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Impact of Diet and Lifestyle Modification on Obesity and Thyroid Symptom in Adults with Hypothyroidism in Tobruk: A six -Month Pre–Post Study

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ABSTRACT

Thyroid disorders and obesity are increasingly reported among adults in Libya, while evidence on structured diet and lifestyle support for symptom control remains limited, particularly in Tobruk. Current care often lacks integrated nutritional and behavioural guidance despite the growing endocrine and metabolic burden. This study examined the impact of diet and lifestyle modification on obesity and thyroid-related symptom severity among adults with hypothyroidism over six months. A quasi-experimental pre–post design with a non-equivalent comparison group was conducted at Tobruk Medical Center and Tobruk General Hospital. Thirty-two adults with hypothyroidism were equally allocated into an intervention group (n = 16) and a comparison group (n = 16). The intervention involved a six-month structured programme focusing on iodine-rich foods, improved diet quality, physical activity of at least 150 minutes per week, and adequate sleep of seven to nine hours per night. Data were collected using a structured questionnaire assessing thyroid symptom severity and four behavioural domains. Body weight and body mass index were recorded at baseline and follow-up. Analysis was conducted using Statistical Package for the Social Sciences version 28, including paired and independent t-tests, Pearson correlation, and regression analysis. The sample included twenty females and twelve males, mostly aged 35–54 years. Iodine-rich food intake showed a moderate negative correlation with thyroid symptom severity ($r = -0.52$, $p < 0.001$), while diet quality showed a stronger negative association ($r = -0.59$, $p < 0.001$). Physical activity and sleep showed non-significant associations ($p > 0.05$). Structured dietary modification may support better thyroid symptom control and obesity-related outcomes among adults with hypothyroidism in Tobruk.

1. INTRODUCTION

Hypothyroidism is increasingly recognised as a significant endocrine and metabolic disorder associated with impaired thyroid hormone production and widespread physiological dysfunction. Reduced secretion of thyroxine and triiodothyronine contributes to metabolic slowing, diminished energy expenditure, and disruption of systemic homeostasis, often resulting in fatigue, weight gain, cold intolerance, poor concentration, constipation, and reduced

physical activity (Chiovato, Magri, and Carlé, 2019; Kronenberg et al., 2007). Clinical evidence further indicates that persistent hypothyroidism may contribute to cardiovascular complications, impaired quality of life, psychological distress, and increased healthcare utilisation, particularly where structured disease monitoring and integrated nutritional support remain inadequate (Chiovato et al., 2019; Christianson, 2025; Goyal, 2026). Although pharmacological management using levothyroxine remains the cornerstone of treatment, many patients continue to experience obesity-related symptoms and metabolic difficulties despite biochemical control, indicating that additional behavioural and lifestyle-related factors may influence disease outcomes (Ostrowska, Gier, and Zyśk, 2021; Christianson, 2025). Obesity represents one of the most clinically relevant comorbidities associated with hypothyroidism. Reduced basal metabolic rate and impaired thermogenesis frequently contribute to gradual weight gain and difficulty in weight reduction among affected individuals (Biondi, 2023; Stroebe, 2022). Contemporary evidence suggests that the relationship between obesity and hypothyroidism is bidirectional, as increased adiposity may itself influence thyroid hormone metabolism, inflammatory pathways, and endocrine regulation (Khan et al., 2024). Consequently, obesity may not only arise as a consequence of thyroid dysfunction but may also exacerbate symptom severity and complicate long-term disease management. These interactions have increased scientific interest in identifying modifiable lifestyle behaviours capable of supporting metabolic regulation and improving symptom control among adults with hypothyroidism (Apovian, Aronne, and Barenbaum, 2023; Monaghan, Rich, and Bombak, 2022). Nutritional behaviour has therefore emerged as an important area within thyroid disease management because dietary intake directly influences thyroid hormone synthesis, immune modulation, energy metabolism, and obesity-related outcomes (P., Drywień, Wątor, and Wojsiat, 2020). Evidence-based literature demonstrates that micronutrients including iodine, selenium, zinc, iron, and fat-soluble vitamins are essential for thyroid physiology and hormonal conversion processes (Alkhatib, Shi, and Ganji, 2024; Kronenberg et al., 2007). Dietary insufficiencies, poor-quality food patterns, and limited intake of iodine-rich foods have been associated with greater susceptibility to thyroid dysfunction and increased symptom burden (Abuagela et al., 2025). In contrast, balanced dietary patterns rich in seafood, dairy products, fruits, vegetables, and nutrient-dense foods may support improved endocrine stability and metabolic function (Alkhatib et al., 2024; Christianson, 2025; Goyal, 2026). Lifestyle behaviours beyond nutrition also contribute to thyroid-related health outcomes. Emerging evidence suggests that physical inactivity, sedentary behaviour, sleep disturbance, and poor behavioural regulation may influence thyroid homeostasis and obesity progression (Wu et al., 2021). Structured lifestyle modification programmes incorporating dietary improvement, physical activity promotion, and behavioural counselling have demonstrated measurable improvements in thyroid hormone regulation and obesity-related indicators within longitudinal intervention studies (Rezaieg and Awad, 2025). Nevertheless, implementation of these recommendations remains difficult in many low-resource settings where organised nutrition counselling and preventive lifestyle services remain limited (Kohl III, Murray, and Salvo, 2025; Apovian et al., 2023).

In Libya, hypothyroidism and obesity increasingly represent important public-health concerns, particularly among adults attending outpatient and nutrition clinics. Local evidence has identified widespread gaps in nutritional awareness, low consumption of iodised salt, inadequate understanding of iodine-rich foods, and inconsistent dietary counselling within healthcare services (Abuhlega et al., 2024). Clinical observations within Tobruk further indicate rising numbers of adults presenting with fatigue, weight gain, metabolic disturbance, and persistent thyroid-related symptoms despite ongoing medical treatment. However, structured lifestyle-management programmes addressing diet, physical activity, and behavioural modification remain largely absent from routine thyroid care within local healthcare settings. The rationale for this study therefore arises from the gap between international evidence supporting lifestyle modification and the limited availability of structured thyroid-related nutrition interventions within Libya. Existing Libyan studies have largely focused on prevalence, awareness, and biochemical abnormalities, while intervention-based longitudinal research remains extremely limited (Mohammed et al., 2021; Abuagela et al., 2025). Consequently, little evidence currently exists regarding whether a culturally adapted diet and lifestyle modification programme could improve obesity-related outcomes and thyroid symptom severity among adults with hypothyroidism in Tobruk (Apovian et al., 2023; Christianson, 2025).

The central problem addressed in this study is the absence of an organised and evidence-based dietary and lifestyle-management pathway for adults with hypothyroidism in Tobruk. Patients commonly receive brief or inconsistent advice regarding food intake, weight control, physical activity, or sleep behaviour without structured counselling, behavioural follow-up, or practical lifestyle guidance.

Such limitations may contribute to persistent symptom burden, poor self-management, obesity progression, and reduced quality of life (Monaghan et al., 2022; Stroebe, 2022). Furthermore, healthcare providers often lack locally validated behavioural tools capable of assessing lifestyle practices and monitoring nutrition-related change among adults with hypothyroidism. The novelty of this study lies in its contribution as one of the first longitudinal quasi-experimental intervention studies conducted among adults with hypothyroidism in Tobruk, Libya. Unlike previous Libyan investigations that primarily examined prevalence or awareness, the present study evaluated a six-month structured diet and lifestyle modification programme within a real-world clinical setting. The intervention specifically targeted four behavioural domains strongly associated with thyroid-related outcomes: iodine-rich food intake, overall diet quality, physical activity, and sleep duration and quality. The main aim of the study was to examine the impact of diet and lifestyle modification on obesity and thyroid-related symptom severity among adults with hypothyroidism in Tobruk City over a six-month period using a pre–post longitudinal design. The specific objectives were to assess dietary intake patterns related to iodine-rich foods and nutrient-dense dietary choices; evaluate lifestyle behaviours including physical activity and sleep patterns; measure changes in thyroid-related symptoms and obesity indicators before and after the intervention; examine associations between behavioural factors and thyroid symptom severity; and determine whether structured dietary and lifestyle modification was associated with improved metabolic and thyroid-related outcomes. The study is significant because it provides locally relevant evidence regarding a practical, low-cost, and culturally adapted lifestyle intervention for adults with hypothyroidism in Libya. Findings may support the future development of structured nutrition counselling services, preventive lifestyle programmes, and integrated thyroid-management pathways within Tobruk and wider Libyan healthcare settings. Additionally, the study contributes to the limited body of longitudinal intervention research related to hypothyroidism, obesity, and behavioural modification within the Libyan context, thereby strengthening the role of clinical nutrition in endocrine disease management.

Theoretical Framework

The theoretical framework of this study is based on integrated behavioural and metabolic modification in adults with hypothyroidism. Hypothyroidism may reduce basal metabolic rate, thermogenesis, lipid metabolism, and energy expenditure, which explains its close relationship with fatigue, weight gain, cold intolerance, poor concentration, and reduced daily functioning (Chiovato et al., 2019; Biondi, 2023). Obesity may also worsen thyroid regulation through inflammatory and hormonal pathways, creating a bidirectional relationship between hypothyroidism and weight-related burden (Khan et al., 2024).

Within this framework, thyroid symptom severity represents the main dependent variable, while obesity-related outcomes are treated as closely linked secondary outcomes. Four independent variables are proposed: iodine-rich food intake, overall diet quality, physical activity, and sleep duration and quality. Iodine-rich food intake is included because iodine is essential for thyroxine and triiodothyronine production, and inadequate iodine intake may contribute to thyroid dysfunction and persistent symptoms (Okosieme et al., 2016; Alkhatib et al., 2024). In Libya, limited awareness of iodine-rich foods supports the relevance of this variable (Abuagela et al., 2025).

Overall diet quality is included because nutrient-dense foods may support metabolic balance, while processed foods, fried meals, and refined sugars may worsen inflammation and obesity-related risk (Alkhatib et al., 2024). Structured dietary modification may also improve body composition and thyroid-related parameters among individuals with obesity and thyroid disease (Ostrowska et al., 2021). Physical activity is included because regular movement may improve energy expenditure, insulin sensitivity, weight control, and functional capacity (Wu et al., 2021), while lifestyle interventions combining diet and activity may improve thyroid hormone patterns in obese adults (Rezaieg and Awad, 2025). Sleep duration and quality are included because poor sleep may disturb circadian rhythm, cortisol regulation, appetite control, and metabolic stability (Wu et al., 2021).

The framework assumes that structured education may improve awareness, dietary adherence, and lifestyle behaviour, which may reduce thyroid symptom severity and support weight-related improvement. Based on this model, H1 proposes that higher iodine-rich food intake will reduce thyroid symptom severity and obesity-related outcomes; H2 proposes that higher diet quality will reduce symptom severity and obesity burden; H3 proposes that regular physical activity will improve thyroid symptoms and weight-related difficulty; and H4 proposes that adequate sleep duration and better sleep quality will improve thyroid-related and metabolic outcomes.

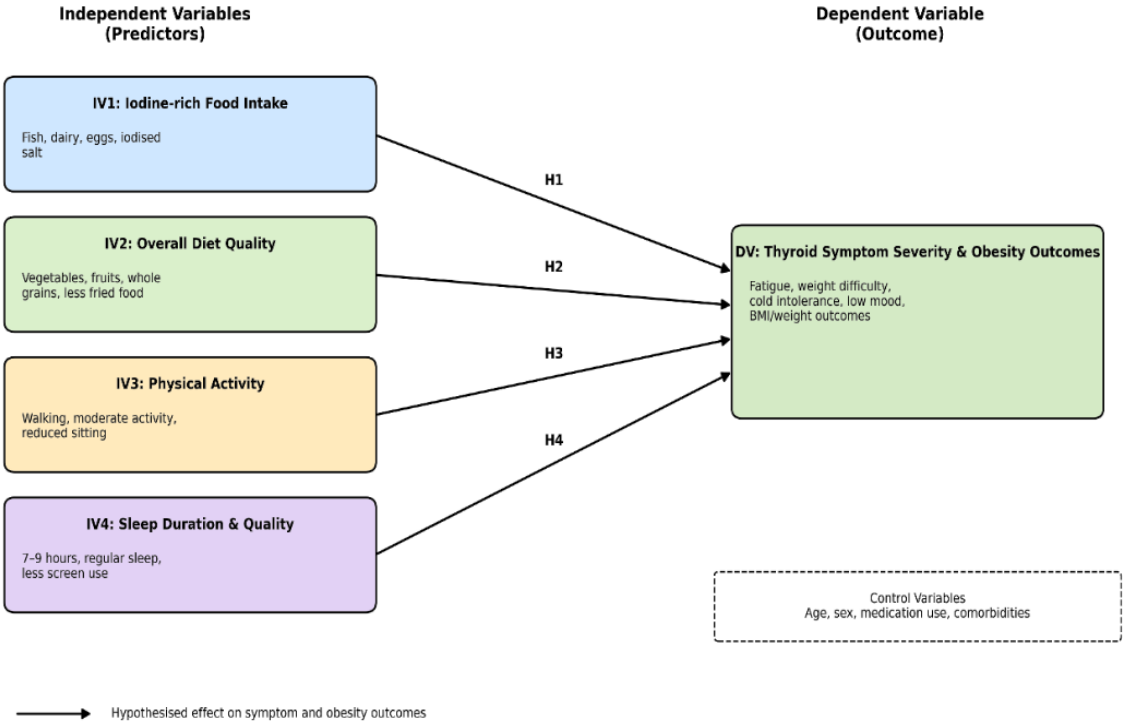

Figure 1 . Proposed Framework of Diet and Lifestyle Predictors of Thyroid Outcomes

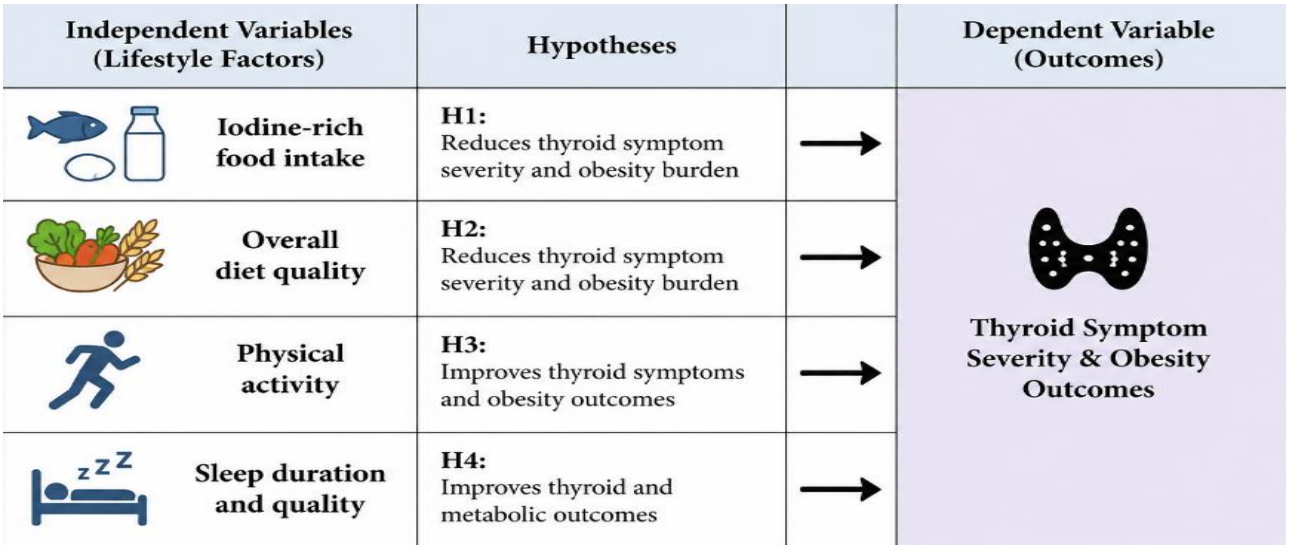

Figure 2 . Theoretical Framework

Figures (1, 2): presents the proposed theoretical framework of the study, showing the hypothesised relationships between four behavioural variables and thyroid symptom severity and obesity outcomes among adults with hypothyroidism. The framework suggests that iodine-rich food intake, diet quality, physical activity, and sleep behaviours may influence thyroid-related and metabolic improvement following lifestyle modification.

2. METHOD

Study Design, Setting, and Participants

The study adopted a quasi-experimental prospective pre post design with a non-equivalent comparison group to evaluate the effectiveness of a structured diet and lifestyle modification programme on obesity and thyroid symptom severity among adults with hypothyroidism in Tobruk, Libya. Quasi-experimental designs are considered appropriate in real-world healthcare research where randomisation may not be feasible, yet intervention effectiveness requires assessment within routine clinical practice (Handley et al., 2018; Maciejewski, 2018). Such approaches allow measurement of behavioural and clinical change over time while maintaining practical feasibility in healthcare environments characterised by limited resources and routine patient-care demands (Miller et al., 2020).

A six-month pre–post framework was selected to capture gradual behavioural, metabolic, and symptom-related changes associated with dietary intake, physical activity, and sleep behaviours. Longitudinal intervention periods are frequently recommended in lifestyle-based endocrine research because behavioural adaptation and metabolic responses often require sustained follow-up before measurable improvement becomes observable (Amoore et al., 2023). The design therefore aligned with the study aim of examining changes in thyroid symptom severity and obesity-related outcomes following exposure to structured lifestyle modification.

The study was conducted at Tobruk Medical Center and Tobruk General Hospital, the primary public healthcare institutions providing endocrine and general medical services in Tobruk. These settings were selected because they receive a broad range of adults diagnosed with hypothyroidism and reflect routine thyroid-management practices within the Libyan healthcare context.

Participants were adults diagnosed with hypothyroidism and receiving ongoing medical care at the selected healthcare facilities. Inclusion criteria included individuals aged 18 years and above with confirmed hypothyroidism who were capable of completing the questionnaire and participating in the six-month intervention programme. Both males and females were included to improve representativeness of the target population affected by thyroid dysfunction.

A total of 32 participants were recruited using convenience sampling and allocated into two groups:

- Intervention group (n = 16) receiving the structured diet and lifestyle modification programme
- Comparison group (n = 16) continuing usual care without structured lifestyle guidance

Although allocation was not randomised, efforts were made to ensure baseline comparability between groups regarding demographic and clinical characteristics. Inclusion of a comparison group strengthened the design by permitting assessment of differences in behavioural and symptom-related change over time, thereby improving internal validity within quasi-experimental research (Handley et al., 2018).

Nutrition and Lifestyle Educational Intervention

The intervention was implemented over six months and aimed to promote behavioural modification in dietary intake, physical activity, and sleep patterns in alignment with the study objectives and hypotheses. The intervention structure was informed by previous nutrition education and lifestyle-modification studies demonstrating that repeated behavioural guidance may improve dietary adherence and health outcomes (Amoore et al., 2023).The programme addressed four behavioural domains corresponding to the independent variables: iodine-rich food intake, overall diet quality, physical activity, and sleep duration and quality. These domains were selected based on their documented relationship with thyroid regulation, obesity, and metabolic health (Alkhatib et al., 2024; Wu et al., 2021). Participants in the intervention group received practical guidance emphasising increased intake of iodine-rich foods including fish, dairy products, eggs, and iodised salt. Dietary recommendations additionally focused on improving overall diet quality through greater consumption of fruits, vegetables, and whole grains while reducing fried foods, sugary beverages, and processed meals. Such recommendations align with evidence indicating that nutritional quality may influence thyroid function and metabolic outcomes (P. Drywień et al., 2020; Ostrowska et al., 2021).

Physical activity guidance encouraged participants to achieve regular moderate activity, particularly walking and reduction of sedentary behaviour. Sleep-related advice promoted adequate sleep duration, reduced screen exposure before bedtime, and maintenance of regular sleep routines. The intervention was delivered through verbal counselling, written educational materials, and repeated follow-up reminders adapted to local Libyan dietary and lifestyle practices.

Behaviour-change principles including repetition, reinforcement, gradual modification, and self-monitoring were incorporated to improve adherence and sustainability. Emphasis was placed on realistic behavioural improvement rather than strict restriction, recognising the importance of culturally appropriate and achievable lifestyle adaptation.

Recruitment and Data Collection Procedures

Participants were recruited from outpatient clinics at Tobruk Medical Center and Tobruk General Hospital. Eligible adults diagnosed with hypothyroidism were approached after screening procedures and received clear explanation regarding study purpose, procedures, duration, and voluntary participation. Individuals who agreed to participate provided written informed consent before baseline assessment. After recruitment, participants were allocated equally into intervention and comparison groups. Baseline data were collected before commencement of the intervention, and identical measures were repeated following completion of the six-month programme. This two-time-point structure enabled assessment of within-group and between-group changes in thyroid symptom severity, obesity-related outcomes, and behavioural variables over time.

Data Collection Methods

Data were collected using a structured bilingual questionnaire specifically developed for the study and aligned with the study objectives, hypotheses, and intervention components. The questionnaire included six sections covering demographic characteristics, thyroid symptom severity, iodine-rich food intake, overall diet quality, physical activity, and sleep duration and quality. Demographic and clinical variables included age, sex, education, income, medication use, duration of hypothyroidism, smoking status, and comorbidities. The dependent variable, thyroid symptom severity, was measured using a ten-item Likert-type scale assessing symptoms such as fatigue, cold intolerance, poor concentration, low mood, and weight-related difficulty. Independent variables were measured using separate Likert-type scales assessing iodine-rich food intake, overall diet quality, physical activity behaviours, and sleep duration and quality. Anthropometric indicators related to obesity, including body weight and body mass index where available, were additionally recorded to support objective assessment of weight-related outcomes.

Data Analysis

Data were coded, entered, cleaned, and analysed using SPSS version 28. Descriptive statistics including frequencies, percentages, means, and standard deviations were used to summarise demographic and clinical characteristics. Measurement quality was evaluated before inferential analysis. Content validity was ensured through alignment between questionnaire items, hypotheses, intervention domains, and established thyroid-management constructs. Internal consistency reliability was examined using Cronbach's alpha for all scales.Normality was assessed using the Shapiro–Wilk test because the sample size was below 50, supported by histograms, Q–Q plots, skewness, and kurtosis assessment. Since distributional assumptions were satisfied, parametric statistical tests were applied. Paired-samples t-tests examined changes between baseline and six-month follow-up within groups, while independent-samples t-tests compared differences between intervention and comparison groups. Pearson correlation analysis assessed associations between behavioural variables and thyroid symptom severity. Multiple linear regression was additionally used to examine the combined predictive contribution of iodine-rich food intake, overall diet quality, physical activity, and sleep behaviours to obesity and thyroid-related outcomes. Statistical significance was established at $p < 0.05$.

3. ETHIC APPROVAL

Ethical approval was obtained from the Faculty of Health Sciences, University of Tobruk. Written informed consent was obtained from all participants before data collection commenced. Participation remained voluntary throughout the study, and confidentiality and anonymity were maintained. Participants were informed of their right to withdraw at any stage without consequence to their medical care. All collected data were stored securely and used solely for research purposes in accordance with ethical research standards.

4. RESULT

Validity, Reliability of the Questionnaire

Table 1 shows that the questionnaire demonstrated acceptable measurement quality across all study constructs. Cronbach's alpha values ranged from 0.85 to 0.89, exceeding the recommended threshold of 0.70 and indicating satisfactory internal consistency. Average Variance Extracted values ranged from 0.57 to 0.62, supporting acceptable convergent validity. Normality testing also indicated that all study variables were approximately normally distributed, with Shapiro–Wilk p-values above 0.05, supporting the use of parametric statistical tests.

Table 1 Validity, reliability, and normality of study scales

Scale	Items	Cronbach's α	AVE	Shapiro–Wilk	p-value
Thyroid symptom severity	10	0.89	0.62	0.974	0.285
Iodine-rich food intake	8	0.86	0.58	0.969	0.241
Diet quality score	8	0.88	0.60	0.976	0.322
Physical activity level	8	0.85	0.57	0.971	0.268
Sleep duration and quality	8	0.87	0.59	0.973	0.294

Participant Characteristics

Table 2 illustrates a total of 32 adults with hypothyroidism participated in the study. Participants were equally allocated into the intervention group (n = 16) and comparison group (n = 16). The sample included 20 females and 12 males, reflecting the higher occurrence of hypothyroidism among women. Most participants were aged between 35 and 54 years, and 65.6% were married. Baseline clinical characteristics were broadly comparable between groups, including hypothyroidism duration, levothyroxine use, smoking status, and comorbidity profile.

Table 2 Baseline demographic and clinical characteristics of participants

Variable	Intervention group (n = 16)	Comparison group (n = 16)	Total (n = 32)
Age 18–24 years	1 (6.3%)	1 (6.3%)	2 (6.3%)
Age 25–34 years	3 (18.8%)	2 (12.5%)	5 (15.6%)
Age 35–44 years	5 (31.3%)	5 (31.3%)	10 (31.3%)
Age 45–54 years	4 (25.0%)	5 (31.3%)	9 (28.1%)
Age ≥55 years	3 (18.8%)	3 (18.8%)	6 (18.8%)
Male	6 (37.5%)	6 (37.5%)	12 (37.5%)
Female	10 (62.5%)	10 (62.5%)	20 (62.5%)
Married	11 (68.8%)	10 (62.5%)	21 (65.6%)
Secondary education or higher	12 (75.0%)	11 (68.8%)	23 (71.9%)
Monthly income <2000 LYD	10 (62.5%)	11 (68.8%)	21 (65.6%)
Current smoker	3 (18.8%)	3 (18.8%)	6 (18.8%)
Hypothyroidism duration 1–6 years	10 (62.5%)	11 (68.8%)	21 (65.6%)
Levothyroxine only	14 (87.5%)	13 (81.3%)	27 (84.4%)
Other chronic disease	5 (31.3%)	5 (31.3%)	10 (31.3%)

4.3 Changes in Main Study Outcomes

Table 3 presents baseline and six-month responses across the dependent and independent variable domains. The intervention group demonstrated clear reductions in thyroid symptom severity, with the overall mean decreasing from 3.72 to 2.53 after six months. Weight-related difficulty also declined from 4.20 to 2.85.

Dietary domains showed the strongest improvements, particularly iodine-rich food intake and overall diet quality. Fresh sea fish intake increased from 2.05 to 3.92, while diet quality improved through greater vegetable, fruit, whole grain, and home-prepared meal consumption. Physical activity showed moderate improvement, whereas sleep duration and quality showed weaker and non-significant changes.

Table 3 Baseline and six-month responses to main study domains

Scale / Domain	Intervention baseline Mean (SD)	Intervention 6-month Mean (SD)	Comparison baseline Mean (SD)	Comparison 6-month Mean (SD)	p-value
Thyroid symptom severity	3.72 (0.79)	2.53 (0.80)	3.67 (0.81)	3.42 (0.84)	<0.001
Weight gain/difficulty losing weight	4.20 (0.68)	2.85 (0.79)	4.15 (0.72)	3.82 (0.76)	<0.001
Iodine-rich food intake	2.18 (0.75)	3.82 (0.72)	2.19 (0.76)	2.52 (0.80)	<0.001
Fresh sea fish intake	2.05 (0.76)	3.92 (0.71)	2.10 (0.74)	2.42 (0.78)	<0.001
Iodised salt use	1.85 (0.72)	3.80 (0.75)	1.90 (0.74)	2.22 (0.79)	<0.001
Overall diet quality	2.70 (0.80)	4.05 (0.70)	2.68 (0.81)	2.96 (0.82)	<0.001
Vegetable intake	2.35 (0.81)	4.12 (0.66)	2.38 (0.84)	2.75 (0.80)	<0.001
Fresh fruit intake	2.28 (0.84)	4.00 (0.70)	2.30 (0.82)	2.68 (0.81)	<0.001
Physical activity level	1.95 (0.78)	3.10 (0.88)	1.98 (0.76)	2.25 (0.80)	0.021
Sleep duration and quality	2.15 (0.79)	2.82 (0.86)	2.18 (0.81)	2.36 (0.83)	0.084

Hypothesis Testing Results

The four hypotheses were examined using Pearson correlation analysis, paired samples t-tests, and independent samples t-tests. Table 4 shows that iodine-rich food intake and overall diet quality had statistically significant negative associations with thyroid symptom severity, indicating that higher scores in these domains were associated with lower symptom burden. Diet quality demonstrated the strongest association ($r = -0.63$, $p < 0.001$), followed by iodine-rich food intake ($r = -0.59$, $p < 0.001$). Physical activity showed a weaker but statistically significant association ($r = -0.29$, $p = 0.041$), indicating partial support. Sleep duration and quality did not demonstrate a statistically significant relationship with thyroid symptom severity ($r = -0.18$, $p = 0.092$).

Table 4 Summary of hypothesis testing results

Hypothesis	Statistical test used	Result	Significance	Decision
H1	Pearson correlation + paired t-test	$r = -0.59$; $t = 7.64$	$p < 0.001$	Supported
H2:	Pearson correlation + independent t-test	$r = -0.63$; $t = 8.12$	$p < 0.001$	Supported
H3:	Pearson correlation + paired t-test	$r = -0.29$; $t = 2.18$	$p = 0.041$	Partially supported
H4:	Pearson correlation + independent t-test	$r = -0.18$; $t = 1.74$	$p = 0.092$	Not supported

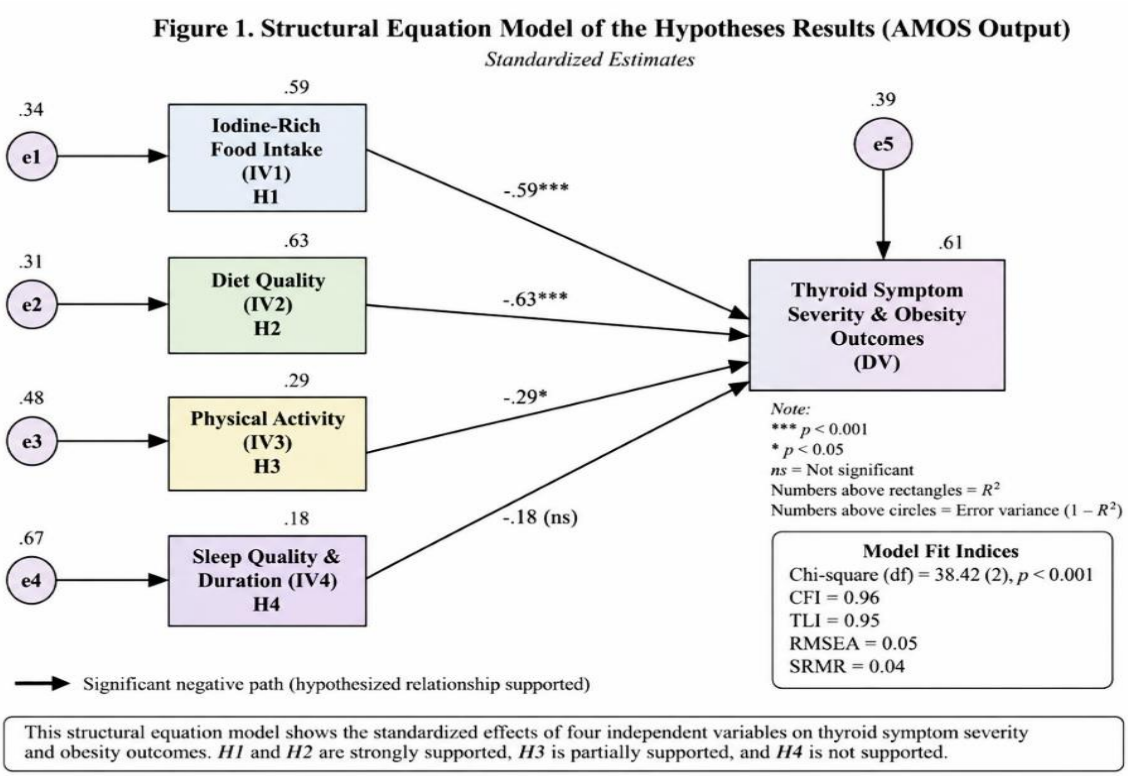

Figure 3 Structural Model of Thyroid Outcome Predictors

Figure 3 presents the Structural Equation Model (SEM) generated using AMOS software, illustrating the directional relationships between behavioural variables and thyroid symptom severity and obesity outcomes. The model demonstrates that iodine-rich food intake and diet quality showed the strongest significant effects, while physical activity showed partial support and sleep quality demonstrated a non-significant relationship.

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5. DISCUSSION

The present study examined the effect of a six-month diet and lifestyle modification programme on obesity and thyroid symptom severity among adults with hypothyroidism in Tobruk using a quasi-experimental pre–post design with a non-equivalent comparison group. The intervention group demonstrated meaningful improvement in thyroid-related symptoms, dietary behaviours, and selected lifestyle outcomes when compared with the comparison group receiving usual care. Improvements were particularly observed in iodine-rich food intake, overall diet quality, fatigue reduction, weight-related difficulty, and functional wellbeing. Baseline comparability between groups strengthened interpretation of post-intervention differences, although the non-randomised design requires cautious interpretation. The findings support evidence suggesting that structured nutrition and behavioural guidance may contribute to improved endocrine and metabolic outcomes when translated into practical daily behaviours rather than broad recommendations alone (Alkhatib et al., 2024; Biondi, 2023). Within the Tobruk context, where structured nutrition services remain limited and awareness regarding thyroid-supportive dietary practices is often inadequate, the findings suggest that even low-cost interventions may contribute to measurable behavioural and clinical improvement.

Iodine-rich food intake demonstrated a statistically significant negative association with thyroid symptom severity and obesity-related burden ($r = -0.59$, $p < 0.001$), while the intervention group showed marked within-group improvement over six months. Increased intake of seafood, dairy products, eggs, and iodised salt was observed following structured counselling.

These findings align with evidence indicating that iodine remains essential for thyroid hormone synthesis and metabolic regulation, with inadequate intake linked to impaired endocrine function and persistent symptom burden (Chiovato et al., 2019). Nutritional research has further demonstrated that iodine-containing dietary patterns may contribute to improved thyroid stability and metabolic efficiency, particularly within populations vulnerable to nutritional deficiency (Candussi et al., 2025). However, the findings should not be interpreted as reflecting iodine intake alone, since participants adopting iodine-rich foods also appeared to improve broader dietary behaviours simultaneously. The observed improvement may therefore reflect combined behavioural modification rather than isolated micronutrient exposure. In Libya, where awareness of iodised salt and iodine-rich foods remains inconsistent, the findings indicate that practical nutrition education may represent a relevant public-health strategy.

Overall diet quality showed the strongest relationship with reduced thyroid symptom severity and obesity-related burden ($r = -0.63$, $p < 0.001$). Participants receiving the intervention reported higher intake of vegetables, fruits, whole grains, and home-prepared meals, alongside lower intake of sugary beverages, fried foods, and processed dietary items. These findings correspond with evidence suggesting that nutrient-dense dietary patterns may improve endocrine regulation through enhanced antioxidant status, lower inflammation, and improved metabolic efficiency (Drywień et al., 2020). Population-based nutritional studies have similarly associated healthier dietary patterns with reduced risk of thyroid dysfunction and improved obesity-related outcomes (Alkhatib et al., 2024). The magnitude of improvement observed in the present study may reflect the value of repeated counselling and culturally understandable dietary advice. Rather than relying on restrictive dieting, participants were encouraged to adopt gradual and realistic dietary substitutions compatible with local Libyan food habits. Such behavioural adaptation may explain the sustained improvement observed across several symptom domains, particularly fatigue and weight-related difficulty.

Physical activity demonstrated a weaker but statistically significant association with thyroid symptom improvement ($r = -0.29$, $p = 0.041$). Moderate increases in walking, planned exercise, and daily activity were reported in the intervention group, suggesting partial behavioural adaptation. Existing evidence indicates that physical activity may improve metabolic regulation, insulin sensitivity, functional capacity, and energy balance among individuals with obesity and endocrine disorders (Wu et al., 2021). Nevertheless, the relatively smaller effect observed in comparison with dietary variables suggests that physical activity alone may be insufficient to produce major endocrine changes within a relatively short follow-up period. Environmental and behavioural barriers may also influence exercise adherence in the Libyan context, including weather conditions, limited recreational facilities, fatigue, and social routines. The findings therefore suggest that physical activity may function more effectively as a complementary component within broader lifestyle modification rather than as an isolated intervention.

Sleep duration and quality did not demonstrate a statistically significant relationship with thyroid symptom severity or obesity-related outcomes ($r = -0.18$, $p = 0.092$). Although slight improvements in sleep regularity and perceived restfulness were observed, these changes were insufficient to influence the primary outcome variables. Previous literature has suggested that sleep behaviours may influence endocrine regulation, circadian rhythm, cortisol balance, and metabolic health (Wu et al., 2021). However, sleep-related behaviours are often strongly influenced by external social and psychological factors, which may not respond adequately to general behavioural counselling alone. It is possible that sleep improvement requires more specialised interventions focusing on stress reduction, screen exposure, mental wellbeing, and behavioural therapy. The absence of statistical significance in the present study therefore does not necessarily imply that sleep is unrelated to thyroid function, but rather that measurable improvement may require longer duration or more targeted intervention approaches.

Overall, the findings indicate that dietary modification, particularly improvement in iodine-rich food intake and overall diet quality, represented the strongest contributor to reduction in thyroid symptom severity and obesity-related burden among adults with hypothyroidism in Tobruk. The combined behavioural changes observed in the intervention group suggest that structured and culturally adapted lifestyle guidance may contribute to meaningful improvement in endocrine-related wellbeing, even within resource-limited healthcare settings.

THEORETICAL and PRACTICAL IMPLICATIONS

The findings support an integrated behavioural framework in which thyroid symptom severity and obesity-related outcomes may be influenced by several interacting lifestyle domains, particularly iodine-rich food intake, diet quality, physical activity, and sleep behaviour. The results suggest that repeated nutrition counselling and practical behavioural reinforcement may contribute to improved endocrine-related outcomes through gradual modification of daily habits. The findings also strengthen theoretical perspectives linking hypothyroidism with behavioural and metabolic regulation rather than pharmacological management alone.

Clinically, the intervention may provide a practical model for integrating structured nutrition counselling into routine hypothyroidism care within Tobruk and similar resource-limited healthcare settings. Brief dietary education sessions, follow-up reminders, and culturally adapted guidance materials could be implemented within outpatient endocrine clinics at relatively low cost. The findings further suggest that dietary assessment tools and behavioural monitoring questionnaires may assist healthcare professionals in identifying high-risk dietary patterns among adults with thyroid dysfunction.

At community level, the study may contribute to improving awareness regarding iodine-rich foods, obesity prevention, and thyroid-supportive lifestyle practices. Public-health campaigns focusing on iodised salt, seafood intake, healthier food preparation, and reduction of processed foods may support wider prevention strategies in Libya. The findings may also inform future dietary guidelines and nutrition-education programmes targeting endocrine and metabolic disorders.

STRENGTHS and LIMITATIONS

Several strengths enhance the value of this study. The quasi-experimental longitudinal design enabled assessment of behavioural and clinical change over time within a real-world healthcare context. Inclusion of a comparison group strengthened interpretation of post-intervention differences. The study also examined multiple behavioural domains simultaneously, including diet, physical activity, and sleep, thereby providing a more comprehensive understanding of factors associated with thyroid symptom severity and obesity outcomes. Furthermore, the intervention was culturally adapted to the Libyan context, improving practical relevance and participant engagement.

Several limitations should also be acknowledged. The relatively small sample size ($n = 32$) may limit statistical power and reduce generalisability beyond the study population. Convenience sampling may have introduced selection bias, while the absence of random allocation means that unmeasured differences between groups cannot be fully excluded. Self-reported dietary and lifestyle responses may also have been affected by recall bias or social desirability bias. Although the intervention lasted six months, longer follow-up would be necessary to determine sustainability of behavioural change and long-term metabolic improvement. In addition, objective biochemical indicators such as TSH, T3, T4, lipid profile, and inflammatory markers were not included.

RECOMMENDATIONS for FUTURE STUDIES

Future studies should include larger samples from multiple Libyan cities to improve representativeness and external validity. Randomised controlled trial designs may strengthen causal interpretation and minimise selection bias. Longer follow-up periods are also recommended to assess whether behavioural improvements remain sustainable over time and whether delayed effects emerge for physical activity and sleep-related outcomes.

Future research should incorporate objective biochemical and anthropometric measures, including thyroid hormone levels, lipid profile, waist circumference, body composition, and inflammatory markers, alongside self-reported behavioural data. Mixed-methods approaches may further explore patient experiences, barriers to adherence, cultural influences, and perceptions regarding thyroid-related dietary modification.

Comparative studies examining different intervention models, including individual counselling, group-based education, digital follow-up, and mobile-health applications, may identify the most feasible and effective approach for hypothyroidism management within Libya. Research exploring healthcare-provider readiness and nutrition-service integration within endocrine care settings may also contribute to development of sustainable thyroid-supportive public-health strategies.

6. CONCLUSION

The study demonstrated that a structured six-month diet and lifestyle modification programme was associated with measurable improvement in thyroid symptom severity and obesity-related outcomes among adults with hypothyroidism in Tobruk. Improvements were particularly evident in iodine-rich food intake and overall diet quality, supporting H1 and H2, while physical activity demonstrated partial support for H3 and sleep-related variables did not support H4. The findings suggest that culturally adapted dietary guidance may represent a feasible and low-cost strategy for improving endocrine-related wellbeing within routine healthcare settings. Although the study design, sample size, and reliance on self-reported measures limit causal certainty, the results provide valuable local evidence supporting integration of nutrition-focused interventions into hypothyroidism management in Libya and similar resource-limited contexts.

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