Determination of Normal Thyroid Gland Volume On Ultrasound In Normal Adults In Jos, North Central Nigeria.

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Abstract- AIM AND OBJECTIVES: This study was done to establish a standard ultrasonographic measurement of the thyroid gland volume in normal adults in Jos University Teaching Hospital.

Background: The thyroid gland is one of the largest endocrine glands in the body weighing about 10-25g. It regulates the rate of metabolism, the growth and rate of function of many other systems in the body. These it does, by producing thyroid hormones, principally thyroxine (T_4) and triiodothyronine (T_3). The accurate estimation of the size of the thyroid is very important for the evaluation and management of thyroid disorders. Thus, knowing the normal size in a geographic location would form a baseline for detecting abnormalities. Ultrasonography is a cheap, readily available, easy to perform and non-invasive method to image the thyroid gland, hence its use in this resource limited setting**.**

METHODOLOGY: This is a cross sectional study of sonographic measurement of thyroid gland volume on 400 normal (healthy) adults in Jos, Plateau State, Northern part of Nigeria. All examinations were performed using LOGIC 5, a real-time ultrasound machine using a 10MHZ linear transducer and ultrasound transmission gel to act as a coupling gel. Measurements of each lobes and isthmus were obtained in longitudinal (length), transverse (width) and depth (breath) in centimeters (cm). Blood samples were taken for thyroid function tests. The weight and heights were obtained. The data obtained were statistically analyzed using SPSS software version 17. The results were presented in forms of tables, graphs and chart.

RESULTS: The mean thyroid volume for males $6.03cm^3 \pm 2.22$ was higher than that of females $5.62cm^3 \pm 2.14$. The mean right lobe volume (RLV) was $3.09cm^3 \pm 1.47$ and that of males and females were $3.16cm^3 \pm 1.34$ and $3.04cm^3 \pm 1.55$ respectively. The mean left lobe volume (LLV) was $2.69cm^3 \pm 1.37$ and that of males and females were $2.89cm^3 \pm 1.32$ and $2.57cm^3 \pm 1.39$ respectively. The right lobe volume was significantly greater than the left lobe (p=0.000).The total mean isthmus volume was $0.27cm^3 \pm 0.31$. The mean isthmus volume in males 0.3±0.28 is significantly higher than that of females 0.24±0.23 (p=0.025)

CONCLUSION: The volume obtained in this study was slightly lower than those reported by previous studies in Nigerian adults. The right lobe volume was higher than that of the left and the volume was higher in males compared to females.

I. INTRODUCTION

The thyroid gland is one of the largest endocrine glands in the body weighing about 10-25g. It regulates the rate of metabolism and control the growth and rate of function of many other systems in the body. These it does, by producing thyroid hormones, principally thyroxine (T_4) and triiodothyronine (T_3)[1,2,3]. The accurate estimation of the size of the thyroid is very important for the evaluation and management of thyroid disorders. Thus, knowing the normal size in a geographic location would form a baseline for detecting abnormalities. Ultrasonography is a cheap, readily available, easy to perform and non-invasive method to image the thyroid gland, hence its use in this resource limited setting[4,5,6,]**.**

The evaluation of thyroid volume by ultrasonography in adults and children has been discussed in many Caucassian reports[7,8] as well as in Africans, Iranians[9] and indians[8.] In Nigeria most of the studies have been conducted in the North-Western[10], North-Eastern,[4] South-Western[11,12],South-South[13] and South-Eastern[6] parts of the country. But none in North Central Nigeria.
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The total thyroid volume(TTV) is a summation of the left and right lobes, the isthmus was not included in the measurement. Several studies done in the past showed a good relationship between the TTV with age in adults. In the study by Ahidjo et al[4], the volume of the thyroid gland was $8.55cm^3 \pm 1.82$ in adults. Mohammed[14] et al in Sudan, obtained a value of 6.44±2.44mls; this value was lower than that obtained by Ahidjo et al in Nigeria.

In both studies, their sample sizes was small, compared to the 400 used in this study. However, Mohammed[14] et al used 10MHz transducer as was done in this study. Ivanac[15] et al in a study among adult females obtained TTV of 10.68±2.83ml. All of them healthy and with normal thyroid hormonal status. Short-comings of the study includes the fact that only female population was selected, isthmus was included in calculation of TTV; and the fact that Zagreb, a region in Croatia, was in an earlier investigations indicted as one with iodine deficiency problem, thus accounting for the apparently slightly elevated figures.

Another study by Adibi[9] in healthy adults of Isfahan, a centrally located city in Iran, an iodine replete area using 200 subjects (123 Males, 77 females, average age: 37.27 ± 11.80 Years). The overall thyroid volume was 9.53 ± 3.68 ml. Males thyroid volume (10.73 ± 3.44 ml) was significantly higher than the females one(7.71 ± 2.63 ml) (P<0.001). The thyroid volume ranges from 3-23.9 ml, 3.6-23.9 ml and 3-14.3 ml in all, males and females, respectively. The knowledge of the fact that sex plays a role in determining the thyroid volume is essential in interpreting results obtained based on the sex of the patient.

The thyroid gland has two lobes that are joined together by isthmus. They are usually of different sizes, with the right being larger. The vascular supply of the right is larger than that of the left.[16] The right lobe is larger than the left in the study done by Suwaid [10]et al among school children. Marchie[13] et al and Anele[17] found no difference in sizes between the right and left lobes in children and adults. Anele[17] also observed that there was no difference in volume between males and females in his study. Ahidjo[4] et al found difference in the sizes of the lobes. The mean volume for both lobes in males and females were 4.48cm^3 and 4.07cm^3 respectively. The right thyroid lobe volume was higher than the left (p=0.000). Ying and Yung[18] in a prospective study of 106 healthy subjects without family history of thyroid diseases, were recruited in the study aimed at investigating the association of handedness and position of esophagus with thyroid size asymmetry using 41 men and 65 women: age range of the subjects was 16–59 years old (mean age 5-37.1 years). For normal thyroid, the right lobe (6.8 ml) was significantly larger than the left lobe (5.66 ml) ($P < 0.05$). Right-handed subjects (mean, 7.11 ml) had a significantly larger right lobe than left-handed subjects (mean, 5.82 ml) ($P < 0.05$). There was no significant difference in the left lobe volume between right-handers (mean, 5.81 ml) and left-handers (mean, 5.18 ml) ($P > 0.05$). Subjects with an esophagus deviated to the left (mean, 7.15 ml) had a significantly larger right lobe than those with a centrally located esophagus (mean, 5.7 ml) ($P < 0.05$). There was no significant difference in the left lobe volume between subjects with different esophageal positions (deviated to left: mean 5.76 ml; centrally located: mean, 5.19 ml) ($P > 0.05$).

Thyroid asymmetry is suggested to be related to the unilateral differentiation of the hypothalamus on the thyroid gland. However, besides the association of the CNS and thyroid gland asymmetry, the asymmetry of paired organs may also be associated with the presence and the size of their adjacent organs. For example, it has been found that the right kidney is significantly smaller than the left kidney, and the asymmetry of renal size is suggested to be related to the smaller size of the spleen than the liver, and thus, the left kidney has more space for growth. In the neck, the esophagus is commonly deviated to the left. Hence, the hypothesis that the smaller size of the left thyroid lobe may be related to the position of the esophagus. The study found scanty information about the association of handedness with thyroid lobe volume asymmetry. The limitation of this study is the small sample size of left-handers and subjects with centrally located esophagus. Moreover, no subject with esophagus deviated to the right was recruited. Another limitation of this study was that the subjects are mainly in the younger population.

The thyroid isthmus is the part of the thyroid gland that connects together the lower thirds of the right and left lobes. The isthmus may be absent in which the two lobes are not connected as noted by Taty-Anna[19] et al. The size of the isthmus is usually assessed separate from the thyroid lobes. Servet[20] et al assessed the isthmus separately. The mean isthmus thickness was 3.23±1.10mm (men; 3.42±1.14, women; 3.10±1.05).

Growth is seen with increase in age in human. The thyroid gland increases with growth of man. Suwaid[10] et al observed that the thyroid volume increases with increase with age. There has been steady increase in the mean thyroid lobe volume with increase in age. The mean thyroid volume at 6years is 2.94 ± 0.79 cm^3 and increases to 8.55 ± 2.79cm^3 at 13years. Marchie[13] et al showed strong correlation between the median thyroid volume and subjects' age (r = 0.804, P <0.001). Anele[17] also found strong correlation between subjects' age and median thyroid gland volume. Barrer[21] et al also noted increase in thyroid volume with increase in age, they, however observed that the increase ceases after the age of 65years. No volume increase was noted in the elderly.

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II. MATERIALS AND METHODS

STUDY AREA

Jos is the capital city of Plateau State. Plateau state has over 30 different ethnic groups. The 2006 Nigerian census put the population of Plateau State at 3,178,712.[22] Jos University Teaching Hospital (JUTH) is one of the three teaching hospitals in the North-Central Zone of Nigeria. It serves as a referral center for the neighbouring states of Bauchi, Gombe, Benue, Kogi, Nassarawa, Taraba, Adamawa and parts of Kaduna State.

STUDY POPULATION AND DESIGN

This was a hospital-based Cross-sectional study that was done in the Department of Radiology, Jos University Teaching Hospital (JUTH), a tertiary health institution situated in the central part of Jos, for the period of twelve months (June 2011-June 2012)

III. INCLUSION CRITERIA

- Patients that consented to have the procedure (sonographic evaluation of thyroid gland volume and laboratory assessment of thyroid function)
- Patients referred for ultrasound examination, other than thyroid ultrasound scan.
- Patients 18 years and above
- Patients with normal laboratory values of T3(0.6-2ng/ml), T4(45-115ng/ml) and TSH(0.3-6.5ng/ml)

IV. EXCLUSION CRITERIA

- Female during menstruation, pregnancy or who have delivered within the last twelve (12) months
- Subjects with anterior neck swelling or clinical evidence of thyroid/endocrine disorder
- Subjects with previous thyroid surgery.
- Subject with abnormal laboratory values of T3, T4 and TSH.
- Subjects who did not consent to participate in the study

V. SAMPLE SIZE DETERMINATION

The sample size was determined using Fisher's statistical[14] formula $n=z^2pq/ d^2$ for population greater than 10,000 and it was calculated to be 384 as shown below:

The formula $n=z^2pq/ d^2$

Where n = Desired sample size.
z = Standard deviation, using set at 1.96, which correspond to 95% confidence level.
p = Proportion in target population estimated to have a particular characteristic. If no reasonable estimate, 50% (0.5) is used.
q = 1.0 – p
d = degree of accuracy desired, usually set at 0.05

Therefore $n=1.96^2 \times 0.5 \times 0.5/0.05^2=384$.
However a sample size of 400 was used.

VI. TECHNIQUE

The procedure was explained to all participants, and informed consent was obtained. A data sheet (appendix I&II) was completed for the all participants in which the ages were obtained and weights and heights were obtained by the participants climbing a weighing scale and standing by a wall that was marked in meters. The participants were asked questions on history of previous thyroid disease or surgery as stated in the questionnaire. Questions on alcohol consumption, cigarette smoking and parity of women were asked as seen in the questionnaires. Patients were examined in supine position with a pillow placed under the shoulders to aid in the extension of the head. All examinations were performed using LOGIC 5, a real-time ultrasound machine fitted with a 10MHZ linear transducer. Ultrasound gel was applied over the anterior neck (thyroid area) and the transducer placed directly on the skin over the thyroid area. Images of each lobe and the isthmus were obtained in transverse (Fig 1) and longitudinal planes (Fig 2). Longitudinal (length) as well as transverse (width) and depth (AP) were measured in centimeters (cm).The right and left thyroid volume data were obtained and analyzed separately. The isthmus was not included in the sum. The lobe volume (cm^3) was calculated from the equation of Brunn et al[20,23] using the ellipsoid model formula by multiplying length (L) by width (w) by depth (d) in cm by a correction factor 0.52 and the lobe volumes are summed. The isthmus volume was calculated from $V_{isthmus}$ (cm^3) equals $length_{isthmus}$ by $width_{isthmus}$ by $depth_{isthmus}$ all in cm multiplied by 0.479[24]. Total Thyroid volume (cm^3) = total sum of lobe volumes (cm^3)
Isthmus volume (cm^3) = $length_{isthmus}$ x $width_{isthmus}$ x $depth_{isthmus}$ x 0.52
The body surface area was calculated using the formula of Dubois and Dubois[25]
Body surface area BSA (m^2) = $Weight^{0.425}$ x $Height^{0.725}$ x 71.84×10^{-4}
and Body mass index (BMI) ($Kg/m^{2)}$ was calculated from $weight/height^2$.

- Blood samples were taken for thyroid function tests(T3,T4 and TSH) in which results that were not within normal range were not included. The normal laboratory values of T3(0.6-2ng/ml), T4(45-115ng/ml) and TSH(0.3-6.5ng/ml)
- **Underweight < 20 kg/m^2**
- **Normal weight 20-25kg/m^2**
- **Overweight >25kg/m^2**
- **BSA CATEGORIZE**[14]
- **Normal 1.91m^2(male) 1.6m^2(female)**
- **Abnormal >1.91m^2(male) >1.71m^2(female)**

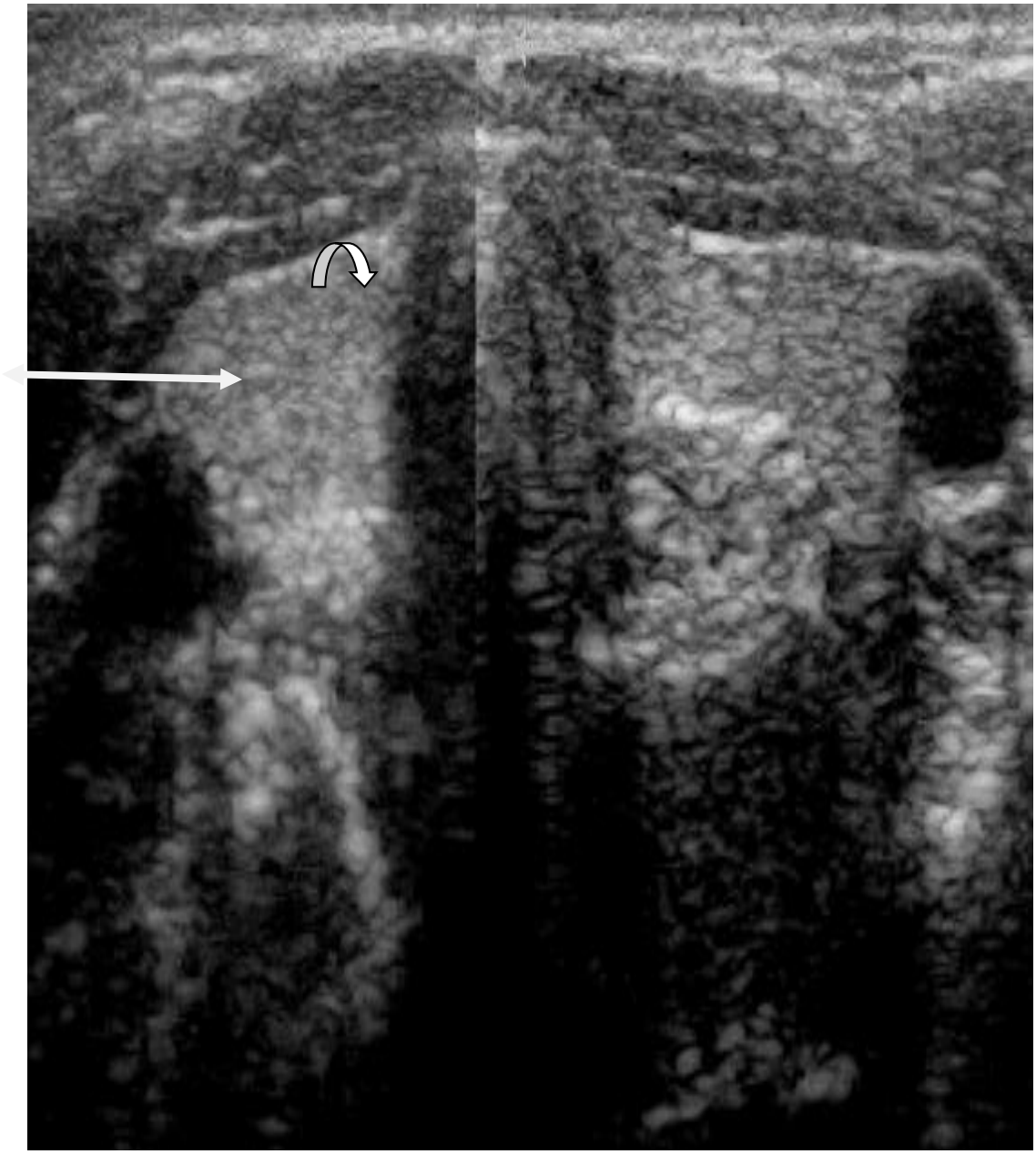


Fig 1: Transverse Ultrasound Scan of the Thyroid Gland at the Level of the Tracheal Cartilage(C6 level) Showing its two lobes (arrows), the isthmus(arrow head) and the trachea centrally(curved arrow).

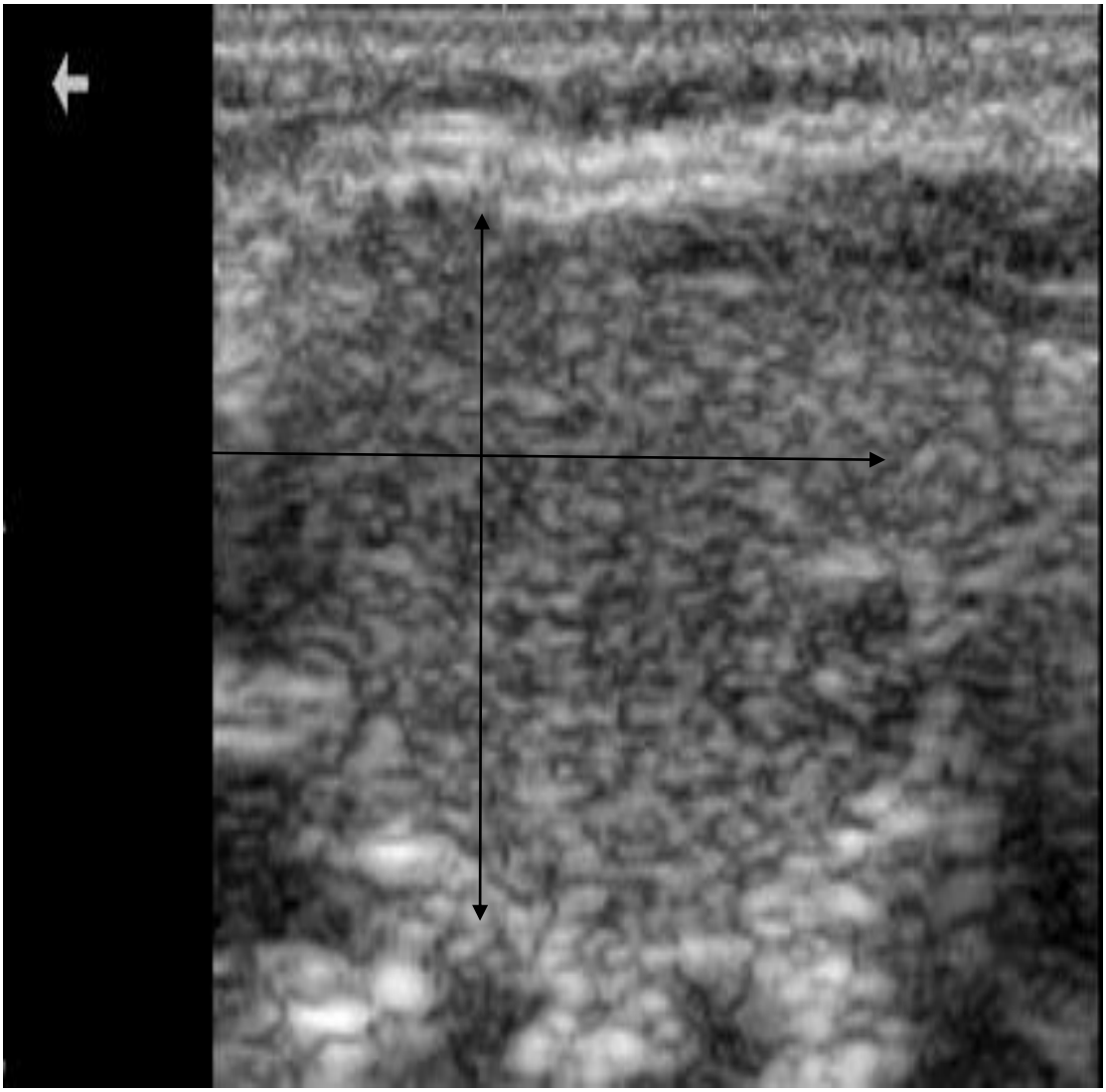


Fig 2: Longitudinal ultrasound scan of the thyroid, showing measurement of the longitudinal (LS) and anteroposterior diameters of the thyroid lobe.

VII. DATA ANALYSIS

The data obtained from the structured questionnaire was entered into a computer to generate a computerized data base for subsequent analysis and processing using SPSS version 17. Statistical parameters such as student's test were used for association between different variables. P value of 0.05 or less was considered statistically significant. The results were presented in the form of tables, chart and graphs.

VIII. ETHICAL CONSIDERATION

Approval was obtained from Research and Ethical Committee of Jos University Teaching Hospital. Informed signed consent was obtained from the volunteers before enrollment for the study and they were given the freedom to withdraw from the study at any stage without consequences. The data collected from the participants were recorded serially and kept with utmost confidentiality.

IX. RESULTS

A total of 400 adults were recruited comprising 150(37.5%) males and 250(62.5%) females (Figure 3).The number of females were more than the males.

Tables 1a and 1b shows the age-sex distribution pattern of the male and female subjects in the study population

The total mean thyroid volume was 6.03±2.49 (range of 1.38-11.34). There is steady increase in thyroid volume with increase in age. The lowest total mean volume of 5.52cm^3 was seen in 20-29years age groups, whereas the highest of 6.12cm^3 was noted on the greater than 50years age groups. There was no statistically significant increase in thyroid volume with increase in age.

The total mean thyroid volume for males was 6.30cm^3±2.37 (range1.38-11.34). The lowest volume of 5.80±1.51cm^3 was seen in 20-29years age groups and the highest of 6.28±3.31cm^3 in

50years age group. No stastistically significant increase in volume with age was noted with a p=0.930. The total mean thyroid volume for females 5.65cm^3±2.61(1.38-15). There is steady increase in thyroid volume with increase in age groups from 21-29years age groups. The lowest is 5.24±2.35cm^3 in 21-29years and the highest was 5.96cm^3 in greater than 50years.The increase was however not statistically significant, with a p=0.637. The thyroid volume was higher in the less than 20years compared to 21-29 years age group in both sexes. But the increase was not statistically significant, with p=0.092 and p=0.55 for females and males respectively. However, there is a statistically significant increase in thyroid volume when the volumes of 20-29 and 30-39years age groups are compared. The male has a p=0.032 and the females p=0.041(Fig 3)

The total mean isthmus volume was 0.27cm^3 ± 0.31and that of males and females are 0.3 ± 0.28 and 0.24 ± 0.23cm^3.There is steady increase in volume with age in both sexes, with the exception of the 40-49 years in males. The increase is statistically significant in males, with a p=0.025.The increase is not statistically significant in females, with a p=0.457.The volumes were highest in males in the 40-49years age group and in >50years in the females. There is no statistically significant increase in isthmus volume between males and females.

Tables 1a and 1b also shows that the total mean right lobe volume was 3.2cm^3±1.47 and that of male was 3.37±1.34 and female 3.08±1.55. There is increase in volume with increase in age in both sexes from 20-29years age group upward. The lowest value is 3.09cm^3±1.17 in the 21-29years age group and the highest in the greater than or equal 20years in males. There was no statistical significant increase in volume with increased age (p=0.65). The lowest value in female was 2.98±1.43cm^3 in the age group of 40-49years and the highest is 3.22±1.93cm^3 in the age group of greater than 50 years. There was no statistically significant increase in right lobe volume with increase in age.

The total mean left lobe volume(LLV) was 2.77cm^3 ± 1.35 and that of males and females are 2.98cm^3 ± 1.32 and 2.57cm^3 ±1.38 respectively (Table Ia and Ib). There was no significant increase in LLV with increase in age in males. The lowest measured 2.34±0.67cm^3 in the less than 20years age groups and the highest was 3.44±1.22cm^3 in the greater or equal 50years age group was noted(p= 0.619). There is a steady increase in LLV with increase in age groups in females. The lowest value is 2.29±0.43 in the less than 20 age groups and the highest is 2.74±2.08 in the greater than or equal to 50years age group. However, the p value was not statistically significant 0.059. There is increase thyroid volume with increase in age as seen in the scatter gram (Fig 5)

Table 1a: Age and sex distribution pattern of thyroid volume in male subjects

Age	Right(MeanSD)	Left(MeanSD)	Mean Total Thyroid Vol(Mean)	Isthmus Vol
<20	3.83±0.33	2.34±0.67*	6.17±0.66	0.17±0.14*
21-29	3.09±0.79	2.71±0.98	5.80±1.51	0.22±0.19
30-39	3.19±1.52	3.09±1.91	6.28±3.31	0.26±0.24
40-49	3.22±1.17	3.30±1.26	6.52±2.16	0.42±0.36
≥50	3.30±1.63	3.44±1.22	6.74±2.47	0.34±0.33
P	0.652	0.619	0.930	0.025
Total	3.326±1.34	2.976±1.32	6.302±2.37	0.30±0.28

Table 1b: Age and sex distribution pattern of thyroid volume in female subjects

Age group	Right(MeanSD)	Left(MeanSD	Mean Total Thyroid Vol(Mean)	Isthmus Vol
<20	3.06±0.89	2.29±0.43	5.35±0.81	0.20±0.17
21-29	3.02±1.58	2.22±1.02	5.24±2.35	0.24±0.23
30-39	3.15±1.46	2.63±1.34	5.80±2.32	0.25±0.23
40-49	2.98±1.43	2.73±1.24	5.91±2.51	0.31±0.25
≥50	3.22±1.93	2.74±2.08	5.96±3.87	0.34±0.16
P	0.927	0.059	0.637	0.457
Total	3.08±1.55	2.57±1.38	5.65±2.61	0.24±0.23

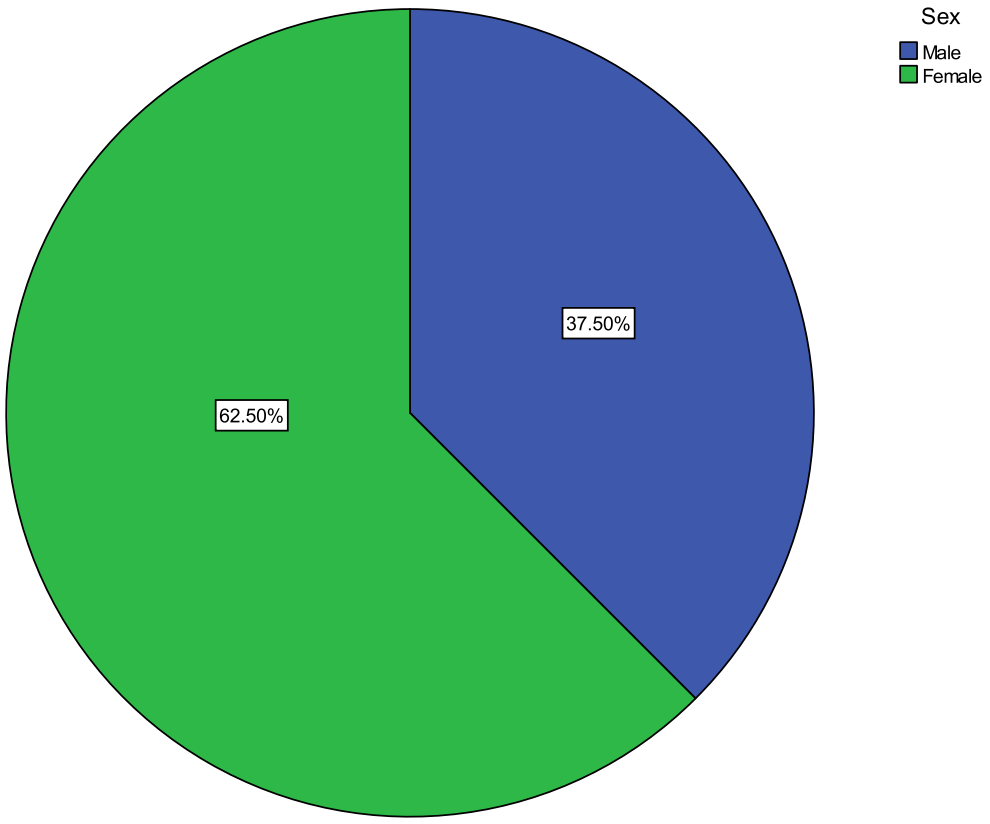
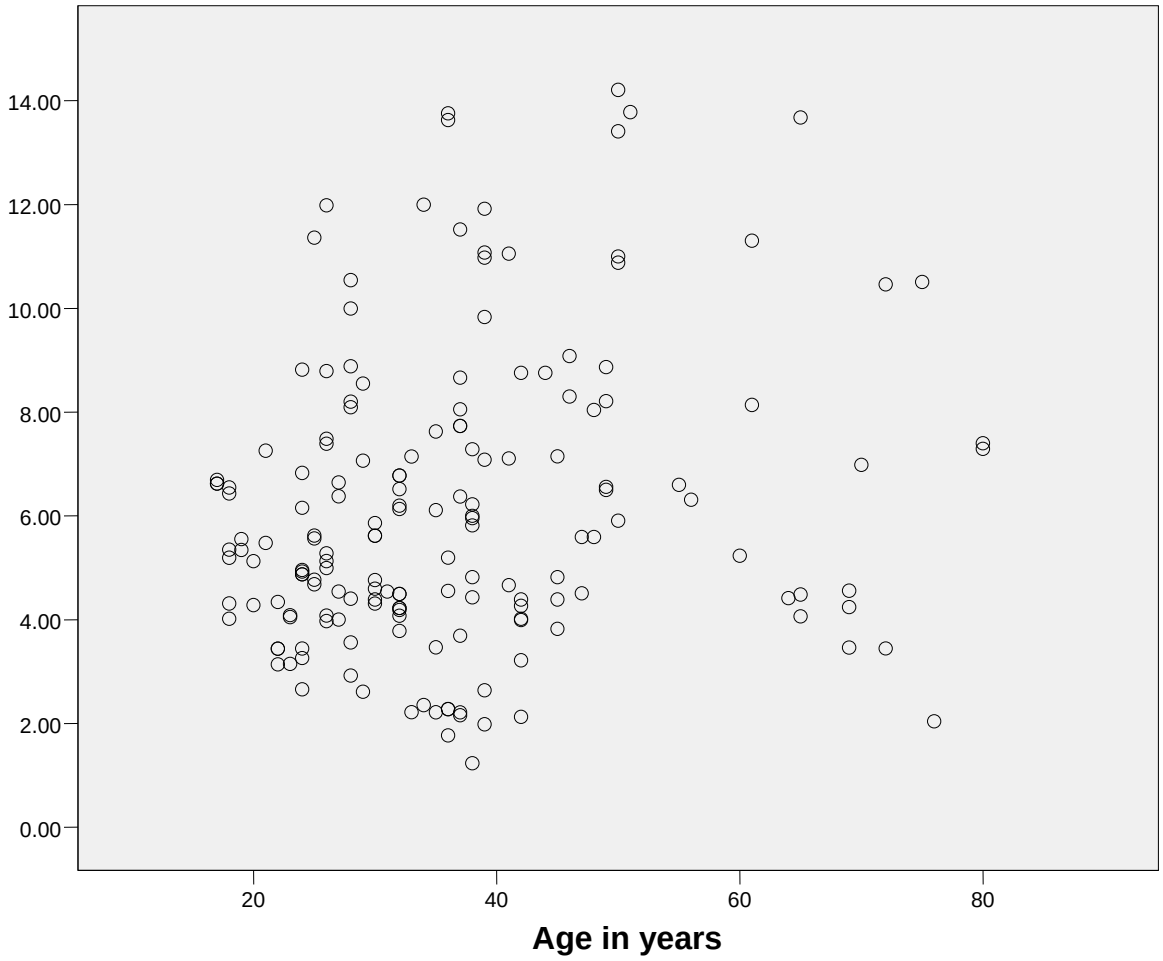


Fig 3: Pie chart of sex distribution of study subjects.

Fig 4: Relationship between mean total thyroid volume with increasing age group.



he right lobe volume was greater than the left lobe. RLV is 3.20 ± 1.47 and LLV is 2.77 ± 1.37 with a p= 0.000. (Table II)

Table II: Comparison between right and left thyroid lobes

Thyroid lobes	Mean±SD	P
Right	3.20±1.47	0.000
Left	2.77±1.37	

X. DISCUSSION

The knowledge of the normal thyroid volume is essential in evaluating diseases affecting the gland. A normogram of thyroid volume in our environment is important to serve as a reference point in managing patients with thyroid pathologies.

This study showed that the mean thyroid volume (Table II) was lower than the values recorded by other investigators among caucasians.26,24 Ahidjo et al4 in Maiduguri found the overall thyroid volume of 8.55 ± 1.82cm3, while that of males and females were 9.72cm3 and 7.58cm3 respectively. Ivanac et al15 in Zagreb obtained thyroid volumes that were higher than what was obtained in this study. In their study, the thyroid volume was 10.68 ± 2.83cm3.The reason for this difference values may be attributed to improved intake of table salt.27 The value obtained in this study is about the same with the study done by kayastha et al28, in which the mean thyroid volume was 6.629 ± 2.502cm3 in a mountainous area that has good iodization programme of food supplements. Increasing use of iodine supplementation in this country in the recent years could be one of the factors reducing the

iodine deficiency prevalent in the country and thus reducing the total thyroid volume.

The male's thyroid volumes (6.30±2.37) were higher than that of females (5.65±2.61). This finding was similar to that of other investigators [4,29,10,30,21]. This may be due to the fact males have increased body mass index than females of the same age. However, Anele T[17] and Marchie et al[13] found no significant difference between males and females thyroid volumes.

The mean right lobe volume was higher than that of the left, and it was statistically significant. Similar findings were noted by other investigators.[4,10,30,21] This increase may likely be due to increased vascularization of the right lobe compared to the left[10].

The mean heights of males were higher than that of females. There was a positive correlation of thyroid and isthmus volume with height. Similar findings were noted by other investigators [4,31,15,20].

Thyroid volume increases steadily with increase in age in the females and male subjects. This increase was however, not statistically significant. Similar findings by Suwaid et al[10] and Barrer et al[21] were statistically significant. It was thought that thyroid volume increases with age up to 65 years as noted by Barrer et al[21]. The thyroid volume was higher in the less than 20years compared with 20-29years age groups in both sexes. The increase was not statistically significant. No obvious reason was found for such. It was however thought to be due to a growth spurt at less than 20years age groups.

The isthmus volume was higher in males (0.30±0.28) compared to females (0.24±0.23) and also increased with age. Servet et al[20] in Turkey obtained values that were similar to this study. They recorded positive correlation between the mean isthmus volume with age, weight, height and BSA. The mean total isthmus volume was 0.45 ± 0.31 and that of males and females was 0.44 ± 0.34 and 0.46 ± 0.29 respectively. However, the mean isthmus volume in this study was lower than what they obtained in their study. The reasons attributed to difference in thyroid lobes volume in my study compared with others may also be applicable here.

In conclusion, there was no statistically significant increase in thyroid volume with increase in age. There was steady increase in isthmus volume with increase in age. The males thyroid volume was higher than that of females across the age groups. Also, the right lobe volume was noted to be bigger than the left.

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