

Original Article

Comparative Analysis of Thyroid Hormone Profiles and Vitamin D Status between Males and Females in Al-Bayda City, Libya: A Cross-Sectional Biochemical Study

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ABSTRACT

Thyroid hormones and vitamin D play essential roles in regulating metabolism, growth, and overall health. Alterations in their concentrations may contribute to various endocrine and metabolic disorders. This study aimed to evaluate thyroid hormone profiles and vitamin D status among adults in Al-Bayda City and to investigate potential gender-related differences. A cross-sectional study was conducted on 40 adult participants (20 females and 20 males) from Al-Bayda City, Libya. Serum levels of triiodothyronine (T₃), thyroxine (T₄), thyroid-stimulating hormone (TSH), and vitamin D were measured. Descriptive statistics, Shapiro-Wilk normality tests, independent samples t-tests, and one-sample t-tests were performed using Minitab version 17. Statistical significance was considered at $p < 0.05$. The overall mean values of T₄, T₃, TSH, and vitamin D were 8.04 ± 1.55 $\mu\text{g/dL}$, 1.41 ± 0.15 , 1.69 ± 1.18 , and 20.75 ± 11.58 ng/mL , respectively. Females exhibited significantly higher T₄ levels than males (8.53 ± 1.70 vs. 7.56 ± 1.25 ; $p = 0.047$), whereas males showed significantly higher vitamin D levels than females (24.44 ± 10.87 vs. 17.07 ± 11.34 ng/mL ; $p = 0.043$). No significant gender differences were observed for T₃ ($p = 0.500$), TSH ($p = 0.979$), or age ($p = 0.221$). Normality testing revealed that T₄, T₃, and age were normally distributed, while TSH and vitamin D showed non-normal distributions. Comparison with reference values indicated that vitamin D levels were significantly lower than the recommended reference level of 30 ng/mL ($p < 0.001$), whereas T₃, T₄, and TSH remained within normal ranges. The study demonstrated significant gender-related differences in T₄ and vitamin D concentrations among adults in Al-Bayda City. Furthermore, vitamin D levels were markedly below the recommended reference value, suggesting a high prevalence of vitamin D insufficiency in the studied population. Regular screening and appropriate vitamin D supplementation strategies may be beneficial for improving public health outcomes.

Introduction

Thyroid hormones are essential regulators of metabolic processes, growth, development, and energy homeostasis in humans. The thyroid gland synthesizes thyroxine (T₄) and triiodothyronine (T₃), which influence nearly every organ system through their effects on cellular metabolism, oxygen consumption, and protein synthesis. Thyroid-stimulating hormone (TSH), secreted by the anterior pituitary gland, plays a critical role in regulating thyroid hormone production through a feedback mechanism involving the hypothalamic-pituitary-thyroid axis. Disturbances in thyroid hormone concentrations may lead to hypothyroidism, hyperthyroidism, and several metabolic complications affecting quality of life and overall health [1].

Vitamin D is a fat-soluble secosteroid hormone that is primarily synthesized in the skin following exposure to ultraviolet B radiation and subsequently undergoes activation in the liver and kidneys. Beyond its classical role in calcium and phosphorus homeostasis, vitamin D has been recognized as an important modulator of immune function, cardiovascular health, and endocrine regulation. Recent studies have demonstrated potential interactions between vitamin D status and thyroid function, suggesting that vitamin D deficiency may contribute to autoimmune thyroid disorders and altered thyroid hormone metabolism [2,3]. Vitamin D deficiency has become a global public health concern affecting populations across different age groups and geographic regions. Despite abundant sunlight in many Mediterranean and Middle Eastern countries, inadequate sun exposure, lifestyle changes, dietary habits, and cultural practices have contributed to a high prevalence of vitamin D insufficiency. Previous investigations have reported that low vitamin D concentrations may be associated with metabolic syndrome, osteoporosis, impaired immune responses, and endocrine dysfunctions [4].

Gender-related differences in thyroid hormones and vitamin D concentrations have also been reported in several epidemiological studies. Females generally exhibit a higher prevalence of thyroid disorders, particularly autoimmune thyroid diseases, whereas variations in vitamin D levels may be influenced by differences in hormonal status, body composition, physical activity, and sunlight exposure. Understanding these differences is important for identifying population-specific risk factors and improving preventive healthcare strategies [5]. In Libya, limited data are available regarding the relationship between thyroid hormones and vitamin D status among apparently healthy adults. Therefore, the present study was designed to evaluate serum levels of T₃, T₄, TSH, and vitamin D among adults in Al-Bayda City and to investigate potential gender-related differences. The findings may provide valuable baseline information for future clinical and epidemiological studies concerning endocrine health and nutritional status in the Libyan population.

Methods

This cross-sectional study was conducted in Al-Bayda City, Libya, to evaluate thyroid hormone profiles and vitamin D status among adult participants. A total of 40 apparently healthy individuals were enrolled in the study, including 20 females and 20 males. Participants were selected randomly from the local population and ranged in age from 23 to 59 years. Approximately 5 mL of venous blood was collected from each participant under aseptic conditions. Blood samples were allowed to clot at room temperature and subsequently centrifuged at 3000 rpm for 10 minutes to obtain serum. The separated serum samples were transferred into sterile Eppendorf tubes and stored at -20°C until biochemical analysis. Serum concentrations of thyroid hormones, including triiodothyronine (T₃), thyroxine (T₄), and thyroid-stimulating hormone (TSH), were determined using commercially available diagnostic kits according to the manufacturer's instructions. Serum vitamin D [25-hydroxyvitamin D, 25(OH)D] levels were also measured using standardized laboratory methods. All analyses were performed in accordance with quality-control procedures to ensure the accuracy and reliability of the results. Demographic data, including age and gender, were recorded for each participant. The biochemical parameters assessed in this study included serum T₃, T₄, TSH, and vitamin D concentrations.

Data were entered into Microsoft Excel and subsequently exported for statistical analysis. Statistical analyses were performed using Minitab Statistical Software version 17. Descriptive statistics were calculated and expressed as mean ± standard deviation (SD), median, quartiles, minimum, and maximum values. The normality of data distribution was assessed using the Shapiro–Wilk test. Comparisons between male and female participants were conducted using the independent samples t-test. In addition, one-sample t-tests were performed to compare the observed mean values of thyroid hormones and vitamin D with established reference values. A p-value of less than 0.05 was considered statistically significant.

Results

(Table 1) presents the descriptive statistical analysis of thyroid hormones (T₃, T₄, and TSH), vitamin D levels, and age distribution among the study population in Al-Bayda City. The findings demonstrated noticeable variability in hormonal and vitamin D measurements among participants. The mean serum levels of T₄, T₃, TSH, and vitamin D were 8.04 ± 1.55, 1.41 ± 0.15, 1.69 ± 1.18, and 20.75 ± 11.58, respectively. Vitamin D showed the highest variability, ranging from 4.80 to 52.70, while T₃ demonstrated the lowest variability with values between 1.08 and 1.68. The mean age of participants was 40.00 ± 9.32 years, with ages ranging from 23 to 59 years.

Table 1. Assessment of Thyroid Hormones and Vitamin D Status in the Adult Population of Al-Bayda City: A Descriptive Statistical Study.

| Variable | N | Mean | Std. Dev | Min | Q1 | Median | Q3 | Max |
|-------------------------|----|--------|----------|--------|--------|--------|--------|--------|
| T ₄ (µg/dl) | 40 | 8.040 | 1.552 | 5.400 | 6.925 | 8.000 | 9.100 | 11.000 |
| T ₃ | 40 | 1.408 | 0.145 | 1.080 | 1.308 | 1.415 | 1.505 | 1.680 |
| TSH | 40 | 1.690 | 1.178 | 0.030 | 0.732 | 1.370 | 2.200 | 4.600 |
| VitD (ng/ml) | 40 | 20.752 | 11.580 | 4.800 | 11.900 | 17.950 | 26.450 | 52.700 |
| Age | 39 | 40.000 | 9.322 | 23.000 | 33.000 | 40.000 | 47.000 | 59.000 |

Females demonstrated higher mean T₄ (8.53 ± 1.70) and T₃ (1.42 ± 0.14) levels than males (7.56 ± 1.25 and 1.39 ± 0.15, respectively), whereas males exhibited higher vitamin D concentrations (24.44 ± 10.87 vs. 17.07 ± 11.34). TSH levels were similar between females (1.69 ± 1.21) and males (1.70 ± 1.18), while the mean age was slightly higher in females (41.90 ± 9.37 years) than in males (38.20 ± 9.14 years).

Table 2. Gender-Based Descriptive Statistics of Thyroid Hormones (T₃, T₄, TSH), Vitamin D Levels, and Age Among Adults in Al-Bayda City

Gender: Female

| Variable | N | Mean | Std. Dev | Min | Q1 | Median | Q3 | Max |
|----------|----|--------|----------|--------|--------|--------|--------|--------|
| T4 | 20 | 8.525 | 1.702 | 5.700 | 7.375 | 8.700 | 9.825 | 11.000 |
| T3 | 20 | 1.424 | 0.143 | 1.080 | 1.372 | 1.420 | 1.505 | 1.680 |
| TSH | 20 | 1.686 | 1.206 | 0.030 | 0.698 | 1.455 | 2.348 | 4.400 |
| VitD | 20 | 17.070 | 11.343 | 4.800 | 9.600 | 14.550 | 20.075 | 52.700 |
| Age | 19 | 41.895 | 9.374 | 29.000 | 34.500 | 40.000 | 48.500 | 59.000 |

Gender: Male

| Variable | N | Mean | Std. Dev | Min | Q1 | Median | Q3 | Max |
|----------|----|--------|----------|--------|--------|--------|--------|--------|
| T4 | 20 | 7.555 | 1.245 | 5.400 | 6.900 | 7.200 | 8.625 | 10.100 |
| T3 | 20 | 1.392 | 0.149 | 1.120 | 1.282 | 1.390 | 1.505 | 1.680 |
| TSH | 20 | 1.695 | 1.181 | 0.550 | 0.748 | 1.280 | 2.125 | 4.600 |
| VitD | 20 | 24.435 | 10.865 | 10.200 | 16.575 | 23.100 | 34.500 | 43.300 |
| Age | 20 | 38.200 | 9.140 | 23.000 | 30.000 | 40.500 | 45.500 | 53.000 |

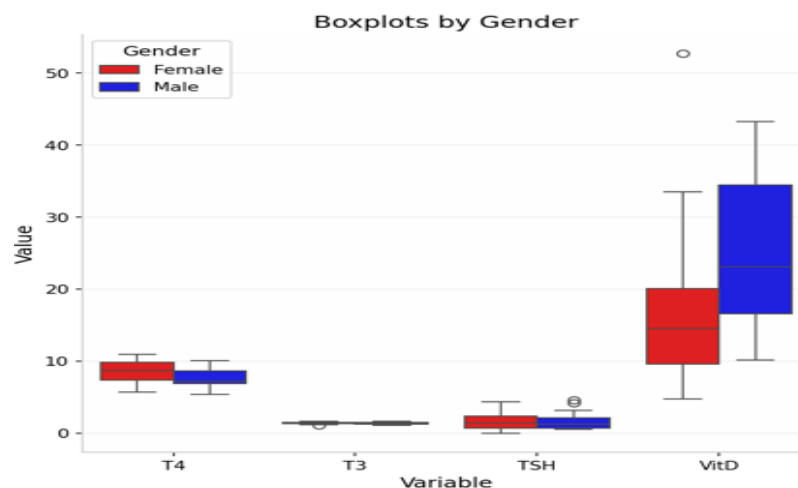


Figure 1. Comparison of Mean Thyroid Hormones (T_3 , T_4 , TSH) and Vitamin D Levels Between Female and Male Participants in Al-Bayda City.

(Table 3) Shapiro–Wilk analysis demonstrated normal distributions for T_4 ($p = 0.363$), T_3 ($p = 0.860$), and age ($p = 0.470$), while TSH ($p = 0.001$) and vitamin D ($p = 0.011$) showed significant departures from normality. Positive skewness was observed for TSH (1.011) and vitamin D (0.926), indicating right-skewed distributions within the study population.

Table 3. Assessment of Data Normality for Thyroid Hormones, Vitamin D Levels, and Age Using the Shapiro–Wilk Test

| Variable | N | Shapiro-W | p-value | Skewness | Normal ($\alpha=0.05$) |
|----------|----|-----------|---------|----------|--------------------------|
| T_4 | 40 | 0.9701 | 0.3626 | 0.128 | Yes |
| T_3 | 40 | 0.9849 | 0.8599 | -0.098 | Yes |
| TSH | 40 | 0.8925 | 0.0012 | 1.011 | No |
| VitD | 40 | 0.9253 | 0.0113 | 0.926 | No |
| Age | 39 | 0.9733 | 0.4699 | 0.245 | Yes |

Independent t-test analysis demonstrated significantly higher T_4 levels in females (8.53 ± 1.70) compared with males (7.56 ± 1.25 ; $p = 0.047$), whereas vitamin D levels were significantly higher in males (24.44 ± 10.87) than in females (17.07 ± 11.34 ; $p = 0.043$). No significant gender differences were detected for T_3 ($p = 0.500$), TSH ($p = 0.979$), or age ($p = 0.221$).

Table 4. Comparison of Thyroid Hormones, Vitamin D Levels, and Age Between Female and Male Participants Using the Independent Samples t-Test

| Variable | Female Mean | Male Mean | Mean Diff | Levene p | t-statistic | p-value | Significant |
|----------|-------------|-----------|-----------|----------|-------------|---------|-------------|
| T4 | 8.525 | 7.555 | 0.970 | 0.117 | 2.057 | 0.047 | Yes * |
| T3 | 1.424 | 1.392 | 0.032 | 0.514 | 0.682 | 0.500 | No |
| TSH | 1.686 | 1.695 | -0.010 | 0.666 | -0.027 | 0.979 | No |
| VitD | 17.070 | 24.435 | -7.365 | 0.629 | -2.097 | 0.043 | Yes * |
| Age | 41.895 | 38.200 | 3.695 | 0.851 | 1.246 | 0.221 | No |

One-sample t-test analysis showed no significant differences between the observed and reference values for T4 ($p = 0.871$), T3 ($p = 0.737$), and TSH ($p = 0.105$). However, vitamin D levels were significantly lower than the reference value of 30 ng/mL (20.75 ± 11.58 ng/mL; $p < 0.001$), indicating vitamin D deficiency or insufficiency in the study population.

Table 5. One-Sample t-Test Comparing Observed Thyroid Hormone and Vitamin D Levels with Reference Values

| Variable | Sample Mean | Reference Value | t-statistic | p-value | Significant |
|----------|-------------|-----------------|-------------|---------|-------------|
| T4 | 8.040 | 8.0 | 0.163 | 0.871 | No |
| T3 | 1.408 | 1.4 | 0.338 | 0.737 | No |
| TSH | 1.690 | 2.0 | -1.662 | 0.105 | No |
| VitD | 20.752 | 30.0 | -5.051 | <0.001 | Yes *** |

Discussion

The present study investigated thyroid hormone profiles (T₃, T₄, and TSH) and vitamin D status among adults in Al-Bayda City, Libya, with particular emphasis on gender-related differences. The overall findings demonstrated that the mean concentrations of T₃, T₄, and TSH were generally within their physiological reference ranges, suggesting normal thyroid function in the majority of participants. However, serum vitamin D levels were substantially lower than the recommended reference value, indicating a high prevalence of vitamin D insufficiency within the studied population. The descriptive analysis revealed relatively stable T₃ concentrations compared with the other measured parameters, whereas TSH and vitamin D exhibited greater variability among participants. The significant variability observed in vitamin D levels may be attributed to differences in sunlight exposure, dietary habits, physical activity, skin pigmentation, and socioeconomic factors. Similar findings have been reported in several Middle Eastern and North African populations, where vitamin D deficiency remains prevalent despite abundant sunlight availability [6].

Gender-based comparisons showed that females had significantly higher T₄ concentrations than males. This finding may be explained by sex-related differences in thyroid hormone metabolism, circulating thyroid-binding globulin concentrations, and hormonal influences, particularly estrogen. Previous studies have reported that women often exhibit subtle differences in thyroid physiology and are more susceptible to thyroid dysfunction than men [7]. Nevertheless, no significant differences were observed in T₃ or TSH levels, indicating that the overall hypothalamic-pituitary-thyroid axis remained relatively comparable between genders. In contrast, males demonstrated significantly higher vitamin D concentrations than females. This observation is consistent with reports suggesting that women in many populations are at greater risk of vitamin D deficiency due to reduced sunlight exposure, clothing practices, lower outdoor activity, and hormonal factors affecting vitamin D metabolism. The lower vitamin D levels observed among females in the present study may reflect similar environmental and lifestyle influences within the Al-Bayda community [8].

The normality assessment showed that T₄, T₃, and age followed approximately normal distributions, whereas TSH and vitamin D exhibited significant positive skewness. The non-normal distribution of TSH is frequently reported in epidemiological studies because thyroid-stimulating hormone concentrations tend to vary considerably among individuals. Likewise, vitamin D concentrations often display skewed distributions due to the coexistence of deficient and sufficient individuals within the same population [9]. The one-sample t-test further demonstrated that the mean concentrations of T₃, T₄, and TSH did not differ significantly from established reference values, confirming the absence of widespread thyroid dysfunction in the study population. However, vitamin D concentrations were significantly lower than the recommended reference level of 30 ng/mL, supporting the hypothesis that vitamin D insufficiency represents an important public health concern in Al-Bayda City [10]. This finding is clinically relevant

because chronic vitamin D deficiency has been associated with impaired bone health, immune dysfunction, metabolic disorders, and increased susceptibility to several chronic diseases [11].

Conclusion

The present study evaluated thyroid hormone profiles (T_3 , T_4 , and TSH) and vitamin D status among adults in Al-Bayda City, Libya. The findings demonstrated that the mean concentrations of thyroid hormones were generally within normal reference ranges, indicating normal thyroid function in most participants. Significant gender-related differences were observed, with females exhibiting higher T_4 levels and males showing higher vitamin D concentrations. Despite normal thyroid hormone profiles, the mean serum vitamin D level was significantly lower than the recommended reference value, suggesting a high prevalence of vitamin D insufficiency among the studied population. This deficiency was particularly evident among female participants. The results highlight the importance of regular monitoring of vitamin D status and the implementation of preventive strategies, including nutritional education, adequate sunlight exposure, and appropriate supplementation programs. Overall, the study provides baseline data on thyroid function and vitamin D status in adults from Al-Bayda City and emphasizes the need for larger epidemiological investigations to further explore the relationship between thyroid hormones, vitamin D, and demographic factors in the Libyan population.

Conflict of interest. Nil

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