Sonographic Determination of Thyroid Gland Volume among Patients with Type 2 Diabetes Mellitus in Northern Nigeria

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Abstract

Background: Thyroid disease and type 2 diabetes mellitus (T2DM) are interconnected endocrine disorders with a bidirectional relationship. T2DM patients may present with various thyroid abnormalities, such as gland enlargement and nodule formation, warranting noninvasive assessment through ultrasound scanning. **Aim:** This cross-sectional study aimed to evaluate thyroid gland volume (TGV) in adult patients with T2DM using ultrasound imaging in Kano. **Materials and Methods:** A total of 160 participants were randomly selected and underwent sonographic scans of the thyroid gland using a medical ultrasound machine with a 7.5 MHz linear probe. Thyroid volumes were recorded, and demographic information was collected. Statistical analysis was performed using the SPSS software version 29, with significance set at $P < 0.05$. **Results:** The mean TGV ± standard deviation was 5.8 ± 3.1 cm^3. Females exhibited a statistically higher TGV (6.1 ± 3.4 cm^3) compared to males (5.6 ± 2.8 cm^3). There was no significant difference in TGV among patients with different diabetes control habits. The mean volume of the right lobe (3.1 ± 1.8 cm^3) was significantly greater than that of the left lobe (2.7 ± 1.6 cm^3). TGV correlated positively with T2DM duration, age, weight, and body mass index. **Conclusion:** This study provides valuable insights into the TGV among patients with T2DM in Kano. The findings indicate a positive correlation between TGV and T2DM duration and demonstrate gender and laterality differences. Ultrasound-based assessment of thyroid volume can be a valuable tool in monitoring thyroid health in T2DM patients and may aid in the early detection and management of thyroid abnormalities.

Keywords: Kano, thyroid gland, thyroid volume, type 2 diabetes mellitus, ultrasound

Introduction

The thyroid gland originates from the primitive pharynx and the neural crest. It is derived from the first and second pharyngeal pouches.[1] The thyroid gland is an endocrine gland situated anteriorly in the neck on either side of the trachea; it consists of two lateral lobes connected in the middle by an isthmus.[2] Anthropological factors such as age, gender, weight, height, body mass index (BMI), waist-to-hip ratio, lean body mass, and body surface area (BSA) all affect the thyroid gland volume (TGV) in normal individuals.[3] Physiological factors such as reproductive state, blood group, and hormonal changes also affect TGV.[4] Socioeconomic factors such as dietary iodine intake, consumption of excess goitrogens, smoking, alcohol consumption, and differences in geographical locations affect the TGV in normal individuals.[5] Pathological conditions that affect the TGV include thyroid disorders, tumors associated with the pituitary gland and hypothalamus, autoimmune syndromes, altered blood pressure, and diabetes.[6]

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Over time, diabetes mellitus (DM) can damage the heart, vascular system, eyes, kidneys, and nerves.[4] Thyroid hormones affect glucose metabolism through several mechanisms. Hyperthyroidism has long been recognized to promote hyperglycemia.[4] Patients with DM have an increased risk of developing disorders that might affect the thyroid volume.[4] In the general population, approximately 6% have some forms of thyroid disorder.[7] However, the prevalence of thyroid disorder increases to over 10% in patients with DM.[7]

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Since patients with the one form of an autoimmune disorder have an increased chance of developing other autoimmune disorders, patients with type 1 DM (T1DM) have a higher risk of autoimmune thyroid disorder.[8] Although type 2 DM (T2DM) is not an autoimmune disorder, there have been many reports showing a higher occurrence of thyroid diseases, particularly hypothyroidism, among patients with T2DM. The association between T2DM and thyroid disorder, however, remains unexplained.[8]

The imaging modalities used for the evaluation of the thyroid gland include sonography, plain radiography, radionuclide scan, computed tomography (CT), magnetic resonance imaging (MRI), and elastrography.[9] Although CT and MRI provide details with high resolution, CT examinations require the use of ionizing radiation. MRI is expensive and requires a relatively long scan time. Nuclear medicine studies are not readily available and require the use of radioisotopes and elastrography.[9] Sonography, on the other hand, is cheap, radiation-free, readily available, easy to perform, and a noninvasive method to image the thyroid gland, hence its use in this resource-limited setting.[3]

In Spain, a study conducted by Gómez *et al*.[10] concluded that T1DM patients had larger thyroid volumes compared with healthy controls with similar anthropometry. Nduka and Adeyekun[11] conducted a similar study in Nigeria; the result of their study shows that the total TGV in all DM subjects was significantly higher than that of controls. To avoid misdiagnosis, TGV should be established in normal subjects and in disease conditions that might affect the volume such as DM. A reference TGV among apparently healthy adults was established by Aminu *et al*.[5] to be 7.6 $cm^3 \pm 1.3$ in Kano, Nigeria. Literature searches have shown that the nomograms of thyroid volume among adult diabetic patients in our locality (Kano, Nigeria) are yet to determined. Reference values used are either that of healthy individuals or borrowed values from other regions despite the recommendations of the WHO for the establishment of regional TGV for the diseases that affect the TGV such as DM, for improved accuracy of the diagnosis. The establishment of TGV will guide clinicians, radiologists, and radiographers in diagnosing, managing, and treating such patients. This study was aimed at evaluating TGV among adult patients with DM in Kano metropolis using ultrasound imaging.

Materials and Methods

This study was prospective and cross-sectional in design to determine the TGV among adult patients with T2DM diabetes mellitus in the Kano metropolis using ultrasound imaging. The study was conducted at Aminu Kano Teaching Hospital. Ethical approval to conduct this study was obtained from the Health Research Ethics Committee of Bayero University Kano and the Kano State Ministry of Health. Consent was obtained from all the participants. They were informed that their consent to participate as participants in the study were strictly voluntary and have the right to withdraw from the study at any time they wished. They were also informed of the confidentiality of the data that were obtained from them. The sample size for this study was calculated using the Taro Yamane formula with a confidence interval of 95%. The formula is presented as follows:

$$n = \frac{N}{1 + N \times (e)^2}$$ [12]

Where:

n = sample size

N = population

e = allowable error (%)

N = Overall pooled prevalence of DM in Nigeria was 5.77%.[13] The population of Kano Metropolis as projected in 2022 was 4,219,000.[14] The projected population of Kano inhabitants with DM is 243,000.

e = There is no concrete objective method of choosing allowable error. It all depends on the resources, time, and availability of data for the researcher.[15] The allowable error (%) for this study was considered at 8% (0.08), considering the stipulated time frame and resources of the researchers.

Substitute numbers into the formula:

$$n = \frac{243,000}{1 + 243,000 \times (0.08)^2} = n = 156$$

After calculating the sample size by substituting the numbers into Yamane's formula, the numbers of the sample size used for this study were rounded to 160. A simple random sampling technique was used to select the samples from the population. This study included only adult subjects with T2DM diabetes mellitus. All non-DM subjects, subjects with DM forms other than T2DM, subjects with known overlying thyroid disorders and/or on thyroid medication, subjects with palpable thyroid, visible neck mass, or any form of malignancy; those with chronic renal or liver disease and sickle cell anemia, pregnant women and women on contraceptive drugs, and pediatric were all excluded from the study. A glucometer (ACCU-CHECK Active. Mannheim, Germany) was used to determine the participant's blood sugar concentration. The participants were interviewed face to face where their demographic information such as age and gender was obtained. The duration of DM was also recorded. A stadiometer (214 cm portable stadiometer, model: HM01) was used to measure the height in meters (m). Their weight was measured in kilograms (kg) using a weighing scale (Baron Fitness and General Merchandise). They all removed their caps and shoes and emptied their pockets before their height and weight were measured. The age, gender, duration of DM, weight, height, and blood sugar concentration were recorded on a data capture sheet. BMI and BSA were calculated using the following formulas:

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

$$\text{BSA (m}^2\text{)} = \sqrt{\frac{(Height(cm)\ X\ Weight(kg))}{3600}}$$

NORTEK CS 3 ultrasound equipment fitted with a 7.5 MHz linear probe was used for scanning the thyroid gland. All participants were examined in a supine position with a pillow under their shoulders to hyperextend their necks. The examiners stood on the right side of the subject. 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 to obtain the depth and the length for each lobe in centimeter. Thyroid volume was calculated by measuring each thyroid lobe and adding together the size of lobes calculated using the formula of an ellipsoid:

$$\text{Volume} = \text{length}(l) \times \text{width}(w) \times \text{height}(h) \times \frac{\pi}{6}(0.52).$$

[16] The data were initially recorded using a data capture sheet which was then entered into an Excel worksheet and imported to SPSS version 29.0 (IBM Corporation, Armonk, New York, United States) for further analysis. The data passed all the parametric assumptions and thus were analyzed with parametric statistics. The mean, standard deviation, and range of the demographic information, duration of DM, blood sugar concentration, thyroid dimensions, and volumes were analyzed using the descriptive statistics. An independent *t*-test was employed to compare differences in thyroid volume between lobes, gender, and participants with controlled and uncontrolled diabetes. The association between the variables and demographic data was obtained using Pearson's correlation coefficient. All statistical significance was set at $P < 0.05$.

Results

The mean age, height, weight, BMI, BSA, blood sugar concentration, and duration of DM of the 160 participants are demonstrated in Table 1. A statistically significant difference in height ($P = 0.00$) and BMI ($P = 0.02$) between male and female participants was seen; however, no statistically significant difference was seen between the other variables as demonstrated in Table 1.

The total mean right lobe, left lobe, and total TGV were 3.1 cm^3 ± 1.8, 2.7 cm^3 ± 1.6, and 5.8 cm^3 ± 3.1, respectively, for the whole participants, as shown in Table 2. The female's thyroid volume was statistically higher than the male's volume, as shown in Table 2.

The right lobe volume (RLV) was statistically higher than the left lobe volume (LLV) in all the participants, as shown in Table 3.

Table 4 indicates the demographic variables of participants with good and poor DM control habits. There was no statistically significant difference in TGV with DM control habit.

DM duration had the strongest correlation with TGV, as shown in Table 5.

Discussion

This study investigated and compared the thyroid dimensions and volumes between gender and DM control habit, and its

Table 1: Demographic information and comparison of participants based on gender

Demographic variables	Gender, mean±SD (range)			*P*
	Males (*n*=83; 52%)	Females (*n*=77; 48%)	Total (*n*=160)	
Age (years)	43.8±13.8 (18–65)	43.7±13.9 (20–65)	43.7±13.7 (18–65)	0.97
Weight (kg)	65.0±8.1 (50–92)	64.0±12.9 (40–109)	64.6±10.7 (40–109)	0.56
Height (cm)	168.5±7.1 (151–187)	161.9±8.1 (146–190)	165.3±8.3 (146–190)	0.00
BMI (kg/m²)	23.0±3.3 (16.5–40.3)	24.7±5.7 (14.2–42.7)	23.8±4.7 (14.2–42.7)	0.02
BSA (m²)	1.7±0.1 (1.5–2.0)	1.7±0.2 (1.4–2.2)	1.7±0.2 (1.4–2.2)	0.58
Duration of DM (years)	8.6±7.7 (1–30)	7.7±6.6 (1–30)	8.1±7.2 (1–30)	0.98
Blood sugar concentration (mmol/L)	9.1±4.2 (3.5–22.3)	8.9±3.9 (3.9–22.3)	9.0±4.0 (3.5–22.3)	0.22

BMI: Body mass index, DM: Diabetes mellitus, BSA: Body surface area, SD: Standard deviation

Table 2: Total mean thyroid gland volumes and comparison between males and females

Variables	Mean±SD (range)			*P*
	Males (*n*=83; 52%)	Females (*n*=77; 48%)	Total (*n*=160)	
RLV (cm³)	3.1±1.7 (0.7–8.8)	3.2±1.9 (0.9–10.3)	3.1±1.8 (0.7–10.3)	0.005
LLV (cm³)	2.4±1.3 (0.6–9.4)	2.9±1.8 (0.6–9.0)	2.7±1.6 (0.6–9.4)	0.027
Thyroid volume (cm³)	5.6±2.8 (1.3–17.0)	6.1±3.4 (1.6–17.2)	5.8±3.1 (1.3–17.2)	0.047

RLV: Right lobe volume, LLV: Left lobe volume, SD: Standard deviation relationship with demographic information among patients with T2DM in Kano metropolis. The mean age of the participants in the current study as indicated in Table 1 was similar to the study of Junik *et al*.[17] Gómez *et al*.[10] reported a higher mean age than the current studies. Gómez *et al*.[10] included patients with T1DM who are usually younger.

The mean weight, height, and BSA of the participants in the current study as shown in Table 1 are in close relationship with most of the previous studies.[10,11] The average recorded BMI in the current study is lower than most of the previous studies.[10,11] This might be attributed to differences in diet and geographical location. The blood sugar level reported in the current is in close relation with those reported by Hansen *et al*.[18] However, they failed to report the duration of the DM as reported in the current studies.

As observed in Table 2, the mean RLV, LLV, and TGV for both genders were lower than the volume reported by other studies.[10,11,17,19] Studies conducted recently tend to have smaller TGV; these might be attributed to more iodine availability recently. Another noticeable trend is that studies conducted in the Caucasian population tend to have higher TGV; this is also attributed to the low iodine consumption in their population probably due to increased campaigns to reduce iodinated salt intake (a major iodine source) due to the risk of hypertension.[19] Consumption of iodine is an important factor in the regulation of thyroid volume Aminu *et al*.;[5] other factors include physiological factors, smoking habits, alcohol consumption, availability of goitrogens in diet, and difference in geographical location.[5]

Table 3: Comparison of the right lobe volume and left lobe volume

	Mean±SD		*P*
	Right lobe	Left lobe	
Male TGV (cm^3)	3.1±1.7	2.4±1.3	0.011
Female TGV (cm^3)	3.2±1.9	2.9±1.8	0.050
General TGV (cm^3)	3.1±1.8	2.7±1.6	0.047

TGV: Thyroid gland volume, SD: Standard deviation

The current study focused on patients with T2DM to determine their TGV; thus, case controls were not included which will be considered one of the limitations of the study. However, a study was conducted by Aminu *et al*.[5] on apparently healthy patients in the same study location and reported a higher TGV than the current study. The possible reasons could be related to several factors such as differences in the participant's anthropometrical parameters operators as ultrasound is highly operator-dependent. Furthermore, patients recruited in the current study are on metformin which is associated with a reduction in TGV.[19]

Both the right lobe and the left lobe thyroid volume in females were significantly higher than that of males, as indicated in Tables 2 and 3. This is not in agreement with the previous studies.[10,11,17,19-21] The studies speculated that the reason for the higher TGV in males could be due to different body habitus between males and females as males tend to have larger body size than females (increased body weight and muscle mass). In this study, from the samples used, the female population had a significantly higher BMI than the males as seen in Table 1. Thus, despite the difference, this study is in agreement with the previous studies that thyroid volume increases with increased BMI.

The right thyroid lobe was significantly higher than the left lobe in both genders, as shown in Table 3. The findings are in agreement with the previous studies.[10,11,17,19-21] The smaller size of the left thyroid lobe may be related to the position of the esophagus.

Table 4 indicates that there was no statistically significant difference in thyroid volumes and dimensions with DM control habit. However, the study by Obasi and Akintomide[19] found that mean TGV was higher among people with diabetes who had poor control than those who had borderline levels of glycated hemoglobin and good control. However, at *post hoc* test, they found that the difference in TV between those with borderline control and good control was not statistically significant. This contrary observation might be due to a variation in mean blood sugar concentration between the two studies.

Table 4: Comparison of volumes of participants with both good control and poor control diabetes mellitus

Variables	Mean±SD (range)		*P*
	Good control DM (*n*=61; 38%)	Poor control DM (*n*=99; 62%)	
RLV (cm^3)	3.2±1.8 (0.7–8.3)	3.1±1.8 (0.9–10.3)	0.636
LLV (cm^3)	2.7±1.7 (0.6–9.0)	2.6±1.5 (0.6–9.4)	0.494
Thyroid volume (cm^3)	5.9±3.2 (1.3–15.2)	5.8±3.1 (1.5–17.2)	0.513

SD: Standard deviation, DM: Diabetes mellitus, RLV: Right lobe volume, LLV: Left lobe volume

Table 5: Correlation between thyroid volumes with demographic variables

TGV (cm^3)	Age	Height	Weight	BMI	BSA	DM duration	Blood sugar concentration
r	0.224	−0.121	0.235	0.274	0.179	0.510	−0.025
P	0.004	0.126	0.003	0.000	0.023	0.050	0.755

TGV: Thyroid gland volume, BMI: Body mass index, DM: Diabetes mellitus, BSA: Body surface area

There was a weak positive correlation between TGV and age in this study as shown in Table 5. This is not in conformity with studies conducted elsewhere that found no correlation with age.[10,11,17,19] Although Aminu *et al*.[5] conducted a study on apparently healthy adults, it was also reported that a positive correlation exists between TGV and age in the same study location as the current study. Mean thyroid volume correlates positively with weight and BMI in the current study, as shown in Table 5. This is in agreement with a study conducted by Gómez *et al*.[10] in Spain. Studies conducted by Nduka and Adeyekun[11] and Obasi and Akintomide[19] in other parts of Nigeria found no correlation with either weight or BMI. The variation in findings might be attributed to the difference in geographical locations and ethnicity of the participants; hence, the need to establish local reference volumes in both normal and diabetic patients. DM duration had a positive moderate correlation with TGV. Thyroid volumes increase steadily with the increasing duration of diabetes as reported by Obasi and Akintomide.[19] Gómez *et al*.[10] reported the strongest correlation with fat-free mass which was not considered in this study, whereas Nduka and Adeyekun[11] reported the best correlation between height and weight. These variations are probably associated with differences in other study parameters and locations.

There was no correlation observed between TGV with height, BSA, and blood sugar concentration, as shown in Table 5. These findings are in agreement with the study conducted by Nduka and Adeyekun[11] in Nigeria. Gómez *et al*.[10] reported a positive correlation between TGV with height and BSA; however, the study was conducted in Spain.

Conclusion

TGV among patients with T2DM in Kano metropolis was determined and correlated best with DM duration. The volume was significantly higher in female than male participants. The right volume was significantly higher than the left volume.

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Conflicts of interest

There are no conflicts of interest.

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