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ORIGINAL ARTICLE

Comparative ultrasound measurement of normal thyroid gland dimensions in school aged children in our local environment

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Abstract

Objective: The objective of this study was to determine the measurement of normal range of ultrasound (US) thyroid gland dimensions in school-aged children (6-16 years) in our environment and compared with what is obtained elsewhere.
Setting and Design: A prospective ultrasound measurement study done in University of Benin Teaching Hospital Benin, Nigeria.
Materials and Methods: A prospective ultrasound (US) study of thyroid dimensions of 500 school-aged children in our environment consisting of 227 boys and 273 girls was done from 1 December 2006 to July 2007. The subjects were examined by the authors and subjects with palpable abnormal thyroid gland were excluded from the study. The thyroid dimensions (length, height, and diameter) were taken for each lobe by means of ultrasound (US). In addition volume of each thyroid lobe was calculated and the summation of volume of the lobes was taken as thyroid gland volume of each subject. Also height and weight of patients were documented from which the subject's body surface was calculated. Incidental thyroid gland lesion in US was excluded from the study. Using the Statistical program of social science (SPSS) and INSTAT (Graph Pad Inc. USA) the data were analyzed. Informed consent was obtained from all the subjects and the study was done in line with the ethical guidelines of the centers.
Results: The US thyroid gland volume in school-aged children in Benin City from this study ranges between 1.17 cm^3 and 7.19 cm^3, mean volume range of 1.76-4.95 cm^3, median volume range of 1.73–4.73 cm^3, and range of standard deviation from 0.39 cm^3 to 1.49 cm^3. The average mean thyroid volume is 2.32 cm^3 with the following average dimensions; anteroposterior right lobe =1.06 cm, mediolateral right lobe = 1.01 cm and craniocaudal right lobe = 2.34 cm, and anteroposterior left lobe = 1.01 cm, mediolateral left lobe = 1.04 cm and craniocaudal left lobe = 2.41 cm for both boys and girls respectively. These data are significantly lower than data obtained by European based World Health Organization/International Council for the Control of Iodine Deficiency Disorders (WHO/ICCIDD) 1997. However there is significant similarity with data obtained in similar environment.
Conclusion: Ultrasound thyroid gland dimensions in school-aged children in our environment are reproducible and the data obtained are comparable to those obtained in other environment. The values may be better used in our environment as reference data for screening purposes.

Key words: Cross-tabulation, dimensions, school- aged children, thyroid gland, and ultrasound

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Introduction

Thyroid gland enlargement as a result of iodine deficiency

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is known as goiter.[1] Iodine deficiency disorder (IDD) is a global public health problem and represents the main cause of preventable mental retardation and permanent brain damage in fetus, infant, and childhood.[2,3] Other detrimental effects of iodine deficiency include increased incidence of still births, abortion, infant and child mortality, and congenital abnormalities such as endemic cretinism.[1,3]

It is estimated that 2 billion (35%) people worldwide have inadequate iodine intake.[3] Prevalence of goiter in school-aged children greater than or equal to 5% is indicative of a public health problem; thus the target group for goiter screening are recommended.[4,5] Normal ranges of thyroid volume by ultrasound (US) in the pediatric age group have been published by many authors.[2,4-11] One documented nutritional study in a Nigerian population was found in the reviewed literature.[12] However, no such similar studies have been done in Benin City Edo State, Nigeria even though cassava products are major staple foods in Edo state. Cassava contains goitrogens which have been implicated in the etiology of goiter in Nigeria. [12] Studies have shown that it is more appropriate to use local reference values in the evaluation of children with goiter, than the World Health Organization (WHO) references which are mostly European based.[6,8-10,13] This study is thus aimed at providing normative thyroid gland volume reference data for children that can be used for IDD screening in Benin city and compare the values with reference values from studies done in other populations. US of the thyroid gland are a universally recognized standard imaging procedure.

Using a high-frequency 5-10 MHz ultrasound probe, the normal thyroid gland has a homogenous increased medium level echo texture. The childhood thyroid gland dimension correlates linearly with age and body surface unlike adults. [14] Iodothyronine (T3) and thyroxine (T4) are thyroid hormones which function to control the basal metabolic rate (BMR). [15, 16, 17] And their blood levels determine thyroid gland dimensions and volume. [14, 15, 16]

Materials and Methods

A prospective study using random sample of 500 school-aged children consisting 227 males and 273 females, in an estimated population of 205,911 school children. The subjects irrespective of the sex or socioeconomic status were randomly recruited from primary and secondary schools in Benin City Nigeria for measurement of their thyroid gland dimensions and volume.

The study was approved by the Ethical Committee of the University of Benin Teaching Hospital, Benin-City. Only subjects who had the written informed consent document approved by their parents and school guardian participated in this study. The duration of the study was from December 2006 to July 2007.

The subjects were clinically examined and the age and sex of subjects were noted. The height and weight were measured and only six subjects with palpable thyroid were excluded from the study. Thyroid sizes were determined by inspection and palpation using the old (1960) criterion if one lobe was deemed larger than the terminal phalanx of the child's thumb is considered enlarged.[18,19] An ultrasound machine, SONOACE 1500 (Medison Inc, Korea 1994) fitted with a 6.5 MHz curvilinear probe was used for examination. The examination was done by the authors who had more than 4 years' experience and training in use of US for diagnosis. With the subject placed in the supine position, the neck was extended with the aid of a sandbag placed under the subjects' shoulders. A coupling gel was applied to the anterior portion of the neck and the transducer placed over it. The transducer was placed across the neck in the midline for the transverse scan. The transducer was then moved in the superoinferior and mediolateral directions until both lobes of the thyroid gland, the left and right common carotid arteries and the adjacent internal jugular vein were visualized. The anteroposterior (thickness) and the mediolateral (width) dimensions were measured. For the longitudinal scan the subject's head was turned to the left side so that the transducer would have better access to the right lobe. To scan the left lobe the head was turned to the right. The transducer was then placed in the longitudinal plane of the neck and moved in the mediolateral direction until the full length of the thyroid lobe was visualized. The craniocaudal length was measured. The scan time was reduced to the barest minimum, while maintaining accuracy, to avoid undue discomfort to the subjects. All measurements were carried out by the authors to avoid individual variation. Subjects with thyroid lesions in ultrasound were to be excluded from the study; however none was found.

The volume of each lobe was calculated using the equation of Brunn *et al.* [18]:

Volume of lobe = Anteroposterior dimension (cm) × Mediolateral dimension (cm) × Craniocaudal dimension (cm) × 0.479.

The thyroid gland volume (TTV) is the summation of the volume of each lobe.
The body surface area (BSA) was calculated using the formula: BSA = Weight (kg) 0.425 × Height (cm) 0.725 × 7184 × 10^{-4}.

The sample size was calculated using the formula for determining sample size for a finite population by Yamane [20] which is stated below:
$n = N / 1 + NE2$

Where n = Desired sample size, N = Population size, E = Maximum acceptable margin of error, 1 = A theoretical constant, N = 205,911, E = 0.05.
Thus, $n = 205{,}911/1 + 205{,}911(0.05)$ [2]
$n = 399.998$.

In order to broaden the scope of this research, the sample size of 500 was taken. Data were analyzed using the Statistical program of social science (SPSS) and INSTAT (Graph Pad Inc. USA) version 11.0. Data comparison (statistical test of significance) was carried out between variables using the nonparametric chi-square and Mann-Whitney tests. Also a comparison was done with other studies in Nigeria and outside.

Results

Five hundred subjects aged 6-16 years consisting of 227 (45.4%) boys and 273 (54.6%) girls took part in this study. Age 7 years had the highest number of boys and age 8 years had the highest number of girls [Figure 1].

The range, mean, median, and standard deviations of the height and weight for each ages for the boys and girls studied showed no statistically significant difference ($P > 0.05$).

The range, mean, median, and standard deviation of the body surface area (BSA) for each ages for the boys and girls studied showed there was no statistically significant difference ($P > 0.05$).

Table 1 shows the summary of median thyroid volume, median values of the height, weight, and BSA for different ages for the boys and girls. There was no statistically significant difference ($P > 0.05$) between the biometric values for median thyroid volume at each age for boys and girls.

Table 2 shows range, mean, median, and standard deviation of the thyroid gland volume for each age of both sex and the median thyroid gland volume for the combine ages of the boys and girls studied. There was an increase in the median thyroid gland volume with age [Figure 2]. The statistical analysis revealed no statistically significant difference ($P > 0.05$) between the median thyroid gland volume of boys and girls. A scattered plot of Pearson correlation coefficient (r) showed a very strong, positive correlation between thyroid volume and age ($r = 0.804$, $P < 0.001$).

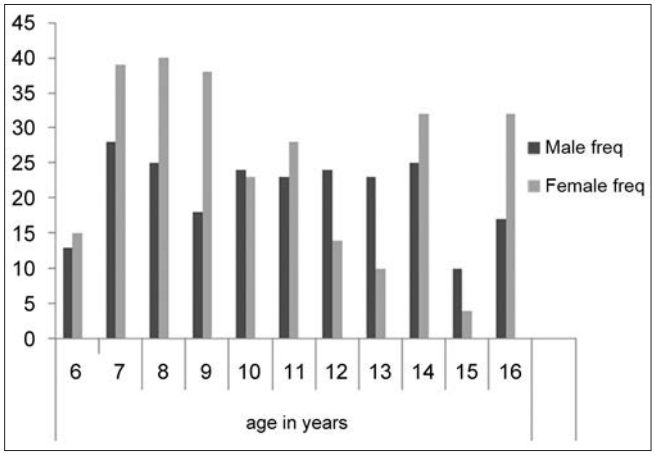

Figure 1: Sex distribution among age groups

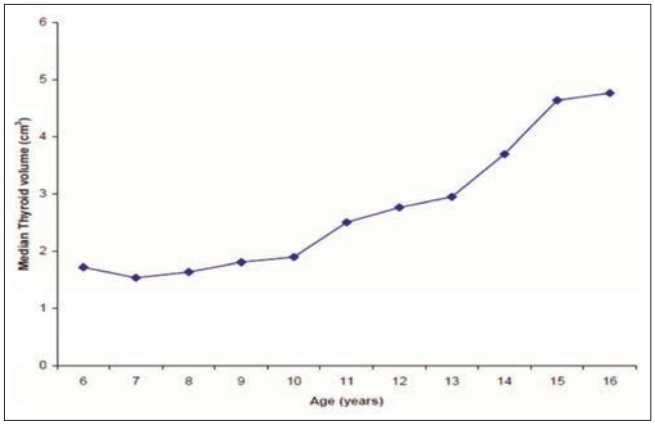

Figure 2: Changes in median thyroid gland volume with age. There is an increase in median thyroid volume with increase in age

Table 1: Summary of the median height, weight, BSA, and thyroid volume for boys and girls at the different age groups

Age (years)	Median height (cm)		Median weight (kg)		Median BSA		Median TV (cm³)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6	122.00	127.00	24.0	25.0	0.90	1.00	1.69	1.73
7	123.25	124.00	23.5	24.0	0.90	0.90	1.54	1.54
8	130.00	129.00	27.0	25.0	1.00	1.00	1.77	1.62
9	133.75	133.75	28.5	28.0	1.05	1.00	1.94	1.61
10	138.50	133.00	31.0	30.0	1.10	1.10	1.99	1.85
11	143.00	140.50	36.0	34.5	1.20	1.20	2.51	2.58
12	147.50	154.50	36.0	39.0	1.20	1.30	2.79	2.75
13	158.00	149.50	45.5	40.0	1.45	1.30	3.07	2.92
14	158.50	159.25	45.5	50.0	1.40	1.60	3.67	3.71
15	163.50	162.75	60.0	60.5	1.50	1.75	4.41	4.64
16	168.00	161.25	59.0	54.0	1.50	1.60	4.89	4.54

The regression of thyroid volume on age was also carried out and found to be highly significant ($F = 909.66$; $P < 0.001$) with a linear regression equation of

$y = 0.3399 \times -1.0276$, where y = total thyroid volume (TTV) and × = age

Pearson's correlation coefficient (r) of thyroid volume against subject height and weight, respectively, showed a very strong positive correlation of thyroid volume with height ($r = 0.779$, $P < 0.001$) and weight ($r = 0.627$, $P < 0.001$).

The regression of thyroid volume on height and weight was also carried out and found to be highly significant ($F = 773.49$; $P < 0.001$ and $F = 839.67$; $P < 0.001$, respectively). With a linear regression equation for height as

$y = 0.0646 \times - 6.5882$, where y = TTV and x = height and or weight;

$y = 0.0781 \times - 0.2783$, where y = TTV and x = weight.

There is an increase in median thyroid volume with increase in age. The range, mean, median, and standard deviation of the thyroid gland volume for BSA of the boys and girls are shown in Table 3. There was no statistically significant difference ($P > 0.05$) between the median thyroid volume/BSA between boys and girls.

The local thyroid ultrasound dimensions were compared to studies done in Port-Harcourt Nigeria, WHO/NHD Study Group and WHO/ICCIDD 1997 Reference Values. The findings in the first and second studies show a linear correlation with what was obtained locally with minor focal variation, while the third studies showed a higher value than the local value [Tables 4-8 and Figures 3-7].

Discussion

This study used a 6.5 MHz transducer frequency to

Table 2: The range, mean, median, and standard deviation of the thyroid gland volume for age

	Thyroid volume (cm^3)				
Age (years)	No. of cases	Range	Mean	Median	SD
6	26	1.17–2.37	1.76	1.73	0.39
7	67	0.90–2.29	1.54	1.54	0.32
8	65	1.01–2.56	1.75	1.64	0.44
9	56	1.00–2.63	1.83	1.81	0.55
10	47	1.11–2.85	1.92	1.90	0.51
11	50	1.48–3.66	2.46	2.51	0.65
12	36	1.44–3.89	2.80	2.77	0.68
13	32	1.20–4.29	3.08	2.95	0.62
14	58	2.53–4.69	3.67	3.70	0.65
15	15	3.49–6.26	4.52	4.64	0.87
16	48	2.42–7.19	4.95	4.73	1.49

SD = Standard deviation.

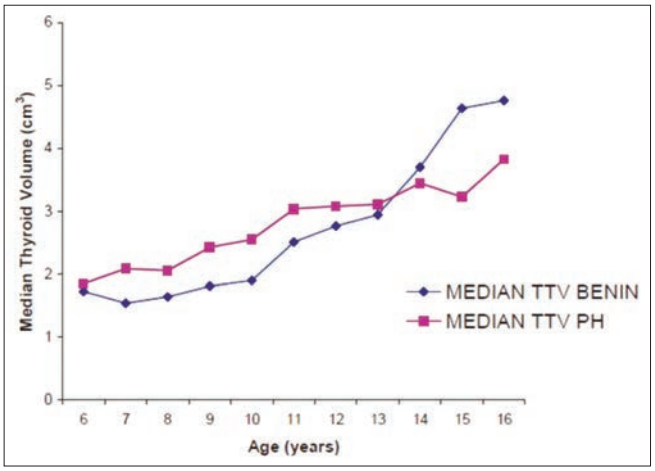

Figure 3: Comparison of the median thyroid volume/age between our study with Port Harcourt study ($P > 0.05$) suggesting linear correlation

Table 3: The range, mean, median, and standard deviation of the thyroid gland volume at the different BSA of boys and girls studied. There is increasing thyroid volume with increasing BSA. SD, standard deviation

	Thyroid volume (cm^3)							
BSA	Boys				Girls			
	Range	Mean	Median	SD	Range	Mean	Median	SD
0.8	1.24–2.09	1.55	1.43	0.36	1.17–1.90	1.47	1.39	0.29
0.9	1.15–2.46	1.65	1.64	0.35	1.03–2.37	1.62	1.61	0.33
1.0	1.00–2.11	1.51	1.53	0.30	0.90–2.56	1.59	1.54	0.44
1.1	1.24–3.24	2.05	1.90	0.55	1.03–2.58	2.11	2.25	0.47
1.2	1.20–3.49	2.39	2.42	0.66	1.67–3.44	2.53	2.52	0.42
1.3	2.42–5.12	3.09	2.68	0.89	1.63–4.52	2.89	2.77	0.88
1.4	1.65–6.87	3.29	3.17	1.18	3.48–7.19	4.72	3.48	2.14
1.5	2.58–6.90	4.04	3.64	1.23	3.07–5.95	3.89	3.70	0.99
1.6	2.46–5.69	3.51	3.39	0.86	2.61–6.72	4.23	3.66	1.33
1.7	3.24–6.41	4.43	4.02	1.18	2.01–4.77	3.89	4.34	0.93
1.8	3.57–4.66	4.14	4.37	0.51	5.02–5.48	5.25	5.25	0.33
1.9	-	-	-	-	3.70–7.04	4.90	4.58	1.25

determine prospectively the thyroid gland volume of Benin-City school-aged children. Although there was difference in the transducer frequency used by different work groups, some groups prefer the transducer frequency used for thyroid scanning to be 7.5 MHz,[11] and others believe that 5–7.5 MHz and 3.5 MHz with water bath can also be used.[5] This was found not to affect the thyroid dimension measurements. In addition reviewed literature confirmed US to be an accurate, precise, and cheap method of measuring the thyroid gland size especially when compared to plain radiography.[5,21,22] The justification for the age group selected for the study was defined by the evidence in the literature that measurement of thyroid gland volume in school-aged children is important for public health considerations as this group effectively reflects the current status of iodine deficiency disorders in the general population.[4,5]

Table 4: Comparison of the median thyroid volume/age of the present study with Port Harcourt Study[12]

Age (years)	Median thyroid volume (cm^3)	
	Benin	Port Harcourt
6	1.73	1.85
7	1.54	2.09
8	1.64	2.06
9	1.81	2.43
10	1.90	2.55
11	2.51	3.04
12	2.77	3.08
13	2.95	3.11
14	3.70	3.45
15	4.64	3.23
16	4.77	3.83

P >0.05; df = 20; t = –0.173 (no significant difference between the present study and the Port Harcourt study).

Five hundred school-aged children in Benin City aged 6-16 years were randomly selected out of a total population of 205,911 school children. In both sexes, the median thyroid gland volume (TV) increased steadily with advancing age. This is in keeping with documented evidence of the thyroid volume increasing as one grows.[23] Previous studies by Anele *et al.*[2] in Port-Harcourt and Zimmerman *et al.*[4] in the World Health Organization/Nutrition for Health and Development (WHO/NHD) study group report also showed an increase in thyroid volume with age. Our study showed

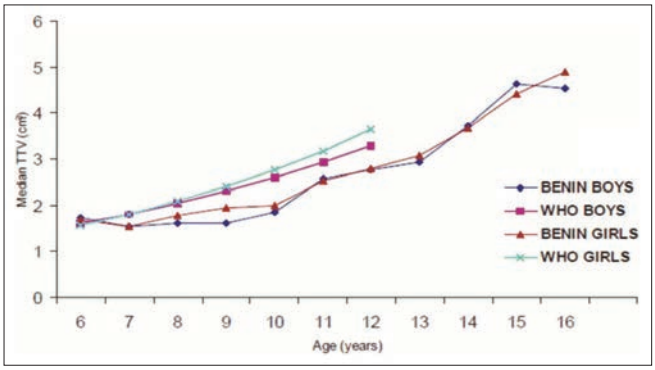

Figure 4: Comparison of the median thyroid volume/age for boys and girls between the present study and WHO/NHD Study Group (*P* >0.05) suggesting linear correlation

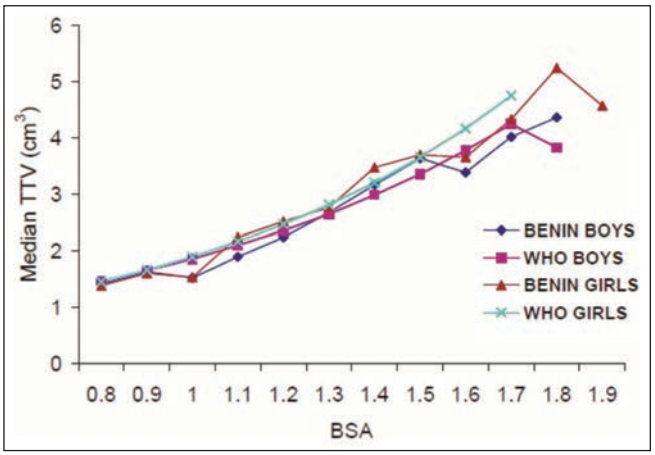

Figure 5: Comparison of the median thyroid volume/BSA for boys and girls between the present study and WHO/NHD Study Group (*P* >0.05) suggesting linear correlation

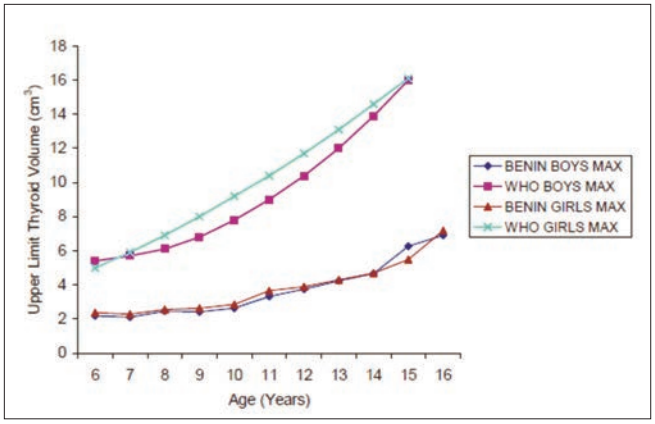

Figure 6: Comparison between the upper limit/age of thyroid volume in the present study and WHO/ICCIDD 1997 reference values (*P* <0.05) suggesting linear correlation

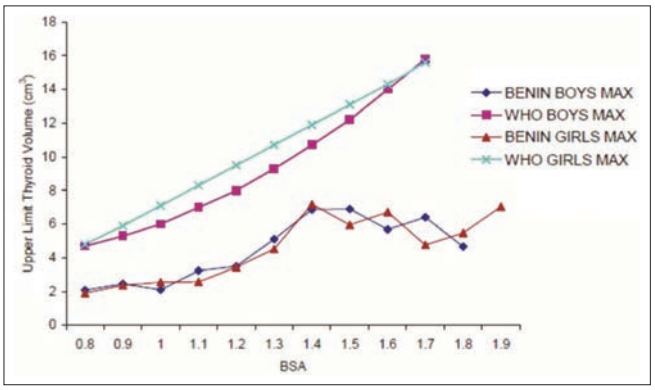

Figure 7: Comparison between the upper limit/BSA of the thyroid volume in the present study and WHO/ICCIDD 1997 reference values (*P* <0.05) suggesting linear correlation

Table 5: Comparison of the median thyroid volume at the different age for boys and girls in the present study with values obtained from the WHO/NHD Study Group[9]

Age (years)	Median thyroid volume (cm^3)			
	Boys		Girls	
	Benin	WHO/NHD	Benin	WHO/NHD
6	1.73	1.60	1.69	1.57
7	1.54	1.80	1.54	1.81
8	1.62	2.03	1.77	2.08
9	1.61	2.30	1.94	2.40
10	1.85	2.59	1.99	2.76
11	2.58	2.92	2.51	3.17
12	2.75	3.30	2.79	3.65
13	2.92	3.07		
14	3.71	3.67		
15	4.64	4.41		
16	4.54	4.89		

Boys = $P > 0.05$; df = 16; t = 0.661 (no significant difference between present study boys and WHO/NHD boys for age). Girls = $P > 0.05$; df = 16; t = 0.531 (no significant difference between present study girls and WHO/NHD girls for age). Thyroid volume is slightly larger in girls than boys in both studies; however, this differences is statistically insignificant ($P > 0.05$).

Table 6: Comparison of the median thyroid volume at the different BSA for boys and girls in the present study with values obtained from the WHO/NHD Study Group.[9]

BSA	Median thyroid volume (cm^3)			
	Boys		Girls	
	Benin	WHO/NHD	Benin	WHO/NHD
0.8	1.43	1.47	1.39	1.46
0.9	1.64	1.66	1.61	1.67
1	1.53	1.86	1.54	1.90
1.1	1.90	2.10	2.25	2.17
1.2	2.42	2.36	2.52	2.47
1.3	2.68	2.65	2.77	2.82
1.4	3.17	2.99	3.48	3.21
1.5	3.64	3.36	3.70	3.66
1.6	3.39	3.78	3.66	4.17
1.7	4.02	4.25	4.34	4.76
1.8	4.37		5.25	
1.9			4.58	

Boys = $P > 0.05$; df = 19; t = 0.955 (no significant difference between present study boys and WHO/NHD boys for BSA). Girls = $P > 0.05$; df = 20; t –0.508 (no significant difference between present study girls and WHO/NHD girls for BSA)

Table 7: Comparison of the upper limit of the normal thyroid gland volume at the different ages for boys and girls in the present study with WHO/ICCIDD 1997 Reference Values.[13]

Age	Upper limit of normal thyroid volume			
	Boys		Girls	
	Benin	WHO/ICCIDD	Benin	WHO/ICCIDD
6	2.19	5.40	2.37	5.00
7	2.11	5.70	2.29	5.90
8	2.46	6.10	2.56	6.90
9	2.42	6.80	2.63	8.00
10	2.64	7.80	2.85	9.20
11	3.32	9.00	3.66	10.40
12	3.74	10.40	3.89	11.70
13	4.24	12.00	4.29	13.10
14	4.66	13.90	4.69	14.60
15	6.26	16.00	5.48	16.10
16	6.90		7.19	

Boys = $P < 0.05$; df = 19; t = −4.570 (significant difference between present study boys and WHO/ICCIDD boys for age) Girls = $P < 0.05$; df = 19; t = −5.107 (significant difference between present study girls and WHO/ICCIDD girls for age)

Table 8: Comparison of the upper limit of the normal thyroid gland volume at the different BSA of boys and girls in the present study with WHO/ICCIDD 1997 Reference Values.[13]

BSA	Upper limit of normal thyroid volume			
	Boys		Girls	
	Benin	WHO/ ICCIDD	Benin	WHO/ ICCIDD
0.8	2.09	4.70	1.90	4.80
0.9	2.46	5.30	2.37	5.90
1.0	2.11	6.00	2.56	7.10
1.1	3.24	7.00	2.58	8.30
1.2	3.49	8.00	3.44	9.50
1.3	5.12	9.30	4.52	10.70
1.4	6.87	10.70	7.19	11.90
1.5	6.9	12.20	5.95	13.10
1.6	5.69	14.00	6.72	14.30
1.7	6.41	15.80	4.77	15.60
18	4.66		5.48	
19			7.04	

Boys = $P < 0.05$; df = 19; t = −3.762 (significant difference between present study boys and WHO/ICCIDD boys for BSA). Girls = $P < 0.05$; df = 19; t = −4.598 (significant difference between present study girls and WHO/ICCIDD girls for BSA)

a sharp increase in the TV between the ages of 13-15 years. This may be due to upsurge of thyroid size at puberty and also documented by Wiersinga *et al.* [7]

The median thyroid volume obtained in this study compared favorably with that of Anele[2] and the noted difference in their values being statistically insignificant ($P > 0.05$). This may be due to the fact that the two studies were carried out within the same geographical location and the populations studied have similar cultural and dietary habits. The median thyroid volume (TV) for age in our study for boys and girls compared favorably with a previous study by Zimmerman *et al.*,[4] though only for age 6-12 years and there was no statistically significant difference ($P > 0.05$). This can be attributed to the multicenter approach to the latter study. However, when the values obtained in our study were compared with the European-based World Health Organization/

International Council for the Control of Iodine Deficiency Disorders (WHO/ICCIDD) 1997 reference values,[13] the values obtained in our study were found to be significantly lower ($P < 0.05$). This is in agreement with previous documentations,[4,7,24] that Caucasian values are slightly different from our local values, because of previously suggested environmental factors such as dietary habits and socioeconomic factors that tend to encourage thyroid size. Thus, our finding collaborates with studies done in other centers [2, 5, 7-10] that the WHO/ICCIDD 1997 reference values grossly underestimate the prevalence of goiter in our environment. This view encourages the need for provision of population-specific reference values.

Our study showed an increase in median thyroid volume (TV) with BSA. The values from Zimmerman *et al.* [4] and WHO/ICCIDD 1997 study [13] also showed an increase in thyroid volume with BSA. When our study TV for boys and girls were compared with those of Zimmerman *et al.*,[4] there was no statistically significant differences between them ($P > 0.05$). However, when the upper limit of our study TV/BSA values was compared with that of WHO/ICCIDD, [13] the values from this study were noted to be significantly lower ($P < 0.05$). This is in agreement with previous studies done elsewhere.[3, 6, 8] Sullivan *et al.* [3] suggested that these differences might be due to the fact that children in developing countries are usually thinner and shorter than their European counterparts, while Wiersinga *et al* [7] studied the thyroid volume in Dutch school children, and attributed these differences to the iodine deficiency that existed in many Europe countries up to the early 1990s.

The sex difference noted in the TV between boys and girls in our study was not statistically significant ($P > 0.05$). This is in agreement with previous studies.[2,5,8,9] However, a study by Azizi *et al.*[25] carried out on school children in the Emirates documented statistically significant differences in the median and upper limit of the TV between boys and girls, in favor of boys ($P < 0.001$). Ahidjo *et al.*[26] in a study for the adult group in Maiduguri, Nigeria also found statistically significant differences in the thyroid volume between males and females in favor of the males. Our study also showed an increase in height and weight with age in the boys and girls with no statistical significant differences in height and weight between the boys and the girls ($P > 0.05$ for height and $P > 0.05$ for weight). This may probably explain the insignificant difference in the age- and BSA-specific median thyroid volumes for boys and girls. A similar study by Sullivan *et al.* [3] that compared different indicators of iodine deficiency in school children showed an increase in the thyroid volume with height.

The dimensions of the thyroid lobes obtained in this study showed no statistical significant difference between the right and left lobes ($P > 0.05$). Previous study by Anele [2] is in agreement with this finding. Tahir *et al.*[27,28] whose study was conducted in adults found significant differences in the dimensions between the right and left lobes in favor of the right in both sexes ($P < 0.001$).

Analysis of data from our study showed strong correlation between the median thyroid volume and subjects' age ($r = 0.804$, $P < 0.001$). Anele [2] also found strong correlation between subjects' age and median thyroid gland volume. This is similar to results obtained in other previous studies. [7, 12]

Our study also showed a strong correlation between subject height and median thyroid volume ($r = 0.779$, $P < 0.01$). Ueda [11] in a previous study also found a similar correlation. The subject weight also correlated strongly with the median thyroid volume ($r = 0.627$, $P < 0.01$). Rossi *et al.*[29] in a study of thyroid volume by US in healthy Brazilian school children also documented a correlation of age, height, and weight with thyroid volume.

There was a strong correlation of median thyroid volume with body surface area (BSA) in both sexes ($r = 0.788$, $P < 0.01$). Hess *et al.* [9] also found strong correlation between median thyroid volumes with BSA.

This study was also able to show a strong correlation between the thyroid gland dimensions with age and BSA. The subjects age correlated well with the antero-posterior diameter right lobe ($r = 0.538$, $P < 0.01$), medio-lateral diameter right lobe ($r = 0.721$, $P < 0.01$) cranio-caudal diameter right lobe ($r = 0.734$, $P < 0.01$), and the anteroposterior diameter left lobe ($r = 0.518$, $P < 0.01$), mediolateral diameter left lobe ($r = 0.728$, $P < 0.01$), and craniocaudal diameter left lobe ($r = 0.767$, $P < 0.01$). Similarly, the subjects BSA correlates well with the antero-posterior diameter right lobe ($r = 0.322$, $P < 0.01$), medio-lateral diameter right lobe ($r = 0.494$, $P < 0.01$), and craniocaudal diameter right lobe ($r = 0.526$, $P < 0.01$). And the anteroposterior diameter left lobe ($r = 0.331$, $P < 0.01$), mediolateral diameter left lobe ($r = 0.475$, $P < 0.01$) and craniocaudal diameter left lobe ($r = 0.546$, $P < 0.01$).

This study has been able to establish a normal range of the thyroid gland volume for school-aged children in Benin City which can be used as local reference values for iodine deficiency disorder screening. The findings of this study also showed correlation with studies done elsewhere both locally and internationally, corroborating an increase in median thyroid gland volume with age. This study also revealed no significant difference between the thyroid gland volume of boys and girls and the right and left thyroid lobes. It showed significantly lower thyroid gland volume than the European based WHO/ICCIDD reference values. We acknowledge the tendency to interobserver and intraobserver variation in ultrasound evaluation of thyroid but as shown in this study and comparable study, they are insignificant and unlikely to affect results in trained hand. [30, 31]

Conclusion

The average median thyroid gland volume in school-aged children in Benin city from this study is taken as 2.32 cm^3 with the following dimensions; anteroposterior right lobe = 1.06 cm, mediolateral right lobe = 1.01 cm and craniocaudal right lobe = 2.34 cm, and anteroposterior left lobe = 1.01 cm, mediolateral left lobe = 1.04 cm and craniocaudal left lobe = 2.41 cm for both boys and girls. These values are recommended as reference values for use in school-aged children in Benin City, Nigeria.

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