Egyptian Journal of Physical Therapy (EJPT)

Egy. J. Phys. Ther. 2022;9:9-14

Original article

https://ejpt.journals.ekb.eg

# Effect of Body Composition on Thyroid Hormones in Euthyroid Post-pubertal Females: An Observational Study

**Esraa H. Mohamed [1]*, Azza B. Nashed [1], Mohamed F. Abo Elainin [2], Doaa A. Osman [1]**

[1] *Department of Physical Therapy for Woman's Health, Faculty of physical therapy, Cairo University, Egypt.*

[2] *Department of Obstetrics and Gynecology, Om El-Masryeen Hospital, Egypt.*

***Correspondence to** Esraa H. Mohamed, Department of Physical Therapy for Woman's Health, Faculty of Physical Therapy, Cairo University, Egypt.
**Tel:** + 0 109 639 2297
**Email:** esraahamamapt@yahoo.com

**Published online:** Mar 2022

**Abstract:**
**Purpose:** To determine the effect of body composition on thyroid hormones in euthyroid post-pubertal females.
**Methods:** Thirty post-pubertal females were classified according to the body mass index (BMI) into three equal groups; Group (A) had normal weight (BMI was 18-25 kg/m$^2$), Group (B) were overweight (BMI was 25-30 kg/m$^2$) and Group (C) had grade I obesity (BMI was 30-35 kg/m$^2$). Body composition parameters (BMI, and muscle, water, bone and fat contents) as well as fasting blood levels of thyroid hormones (serum free triiodothyronine (T3), serum free thyroxine (T4) and serum thyroid stimulating hormone (TSH)) were assessed for each female in the three groups.
**Results:** There were non-significant differences between the three groups ($p<0.05$) regarding muscle content, bone content, serum free T3 and serum TSH. However, group (C) had significantly lower water content as well as significantly higher fat content and serum free T4 than group (A) ($p<0.05$).
**Conclusion:** Obesity is associated with low water content as well as high fat content and serum free T4 levels in euthyroid post-pubertal females.
**Key words:** Body composition, thyroid hormones, euthyroid, post-pubertal females.

## 1. Introduction

Thyroid is a ductless endocrine gland that is found just inferior to the larynx at both sides of trachea and in front of it. The triiodothyronine (T3) and thyroxine (T4) represent the main thyroid hormones whose secretion is primarily controlled by thyroid stimulating hormone (TSH) (1).

The thyroid hormone's active form is T3 that accounts for only 20% of the secreted hormone, with most of T3 coming through peripheral T4 conversion to T3. T4 accounts for about 80% of the hormone that is produced. De-iodination occurs when T4 is discharged into the circulation, resulting in T3 formation. Both hormones can then act as a negative feedback loop on the anterior pituitary, with increased T3/T4 concentrations lowering TSH release while decreased T3/T4 concentrations enhancing TSH secretion.

The majority of T3/T4 in the circulation is bounded to thyroxine-binding globulin (TBG), whereas a little amount only has a free circulation in the blood and are physiologically active (2).

Thyroid hormones are required for appropriate growth, sexual development, and reproduction. Alterations in thyroid functioning and a rise in thyroid volume occur during puberty as a result of body and sexual development (3). Thyroid hormones regulate energy homeostasis, oxygen consumption and thermogenesis, as well as glucose and lipid metabolism (4).

Obesity is a chronic, inflammatory, metabolic condition with a positive energy balance. The adipose tissues produce various hormones as well as adipocytokines, including leptin, that can alter thyroid state at various degrees. There is evidence about the effect of thyroid malfunction on increasing obesity risk; contrariwise, there is evidence concerning the impact of obesity on inducing thyroidal changes (5).

Body composition is intimately connected to thyroid hormones levels that are correlated with the magnitude of body weight alteration, involving fat, muscle and water contents (6). The nature of relationship between nonpathological variation in thyroid state and body composition is unclear. Previous studies lacked measuring body composition parameters. Additionally, they included both males and females in the same study; they did not focus on a female sample only, especially that estrogen has a direct impact on females' thyroid cells (7). Therefore, the current study aimed to investigate the effect of body composition on thyroid hormones in euthyroid post-pubertal females.

## 2. Participants and Methods

*2.1. Design*

The study was a cross-sectional observational study. The research ethical committee of Cairo University's faculty of physical therapy approved it (No: P.T.REC/012/001950).

*2.2. Recruitment*

A sample of thirty post-pubertal females participated in this study; ten of them had normal weight (BMI was 18-25 kg/m$^2$), another ten were overweight (BMI was 25-30 kg/m$^2$) and the last ten had grade I obesity (BMI was 30-35 kg/m$^2$). They were selected from secondary schools, Kafr Elsheikh, Egypt. Each participant gained informed consent after identifying the study's nature, aim and benefit, telling them at all times of their right to decline and withdraw, and the confidentiality of any information taken.

*2.3. Inclusion and Exclusion criteria*

Females should be at least 1 year post-pubertal. Their ages were 15-16 years. All of them were non-smokers, healthy euthyroid. They should have no thyroid illness, cancer or surgical interference, history of obesity-related endocrine disease, diabetes, liver problems, hypertension, cardiovascular illness, stroke or renal disease. They shouldn't receive any drugs that may affect the thyroid function or reduce weight for 6 months as a minimum before study entry. They were distributed into 3 groups in accordance with their BMI, because it is simple, non-invasive and inexpensive (8). Group (A) consisted of 10 post-pubertal females, having normal weight (BMI was 18-25 kg/m$^2$), group (B) consisted of 10 post-pubertal females, suffering from overweight (BMI was 25-30 kg/m$^2$), and group (C) consisted of 10 post-pubertal females, suffering from grade I obesity (BMI was 30-35 kg/m$^2$).

*2.4. Outcome measures*

*2.4.1. Body composition parameters*

Each female in all groups had her weight and height measured by a weight-height scale to calculate the BMI through dividing weight by the square of height (Kg/m$^2$) for their classification into three groups. Then, the muscle, water, bone and fat contents were measured for each female in the three groups through Beurer InBody scale, a reliable non-invasive body composition analyzer that acts as an alternative for dual-energy x-ray absorptiometry (9). All parameters were evaluated between 8:00 a.m. and 9:00 a.m. while the participant did not take breakfast, with only light clothes, after removal of shoes, socks and all metal accessories, before taking blood samples.

*2.4.2. Fasting blood levels of thyroid hormones*

Venous blood samples were collected from antecubital veins of all females in the three groups after sterilization of area with alcohol swaps. All samples were taken at morning following no less than 10 hours of fasting to determine fasting blood levels of serum free triiodothyronine (T3), serum free thyroxine (T4) and serum thyroid stimulating hormone (TSH), using MINI VIDAS, a compact automated immunoassay system depending on the Enzyme Linked Fluorescent Assay (ELFA) principles. MINI VIDAS has world-wide reputation as simple, flexible, reliable and available (10).

**Data analysis**

All statistical analysis was carried out with Windows version 25 of the Social Studies Statistical Package (SPSS) (IBM SPSS, Chicago, IL, USA). For comparing age between groups, the ANOVA test was carried used. Utilizing the Shapiro-Wilk test for all variables, normal data distribution has been validated. In order to check the homogeneity between groups, Levene's homogeneity test was undertaken. For comparison of the body composition parameters and blood levels of thyroid hormones between groups, one-way ANOVA test was performed. For all statistical analyses, the level of significance was set at $p<0.05$.

## 3. Results

Regarding the basic characteristics of participants, there was no significant difference in age between groups ($p>0.05$) (table 1). Regarding body composition parameters, there was a significant increase in BMI of group (C) compared to groups (A & B) ($p<0.05$), and a significant increase in BMI of the group (B) compared with that of group (A) ($p<0.05$). There were no significant differences in the muscle and bone contents between the three groups ($p>0.05$). There was a significant decrease in water content and a significant increase in fat content of the group (C) compared with that of group (A) ($p<0.05$). There were no significant differences in water and fat contents between the group (A) and (B) as well as between group (B) and (C) ($p>0.05$) (table 2).

Regarding thyroid hormones, there was a significant increase in serum free T4 of the group (C) compared to group (A) ($p<0.05$). There were no significant differences in serum free T4 between the group (A) and (B) and between group (B) and (C) ($p>0.05$). There were no significant differences in the serum free T3 and serum TSH between the three groups ($p>0.05$) (table 3).

**Table (1): Basic characteristics of participants**

| | Group (A) | Group (B) | Group (C) | P value |
|---|---|---|---|---|
| | x̄±SD | x̄±SD | x̄±SD | |
| **Age** (years) | 15.6 ± 0.51 | 15.4 ± 0.52 | 15.3 ± 0.48 | 0.185 NS |

**NS P > 0.05 = non-significant, P = Probability.**

**Table (2): Body composition parameters of the three groups A, B and C**

| | Group (A) | Group (B) | Group (C) |
|---|---|---|---|
| | x̄±SD | x̄±SD | x̄±SD |
| **BMI** (kg/m²) | 20.56 ± 2.62 | 25.18 ± 1.81 | 31.77 ± 2.07 |
| **Muscle content** (%) | 29.1 ± 2.33 | 29.6 ± 1.5 | 29.1 ± 2.72 |
| **Water content** (%) | 41.6 ± 2.11 | 37.9 ± 3.24 | 35.2 ± 5.32 |
| **Bone content** (%) | 9.9 ± 0.31 | 9.8 ± 0.42 | 9.7 ± 0.48 |
| **Fat content** (%) | 19.6 ± 2.83 | 23.2 ± 3.67 | 26.3 ± 4.9 |

**One-way ANOVA test for the body composition parameters between the three groups**

| p-value | A vs B | A vs C | B vs C |
|---|---|---|---|
| **BMI (kg/m²)** | 0.001 S | 0.001 S | 0.001 S |
| **Muscle content** (%) | 0.87 NS | 1 NS | 0.87 NS |
| **Water content** (%) | 0.09 NS | 0.002 S | 0.26 NS |
| **Bone content** (%) | 0.85 NS | 0.53 NS | 0.85 NS |
| **Fat content** (%) | 0.11 NS | 0.002 S | 0.19 NS |

**NS p>0.05 = non-significant, S p<0.05 = significant, p = Probability**

**Table (3): Fasting blood levels of thyroid hormones of the three groups A, B and C**

| | Group (A) | Group (B) | Group (C) |
|---|---|---|---|
| | x̄±SD | x̄±SD | x̄±SD |
| **Serum free T3** (pg/ml) | 2.72 ± 0.28 | 2.85 ± 0.26 | 3.03 ± 0.34 |
| **Serum free T4** (pg/ml) | 0.08 ± 0.01 | 0.09 ± 0.01 | 0.1 ± 0.02 |
| **Serum TSH** (uIU/ml) | 3.57 ± 0.66 | 3.32 ± 0.6 | 3.09 ± 0.59 |

**One-way ANOVA test for the body composition parameters between the three groups**

| p-value | A vs B | A vs C | B vs C |
|---|---|---|---|
| **Serum free T3** (pg/ml) | 0.58 NS | 0.06 NS | 0.37 NS |
| **Serum free T4** (pg/ml) | 0.86 NS | 0.03 S | 0.09 NS |
| **Serum TSH** (uIU/ml) | 0.63 NS | 0.2 NS | 0.68 NS |

**NS p>0.05 = non-significant, S p<0.05 = significant, p = Probability**

## 4. Discussion

Although thyroid hormones disorders are accompanied by body composition alterations, the response of thyroid hormones to body composition in an euthyroid population is unclear (4). For that reason, this study was designed to determine body composition effect on thyroid hormones in euthyroid post-pubertal females.

Regarding body composition parameters, our results demonstrated that the BMI showed a significant increase in group (C) in comparison to the other two groups (A & B), and a significant increase in group (B) in comparison to group (A). The muscle and bone contents showed non-significant differences between the three groups. Although water content showed a significant decrease and fat content showed a significant increase in group (C) in comparison to group (A), they showed non-significant differences between groups (A) and (B) as well as between groups (B) and (C).

These results indicated that obesity did not influence muscle and bone contents of post-pubertal females. There is a contrast among studies on the obesity effect on muscle and bone contents. Some studies found that children with overweight or obesity had greater mass and density of bone (11-13), others found that they had lower (14-15) or similar as in the current study in comparison to children with normal weight (16-17). Likewise, previous research revealed that obesity was associated with high muscle mass (18), while others reported that it was accompanied by poor muscle quality (19). The contrast between studies could be related to variations in participants' age, sex, physical activity level and nutritional status, as well as differences in evaluated skeletal areas.

The significant reduction in water content and increase in fat content of group (C) in comparison to group (A) could be supported with Laja García et al. (20) who found that overweight/obese persons, according to BMI, drank water not as much as persons with normal weight. Additionally, another research reported that BMI was positively correlated to body fat percent, and both were negatively correlated to body water content (21). Moreover, cross-sectional research was performed in healthy persons, in which inversely related links were established between water intake and body weight, as well as body fat. Understanding the reasons behind such connections is important, and while the answer is yet unknown, it has been postulated that a combination of water-related factors could explain them. Thus, water intake increases satiety, increases rate of lipolysis and expenditure of energy through sympathetic stimulation and thermogenesis induction, decreases calorie intake due to errors in hunger and thirst cue perception, and improves meal quality, among other things (22).

Regarding thyroid hormones, serum free T4 showed a significant increase in group (C) in comparison to group (A) but still within normal range, while it showed non-significant differences between groups (A) and (B) as well as between groups (B) and (C). Additionally, serum free T3 and serum TSH showed non-significant differences between the three groups. These findings suggested that obesity alters only serum free T4 levels, with no effect on serum free T3 and serum TSH levels.

Regarding free T4, our findings were supported by Reinehr and Andler (23) who found higher total T4 concentrations in children with obesity in comparison to those with normal weight, at age ranging from 4.5 to 16 years, and declined following weight reduction program. Additionally, Milionis and Milionis (24) demonstrated a positive association between total T4 and BMI in euthyroid women. Moreover, an animal study concluded that obesity is accompanied by a significant rise in free T4, but within the normal range (25). On the other hand, some studies found no difference in free T4 between obese and non-obese euthyroid persons (26,27), while other studies demonstrated a significant negative relationship between free T4 and BMI in euthyroid individuals (28,29).

The increased free T4 in obese females in the current study could be related to the effect obesity on inducing a relative status of thyroid hormones resistance, either resulted from the impact of leptin and/or from the influence of increased no esterified fatty acids levels. An increased free T4 plus a normal or elevated TSH levels represent the diagnostic criterion for thyroid hormones resistance (25), and so the current study's observations were consistent with this criterion.

Regarding free T3, the results of the current study came in line with Iacobellis et al. (30) who reported absence of relationship between free T3 levels and BMI. On the contrary, the results of the current study disagreed with previous research demonstrating an increase in T3 or free T3 in overweight and obese persons when compared to normal weight counterparts (23,31). Moreover, some studies revealed positive association of T3 or free T3 levels with BMI in euthyroid individuals (24,32).

Regarding TSH, the present study's findings coincided with previous research showing non-significant difference in TSH levels between obese, overweight and normal weight persons (26). Additionally, several studies reported non-significant relationship between TSH levels and BMI (28,33). In contrast, the existence of a positive correlation between adiposity parameters and TSH in euthyroid individuals was reported by many investigators (32,34,35).

The controversy among studies concerning thyroid hormones levels in persons with different BMI could be related to dissimilarities in sample size, age, sex, exercise participation, dietary patterns and lifestyle habits of study participants.

## 5. Conclusion

Obese, overweight and normal weight euthyroid post-pubertal females have similar muscle content, bone content, serum free T3 and serum TSH. However, obese females have lower water content along with higher fat content and serum free T4 than normal weight females.


## Funding

Not funded.


## Conflict of Interest

Authors declare no potential conflicts of interest.


## Acknowledgments

Authors would like to thank all females who participated in the current study.


## References

1. Ahmed Z, Khan M, ul Haq A, Attaullah S, ur Rehman J. Effect of race, gender and age on thyroid and thyroid stimulating hormone levels in Northwest Frontier Province Pakistan. J Ayub Med Coll Abbottabad 2009; 21(3): 21-24.
2. Pirahanchi Y, Toro F, Jialal I. Physiology, Thyroid Stimulating Hormone. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021.
3. Weber G, Vigone M, Stroppa L, Chiumello G. Thyroid function and puberty. J Pediatr Endocrinol Metab 2003; 16 Suppl 2: 253-257.
4. Ren R, Jiang X, Zhang X, Guan Q, Yu C, Li Y, Gao L, Zhang H, Zhao J. Association between thyroid hormones and body fat in euthyroid subjects. Clin Endocrinol (Oxf). 2014; 80(4): 585-590.
5. García-Solís P, García OP, Hernández-Puga G, Sánchez-Tusie AA, Sáenz-Luna CE, Hernández-Montiel HL, Solis-S JC. Thyroid hormones and obesity: a known but poorly understood relationship. Endokrynol Pol. 2018; 69(3): 292-303.
6. Stangierski A, Ruchała M, Krauze T, Moczko J, Guzik P. Treatment of severe thyroid function disorders and changes in body composition. Endokrynol Pol. 2016; 67(4): 359-366.
7. Santin AP, Furlanetto TW. Role of estrogen in thyroid function and growth regulation. J Thyroid Res. 2011; 2011: 875125.
8. Akindele MO, Phillips JS, Igumbor EU. The Relationship Between Body Fat Percentage and Body Mass Index in Overweight and Obese Individuals in an Urban African Setting. J Public Health Afr. 2016 Aug 17;7(1):515. doi: 10.4081/jphia.2016.515. PMID: 28299149; PMCID: PMC5349253.
9. McLester CN, Nickerson BS, Kliszczewicz BM, McLester JR. Reliability and Agreement of Various InBody Body Composition Analyzers as Compared to Dual-Energy X-Ray Absorptiometry in Healthy Men and Women. J Clin Densitom. 2020;23(3):443-450.
10. Yasmin T, Siddiqui SI, Prasad KR, Ahmad N, Gupta A. Effects of neonatal Thyroid Stimulating hormone and free T4 levels on Apgar score, Maturity and Modes of delivery. JMSCR. 2014; 2(5): 890-895.
11. El Hage R, Jacob C, Moussa E, Benhamou CL, Jaffré C. Total body, lumbar spine and hip bone mineral density in overweight adolescent girls: decreased or increased? J Bone Miner Metab 2009; 27(5): 629-633.
12. Leonard MB, Shults J, Wilson BA, Tershakovec AM, Zemel BS. Obesity during childhood and adolescence augments bone mass and bone dimensions. Am J Clin Nutr. 2004;80(2):514-523.
13. Ellis KJ, Shypailo RJ, Wong WW, Abrams SA. Bone mineral mass in overweight and obese children: diminished or enhanced? Acta Diabetol. 2003;40 Suppl 1: S274-277.
14. Ivuskans A, Lätt E, Mäestu J, Saar M, Purge P, Maasalu K, Jürimäe T, Jürimäe J. Bone mineral density in 11-13-year-old boys: relative importance of the weight status and body composition factors. Rheumatol Int. 2013; 33(7): 1681-1687.
15. Goulding A, Taylor RW, Jones IE, McAuley KA, Manning PJ, Williams SM. Overweight and obese children have low bone mass and area for their weight. Int J Obes Relat Metab Disord. 2000; 24(5): 627-632.
16. Hasanoğlu A, Bideci A, Cinaz P, Tümer L, Unal S. Bone mineral density in childhood obesity. J Pediatr Endocrinol Metab. 2000; 13(3): 307-311.
17. Manzoni P, Brambilla P, Pietrobelli A, Beccaria L, Bianchessi A, Mora S, Chiumello G. Influence of body composition on bone mineral content in children and adolescents. Am J Clin Nutr. 1996; 64(4): 603-607.
18. Kutlu R, Cihan FG. Comparison of the body compositions in obese and nonobese individuals: Can learning body compositions motivate losing weight? Niger J Clin Pract. 2017; 20(1): 82-87.
19. Valenzuela PL, Maffiuletti NA, Tringali G, De Col A, Sartorio A. Obesity-associated poor muscle quality: prevalence and association with age, sex, and body mass index. BMC Musculoskelet Disord. 2020; 21(1): 200.
20. Laja García AI, Moráis-Moreno C, Samaniego-Vaesken ML, Puga AM, Varela-Moreiras G, Partearroyo T. Association between Hydration Status and Body Composition in Healthy Adolescents from Spain. Nutrients. 2019; 11(11): 2692.
21. Odo IF, Ezeanyika LUS, Uchendu N. The Relationship among Body Composition and Body Mass index in a Population of Adolescents in Enugu State, Nigeria. Int J Curr Microbiol App Sci 2015; 4(1): 884-897.
22. Laja García AI, Moráis-Moreno C, Samaniego-Vaesken ML, Puga AM, Partearroyo T, Varela-Moreiras G. Influence of Water Intake and Balance on Body Composition in Healthy Young Adults from Spain. Nutrients. 2019; 11(8): 1923.
23. Reinehr T, Andler W. Thyroid hormones before and after weight loss in obesity. Arch Dis Child. 2002; 87(4): 320-323.
24. Milionis A, Milionis C. Correlation between Body Mass Index and Thyroid Function in Euthyroid Individuals in Greece. ISRN Biomarkers 2013; 2013: 1-7.
25. Ferguson DC, Caffall Z, Hoenig M. Obesity increases free thyroxine proportionally to nonesterified fatty acid concentrations in adult

neutered female cats. J Endocrinol. 2007; 194(2): 267-273.
26. Ekinci F, Merder-Coşkun D, Tuncel B, Atila D, Yildiz H, Uzuner A. Relationship between obesity and thyroid function in adults. Marmara Medical Journal 2018; 31: 76-80.
27. Manji N, Boelaert K, Sheppard MC, Holder RL, Gough SC, Franklyn JA. Lack of association between serum TSH or free T4 and body mass index in euthyroid subjects. Clin Endocrinol (Oxf). 2006; 64(2): 125-128.
28. Makepeace AE, Bremner AP, O'Leary P, Leedman PJ, Feddema P, Michelangeli V, Walsh JP. Significant inverse relationship between serum free T4 concentration and body mass index in euthyroid subjects: differences between smokers and nonsmokers. Clin Endocrinol (Oxf). 2008; 69(4): 648-652.
29. Shon HS, Jung ED, Kim SH, Lee JH. Free T4 is negatively correlated with body mass index in euthyroid women. The Korean Journal of Internal Medicine 2008; 23: 53-57.
30. Iacobellis G, Ribaudo MC, Zappaterreno A, Iannucci CV, Leonetti F. Relationship of thyroid function with body mass index, leptin, insulin sensitivity and adiponectin in euthyroid obese women. Clin Endocrinol (Oxf). 2005; 62(4): 487-491.
31. Michalaki MA, Vagenakis AG, Leonardou AS, Argentou MN, Habeos IG, Makri MG, Psyrogiannis AI, Kalfarentzos FE, Kyriazopoulou VE. Thyroid function in humans with morbid obesity. Thyroid. 2006; 16(1): 73-78.
32. Marwaha RK, Tandon N, Garg MK, Ganie MA, Narang A, Mehan N, Bhadra K. Impact of body mass index on thyroid functions in Indian children. Clin Endocrinol (Oxf). 2013; 79(3): 424-428.
33. Archana N, Ipsita R, Naorem S, Prasad L, Ranabir S. Is there a correlation between body mass index and thyroid stimulating hormone? Endocrinol Metab Int J. 2019; 7(5):151–154.
34. Bétry C, Challan-Belval MA, Bernard A, Charrié A, Drai J, Laville M, Thivolet C, Disse E. Increased TSH in obesity: Evidence for a BMI-independent association with leptin. Diabetes Metab. 2015; 41(3): 248-251.
35. Muscogiuri G, Sorice GP, Mezza T, Prioletta A, Lassandro AP, Pirronti T, Della Casa S, Pontecorvi A, Giaccari A. High-normal TSH values in obesity: is it insulin resistance or adipose tissue's guilt? Obesity (Silver Spring). 2013; 21(1): 101-106.