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(RESEARCH ARTICLE)

Effect of BMI, age, and gender on thyroid profile and the distribution of thyroid dysfunction in healthy Iraqi adults

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Abstract

This study aimed to investigate the relationship between thyroid hormone, body mass index, age and gender in an Iraqi population sample of 177 healthy individuals. Results: The study showed that the majority of participants were female (89.3%) compared to males (10.7%). A significant proportion of the total participants were found to be obese (57.1%). We also found that older adults had higher levels ($p = 0.011$) of thyroid-stimulating hormone (TSH) while there was no significant relationship between T4 (0.271) and T3 (0.537) and age. Women were found to have higher levels ($p = 0.034$) of thyroid-stimulating hormone (TSH) and lower levels of active thyroid hormones (T4 ($p < 0.001$) and T3 ($p = 0.006$)) compared to men. We also found that TSH levels were significantly and gradually increased in overweight and obese individuals compared to normal individuals, and the highest increase in TSH levels was found between the normal weight and obese groups ($p < 0.001$). While total T3 and total T4 were found to decrease gradually and significantly, the highest decrease in total T3 ($p < 0.007$) and total T4 ($p < 0.011$) levels was observed between the normal weight and obese groups. Our results also showed that BMI was the best predictor of thyroid hormone levels ($p = 0.000$) when using the ROC curve, with an area under the curve (AUC) of 0.805, followed by gender ($p = 0.002$) with an AUC value of 0.719. However, age did not appear to have any effect on the levels of the thyroid hormones under study ($p = 0.063$). Therefore, we focused on studying the relationship between obesity and hypothyroidism, where the association was positive with a value of 25.134, and individuals with hypothyroidism were more likely to be overweight (30.0%) or obese (70.0%). Conversely, individuals with hyperthyroidism were less likely to be obese (0.0%). Conclusion: These results suggest that factors such as obesity and gender play an important role in regulating thyroid function and emphasize the need for further studies to understand this relationship more deeply. These findings may help in developing better diagnostic and therapeutic strategies for thyroid disorders, especially in women and those with obesity. Regular thyroid screening is recommended for all individuals regardless of their health status, especially those with specific risk factors.

Keywords: BMI; Gender; Age; Thyroid Profile; Thyroid Dysfunction; Healthy; Iraq

1. Introduction

Obesity is a complex, multifactorial disease. The prevalence of overweight and obesity has increased worldwide to the point of affecting nearly one-third of the world's population. Regardless of ethnicity, geographic location, or socioeconomic status, it affects all ages and genders [1]. Previous research has shown that overweight and obesity are associated with impaired glucose tolerance, hypertension, and risk factors for atherosclerosis and type 2 diabetes [2,3]. In addition, obesity is closely associated with thyroid dysfunction such as hypothyroidism and hyperthyroidism [4]. Published reports have revealed an association between body weight and thyroid hormone levels [5]. These hormones are suggested to regulate body metabolism, thermogenesis, and weight regulation as well as to be involved in appetite regulation [6,7]. Furthermore, numerous studies have claimed that alterations in thyroid function, even within the normal range, in themselves contribute to the development of metabolic syndrome, with circulating TSH reported to be associated with visceral obesity, dyslipidemia, insulin resistance, hypertension, and nonalcoholic fatty liver disease

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(NAFLD) [8–11]. Thyroid dysfunction is associated with fluctuations in body weight and composition [12]. However, study on thyroid dysfunction in obese adults are inconsistent [13]. However, the exact mechanisms of this relationship remain unclear, especially in the Iraqi population. These data will be used to explore the relationship between body mass index (BMI) and thyroid hormone levels (thyroid stimulating hormone (TSH), triiodothyronine (T3), and thyroxine (T4)) in our local population, with the aim of determining whether obesity is a risk factor for thyroid dysfunction in healthy Iraqi adults with of gender and age.

2. Method and Participants

For routine check-ups, about 177 healthy adults visited Al-Sadr Teaching Hospital. Therefore, this cross-sectional study was conducted in Najaf, Iraq in 2022. All study participants provided their information regarding their detailed history and laboratory tests such as gender, age group, BMI, and thyroid parameters (TSH, T3, and T4). All these information was collected from healthy Iraqi individuals from electronic and medical records and examined. Participants with a history of metabolic syndrome, thyroid disorders, diabetes, renal disease, and hypertension were excluded from our study. The selected participants were divided into two groups based on gender, male and female, and divided into two groups based on age, less than 50 years and more, and divided into three groups based on BMI according to the WHO standard criteria: obese: ≥ 30 kg/m2, overweight: 25-29.9 kg/m2, and healthy (normal): 18.5-24.9 kg/m2. Statistical analysis of the selected data was performed using SPSS version 26, including Student's t-test, ANOVA test with LSD, frequency, percentage, ROC analysis, and Pearson's chi-square test. Statistical significance was set at $p < 0.05$.

3. Results

Our results showed significant statistical differences in BMI categories between males and females. The majority of participants were females (89.3%) compared to males (10.7%). A large proportion of the total participants were found to be obese (57.1%) when distributing BMI between groups (normal, overweight, obese). However, age did not appear to significantly affect male and female participants when distributing age between the two groups (<50 years and ≥50 years).

Table 1 Gender distribution based on BMI and age.

Variables	**Gender**			**P-value**
	Male 19 (10.7 %)	**Female 158 (89.3 %)**	**Total 177(100.0%)**	
Age (years)				
<50	2(10.5%)	59 (37.3%)	61 (34.5%)	0.060 $\chi2$ =4.581
≥50	17(89.5%)	99(62.7%)	116 (65.5%)	
BMI				
Normal (18.5-24.9)	7(36.8%)	13(8.2%)	20(11.3%)	0.001* $\chi2$ =14.005
Overweight (25-29.9)	5(26.3%)	51(32.3%)	56(31.6%)	
Obese (≥30)	7(36.8%)	94(59.5%)	101(57.1%)	

The results of our study also indicated that there were statistically significant differences in thyroid hormone levels between males and females. There were statistically significant differences ($p=0.034$) in the data related to a higher mean level of TSH in females compared to males, while there were lower levels of T4 ($p<0.001$) and T3 ($p=0.006$) in females compared to males (Table 2).

Table 2 Gender distribution based on Thyroid hormones**.**

Thyroid hormones	Gender		Sig.
	Male (n=19) Mean±SD	Female (n=158) Mean±SD	
TSH	1.7129±1.70795	2.5070±1.50898	0.034*
T4 (nmol/L)	101.2924±11.96656	85.7862±18.50576	0.000*
T3 (nmol/L)	1.7700±0.38883	1.5280±0.35474	0.006*

The results of our study also indicated that there were statistically significant differences (p=0.011) in the data related to the increase in the mean level of TSH hormone in the elderly ≥50 years, while there was no statistically significant relationship between T4 (0.271) and T3 (0.537) hormones and age, which indicates that the level of T3 and T4 hormones was not significantly affected by age in this sample (Table 3).

Table 3 Age distribution based on Thyroid hormones.

Variables	Age		Sig.
	(<50) (n=57) Mean±SD	(≥50) (n=120) Mean±SD	
TSH	2.0355±1.22397	2.6052±1.65072	0.011*
T4 (nmol/L)	89.6786±16.85292	86.3924±19.25063	0.271
T3 (nmol/L)	1.5314±0.30275	1.5647±0.39211	0.537

We also found that the mean TSH levels gradually increased significantly in overweight and obese individuals compared to normal individuals, and the highest increase in TSH levels was between the normal weight and obese groups (p<0.001). While total T3 and total T4 were found to gradually decrease significantly in the studied individuals, the highest decrease in total T3 (p<0.007) and total T4 (p<0.011) levels was between the normal weight and obese groups (Table 4).

Table 4 Influence of BMI on thyroid hormone levels

Variabls	BMI			Sig.	LSD (P-Value)		
	Normal (18.5-24.9) (n=20) Mean±SD	Overweight (25-29.9) (n=56) Mean±SD	Obese (≥30) (n=101) Mean±SD		1^{st}&2^{nd}	1^{st}&3^{rd}	2^{nd}&3^{3rd}
TSH	0.9130±0.45955	1.9693±1.55670	2.9713±1.39965	0.000*	0.004*	0.000*	0.000*
T4 (nmol/L)	96.8550±18.12167	89.0118±18.24697	84.7229±18.22460	0.020*	0.100	0.007*	0.159
T3 (nmol/L)	1.7209±0.42822	1.6021±0.37576	1.4943±0.33429	0.019*	0.206	0.011*	0.073

Our statistical analysis results showed that BMI was the best predictor of TSH levels (p=0.000) when using the ROC curve, with an area under the curve (AUC) of 0.805, followed by gender (p=0.002) with an AUC value of 0.719. However, age did not appear to have any effect on the levels of the thyroid hormones under study (p = 0.063) (Table 5).

Table 5 AUC Values for BMI, Gender, and Age in predicting Thyroid Hormone Levels

Variable		Area Under the Curve	Sig
BMI	TSH	0.805	0.000*
	T4	0.399	0.022*
	T3	0.406	0.032*
Gender	TSH	0.719	0.002*
	T4	0.225	0.000*
	T3	0.305	0.006*
Age	TSH	0.587	0.063
	T4	0.469	0.509
	T3	0.519	0.676

Our study also revealed a heterogeneous distribution of thyroid disorders according to BMI categories within the study. A significant increase ($p<0.001$) was observed in cases of hypothyroidism, which were concentrated in the obesity (70%) and overweight (30%) categories, while hyperthyroidism cases ($p<0.019$) were concentrated in the normal weight category (100%). This indicates a direct relationship between obesity, overweight, and hypothyroidism, and an inverse relationship between obesity and hyperthyroidism (Table 6 and 7).

Table 6 Distribution of thyroid dysfunction by BMI category**.**

Variables	N	BMI			Sig.
		Normal (18.5-24.9) (n=20)	Overweight (25-29.9) (n=56)	Obese (≥30) (n=101)	
Hypothyroid	10	0(0.0%)	3(30.0%)	7(70.0%)	0.000*
Euthyroid	164	17(10.4%)	53(32.3%)	94(57.3%)	0.020*
Hyperthyroid	3	3(100.0%)	0(0.0%)	0(0.0%)	0.019*

Table 7 Association between thyroid dysfunction and BMI by the Chi-square test.

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.134a	4	0.000
Likelihood Ratio	15.780	4	0.003
Linear-by-Linear Association	7.613	1	0.006
a. 5 cells (55.6%) have expected count less than 5. The minimum expected count is .34.			

4. Discussion

Our study of 177 participants (158 females and 19 males) showed a significant increase in the distribution of BMI by gender, with females being significantly higher (89.3%) than males (10.7 %). This study was consistent with Chooi et al. [1] who found that the prevalence of obesity was higher in females. The results indicated statistically significant differences in thyroid hormone levels between the two sexes, with higher TSH levels observed in females and lower T4 and T3 levels compared to males. The result was somewhat consistent with studies [14-19] who reported that females showed higher TSH levels than males. This increase may be due to factors such as iodine deficiency, race, or genetic factors, etc. Two Danish studies also explained that mild to moderate iodine deficiency can affect TSH, with reference

ranges for TSH from 0.58-4.07 mIU/L [20] and 0.40-3.6 mIU/L [21], while another study free of diseases reported the reason for high TSH values, explaining that race can affect TSH [22].

Our study also found that TSH levels increased with age. This study is consistent with that of Chen et al. [17], who confirmed that TSH values increase during aging and that their high serum TSH may be due to their exceptional longevity and genetic longevity [23,24,25]. However, the results regarding the relationship between BMI and other thyroid hormones levels varied between different studies. Our study showed a negative association between BMI and T3 and T4 levels and a positive association with TSH levels. These results are partially consistent with previous studies [26-29] which showed an inverse relationship between BMI and FT4 levels and a positive relationship with TSH levels. However, our results differ from some studies [30-33] which showed no relationship between BMI and thyroid hormone levels in healthy individuals. These discrepancies in all results may be due to unaccounted confounding factors such as smoking, leptin level, body fat type, insulin sensitivity levels, iodine intake, ethnic differences, differences in tissue sensitivity to thyroid hormones, and the conditions in which the studies were conducted.

By ROC analysis, it was shown that BMI was the best predictor of TSH levels, compared to sex and age, so we investigated the relationship between thyroid disorders and BMI. Our study showed a significant overall association between them according to chi-square tests. By Pearson correlation, our results also showed that the majority of individuals with hypothyroidism were overweight (30.0%) or obese (70.0%) with a correlation value of 25.134, confirming previous findings (34-37) that obesity is a risk factor for hypothyroidism. The reason for thyroid dysfunction may be due to the stimulation of cytokine production by fat accumulation in adipose tissue, which in turn affects the hypothalamic-pituitary-thyroid (HPT) axis. However, other studies have not reported a direct association between obesity and the risk of hypothyroidism (38). These results suggest a possible relationship between obesity and thyroid dysfunction, as the obesity category may lead to hypothyroidism. While hyperthyroidism is concentrated in the normal weight category. Indicating a direct relationship between obesity and hypothyroidism and an inverse relationship between obesity and hyperthyroidism.

5. Conclusion

Conclusion These results indicate that BMI and gender play an important role in predicting thyroid hormone levels, while age did not affect thyroid hormone levels in this sample. These results indicate the importance of obesity as a potential risk factor for thyroid disorders and support the urgent need for more studies to understand and clarify the biological mechanisms underlying this association.

Compliance with ethical standards

Statement of ethical approval

The work was approved by the Ethics Committee of the University of Kufa.

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