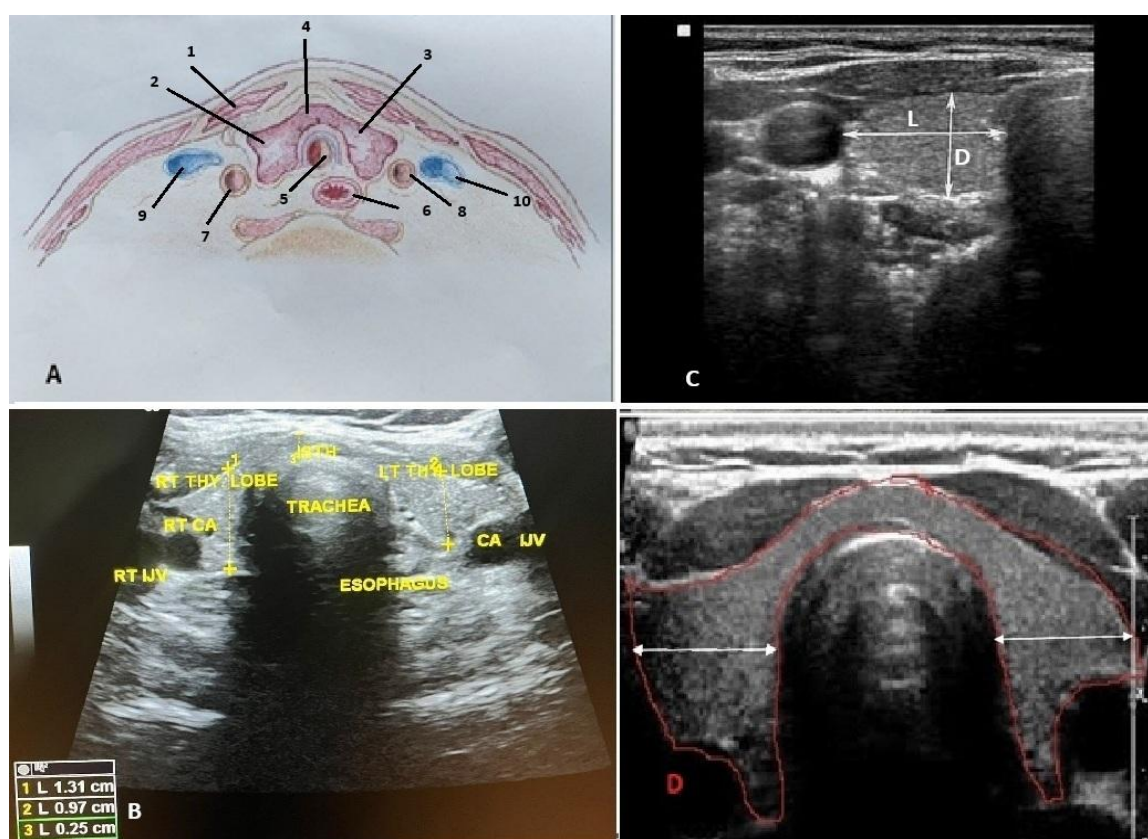


Figure 1:

- (A) Schematic representation of a normal thyroid gland and its surrounding anatomical landmarks in a transverse section: 1- strap muscles, 2- right lobe, 3- left lobe, 4- isthmus, 5- trachea, 6- Oesophagus, 7 & 8- common carotid arteries, 9 & 10- internal jugular vein
- (B) Normal sonographic appearance of the thyroid gland and surrounding anatomical landmarks corresponding to the sketch (A)
- (C) Longitudinal view of sonographic appearance of the thyroid gland showing length (L) and depth of Right lobe
- (D) Transverse view of sonographic appearance of the thyroid gland showing delineation of parts of the thyroid gland and measurement of width of each lobe.

Table 1 presents the ultrasonographic dimensions of the thyroid lobes and isthmus among male and female participants. The mean right lobe length, width, and depth in males were 5.2 ± 0.5 cm, 1.8 ± 0.3 cm, and 2.0 ± 0.2 cm, respectively, while in females

these measurements were 4.8 ± 0.4 cm, 1.6 ± 0.3 cm, and 1.8 ± 0.2 cm, respectively. The differences between males and females in all three dimensions were statistically significant ($p = 0.001$, 0.003 , and 0.002 , respectively). Similarly, the mean left lobe

length, width, and depth were significantly greater in males (5.0 ± 0.5 cm, 1.7 ± 0.2 cm, and 1.9 ± 0.2 cm) compared to females (4.6 ± 0.4 cm, 1.5 ± 0.2 cm, and 1.7 ± 0.2 cm) with corresponding p-values of 0.004, 0.005, and 0.006. The isthmus length also showed a higher mean value in males (1.4 ± 0.3 cm) than in females (1.3 ± 0.2 cm), with the difference being statistically significant ($p = 0.008$).

Likewise, the isthmus thickness was greater in males (0.40 ± 0.07 cm) compared to

females (0.35 ± 0.06 cm), and this difference was also statistically significant ($p = 0.009$). The results demonstrated that the thyroid lobes and isthmus were consistently larger in males than in females across all measured parameters (Figures 1, and 2), and these gender-based differences were statistically significant ($p < 0.05$), aligning well with existing literature that reports larger thyroid dimensions in males due to greater body surface area and hormonal influence.

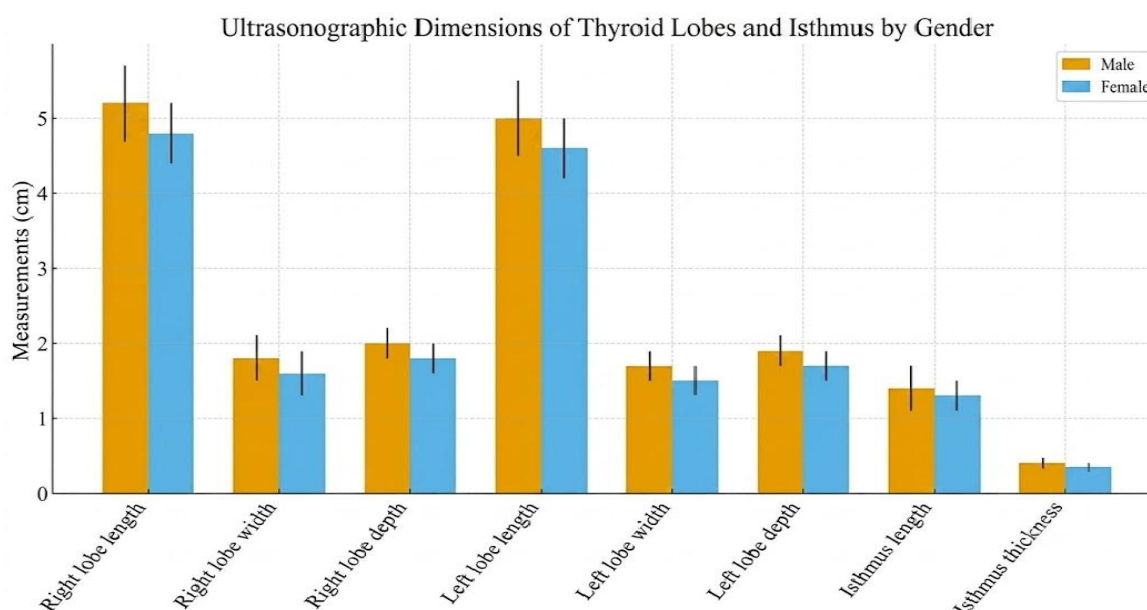


Figure 2: Bar chart diagram showing graphical presentation of ultrasonographic dimensions of the thyroid lobes and isthmus.

Table 2: Thyroid Volumes by Gender (Calculated Using Ellipsoid Formula)

Parameter	Male (n=150) Mean ± SD	Female (n=150) Mean ± SD	p-value
Right lobe volume (mL)	9.3 ± 1.5	7.6 ± 1.2	0.001
Left lobe volume (mL)	8.5 ± 1.3	6.7 ± 1.0	0.002
Total thyroid volume (mL)	17.8 ± 2.5	14.3 ± 2.0	0.003

Table 2 presents the ultrasonographic measured thyroid volumes calculated using the ellipsoid formula ($\text{Length} \times \text{Width} \times \text{Depth} \times 0.524$). The mean right lobe volume was significantly higher in males (9.3 ± 1.5 mL) compared to females (7.6 ± 1.2 mL) with a p-value of 0.001. Similarly, the left lobe volume was greater in males (8.5 ± 1.3 mL) than in females (6.7 ± 1.0 mL), showing a statistically significant difference ($p = 0.002$). The total thyroid volume also followed a similar pattern,

being significantly higher in males (17.8 ± 2.5 mL) compared to females (14.3 ± 2.0 mL) with a p-value of 0.003. These findings indicate that thyroid volume is consistently larger in males across both lobes, which is statistically significant ($p < 0.05$).

DISCUSSION

The present study establishes ultrasonographic reference values for thyroid morphometry in a healthy adult Kashmiri population and highlights

consistent patterns of sexual dimorphism and lobar asymmetry. From an applied anatomical perspective, these findings reinforce the concept that thyroid size and shape demonstrate predictable physiological variation, which must be distinguished from pathological enlargement during clinical and imaging-based evaluation.

In the present study involving 300 Kashmiri adults, the mean right thyroid lobe dimensions were 5.2 ± 0.5 cm in length, 1.8 ± 0.3 cm in width, and 2.0 ± 0.2 cm in depth, values that align closely with the classical sonographic description of an adult thyroid lobe measuring approximately $5 \times 2 \times 2$ cm in the sagittal, transverse, and anteroposterior planes (Figure 1). These results also correspond with standardized imaging references that describe lateral lobe lengths between 4 and 6 cm and transverse or AP diameters around 1.3–2.0 cm. [8-11] The linear dimensions of both thyroid lobes observed in this study correspond closely with standard anatomical descriptions of the adult thyroid gland, confirming the reliability of ultrasonography as a modality for in vivo anatomical assessment. The slight predominance of the right lobe over the left in length, width, depth, and volume represents a well-recognized anatomical asymmetry. This right–left difference is generally attributed to developmental and vascular factors and should be regarded as a normal anatomical feature rather than an indicator of unilateral pathology. Awareness of this asymmetry is particularly important in routine ultrasound reporting and surgical planning to prevent overinterpretation of mild lobar differences. [12-14]

Sexual dimorphism emerged as a prominent anatomical finding, with males demonstrating significantly larger thyroid dimensions and volumes across all parameters. This observation is consistent with established anatomical principles linking organ size to body surface area, lean body mass, and metabolic demand. Hormonal influences, particularly the trophic effects of androgens on thyroid tissue, may further contribute to increased

glandular volume in males. From an applied standpoint, these findings emphasize that sex-specific anatomical reference values should be considered during thyroid assessment, as the use of uniform cut-off values may lead to misclassification of normal glands as enlarged, particularly in male subjects. [14,15]

The morphometric assessment of the thyroid isthmus adds further applied anatomical value to the study. The isthmus is frequently underemphasized in routine evaluation despite its importance in anterior neck anatomy and surgical access to the thyroid gland. The observed sex-based differences in isthmus length and thickness parallel those seen in the lobes and support the view that the isthmus exhibits proportional growth as part of the gland rather than functioning as a negligible structure. Accurate knowledge of isthmus dimensions is particularly relevant during tracheostomy, thyroidectomy, and other anterior cervical procedures, where anatomical variation may influence operative planning and risk of complications. [13, 16-18]

Volumetric analysis further substantiated the presence of sexual dimorphism, with males exhibiting significantly greater right, left, and total thyroid volumes. While absolute thyroid volumes vary across populations, the values observed in this study fall within globally reported adult ranges. Minor interpopulation differences are likely influenced by genetic background, nutritional status, and environmental factors, including historical iodine intake. In regions such as Kashmir, where iodine deficiency disorders have been endemic, reliance on population-specific volumetric norms is essential for accurate anatomical and clinical interpretation. [19-21]

From an applied anatomical and diagnostic standpoint, the establishment of region-specific ultrasonographic reference values has practical implications. These data provide a baseline for differentiating physiological variation from diffuse goiter and early pathological enlargement, thereby improving diagnostic precision.

Furthermore, such normative values are useful in anatomical teaching, radiological reporting, and clinical decision-making, particularly in regions where thyroid disorders are prevalent.

CONCLUSION

The present study provides population-specific ultrasonographic reference values for thyroid morphometry in healthy Kashmiri adults and demonstrates consistent sexual dimorphism and right-left lobar asymmetry. Males exhibited significantly larger thyroid dimensions and volumes than females across all measured parameters, reflecting normal physiological variation related to body habitus and hormonal influences rather than pathology. The observed predominance of the right lobe and proportional variation in isthmus dimensions further emphasize the presence of predictable anatomical asymmetry within the thyroid gland.

From an applied anatomical perspective, these findings have direct relevance for anatomical education, radiological interpretation, and clinical practice. Recognition of sex-based and lobar variations is essential for accurate differentiation between normal anatomy and early thyroid enlargement, thereby reducing the risk of misdiagnosis. The inclusion of isthmus morphometry also highlights its anatomical and surgical significance in anterior neck procedures.

Overall, the normative data generated by this study contribute to applied anatomy by refining anatomical reference standards for a specific population. These values may serve as a useful baseline for clinicians, radiologists, and anatomists involved in thyroid evaluation, teaching, and surgical planning, particularly in regions with a high prevalence of thyroid disorders

Declaration

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Conflict of Interest: The authors declare no conflict of interest.

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