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THYROID GLAND MORPHOMETRY: AGE- AND SEX-RELATED ANATOMICAL DIFFERENCES—A NARRATIVE REVIEW

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Abstract: Thyroid gland morphometry provides a quantitative basis for evaluating anatomical variation and interpreting ultrasound findings. Nevertheless, differences in thyroid size cannot be attributed exclusively to age or biological sex because anthropometric characteristics, iodine nutrition, population background, and measurement methods also influence volumetric assessment. This narrative review examines selected primary studies addressing ultrasound-based thyroid morphometry, demographic variation, and population-specific reference values. Relevant publications were identified through targeted searches and synthesized qualitatively without statistical pooling. The reviewed evidence indicates that males frequently exhibit greater unadjusted thyroid volume than females; however, body size explains part or, in some populations, most of this difference. Associations between age and thyroid volume vary across populations and do not support a universally applicable pattern of enlargement with advancing age. Recent investigations emphasize reference values incorporating individual anthropometric characteristics and population context. Standardized ultrasound protocols and locally validated reference intervals are therefore essential for reliable assessment. Future anatomical investigations should evaluate total gland volume, individual lobe dimensions, and isthmus thickness as distinct outcomes while accounting for potential confounding factors.

Keywords: thyroid gland, morphometry, anatomical variation, ultrasonography, thyroid volume, age, sex differences, body surface area.

Introduction

Thyroid gland morphometry involves the quantitative assessment of gland dimensions and volume. It provides an approach to describing anatomical variation in living populations and supports comparisons between demographic groups. Ultrasound-based volumetry has become an established research method because it permits estimation of thyroid size from measurable linear dimensions. The validation work of Brunn and colleagues contributed substantially to the development of this approach by comparing ultrasound-derived estimates with directly measured cadaveric thyroid volumes (1).The interpretation of thyroid morphometric findings requires consideration of the relationships among age, sex, and body size. Although larger average thyroid volumes have been reported in males, such differences do not necessarily indicate an independent effect of biological sex. In an early population study, Hegedüs and colleagues demonstrated that body weight was more strongly associated with thyroid volume than age and explained the observed difference between male and female participants (2). This finding illustrates the importance of distinguishing unadjusted demographic comparisons from associations that remain after anthropometric adjustment.Population characteristics further complicate the establishment of universal anatomical reference values. Investigations conducted in France and Spain reported relationships between thyroid volume, demographic variables, anthropometric characteristics, and

iodine-related factors (3, 4). More recent studies in China and Germany have developed reference approaches that account for individual characteristics rather than relying exclusively on fixed sex-specific thresholds (5, 6). These findings suggest that thyroid size should be interpreted within an appropriate demographic and environmental context.The purpose of this review is to examine published evidence concerning age- and sex-related variation in thyroid gland morphometry, evaluate the influence of anthropometric and population factors, and identify methodological considerations for future anatomical research.

Materials and Methods

This study was designed as a focused narrative review of published primary research. It did not involve recruitment of participants, acquisition of new ultrasound measurements, or analysis of individual patient records. Targeted web searches were performed on October 1, 2026, using combinations of the terms “thyroid volume,” “thyroid morphometry,” “age,” “sex,” “ultrasonography,” “body weight,” “body surface area,” and “reference values.”Publications were assessed through accessible abstracts or full texts available on PubMed, PubMed Central, and journal websites. Selection emphasized studies that directly addressed ultrasound volumetric methodology, demographic differences in thyroid size, or the development of population-specific reference values. Foundational methodological research was considered alongside more recent population investigations. Commercial calculators and general health information websites were not used as scientific evidence.Six primary studies were selected for qualitative synthesis. Information extracted from these publications included population characteristics, volumetric methods, associations with age and sex, anthropometric determinants, and the interpretation of reference intervals. The findings were compared descriptively because the studies differed in population composition, iodine context, selection criteria, and statistical methods. No meta-analysis, pooled effect estimate, or newly calculated significance test was performed.The review primarily concerns total ultrasound-estimated thyroid volume. Individual lobe dimensions and isthmus thickness are discussed as relevant research outcomes, but separate reference intervals for these measurements were not established. Because the search was focused and non-exhaustive, the article should be interpreted as a narrative synthesis rather than a systematic review.

Results

Brunn and colleagues investigated the accuracy of ultrasound-based thyroid volumetry by comparing estimated lobe volumes with direct measurements obtained from cadaveric specimens. Their work proposed an optimized correction coefficient of 0.479 for calculating volume from three perpendicular lobe dimensions (1). According to this approach, lobe volume is estimated using the following equation:

$$V_{\mathrm{lobe}}=L\times W\times D\times0.479$$

In this equation, (L), (W), and (D) represent lobe length, width, and depth in centimetres, respectively, and the calculated volume is expressed in millilitres. The formula approximates the lobe as a geometric structure rather than reproducing its precise anatomical contours. Consequently, the coefficient and measurement protocol should be reported when comparing findings across studies.

Several reviewed studies identified greater unadjusted thyroid volume in males than in females. Hegedüs and colleagues reported mean volumes of 19.6 ± 4.7 mL in males and 17.5 ± 4.2 mL in females. Although the difference was statistically significant, the investigators concluded that differences in body weight explained the observed sex-related variation in their sample (2).

Maravall and colleagues also reported larger thyroid volumes in males within a healthy Spanish reference population. Mean volume was 9.87 mL in men and 6.57 mL in women (4). These values were substantially lower than those reported by Hegedüs and colleagues, demonstrating that a similar direction of sex differences can coexist with considerable variation in absolute gland size across populations. The comparison therefore supports cautious interpretation of demographic differences and discourages the assumption that a single mean value represents all healthy adults.The reviewed evidence did not identify a uniform relationship between chronological age and thyroid volume. Hegedüs and colleagues reported a positive association with age, although the contribution of body weight was stronger (2). In the Spanish investigation, thyroid volume differed between male age groups, with lower values in the younger group (4).By contrast, the French SU.VI.MAX study found a negative association between age and thyroid volume among women (3). These differing observations indicate that age-related variation depends on the population studied and the accompanying anthropometric and environmental characteristics. They do not justify a general conclusion that thyroid volume invariably increases or decreases throughout adult life.

The French study included 2,987 adults without previous or current thyroid disease. Thyroid volume was positively associated with weight, height, body mass index, and body surface area in both sexes. The investigators also identified associations with urinary iodine and thiocyanate measurements, illustrating the importance of interpreting anatomical findings alongside environmental and nutritional factors (3).Lin and colleagues developed reference intervals in a Chinese population and reported sex-stratified ranges of 3.92–19.06 mL for males and 3.10–16.17 mL for females. Their analysis identified body surface area as an important factor influencing thyroid volume (5). These findings support the use of anthropometric information when interpreting measurements within the population for which the reference values were developed.A German study published in 2025 analyzed 11,549 individuals and used a thyroid-healthy reference population of 8,606 participants to develop individualized equations. These equations incorporated age, body weight, and height. Compared with established fixed cut-offs, their application reduced the proportion classified as having goitre from approximately 34% to 7% (6). This change demonstrates the influence of reference methodology on classification, while leaving the applicability of these equations to other populations dependent on further validation.

Discussion

The reviewed evidence indicates that thyroid morphometry should be interpreted through a combination of demographic, anthropometric, and population variables. Larger mean volumes in males are a recurrent finding, but unadjusted differences cannot establish that sex independently determines thyroid size. An appropriate analysis should examine whether the association persists after accounting for relevant measures of body size.Age-related findings require similar caution. The contrast between positive and negative associations across studies suggests that chronological age does not adequately explain thyroid volume in isolation. Moreover, a cross-sectional difference between younger and older participants is not equivalent to a documented change within the same

individuals over time. Cohort differences and exposure histories may contribute to the observed pattern. This is a methodological interpretation of the study designs and contrasting findings rather than a causal relationship established by this review.Future morphometric investigations should use a clearly defined ultrasound protocol and document how each anatomical dimension is obtained. The volumetric coefficient should remain consistent throughout data collection and analysis. When more than one operator performs examinations, a reproducibility assessment would help distinguish biological variation from measurement variation.Total volume should also be differentiated from other anatomical outcomes. Similar calculated volumes may arise from different combinations of lobe length, width, and depth. Therefore, a study intended to characterize gland morphology should analyze these dimensions separately. Isthmus thickness and lobe asymmetry may provide additional information, but their demographic associations should be evaluated directly rather than inferred from evidence concerning total volume.Statistical interpretation should distinguish descriptive comparisons from adjusted analyses. Reporting a difference between male and female group means is useful, but an assessment of independent associations requires consideration of anthropometric and other relevant variables. Likewise, age should be analyzed in a manner that permits examination of potentially non-linear relationships rather than assuming a constant change across all adult age groups.Reference values have practical consequences because they influence whether a measured gland is classified as enlarged. The contrast between the Chinese and German investigations indicates that reference intervals reflect the populations and methods from which they are derived (5, 6). This supports local validation before international values are adopted as definitive anatomical standards.For research in Uzbekistan, a useful objective would be to characterize thyroid dimensions and volume in a well-defined reference population while documenting relevant anthropometric and thyroid-related characteristics. Such an investigation could assess the suitability of existing international reference approaches. The present review does not establish normal values for the Uzbek population or demonstrate that any particular foreign interval is appropriate locally.

This review was based on a focused search and a limited selection of primary studies. It did not apply a formal risk-of-bias assessment or include all potentially relevant publications. Some information was evaluated through abstracts rather than complete articles. Differences in study populations and measurement protocols restrict direct comparison of absolute values.The evidence is predominantly observational and cannot establish causal effects of age, sex, or environmental exposure on gland morphology. Furthermore, the emphasis on total volume limits conclusions concerning isthmus anatomy, lobe shape, and asymmetry. These outcomes require dedicated investigation.

Conclusion

Thyroid gland morphometry exhibits demographic variation, but age and sex should be interpreted in conjunction with body size, population characteristics, and measurement methodology. Males frequently have larger unadjusted thyroid volumes, although anthropometric differences explain part of this association. Age-related patterns vary across populations and do not support a universal trajectory of adult thyroid enlargement.

Reliable anatomical assessment requires standardized ultrasound measurements and appropriately validated reference values. Future investigations should evaluate individual anatomical dimensions alongside total gland volume and distinguish demographic associations

from the influence of confounding factors. Population-specific research would provide a stronger basis for interpreting thyroid morphometry in local clinical and academic settings.

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