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Impact of Lifestyle Modification on Thyroid Axis in Obese Adults: A quasi-experimental longitudinal study

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Abstract

Obesity is a complex and chronic disease characterized by the accumulation of fat in the body, which negatively impacts the thyroid axis, which controls basal metabolic rate and energy expenditure. The study aims to investigates the mechanisms correlating obesity with thyroid disorders, focusing on its impact on metabolic indicators, lipid profile at baseline, and assessing changes in hormonal balance resulting from health intervention. A quasi-experimental longitudinal controlled study was done on 100 participants from Ramadi city, Iraq, including 50 healthy individuals and 50 obese participants. All participants were initially assessed to classify them into healthy and obese groups. The obese group then followed a healthy lifestyle program for six months. Thyroid hormones were measured for the healthy and obese groups pre- and post-intervention, while the metabolic indicators and lipid profile were assessed at baseline for the obese groups only. The results showed a significant improvement in thyroid hormones post-intervention, with TSH and free T3 concentrations decreasing, and free T4 levels increasing, although they remained below normal levels. Baseline data revealed significant metabolic and lipid abnormalities among obese participants. Results of the current study indicate that a healthy lifestyle improves thyroid parameters in obese individuals, but restoring full hormonal balance may require a longer period. Baseline metabolic and lipid profile measurements highlight their importance as diagnostic tools for characterizing the metabolic effects of obesity.

1. Introduction:

Neuroendocrine signaling permits for combination of functions of various tissues in the body, leading to a coordinated response to regulate metabolism, body temperature, energy balance, and growth. The hypothalamic-pituitary-thyroid (HPT) axis is an example of how the endocrine system regulates these integrated vital functions [1]. The HPT axis consists of three regulatory levels: the hypothalamus (HT), the pituitary gland, and the thyroid gland. The HT and pituitary gland are in adjacent anatomical proximity at the brain base and extend over the pituitary stem to the sella turcica. The pituitary stem permits passage of stimulatory and inhibitory hormones, as well as other signaling molecules. The organs that are targeted by the hormones of this axis are placed in the periphery, and their function is impacted via stimulation or inhibition of hormones [2]. The HPT axis is activated in response to the body's metabolic and energy demands. It stars with nerve cells in the paraventricular nucleus (PVN) of the HT being activated, which secrete thyrotropin-releasing hormone (TRH) [3]. TRH travels throughout the hypothalamic-pituitary portal system to stimulate the thyrotroph cells (also called thyrotropes) in the anterior pituitary gland to release thyroid-stimulating hormone (TSH), which then promotes the thyroid gland to produce and release the thyroid hormones T4 (thyroxine) and T3 (triiodothyronine). As T3 is the active form responsible for regulating metabolism, energy intake,

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and body temperature [4]. In order for the CNS to regulate the secretion of thyroid hormones, it necessarily has a sensitive and accurate mechanism for sensing alterations in thyroid hormone levels. Thyroid hormones (T4 and T3) cross the blood-brain barrier (BBB) by special transporter proteins to enter the brain, and do not pass the BBB passively [5]. In the brain, after T4 enters, it is locally transformed to the active form T3 via the Type 2 iodothyronine deiodinase (DIO2) in glial cells. Then T3 binds to special nuclear receptors known as thyroid hormone receptors (TRs). T3 enters the cells via specialized membrane transporters as monocarboxylate transporter 8 (MCT8) and organic anion transporting polypeptide 1C1 (OATP1C1) [6]. After linking to the nuclear receptors, T3 forms a complex with the receptor, able to bind with particular DNA sequences called thyroid response elements (TREs). Throughout this interaction, the transcription of certain genes is stimulated or inhibited, which directly impacts the regulation of other hormone excretion in the axis [7]. In the HT, T3 linking to its receptors prevents transcription of the TRH gene, decreasing its production and excretion. As well, in the anterior pituitary gland, this interaction inhibits the production and secretion of TSH [8]. These genetic modifications composed the primary negative feedback mechanism that keeps the balance levels of thyroid hormone in the body, decreasing the secretion of TRH and TSH when the levels of T3 are high, which leads to a reduction in the production of T4 and T3 from the thyroid gland, and vice versa when these hormone levels are low [9] Figure 1. In obesity case, the central nervous system undergoes basic changes that weaken the functioning of the HPT axis. The most important of these changes is chronic low-grade inflammation, which starts in peripheral tissues and reaches the brain, particularly the HT, through inflammatory cytokines. TNF$-\alpha$, IL-6, and IL-1β, all of them are inflammatory cytokines that activate immune receptors found on glial cells in the HT. This activation leads to the stimulation of intracellular inflammatory signaling pathways, which causes additional secretion of inflammatory substances and thus changes in neuronal functions occur [10]. Regarding low-grade inflammation, there is a marked inhibition of the DIO2 enzyme activity, which decreases the conversion of T4 to T3 within the brain. Therefore, despite levels of T3 in the blood may remain typical or relatively high, central sensing of T3 concentration within neurons is reduced, rendering the negative feedback mechanism inaccurate [11]. It is worth mentioning, the neuro-inflammation damages the function of neurons that produce TRH, either by cytokines or via impacting neurotransmission and the activity of leptin and insulin receptors, which also suffer from central resistance in obesity [12]. In this case, the HPT axis loses its capacity to accurately regulate TSH and TRH levels, and a slightly compensatory increase in TSH may be observed, without real regulatory effectiveness. Over time, this disorder is exacerbated by persistent inflammation, deterioration of central hormone sensitivity, and neuronal inhibition, which contribute to the entrenchment of the metabolic state characteristic of obesity and make breaking the pathological cycle more complex [13]. The study aims to investigate the impacts of a healthy intervention, including balanced diet and regular exercise, on thyroid function in obese participants, and assess baseline lipid profile and metabolic indicators to explain the relation between obesity, thyroid dysfunction, and metabolic disorders.

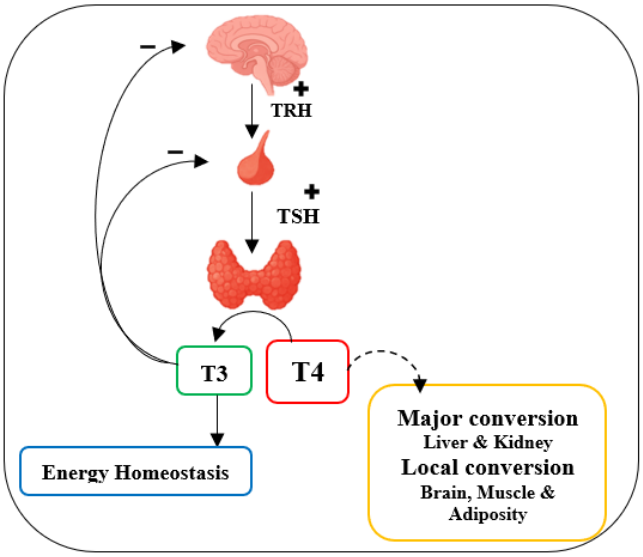

Figure 1. The hypothalamic-pituitary-thyroid axis regulates thyroid hormone secretion. *Abbreviation: T3: Triiodothyronine. T4: Thyroxine. TRH: Thyrotropin-releasing hormone. TSH: Thyroid-stimulating hormone. +: indicates increased or stimulated hormone secretion, -: indicates decreased or inhibited hormone secretion (Designed by researcher).

2. Materials and Methods:

2.1 Study Design:

A longitudinal quasi-experimental controlled design was adopted to assess the impact of a structured healthy lifestyle, including a balanced healthy diet and regular exercise, applied to obese participants in comparison with a healthy control group. The study involved three time points: (1) baseline measurements of the healthy control group, (2) baseline measurements of the obese group pre-intervention, and (3) re-evaluation post-intervention in the same obese participants, to evaluate changes in thyroid profile.

2.2 Study Period and Setting:

The study was conducted from 1st December 2024 to 30th July 2025. The clinical nutrition clinics at Anbar governorate (for participant induction and health intervention). While

laboratory examinations were done at the University of Anbar, College of Education for Pure Sciences.

2.3 Participants:

The study included adults of both sexes between the ages of 20 and 40, They were classified into three groups according to specific inclusion criteria:

• Obese participants ($n = 50$) (BMI $\geq 30 kg/m^2$) without associated chronic diseases or endocrine disorders, with mild insulin resistance and increased fasting insulin allowed.

• Healthy control with normal weight ($n = 50$) (BMI 18.5–24.9 kg/m^2) free from chronic diseases and endocrine disorders.

• Follow-up group ($n = 50$) the same sample of obese participants who were re-evaluated after 6 months of adherence to a healthy lifestyle intervention that included healthy dietary modifications and regular exercise Figure 2.

2.4 Exclusion Criteria:

Participants with any of the following were excluded: Acute illnesses, renal/liver failure, uncontrolled endocrine disorders (as untreated hypo/hyperthyroidism), use of medications affecting appetite, recent weight loss surgery, pregnancy, and feeding, and individuals who are taking hormonal supplements.

2.5 Intervention Protocol:

The study protocol included a 6-month program that included a healthy diet and regular exercise 3-5 days a week, aiming to promote weight loss and improve health indicators in obese participants. The protocol did not include any pharmacological interventions, surgical procedures, or fat-reducing techniques (as laser), but rather was restricted to dietary and lifestyle modifications. Very low-calorie diets (VLCDs) were excluded due to their likelihood of providing inadequate micronutrient intake, which may result in adverse health consequences. The diet was designed by a certified nutritionist, taking into account individual differences in body composition as determined by the InBody device, as well as each participant's specific nutritional needs. The diet was low-cost, easy to implement, and widely scalable without the need for advanced resources, it was summarized by the researcher in the visual diagrams below: Figure 3.

2.6 Study Outcomes:

The primary variable in this study was the measurement of thyroid function. TSH, FT3, and FT4 were measured in both obese and healthy participants at baseline, and re-measured 6 months post-intervention in the obese group only. Secondary variables included metabolic indicators, including fasting glucose, insulin, HOMA-IR, and lipid profile, including total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL), which were measured at baseline only in the obese group to determine the initial metabolic status.

2.7 Blood Collection:

Blood samples were collected from 50 normal-weight participants and 50 obese (pre-intervention) participants after an overnight fast by vein puncture using a sterile medical syringe. The blood samples were put in a gel tube free of coagulants and left at room temperature. Then, the samples underwent a centrifugation process at 3500 rpm for 15 min. The serum was isolated and stored at 2–8 °C, for biochemical analyses were done according to the manufacturer's instructions.

After six months of undergoing a healthy lifestyle, blood samples were collected from obese participants to reassess the same variables. While specimens from the normal weight participants were collected once.

2.8 Participant classification and body measurements:

All participants were classified as obese or normal weight by the InBody device to assess body mass index, body fat percentage, and muscle mass.

2.9 Metabolic indicators and lipid profile measurements:

Lipid profile was measured in serum using commercial diagnostic kits (Linear Chemicals S.L., Barcelona, Spain) according to the manufacturer's instructions, based on the enzyme colorimetric method using a Spectrophotometer. While metabolic indicators were measured by the Cobas e411 device.

2.10 Thyroid hormone measurements:

Thyroid hormones (TSH, free T4, and free T3) were measured using the Cobas e411 device (Roche Diagnostics, Germany) in obese individuals before and after the intervention, and compared with values in a healthy, normal-weight group.

2.11 Statistical Analysis:

Statistical analyses were performed using SPSS version 24 (IBM Corp., Armonk, NY, USA) and GraphPad Prism version 9 (GraphPad Software, San Diego, CA, USA). Data were presented as mean ± SD for variables. Comparisons among the three groups. were assessed using one-way ANOVA followed by the Least Significant Difference (LSD) post hoc test. Pearson's correlation analysis was used for correlation analysis

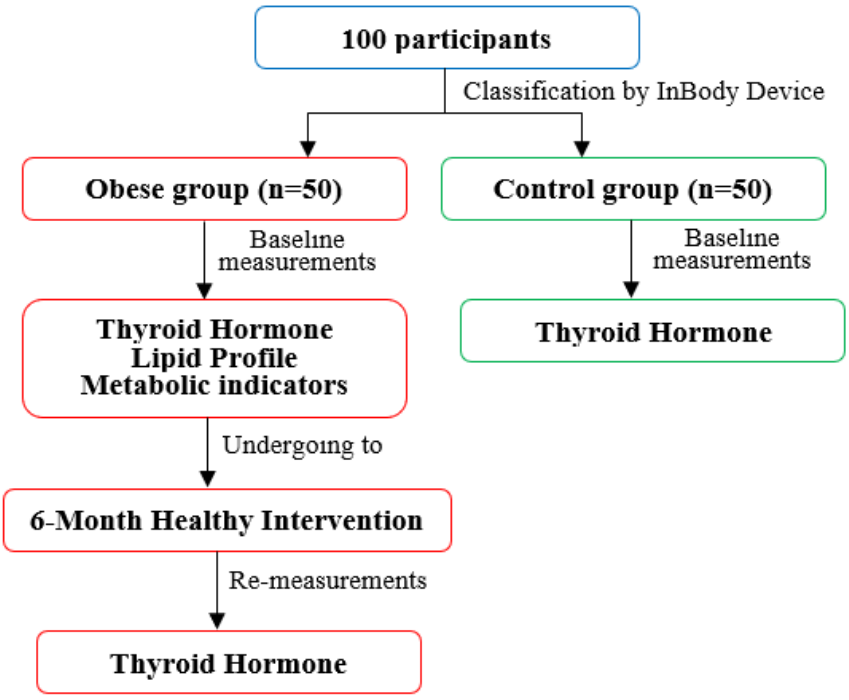

Figure 2. The study plan (Designed by the researcher).

between variables. Logistic regression was used to determine predictors of obesity status. Receiver operating characteristic (ROC) curve and area under the curve (AUC) analyses were applied for assess the discriminative ability of study variables between groups. Subgroup analyses were conducted according to age categories and sex. Statistical significance was set at $p < 0.05$.

2.12 Ethics information:

The study was approved by the Institutional Ethics Committee at the University of Anbar (Approval No. 223, Date 24/2/2024). Written informed consents were signed by all participants. All procedures were done in accordance with the international ethical standards for research, including human participants. The study was done in accordance with the Declaration of Helsinki.

3. Results and Discussion:

3.1 Demographic Characteristics:

Table 2.12 shows the demographic characteristics of the three groups. No statistically significant differences were recorded in age, age groups, gender, or geographical distribution between the groups. Scientific studies [14] have emphasized the importance of achieving demographic balance between study groups to reduce the influence of confounding factors and ensure the reliability of the results.

Table 2 presents the mean concentrations of thyroid profile across the three groups. Pre-intervention, the obese group recorded increased FT3, TSH concentrations and decreased T4 concentrations compared to healthy controls. Post - intervention, FT3, TSH concentrations decreased and FT4 concentrations increased, with values remaining higher than healthy control concentrations, except FT4 showed lower than normal values.

The high concentrations of TSH and FT3 versus decreased FT4 in obese adults demonstrated by the results of the current study, is a pattern consistent with what has been reported in the literature, which has documented a positive relationship between BMI and TSH and a negative relationship with FT4, with an increased FT3/FT4 ratio [15]. Available evidence shows that increased TSH and FT3 a physiological responses linked with increased fat mass, as this pattern is associated with the body's attempt to control energy homeostasis by increasing basal metabolic rate and raising energy expenditure at rest [16]. This adaptation is consistent with the concept that the thyroid acts as a main regulator of energy expenditure, with FT3 particularly impacting the dynamics of calorie consumption and body temperature regulation. So, these changes in obesity can be viewed as a metabolic strategy aimed at restricting the progression of weight gain, though their impact against the high metabolic load resulting from fat accumulation is limited [17].

Moreover, the accumulation of FFA and low-grade inflammation related to obesity likely contributes to the enhance-

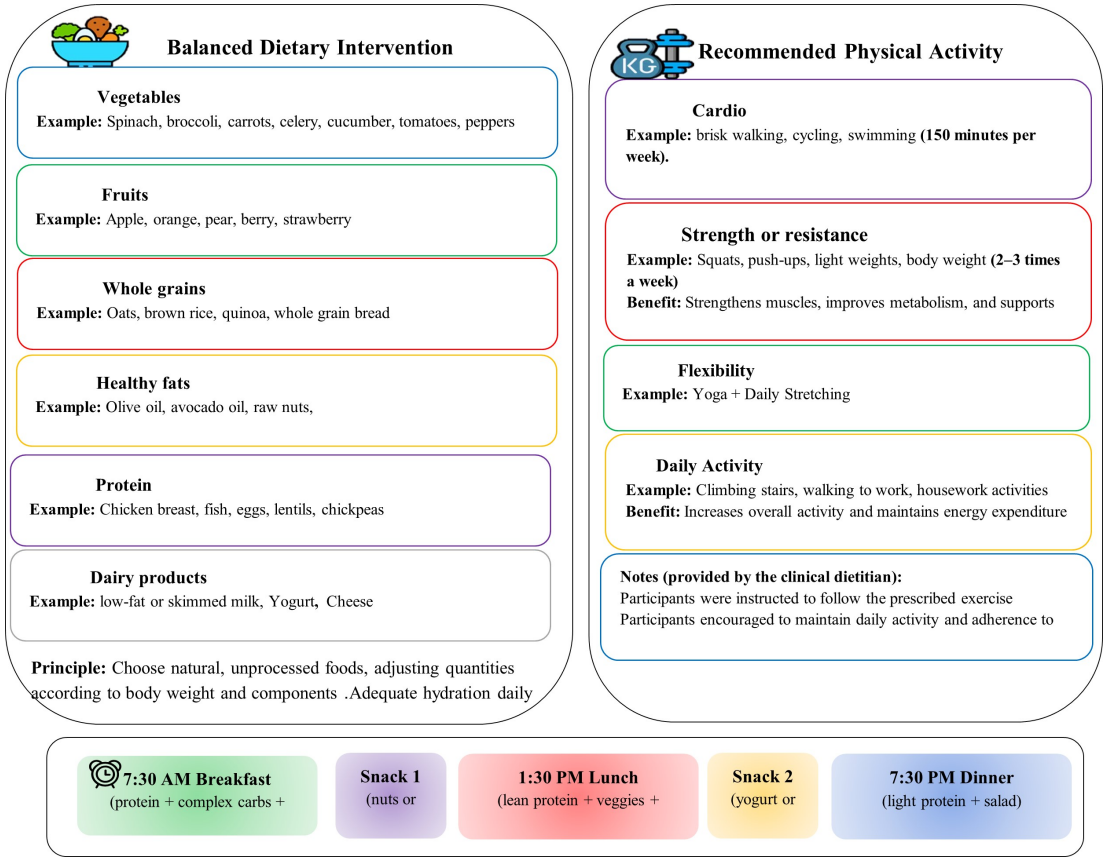

Figure 3. RVisual representation of the health intervention protocol. The figure shows the permitted dietary components on the left side, the recommended exercise program on the right side, and a structured meal schedule at the bottom (Designed by a researcher).

ment of peripheral resistance to thyroid hormones through impacting receptor sensitivity and target tissue response [18]. However, the current results are not entirely consistent with a study conducted in Basrah on obese women, which showed a decrease in T3 with a slight increase in TSH and a slight decrease in T4 that remained within normal values [19], it also disagrees with another study conducted on obese women that showed increased T4 concentrations [20].

These results may be attributed to variations in the characteristics of the studied samples in terms of gender and age distribution, in addition to differences in the severity of obesity and the prevailing lifestyle between groups, which confirms the complex nature of hormonal regulation of the thyroid axis in the of obesity. From a neurophysiological perspective, the observed improvement in thyroid hormone concentrations post-intervention reflects numerous interconnected mechanisms. First, a decrease in chronic low-grade inflammation leads to a reduction in the secretion of inflammatory cytokines as IL-17A, which previous studies have shown to inhibit the HPT-axis and weaken the thyroid's sensitivity to TSH signals. Second, weight reduction appears to improve the response of peripheral tissues to FT3. In obesity, adipose and muscle tissues exhibit a type of functional resistance to thyroid hormones that is very similar to insulin resistance, which explains the resurgence of FT4 concentrations and the decline in TSH and FT3 in the current results post-intervention [21].

The results of a study conducted on obese individuals are consistent with the results of the current study, indicating that calorie limitation and weight loss induce an adaptive response known as energy conservation. The body decreases FT3 production and relies on increased energy effectiveness as a means of survival, facilitating the rebuilding of fat stores when energy intake returns to its previous level [22]. From this perspective, the reduction in TSH and FT3 and the increase in FT4 post-intervention can be interpreted as a compensatory response reflecting improved sensitivity of peripheral tissues to thyroid hormones, with the continued presence of adaptive neural signs from the brain aimed at maintaining energy homeostasis and preventing depletion of fat stores [23]. The improvement in thyroid function parameters after adopting a healthy lifestyle suggests the presence of enduring cellular mechanisms attributed to what is known as metabolic memory. Since reducing systemic inflammation and improving insulin sensitivity reprogram intracellular metabolic pathways,

Table 1. Mean ± standard deviation of demographic characteristics in healthy controls, obese participants pre-intervention, and 6 months post-intervention.

Variables		Healthy Controls	Obese Group		X^2 F	p-value
			Pre-intervention	Post-intervention		
Age (Years)	Mean±SD	29.9 ± 5.9	30.06 ± 5.9	30.06 ± 5.9	0.007	0.993 N.S
Age periods (Years) (%)	20–25	16	13	13	3.92	0.685 N.S
	26–30	9	15	15		
	31–35	15	10	10		
	36–40	10	12	12		
Sex (%)	Male	37	30	30	2.85	0.239 N.S
	Female	13	20	20		
Region (%)	Urban	31	33	32	0.174	0.917 N.S
	Rural	19	17	18		

*Significant differences (p-value less than 0.05), Abbreviation: SD: Standard deviation. Min.: Minimum, Max.: Maximum, N.S: No significant difference between groups.

contributing to enhanced T4 to T3 conversion and long-term restoration of the HPT-axis [13]. The results of the statistical analysis did not show a significant relationship between the age groups and mean concentrations of thyroid profile in obese participants pre-intervention (P¡0.05) Table 3, Figure 4.

The results of the current study showed no significant relationship between age groups and mean thyroid hormone concentrations in obese participants at baseline. This suggests that thyroid function within this age group is relatively stable, and that variation in hormone levels is primarily due to metabolic status and obesity, rather than age differences within the studied range. These results are consistent with what was shown in the study by Barman et al. [24]. Statistical analysis results presented a statistically significant relationship between gender and the mean concentrations of thyroid profile in obese participants before the intervention (P¡0.05). Males recorded higher concentrations of TSH, while no differences were recorded in FT3 and FT4 concentrations among sexes Table 4, Figure 5.

Data from the current study showed that mean TSH concentrations were higher in obese males than in females. This observation fits into a pattern documented in recent literature linking obesity to changes in the HPT-axis, with clear sex differences [25]. One possible reason for this result is a variance in fat distribution between the sexes, male tend to accumulate more visceral fat, while female have a more gynoid fat distribution. Visceral fat is related with raised inflammatory

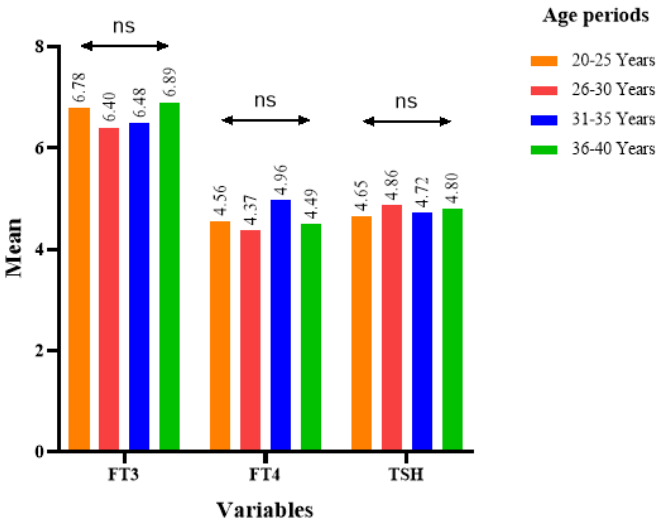

Figure 4. Relation between age and thyroid hormones in obese participants pre-intervention. *ns: No significant difference between groups.

Table 2. Mean ± standard deviation of thyroid hormones in healthy controls, obese participants pre-intervention, and 6 months post-intervention.

Variables		Healthy Control (n=50)	Obese Group (n=50)		F	p-value
			Pre-intervention	Post-intervention		
FT3 (pmol/L)	Mean±SD	4.19±0.79 a	7.58±1.11 b	5.69±0.99 c	151.1	0.0001
	Min. – Max.	2.0 – 5.89	5.43 – 9.58	4.0 – 7.76		
FT4 (pmol/L)	Mean±SD	11.4±1.20 a	3.72±1.20 b	5.42±1.33 c	521.8	0.0001
	Min. – Max.	9.54 – 14.21	1.99 – 6.11	2.99 – 8.22		
TSH (IU/mL)	Mean±SD	1.40±0.48 a	5.49±1.14 b	4.04±0.98 c	257.1	0.0001
	Min. – Max.	0.64 – 2.70	3.34 – 8.23	2.01 – 7.0		

*Significant differences (p-value less than 0.05), Abbreviation: a: control group, b: Obese group before, c: Obese group after, Different superscript letters (a, b, c) indicate statistically significant differences between groups, SD: Standard deviation, Min.: Minimum, Max.: Maximum, FT3: free triiodothyronine, FT4: Free Thyroxine, TSH: Thyroid-Stimulating Hormone.

Table 3. Relation between thyroid hormones with age periods for obese participants.

Variables	Age periods	Mean	Std. Deviation	p-value
FT3(pmol/L)	20-25 years	6.78	1.48	0.563
	26-30 years	6.40	1.37	
	31-35 years	6.48	1.35	
	36-40 years	6.89	1.46	
FT4(pmol/L)	20-25 years	4.56	1.45	0.599
	26-30 years	4.37	1.57	
	31-35 years	4.96	1.73	
	36-40 years	4.49	1.39	
TSH(μIU/mL)	20-25 years	4.65	1.30	0.946
	26-30 years	4.86	1.22	
	31-35 years	4.72	1.37	
	36-40 years	4.80	1.34	

*Significant differences (p-value less than 0.05), Abbreviation: SD: Standard deviation, Min.: Minimum, Max.: Maximum, FT3: free triiodothyronine, FT4: Free Thyroxine, TSH: Thyroid-Stimulating Hormone.

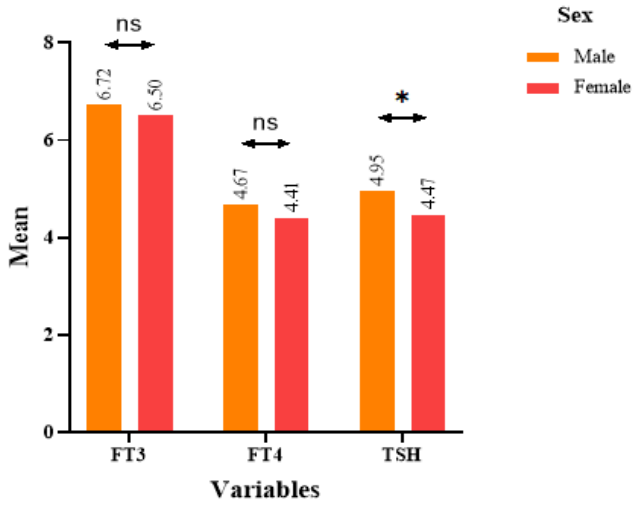

Figure 5. Relation between sex and thyroid hormone concentrations in obese participants pre-intervention. *ns: No significant difference between groups.

Table 4. The relation between thyroid hormones with sex for obese participants.

Variables	Sex	Mean	Std. Deviation	p-value
FT3(pmol/L)	male	6.72	1.40	0.438
	female	6.50	1.43	
FT4(pmol/L)	male	4.67	1.51	0.404
	female	4.41	1.56	
TSH(μIU/mL)	male	4.95	1.30	0.043
	female	4.47	1.22	

*Significant differences (p-value less than 0.05), Abbreviation: SD: Standard deviation, Min.: Minimum, Max.: Maximum, FT3: free triiodothyronine, FT4: Free Thyroxine, TSH: Thyroid-Stimulating Hormone.

Table 5. AUC and ROC curve for thyroid hormone comparison between obese group pre-intervention with control group.

Variables	AUC	Specificity %	Sensitivity %	Cut-off	p-value
FT3	0.999	98	100	5.425	0.0001
FT4	1.0	100	100	7.825	0.0001
TSH	1.0	100	100	3.02	0.0001

*Significant differences (p-value less than 0.05), Abbreviation: AUC: Area under curve, ROC: receiver operating characteristic.

cytokines, which may decrease tissue sensitivity to thyroid hormones or change peripheral T4 to T3 conversion, thus leading to a compensatory raise in TSH. Recent studies by Yang et al. [26], have shown that Body Roundness Index (BRI) is connected with thyroid hormone levels. Recent studies point that decreased tissue sensitivity to thyroid hormones is linked with metabolic syndrome, suggesting that increased TSH in obese participants may be a compensatory physiological response rather than true hypothyroidism [27]. This phenomenon is more pronounced in men than in women, consistent with the results of the current study on sex differences in TSH, while another study found no sex difference in thyroid hormone concentrations, suggesting potential variation across populations [28]. In another study conducted on obese Iraqis, it was found that the concentration of TSH hormone was higher in female compared to male [29]. A receiver operating characteristic (ROC) curve analysis was used to determine a potential predictive quality of thyroid profile concentrations between obese and healthy participants pre- and post-intervention Table 5, 6, Figure 6, 7. According to the area under the curve (AUC) value, FT4, TSH had the highest ability to predict and differentiate between the two groups, while FT3 presented considerable but relatively less. ROC curve results presented that the three thyroid hormones (TSH, FT3, and FT4) had a very high discriminatory ability between obese and healthy

Table 6. AUC and ROC curve for study variables comparison between obese group post-intervention with control group.

Variables	AUC	Specificity %	Sensitivity %	Cut-off	p-value
FT3	0.893	90	76	5.015	0.0001
FT4	1.0	100	100	8.88	0.0001
TSH	0.998	100	96	2.755	0.0001

*Significant differences (p-value less than 0.05), Abbreviation: AUC: Area under curve, ROC: receiver operating characteristic.

participants at baseline. These results point that the concentrations of thyroid hormones are reliable and accurate indicators of obesity-related thyroid status, reflecting the high reliability of these biomarkers in assessing weight-related metabolic imbalances. These results are consistent with what Tang and his colleagues reported [30].

Post-intervention, ROC curves showed variation in the discrimination ability of thyroid hormones, with both TSH and FT4 maintaining excellent discrimination performance, while a slight decrease in the accuracy of FT3 was observed. These results reflect the positive metabolic changes resulting from a healthy lifestyle, with TSH and FT4 remaining reliable indicators of thyroid function after the intervention, confirming the effectiveness of hormonal assessment for monitoring metabolic improvement [31]. ROC analysis provides an accurate tool for assessing the ability of hormones to differentiate between clinical conditions and identifying optimal cut-off points, enhancing the reliability of TSH, FT4, and FT3 as biomarkers for assessing metabolic and thyroid status before and after intervention, and enabling clear and objective monitoring of changes resulting from a healthy lifestyle [32].

Baseline Variables

At baseline, statistical analyses showed no significant differences between males and females in metabolic marker and lipid profile concentrations (P ¡0.05) Table **??**, Figure8.

At baseline, all obese participants showed significant metabolic indicators abnormalities, as elevated fasting glucose and insulin and high in HOMA-IR. Similarity high concentration in TG, TC, HDL, and decreased in LDL, reflecting the impact of obesity on energy balance and metabolic regulation [33]. Post-interventions, a significant improvement in thyroid function was observed, although values did not yet reach normal levels. This improvement suggests that lifestyle modifications can stimulate the endocrine-metabolic axis and reduce metabolic stress on the thyroid, enhancing the body's response to future interventions and providing a scientific basis for interpreting potential changes in the metabolic profile later [34]. Correlation analysis between thyroid hormones and lipid variables at baseline showed a positive relationship between FT3 and TG, TC (r= 0.40, p= 0.0001; r= 0.593, p=

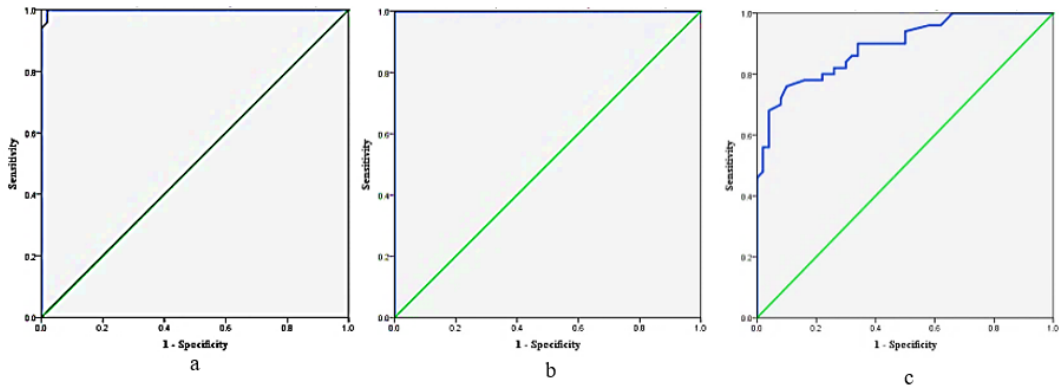

Figure 6. ROC curves for a-TSH, b-FT4 and c-FT3 in obese participants pre-intervention compared to control group.

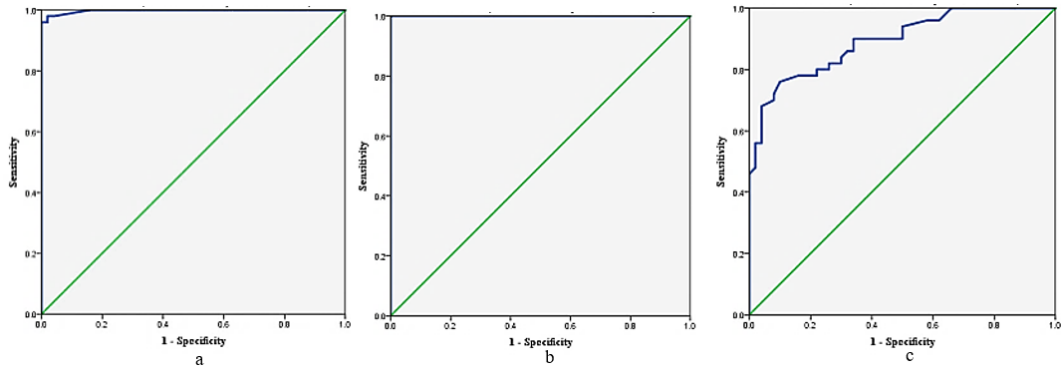

Figure 7. ROC curves for a-TSH, b-FT4 and c-FT3 in obese participants post-intervention compared to control group.

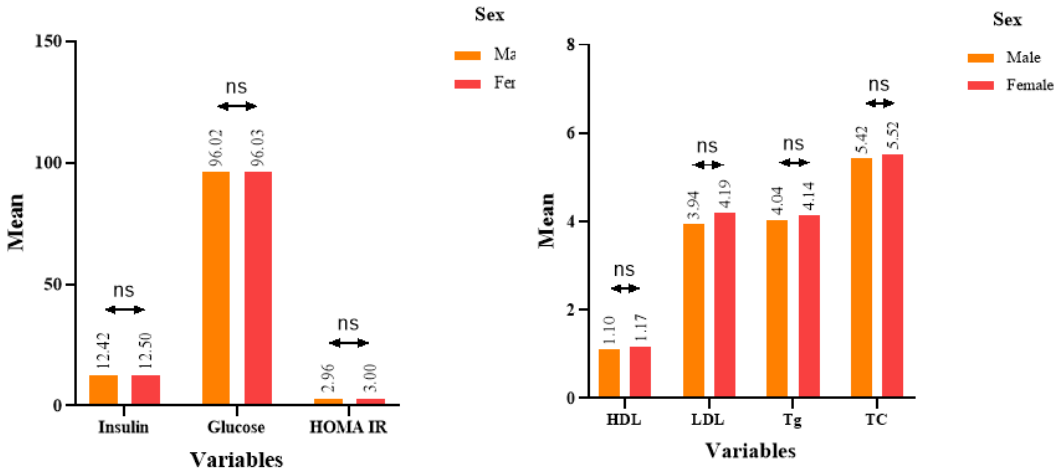

Figure 8. Relation between sex and a-metabolic indicators and b-lipid profile concentrations in obese participants pre-intervention. *ns: No significant difference between groups.

0.0001) respectively, also between FT4 and HDL (r= 0.35, p= 0.004). On the other hand, a negative correlation was observed between TSH and HDL (r= -0.55, p= 0.0001), and a positive correlation with HOMA-IR (r=0.437, p= 0.0003). The observed relationships between thyroid hormones and metabolic profile components suggest adaptive mechanisms in obesity. The positive correlation of T3 with TG and TC may reflect increased conversion of T4 to T3, accompanied by metabolic disturbances such as excessive VLDL production. This result is consistent with what Sabatino and et al., indicated about the role of peripheral conversion in enhancing energy requirements in obese people [35]. The inverse relationship between TSH and HDL is also consistent with what Zhang et al. described, that elevated TSH is associated with increased inflammation, insulin resistance, and associated disturbance in HDL metabolism [36]. The positive correlation between T4 and HDL, despite both being low in our sample, suggests that hypothyroidism may exacerbate the deterioration of the lipid profile, which is supported by the findings of a previous study by Zhu and his team that showed an association between lipid and glucose indices and thyroid disorders. This evidence suggests that the interaction between thyroid hormones and lipids represents a central link in the pathophysiology of obesity [37].

A study published in 2025 by Bano and his team indicated that changes in thyroid hormones following a healthy lifestyle not only reflect improved HPT-axis function but are also associated with increased metabolic sensitivity to energy and improved lipid profile levels [38]. This is explained by decreased insulin resistance, which enhances peripheral conversion of T4 to the active form T3 via activation of the enzyme deiodinase type II. This increases basal metabolic rate, improves weight regulation, and stabilizes energy balance

4. Conclusions:

An unhealthy lifestyle, characterized by an unbalanced diet and lack of exercise, is a main cause of obesity, which in turn is related to marked metabolic and lipid profile disturbances, increasing the risk of cardiovascular disease and diabetes. At baseline, obese participants showed significant metabolic dysfunction, regardless of sex. After 6 months of adhering to a healthy lifestyle that included a balanced diet and an exercise program, my thyroid function improved significantly, although it did not reach normal levels, highlighting its role in supporting metabolic balance. The results of the current study suggest the need for long-term studies to assess the independent influence of dietary and exercise interventions on the thyroid and metabolic profile, to support clinical obesity management strategies.

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Data Availability Statement:

Declarations:

Conflict of interest: The author declare that they have no competing interests.

Ethical approval: The study was approved by the Institutional Ethics Committee at University of Anbar (Approval No. 223, Date 24/2/2024). Written informed consents were signed by all participants. All procedures done in accordance with the international ethical standards for research including human participants. The study was done in accordance with Declaration of Helsinki.

Author contributions: PhD student Nour Shakir Rezaieg collected data, designed the study, and analyzed the results, while Prof. Dr. Muthanna M. Awad oversaw the research design, reviewed the scientific content, and provided academic guidance. All authors approved the submission of the manuscript for publication.

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تأثير تعديل نمط الحياة على محور الغدة الدرقية لدى البالغين المصابين بالسمنة: دراسة طولية شبه تجريبية

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الخلاصة

السمنة مرضٌ مُعقّد ومزمن، يتسم بتراكم الدهون في الجسم، مما يؤثر سلبًا على محور الغدة الدرقية، الذي يتحكم في معدل الأيض الأساسي واستهلاك الطاقة. الهدف: تهدف الدراسة إلى التحقق من الآليات التي تربط السمنة باضطرابات الغدة الدرقية، مع التركيز على تأثيرها على المؤشرات الأيضية، ومستوى الدهون عند خط الاساس، وتقييم التغيرات في التوازن الهرموني الناتجة عن التدخلات الصحية. تصميم الدراسة والمشاركون: أُجريت دراسة شبه تجريبية طولية مُحكمة على 100 مشارك من مدينة الرمادي، العراق، من بينهم 50 فردًا سليمًا و 50 مشاركًا مصابًا بالسمنة. خضع جميع المشاركين لتقييم أولي لتصنيفهم إلى مجموعات سليمة وأخرى مصابة بالسمنة. ثم اتبعت المجموعة المصابة بالسمنة برنامجًا لنمط حياة صحي لمدة ستة أشهر. الطريقة: تم قياس هرمونات الغدة الدرقية للمجموعتين السليمة والسمنة قبل وبعد التدخل، بينما تم تقييم المؤشرات الأيضية ومستوى الدهون عند خط الاساس للمجموعة المصابة بالسمنة فقط. النتائج: أظهرت النتائج تحسنًا ملحوظًا في مستويات هرمونات الغدة الدرقية بعد التدخل، مع انخفاض تركيزات *TSH* و *T3* الحر، وارتفاع مستويات *T4* الحر، على الرغم من بقائها دون المستويات الطبيعية. كشفت البيانات الأساسية عن وجود اختلالات أيضية ودهنية ملحوظة لدى المشاركين المصابين بالسمنة. الخلاصة: تشير نتائج الدراسة الحالية إلى أن اتباع نمط حياة صحي يُحسّن مؤشرات الغدة الدرقية لدى المصابين بالسمنة، إلا أن استعادة التوازن الهرموني الكامل قد تتطلب فترة أطول. تُبرز قياسات مستوى الأيض ومستوى الدهون أهميتها كأدوات تشخيصية لتحديد الآثار الأيضية للسمنة.

الكلمات الدالة : السمنة؛ هرمونات الغدة الدرقية؛ التدخل الصحي؛ مؤشرات الايض؛ مستوى الدهون.

التمويل: لم يتلق المؤلفون أي دعم مالي للبحث أو التأليف أو نشر هذه المقالة.

بيان توفر البيانات: جميع البيانات الداعمة لنتائج الدراسة المقدمة يمكن طلبها من المؤلف المسؤول.

اقرارات: تضارب المصالح: يعلن المؤلفون عدم وجود أي تضارب في المصالح.

الموافقة الأخلاقية: تمت الموافقة على الدراسة من قبل لجنة الأخلاقيات المؤسسية في جامعة الأنبار (رقم الموافقة ٣٢٢، بتاريخ ٤٢ ووقع جميع المشاركين على موافقات كتابية مستنيرة. وتمت جميع الإجراءات وفقًا للمعايير الأخلاقية الدولية للبحوث، بما في ذلك مشاركة المشاركين من البشر. وأُجريت الدراسة وفقًا لإعلان هلسنكي.

مساهمات المؤلفين: قامت طالبة الدكتوراه نور شاكر رزيج بجمع البيانات وتصميم الدراسة وتحليل النتائج، بينما أشرف الأستاذ الدكتور مثنى محمد عواد على تصميم البحث ومراجعة المحتوى العلمي وتقديم التوجيه الأكاديمي. وقد وافق جميع المؤلفين على تقديم المخطوطة للنشر.