Sonographic Determination of Thyroid Gland Volume among Apparently Healthy School-aged Children in Northern Nigeria

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Abstract

Introduction: The establishment of normative thyroid volumes for school-aged children is pivotal for accurate assessments of thyroid health, especially in regions impacted by iodine-related interventions. This study aimed to determine the normal thyroid gland volume in apparently healthy school-aged children within Kano metropolis using ultrasonography. **Materials and Methods:** A cross-sectional and prospective study enrolled 276 randomly selected school children. Ultrasonography, facilitated by a 7.5 MHz linear probe-equipped machine, assessed thyroid volume alongside the collection of demographic data (age, height, and weight). Statistical analysis employed the Statistical Package for the Social Sciences (SPSS) version 21, with significance set at $P < 0.05$. **Results:** The findings revealed a total thyroid gland volume (TTGV) of 1.9 ± 0.5 cm^3, with no statistically significant gender-based differences observed. Interestingly, the mean right lobe volume (1.1 ± 0.3 cm^3) was significantly larger than the left lobe volume (0.9 ± 0.3 cm^3) with $P = 0.001$. Furthermore, positive correlations were noted between overall thyroid gland volume and factors such as age, height, weight, and body surface area. **Conclusion:** This study establishes the normative thyroid gland volume for school-aged children in the Kano metropolis, emphasizing the correlation primarily with age. These findings serve as a vital reference for accurate thyroid assessments in this population. The identified correlations between thyroid volume and demographic factors underscore the importance of considering these variables in thyroid health evaluations.

Keywords: School-aged children, thyroid gland, thyroid volume, ultrasonography

Introduction

The thyroid is a butterfly-shaped gland in the front of the neck that crosses the trachea.[1,2] It orchestrates the production of thyroxine and triiodothyronine the two essential hormones that play a crucial role in various physiological processes. Thyroid health is of paramount importance, particularly during childhood and adolescence. The thyroid hormones mainly act by increasing the basal metabolic rate and stimulating growth in children, pivotal stages for growth, development, and metabolic regulation.[3-5] Dysfunctions in thyroid health during childhood can significantly impact overall well-being, cognitive development, and metabolic homeostasis.[6]

Thyroid disorders encompass a spectrum of conditions, ranging from hypothyroidism and hyperthyroidism to structural irregularities such as goiter, nodules, and thyroid cancer.[7] Precise measurement of the thyroid gland volume through noninvasive and nonionizing imaging methods, such as ultrasound, is fundamental in assessing structural anomalies and deviations that could signify underlying thyroid pathologies.[8]

In the context of Kano metropolis, a region marked by unique socioeconomic and environmental characteristics, examining

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thyroid gland volume among school-aged children is particularly relevant. However, it is crucial to recognize a significant temporal gap since a similar study was conducted a decade ago by Suwaid *et al*.[9] Over the past decade, there may have been significant changes in dietary habits, lifestyle, socioeconomic factors, and even iodine supplementation programs. These changes could have had a notable impact on thyroid health and thyroid gland volume among school-aged children. A new study can capture these current dynamics and provide updated and relevant information. These transformations may influence the prevalence and presentation of thyroid conditions among the pediatric population in the Kano metropolis.

This study aims to address the temporal and knowledge gaps left by the previous study by utilizing modern sonographic techniques to measure thyroid gland volume in apparently healthy children within this region. Through this research, we intend to provide up-to-date, specific, and locally relevant information regarding thyroid gland size. These data will contribute to a more accurate understanding of thyroid volume in the studied population and serve as a foundation for enhancing pediatric thyroid healthcare initiatives.

Materials and Methods

The study was cross-sectional and involved sonographic evaluation of thyroid volume among school-aged children in Kano metropolises from October 2022 to September 2023. Ethical approval to conduct the study was obtained from the Human Research and Ethics Committee, Ministry of Health, Kano and State Universal Basic Education Board, Kano, with approval number (NHREC/17/03/2018). Assent was obtained from the pupil's parent through the school management. Their consent for the children to participate as participants in the study was strictly voluntary and has the right to withdraw from the study at any time they wish. They were also informed of the confidentiality of the data that were obtained from them. The sample size for this study was calculated using Taro Yamane's formula. The procedures used follow the guidelines laid down in the Declaration of Helsinki. The formula is presented as follows:

$$n = \frac{N}{1 + N \times (e)^2} \text{ [10]}$$

where n = sample size

N = population: the overall population of children 6–11 years in Kano according to the census 2006 was 3,322,489[11]

e = allowable error (%): there is no concrete objective method of choosing allowable error. It all depends on the resources, time, and availability of data for the researcher.[12,13] The allowable error (%) for this study will be considered at 6.01% (0.0601) considering the stipulated time frame and resources of the researcher.

Substitute numbers into the formula: $N = \dfrac{3322489}{1 + 3322489 \times (0.0601)^2}$

n = 276.

After calculating the sample size by substituting the numbers into Yamane's formula, the numbers of the sample size used for this study was 276. A simple random sampling technique was used to obtain the desired sample size. The study included only healthy school-age children within 6–11 years with no history of any pathological condition affecting the thyroid gland. The study excluded subjects below the age of 6 years and above 11 years and those that have a history of any pathological conditions or were detected during the scanning. Their height was measured in meters (m) using a 214 cm portable stadiometer, model: HM01, their weight was measured in kilograms using Baron fitness and general merchandise weight measuring scale. However, body mass index (BMI) and body surface area (BSA) were also calculated using the following formulas:

$$\text{BMI (kg/m}^2) = \frac{\text{Weight}}{\text{Height}^2} \text{ [14]}$$

$$\text{BSA (m}^2) = \sqrt{\frac{(\text{Height}(\text{cm}) \times \text{Weight (kg)}}{3600}} \text{ [15]}$$

All participants were examined in a supine position with a pillow under their shoulders to hyperextend their necks. The examiner stood on the right side of the subjects. A suitable amount of ultrasound gel was applied to the midpoint of the neck. The linear probe was then gently placed directly on the skin over the thyroid gland sliding in a transverse plane from the breastbone to the hyoid bone until the thyroid tissue was identified and then frozen. From the frozen transverse image, the width of each lobe was obtained. From the transverse plane, the probe was medially rotated to 90° to the longitudinal plane the length and height (anteroposterior dimensions) of each lobe were obtained in cm, as shown in Figure 1. Thyroid volume was calculated by measuring each thyroid lobe and adding together the size of lobes calculated using the formula of an ellipsoid:

Volume = Length × width × height h × (0.52)[16]

All measurements obtained were recorded in a data capture sheet. Both descriptive and inferential statistics were used to analyze the data. The data were tested for parametric assumptions, both Shapiro–Wilk and Kolmogorov–Smirnov test results were greater than 0.05, and the skewness was between −0.5 and 0.5 in all the data, thus the parametric method of data analysis was used. Frequency, mean, standard deviation (SD), and range were obtained with descriptive statistics. An independent *t*-test was used to compare male and female thyroid gland volume. Pearson correlation coefficient was used to determine the relationship of thyroid gland volume

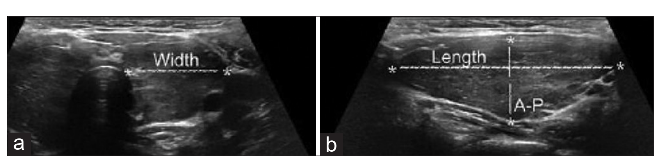

Figure 1: Transverse (a) and longitudinal (b) dimensions of the thyroid gland

with age, weight, height, BMI, and BSA. All statistical analysis was carried out using the SPSS version 23 (IBM SPSS, Version 23.0. Armonk, NY: IBM Corp). The statistical significance level was considered at ≤0.05 ($P \leq 0.05$).

Results

The study comprised 276 participants, involving 162 (58.7%) males and 114 (41.3%) females, as indicated in Table 1. The participant's ages ranged from 6 to 11 years, and those between the ages of 10 and above had the highest participation, as shown in Table 2.

The mean, SD, and ranges based on gender distribution are highlighted in Table 3.

The thyroid dimensions increased progressively with increased age. Participants within the age of 6 years had the lowest volumes while those within the age of 11 years had the highest volumes, as shown in Table 4.

There was no statistically significant difference in the TTV between the boys and girls participants with $P = 0.71$; however, a statistically significant difference was noticed between the right and left thyroid volumes with $P = 0.0001$, as indicated in Tables 5 and 6, respectively.

A moderate positive correlation was seen between the thyroid gland volume with age, height, weight, and BSA while a weak positive correlation was seen with BMI, as indicated in Table 7.

Discussion

The study encompassed a cohort of 276 participants, with a higher representation of boys (162 individuals, 58.7%) compared to girls (114 individuals, 41.3%), as outlined in Table 1. While the current study involved a substantial sample size, it is noteworthy that some prior research, such as that by Suwaid *et al*.,[9] Idigo *et al*.,[17] Marchie *et al*.,[18] and Taş *et al*.,[19] included larger participant groups, while others, like Kim *et al*.,[20] had a smaller sample size. These variations in sample size might impact the study's statistical power and the precision of estimates. The participants were recruited randomly, displaying diverse age distributions, as demonstrated in Table 2. Notably, studies conducted by Suwaid *et al*., Marchie *et al*., and Kim *et al*.[9,18,20] showed similar age distributions to the current study. Conversely, the studies by Idigo *et al*.[17] and Taş *et al*.[19] differed significantly, including participants spanning from neonates to adolescents, thereby diverging from the age range focused on in the present study. A comparison of demographic variables such as mean age, height, weight, BMI, and BSA in Table 3 revealed similarities between the current study and that of Kim *et al*.[20] This similarity may stem from the aligned age specifications in both studies. In contrast, studies by Suwaid *et al*., Marchie *et al*., and Kim *et al*.[9,18,20] did not report these demographic characteristics. Analysis of thyroid gland volume dimensions across different age groups shows a progressive increase in thyroid dimensions with advancing age, as highlighted in Table 4. Notably, findings from Idigo *et al*. and Marchie *et al*.[17,18] corroborated this trend, while other studies showed higher values, potentially influenced by factors such as geographical location, anthropometric parameters, and diet variations. The mean TTG of participants in the current study aligned with the values reported by Idigo *et al*.[17] and Kim *et al*.[20] differing from the results obtained by Suwaid *et al*.,[9] Marchie *et al*.,[18] and Taş *et al*.,[19] as shown in Table 5. Differences might be attributed to iodine content in dietary intake, possibly reflecting recent advancements in iodine availability due to increased awareness following the WHO campaigns. Contrary to various studies reporting gender-based differences in thyroid volume, the current study found no statistically significant difference between boys and girls participants in TTV, as shown in Table 5. This contradicted findings from Suwaid *et al*.,[9] Marchie *et al*.,[18] Kim *et al*.,[20] and Aminu *et al*.[21] The absence of statistically significant gender-based differences in total thyroid gland volume (TTV) within the current study could be multifactorial. Variations in sample characteristics, such as demographic composition, ethnic diversity, and geographical location, may lead to diverse thyroid volume patterns between boys and girls. Hormonal variations, including estrogen and testosterone levels, along with differences in iodine intake and nutritional status, may contribute to thyroid development disparities among studied populations. However, consistent with previous research, the volume of the right thyroid lobe was significantly larger than the left lobe for both genders, as shown in Table 6, corroborating findings from Suwaid *et al*., Marchie *et al*., and Kim *et al*.[9,18,20] This discrepancy in lobe size might be attributed to the position of the esophagus, commonly deviated to the left, allowing more space for growth in the right lobe. Correlations between thyroid gland volume and age, height, weight, and BSA displayed moderate positive associations, consistent with Suwaid *et al*. and Marchie *et al*.[9,18] Conversely, BMI exhibited a weak positive correlation with TTGV, diverging from findings in Suwaid *et al*. and Marchie *et al*.,[9,18] emphasizing the multifaceted nature of factors influencing thyroid gland volume in school-aged children, encompassing ethnicity, environmental aspects, and

Table 1: Frequency distribution based on gender

Gender	Frequency, *n* (%)
Male	162 (58.7)
Female	114 (41.3)
Total	276 (100)

Table 2: Frequency distribution based on age

Age (years)	Frequency, *n* (%)
6	58 (21)
7	36 (13)
8	28 (10.1)
9	28 (10.1)
10	49 (17.8)
11	77 (27.9)

Table 3: Demographic information based on age distribution

Age	Boys (n=162)				Girls (n=114)			
	Height	Weight	BMI	BSA	Height	Weight	BMI	BSA
6	1.1±0.5 (1.0–1.3)	19.2±1.7 (15.0–23.0)	15.4±1.3 (13.4–18.5)	0.8±0.0 (0.7–0.9)	1.1±0.8 (1.0–1.3)	18.1±3.9 (12.5–26.0)	14.1±2.1 (10.5–16.6)	0.8±0.1 (0.6–0.9)
7	1.18±0.05 (1.10–1.26)	21.62±1.78 (19.0–24.0)	15.50±1.00 (14.37–17.39	0.84±0.52 (0.78–0.92	1.211±0.5 (1.15–1.31)	22.32±2.1 (18–26)	15.22±1.1 (11.9–16.38)	0.86±0.52 (0.78–0.95)
8	1.27±0.51 (1.18–1.36)	23.86±3.06 (21.00–30.00)	14.85±1.07 (13.43–16.22)	0.914±0.73 (0.83–1.06)	1.29±0.67 (1.18–1.38)	24.14±4.01 (19–32)	14.37±1.39 (0.79–1.11)	0.93±0.96 (0.79–1.11)
9	1.29±0.39 (1.24–1.35)	24.67±2.95 (20.00–30.00)	15.31±1.63 (13.01–19.20)	0.96±0.06 (0.83–1.02)	1.28±0.4 (1.24–1.33)	26±2.4 (23–39)	15.74±0.71 (14.88–16.39)	0.96±0.59 (0.89–1.04)
10	1.32±0.44 (1.26–1.39)	27.05±2.83 (23.00–34.00)	15.54±1.25 (13.46–18.66)	0.99±0.06 (0.9–1.13)	1.29±0.6 (1.22–1.4)	23.33±2.41 (21–30)	14.05±1.34 (11.87–15.75)	0.91±0.61 (0.84–1.08)
11	1.37±0.49 (1.28–1.45)	30.52±3.31 (25.0–38.0)	16.15±1.27 (14.08–18.66)	1.08±0.07 (0.95–1.24)	1.35±0.1 (1.2–1.44)	27.37±3.92 (21–34)	15.02±1.42 (12.07–17.6)	1.01±0.91 (0.86–1.17)

Table 4: Thyroid volume based on age distribution and comparison of total gland volume between male and female gender

Age	Boys (n=162)			Girls (n=114)		
	Mean RLV	Mean LLV	Mean TTV	Mean RLV	Mean LLV	Mean TTV
6	0.89±0.21 (0.44–1.21)	0.72±1.96 (0.42–1.00)	1.61±0.41 (0.86–2.21)	0.85±0.24 (0.40–1.23)	0.69±0.18 (0.37–0.98)	1.54±0.411 (0.77–2.08)
7	0.95±0.21 (0.71–1.40)	0.76±0.18 (0.58–1.07)	1.72±0.37 (1.29–2.47)	0.85±0.17 (0.62–1.11)	0.72±0.19 (0.51–1.08)	1.57±0.34 (1.13–2.04)
8	1.02±0.32 (0.66–1.70)	0.94±0.36 (0.47–1.69)	1.96±0.66 (1.13–3.39)	0.90±0.29 (0.58–1.44)	0.74±0.21 (0.49–1.08)	1.64±0.49 (1.07–2.52)
9	1.08±0.25 (0.76–1.45)	0.86±0.19 (0.54–1.09)	1.93±0.40 (1.30–2.44)	0.97±0.23 (0.63–1.26)	0.88±0.30 (0.53–1.39)	1.85±0.52 (1.16–2.65)
10	1.14±0.21 (0.89–1.69)	0.92±0.24 (0.60–1.44)	2.06±0.41 (1.57–3.09)	1.13±0.43 (0.62–1.73)	1.13±0.43 (0.45–1.69)	2.29±0.71 (1.07–3.11)
11	1.24±0.21 (0.75–1.67)	1.02±0.24 (0.62–1.53)	2.23±0.42 (1.37–3.20)	1.26±0.28 (0.71–1.69)	1.08±0.27 (0.55–1.58)	2.33±0.49 (1.26–3.2)

RLV: Right thyroid lobe volume, LLV: Left thyroid lobe volume, TTV: Total thyroid gland volume

Table 5: Comparison of total thyroid gland volume between male and female genders

Variables	Boys (n=162)	Girls (n=114)	P
TTV (cm^3)±SD	1.9±0.5	1.9±0.5	0.71

TTV: Total thyroid gland volume

Table 6: Comparison of the mean total right and left thyroid lobes

Variables	RTV	LTV	P
Thyroid volumes (cm^3)	1.1±0.3	0.9±0.3	0.001

RTV: Right thyroid volume, LTV: Left thyroid volume

Table 7: Relationship of thyroid gland volume with anthropological parameters

Variables TTV (cm^3)	Age (years)	Height (m)	Weight (kg)	BMI (kg/m^2)	BSA (m^2)
r	0.528	0.44	0.503	0.298	0.501
P	0.0001	0.0001	0.0001	0.0001	0.0001

BMI: Body mass index, BSA: Body surface area, TTV: Total thyroid gland volume

various anthropometric variables. The current study's findings contribute valuable insights into thyroid gland volume among school-aged children, highlighting nuanced associations with age, anthropometric parameters, gender-related differences, and lobe dimensions. However, further investigations encompassing diverse populations and considering additional influencing factors are warranted to comprehensively elucidate the determinants of thyroid gland volume in this demographic.

Conclusion

This study has successfully established normative thyroid gland volume values for school-aged children in the Kano metropolis. The mean total thyroid gland volume (TTGV) was determined to be 1.9 ± 0.5 cm^3, with no statistically significant differences between male and female participants (P = 0.71). However, the right thyroid lobe volume (1.1 ± 0.3 cm^3) was significantly larger than the left lobe volume (0.9 ± 0.3 cm^3) with P = 0.001. Positive correlations were observed between thyroid gland volume and demographic factors such as age (r = 0.528), height (r = 0.44), weight (r = 0.503), BSA (r = 0.501), and a weaker correlation with BMI (r = 0.298), all statistically significant at P = 0.0001. These findings underscore the influence of age and other anthropometric factors on thyroid volume, serving as a critical reference for evaluating thyroid health in this population. The study also highlights the importance of considering demographic and physiological factors when interpreting thyroid ultrasound measurements. These data contribute significantly to improving the understanding of pediatric thyroid health and can inform healthcare policies and iodine supplementation strategies in Northern Nigeria.

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Conflicts of interest

There are no conflicts of interest.

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