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Effects of body weight, height, and body mass index on thyroid volume among healthy undergraduate Saudi males using ultrasound.

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Abstract

The aim of the current study was to correlate the effects of body weight, height, and body mass index (BMI) on thyroid volume of healthy undergraduate Saudi males by using ultrasound. After retaining an acceptance from the local ethics committee, a total of 100 (mean age was 21.8 ± 1.3 y; ages range from 18 to 22 y) participants were recruited between September 2016 and January 2018 in this prospective cohort study. Ultrasonographic measurements of the gland were performed using a HI vision Avius ultrasound unit (Hitachi), equipped with a high frequency direct contact 10 MHz linear array ultrasound probe. The calculated mean of thyroid volume was 7.5 ± 2.4 ml (right lobe volume was 3.9 ± 1.6 ml while that for left lobe was 3.6 ± 1.2 ml). Extremely statistically significant correlation (P<0.0001) was found between gland volume (ml) and participants' weight (kg), height (cm), and BMI (kg/m^2). In conclusion, the estimated thyroid volume was decreased significantly as participants' weight and BMI increase. In contrast, the volume increases significantly as height increases. Also, a local reference of thyroid volume among healthy undergraduate Saudi males was conducted.

Keywords: Body height, Body mass index, Body weight, Goiter, Thyroid gland.

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Introduction

The thyroid gland is an essential endocrine gland in humans and other animals; it is situated in the infra-hyoid portion of the neck [1]. The gland contains many follicular cells that store the thyroid hormones within the thyroglobulin molecule until they are needed by the body. The thyroid hormones often referred to as the major metabolic hormones; affect virtually every cell in the body. Synthesis and secretion of the thyroid hormones depend on the presence of iodine and tyrosine as well as maturation of the hypothalamic-pituitary-thyroid system [2]. Iodine is crucially necessary for ordinary gland activity. Iodine attains the gland follicular cells as mineral iodide and is converted through sequences of metabolic actions into Tetraiodothyronine (T4) and Triiodothyronine (T3) hormones. Major steps of the iodine metabolism contain: 1) quick iodide transportation; 2) iodination of tyrosyl residues of Thyroglobulin (Tg); 3) connecting of iodotyrosine molecules to produce T3 and T4; 4) proteolysis of Tg, with the liberate of unrestrained iodotyrosines with iodthyronines; 5) deiodination of iodotyrosines and reuse of extricated iodide and 6) deiodination of T4 to T3 [3].

The true measurement of thyroid size is essential in the investigation of the gland and rating its abnormalities. The size of the gland can be decided by palpation, Nuclear Medicine (NM) or Ultrasound (US). Nowadays US and NM are used in examining the adult thyroid gland [4-7]. The reliability of palpation particularly in children is inaccurate. Therefore, US is the most beneficial modality in determining the gland size in children [8]. In addition, US can be applied satisfactorily in testing cystic or solid masses of the gland and in determining extrathyroid or intrathyroidal pathologies [6,9,10].

The valuation of the gland volume sonographically, is supported on the applied of an ellipsoid formula. Where thyroid height, width, and depth of each lobe are measured and multiplied by a correction constituent [11]. Brunn et al. conducted a volumetric analysis of gland lobes by US in cadaver glands immersed in water [12]. Their results present a moderate correction constituent of 0.479 that will produce more correct assessment of the gland volume compared to the approved factor of $\pi/6$ or 0.524 [12].

This study established with an aim to correlate the effects of body weight, height, and body mass index (BMI) on thyroid volume of healthy undergraduate Saudi males by using ultrasound.

Materials and Methods

Participants

After retaining an acceptance from the local ethics committee of College of Applied Medical Sciences, King Saud University, a total of 100 healthy undergraduate Saudi males were recruited between September 2016 and January 2018 in this prospective cohort study. All of the ultrasound measurements of the gland were performed by the same sonographer to avoid bias and any intra-observer errors. Participants with frontal neck swelling or clinical proof of gland disorder were excluded, since these may alter the volume of the gland.

Technique

Sonographic measurements of the gland were performed using a HI vision Avius ultrasound unit (Hitachi), equipped with a high frequency direct contact 10 MHz linear array ultrasound probe. The Aquasonic 100 US gel was applied as a coupling material. Hard copies of thyroid sonographic images were obtained using US printer (Sony), 100 V; 1.5 A; and 50/60 Hz.

US examinations were conducted in a dorsal position with maximum neck extension. In each thyroid lobe a long and short axis US scan were used, as to obtain the length, width and depth in centimeters. Gland volume was fitted as a sum of lobe volumes [13,14]. The lobe volume was calculated using the rotation ellipsoid model formula [15,16].

Statistical analysis

Data were initially sum up as mean ± SD in a form of tables. Analysis was initiated using the Statistical Package for the Social Sciences (SPSS) transformation 20 for Windows (Microsoft). A P-value<0.05 was contemplating significant.

Results

Thyroid gland volume was estimated in 100 health undergraduate Saudi males. Participants' mean age was 21.8 ± 1.3 y and ranged from 18 to 22 y. The calculated mean of the gland volume was 7.5 ± 2.8 ml. Right lobe volume was 3.9 ± 1.6 ml while that for left lobe was 3.6 ± 1.2 ml (Table 1). Among participants the greater volume detected for the gland was 13.5 ml, while the lesser volume was 2.4 ml.

As presented in Table 2, the mean height of participants was 172 ± 7.9 cm. Maximum participants' height was 200 cm and minimal height was 140 cm. While in Table 3, the calculated mean weight of participants was 79.4 ± 22.2 kg. Also the maximum participants' weight was 147 kg and minimal weight was 46 kg. The mean BMI was 26.8 ± 7.4 kg/m^2.

Maximum participants' BMI was 49.7 kg/m^2 and minimal BMI was 16.2 kg/m^2. Also, the BMI of participants was ranged from 21.7 ± 2.5 kg/m^2 to 138.5 ± 12.02 kg/m^2 as shown in Table 4.

The results also demonstrate an extremely statistically significant relationship (P<0.0001) between the entire gland volume (ml) and the participants' weight (kg) (y=-0.2 x+80.8); R^2=0.0004) where (y) refers to body weight (kg) and (x) refers to the gland volume (ml). Also, another significant correlation (P<0.0001) found between the mean thyroid volume (ml) and participants' height (cm) (y=0.009 x+172.2); (R^2=8E-06]; where (y) denotes to body height (cm) and (x) represents thyroid volume (ml).

The two-tailed P-value was <0.0001 among participants BMI (kg/m^2) and thyroid volume (ml) (y=-0.05 x+27.1); (R^2=0.0002); where (y) denotes BMI (kg/m^2) and (x) presents thyroid volume (ml), by conventional criteria, this difference is considered to be extremely statistically significant.

Table 1. *Calculated thyroid gland volume (ml).*

Variables	Right lobe volume (ml)	Left lobe volume (ml)	Participants thyroid volume (ml)
N	100	100	100
Mean	3.9	3.6	7.5
± SD	± 1.6	± 1.2	± 2.8

Table 2. *Height (cm) of the participants.*

Range of participants' height (cm)	Frequency and percentage of participants height (n; %)	Mean participants' height (cm ± SD)
1.4-1.5	1 (1%)	140 ± 0.0
1.51-1.61	2 (2%)	156 ± 7.0
1.62-1.72	51 (51%)	167 ± 3.1
1.73-1.83	40 (40%)	176 ± 2.5
1.84-1.94	5 (5%)	186 ± 1.8
1.95-2.05	1 (1%)	200 ± 0.0
Total	100 (100%)	172 ± 7.9

Table 3. *Weight (kg) of participants.*

Range of participants' weight (kg)	Frequency and percentage of participants weight (n; %)	Mean participants' weight (kg ± SD)
46-66	36 (36%)	57.62 ± 5.87
67-87	34 (34%)	76.54 ± 5.79
88-108	18 (18%)	96 ± 4.82
109-129	10 (10%)	119.5 ± 6.29
130-150	2 (2%)	138.5 ± 12.02
Total	100 (100%)	79.4 ± 22.2

Table 4. BMI (kg/m²) of participants.

Range of participants' BMI (kg/m²)	Frequency and percentage of participants BMI (n; %)	Participant's BMI (kg/m² ± SD)
16.2-26.2	59 (59%)	21.7 ± 2.5
26.3-36.3	27 (27%)	29.9 ± 2.7
36.4-46.4	13 (13%)	40.5 ± 2.7
46.5-56.5	1 (1%)	49.7 ± 0.0
130-150	2 (2%)	138.5 ± 12.02
Total	100 (100%)	26.8 ± 7.4

Discussion

Accurate knowledge of thyroid gland dimension is necessary in the diagnosing of gland pathologies. Observation of the efficiency of the therapy in goiter is beneficial indicators for the prediction of hyperthyroidism. Although, in diffuse thyroid diseases the value of US may be limited to some extent [17]. Recently, the World Health Organization (WHO) has substituted the palpation by US measurement of gland volume as a diagnostic criterion for goiter. Thyroid dimension measurement is easy to gain, because it has a distinct echogenicity compare to neighboring structures [12]. Due to its cone-shaped morphemic, its lobe is supposed to mimic an ellipsoid, and its volume is calculated by multiplying height × width × depth × a correction factor. Also the automated transverse surface area method using the three-dimensional ultrasound (3D US) has been designed to rate thyroid volume [18,19].

Our study revealed a mean gland volume of 7.5 ± 2.4 ml. Such value is lesser than the value demonstrated by Hegedus et al. and Ivanac et al. and it's more than the volume presented by Kayastha et al. and Yousef et al. [3,5,20,21]. Due to the increasing in the usage of iodine supplementation in our region recently, this could be one of the reasons reducing iodine inadequacy and thus decreases goiter incidence. In addition, a notable inconsistency exists between the sizes of right and left thyroid in individual [22]. Where in our study, right lobe presents a volume of 3.9 ± 1.6 ml greater than that of left one, 3.6 ± 1.2 ml as presented in Table 1.

In the current study an extremely statistically significant relation ($P<0.0001$) found between thyroid volume (ml) and the participants' weight (kg) ($y=-0.2x+80.8$); $R^2=0.0004$]. This finding is compatible with the results of Hegedus et al., Svensson et al., and Sari et al. [5,23,24]. Furthermore, Ivanac et al. correlated gland volume with participants height ($r=0.37$; $P=0.001$) [3]. Their findings supported our findings in this study, where a significant relationship ($P<0.0001$) was found between participants' thyroid volume (ml) and their height (cm) ($y=0.009x+172.2$); ($R^2=8E-06$).

The obtained results found that the two-tailed P-value is <0.0001 among participants BMI (kg/m²) and thyroid volume (ml) ($y=-0.05x+27.1$); ($R^2=0.0002$), by conventional criteria, this difference is considered to be extremely statistically significant. Such finding was supported by Sari et al. in where they found a positive relation of thyroid volume with BMI ($r=0.504$, $P<0.001$). In contrast to our findings, Kaloumenou et al. was detected a least correlation of thyroid volume with BMI ($r=0.166$, $P=0.023$) [24,25].

Limitations of the current study, include the relatively small number of participants (n=100), and the homogeneity of the sample (health undergraduate Saudi males). But the strength of this study comes from the fact that it is the first study carried in the kingdom of Saudi Arabia among healthy undergraduate Saudi males in the age of 18 to 22 years.

In conclusion, a local reference of thyroid volume among healthy undergraduate Saudi males was conducted. The volume of the right thyroid lobe found to be greater than the left one. In addition, the estimated thyroid volume was decreasing significantly as participants' weight and BMI increase. While in contrast, it increases significantly as height increases.

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