ASSESSMENT OF THE RELATIONSHIP BETWEEN VITAMIN D LEVELS AND THYROID HORMONES ACROSS DIFFERENT AGE GROUPS IN THE SABRATHA REGION

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Abstract

The present study analyzed age-related changes in thyroid hormones and Vitamin D levels in male and female subjects, exploring correlations between age, thyroid function, and Vitamin D status. Serum levels of T3, T4, TSH, and Vitamin D were assessed across age groups to identify hormonal trends and associations. In males, T3 peaked at ages 0–10 and declined with age, reaching the lowest levels in those aged 61 and above. T4 varied moderately, with the highest levels in the 41–50 years group and lowest in individuals aged 61 and older. TSH levels exhibited variability without a consistent trend, although older adults had the highest mean concentration. Vitamin D levels were highest in younger males and decreased with age, particularly in the 51–60 years group. In females, T3 and T4 demonstrated age-related variations, peaking in the 31–40 years age group, with lower concentrations in older categories. TSH levels varied significantly, suggesting age-related changes in thyroid regulation. Female Vitamin D levels remained low across all age groups, predominantly within deficient or insufficient ranges. Correlation analysis indicated a moderate negative relationship between age and T3 levels in males ($r = -0.42$), suggesting a decline in thyroid activity with aging. A moderate positive correlation was found between T3 and T4 in males ($r = +0.46$), while females showed a stronger positive correlation ($r = +0.63$). Furthermore, in females, TSH was moderately negatively correlated with T3 and T4, reflecting the physiological negative feedback loop of the thyroid system. In both genders, correlations between Vitamin D and thyroid hormones were weak and inconclusive. In summary, the results reveal age-dependent variations in thyroid hormone levels and a high rate of Vitamin D deficiency, particularly in adult and elderly populations, despite overall thyroid function remaining largely within normal limits.

Keywords: Vitamin D status, Thyroid hormones, Gender, Age groups, Sabratha region

Introduction

Studies have shown that vitamin D deficiency is associated with impaired sensitivity to thyroid hormones in euthyroid adults. This is evidenced by increased thyroid feedback indices such as TFQI, TSHI, and TT4RI in individuals with low vitamin D levels **(Li *et al*., 2023, Zhou *et al*., 2023).**

A U-shaped relationship between vitamin D levels and thyroid hormone sensitivity indices like TFQI has been observed, suggesting that both low and high levels of vitamin D can affect thyroid hormone sensitivity **(Chen *et al*., 2023).**

Babić Leko *et al.* (2023) indicate that studies on the association between vitamin D levels and thyroid hormones show high variability, with some observing negative correlations or no association in healthy participants. Notably, a meta-analysis found that vitamin D deficiency is associated with autoimmune thyroid diseases, particularly in older subjects with Graves'

disease. However, the overall impact of age on the relationship between vitamin D levels and thyroid hormones remains unclear, necessitating further research across different age groups.

Quantitative evaluations of vitamin D, TSH, and the thyroid hormones T3 and T4 were performed. Findings revealed that hypothyroid patients exhibited markedly reduced vitamin D levels compared to healthy subjects. Furthermore, an inverse correlation between vitamin D and TSH was observed. The study inferred that vitamin D deficiency could exacerbate hypothyroidism. It advocated for the evaluation of vitamin D levels in patients with thyroid disorders. Additionally, the results highlighted the crucial role of vitamin D in the regulation of hormonal and immune functions **(Wang, 2015).**

In another study **(Chailurkit, 2018a),** vitamin D and TSH levels were measured, showing an inverse relationship. Those with lower vitamin D levels exhibited a heightened risk for thyroid disorders. The research suggested that vitamin D could influence TSH secretion. However, a strong link with T3 and T4 levels was not found. The researcher highlighted vitamin D's protective effects and the importance of sufficient sunlight exposure, advocating for its inclusion in preventive health strategies.

Mackawy *et al.* (2013) analyzed participants with hypothyroidism who did not have autoimmune disorders. Vitamin D levels and thyroid hormones were evaluated, revealing that most individuals had vitamin D deficiency. Additionally, a connection was noted between the severity of hypothyroidism and vitamin D levels. The research suggested that vitamin D deficiency might negatively impact thyroid gland function. No significant differences were observed in T3 levels. The researcher concluded that vitamin D indirectly influences thyroid function and recommended regular monitoring of vitamin D levels, as well as conducting extensive studies to validate these results. A cohort study was conducted on individuals with autoimmune thyroiditis, analyzing vitamin D levels and thyroid autoantibodies. Results showed that vitamin D deficiency correlated with increased thyroid autoantibody levels. Additionally, severe deficiency was associated with impaired thyroid function. The study suggested that vitamin D may offer immunological protection. The investigator asserted that vitamin D deficiency could trigger autoimmune thyroid conditions. The research called for future interventional trials and highlighted the importance of vitamin D in immune regulation **(Kim, 2017).**

Bozkurt *et al.* (2017) reported that participants with vitamin D deficiency who received prolonged vitamin D supplementation showed a significant rise in vitamin D levels post-intervention. Moreover, reductions in thyroid autoantibody levels were observed. However, no significant changes were detected in T3 and T4 levels. Some instances did show a reduction in TSH levels. The study concluded that vitamin D could alleviate autoimmune condition severity. The researcher recommended incorporating vitamin D into treatment protocols and advocated for additional longitudinal studies.

D'Aurizio (2021) performed a thorough review of various clinical studies. The results indicated a high prevalence of vitamin D deficiency in patients with autoimmune thyroid diseases. It was found that vitamin D influences immune cell functionality. The study suggested that vitamin D may reduce thyroid inflammation and highlighted its essential role in immune modulation. Although definitive therapeutic conclusions were not reached, supplementation

was supported. The investigator deemed vitamin D a crucial ancillary factor and advised its careful application in clinical settings.

Vitamin D and thyroid hormone levels were quantitatively analyzed. Findings revealed that vitamin D deficiency is common among women with thyroid disorders. A positive correlation was found between vitamin D deficiency and elevated TSH levels. Nonetheless, no significant impact was observed on free T4 levels. The study emphasized the importance of vitamin D in endocrine health and suggested its effects may vary by sex. The researcher concluded that routine vitamin D screening is essential and recommended combining nutritional and medical interventions **(El-Hajj, 2024).**

Yasmeh *et al.* (2016) examined the association between vitamin D levels and thyroid function in women, focusing on common thyroid disorders. The study included a sample of women with various thyroid conditions, measuring vitamin D, TSH, T3, and T4 levels quantitatively. Results indicated a high prevalence of vitamin D deficiency among women with thyroid disorders, revealing an inverse correlation between vitamin D levels and TSH. Conversely, no significant impact of vitamin D on T3 and T4 levels was found. The findings proposed that vitamin D deficiency may contribute to thyroid dysfunction in women. The researchers concluded that regular assessment of vitamin D levels in women is crucial, emphasizing its supportive function in maintaining thyroid health.

Despite growing evidence suggesting a potential interaction between vitamin D and thyroid function, the nature of this relationship remains unclear, particularly across different stages of life. Existing studies have primarily focused on selected age groups or patients with thyroid disorders, leaving a significant gap in understanding how vitamin D status is associated with thyroid hormone profiles in the general population across various ages. Addressing this gap may improve our understanding of endocrine interactions and support the development of age-specific strategies for maintaining optimal thyroid health.

Materials and Methods

Research Methodology: A descriptive and analytical framework was employed in this investigation.

Study Limitations :

Spatial parameters: The research was implemented at the Prevention Laboratory situated in the city of Sabratha.

Temporal parameters: From July 2025 to December 2025.

This research encompassed 133 samples collected during the timeframe from July 2025 to December 2025. The specimens were retrieved from patient records within the laboratory of the designated study region (n = 133), comprising (53) males and (80) females who were enrolled in this investigation. The patients were categorized into seven distinct age cohorts.

Data were analyzed independently for males and females, with thyroid hormone concentrations and vitamin D levels summarized using descriptive statistical metrics such as the mean and standard deviation, in order to elucidate the overall distribution of values within each cohort. Participants were additionally categorized into various age groups to scrutinize

the influence of age on thyroid hormone and vitamin D levels, as well as to explore alterations associated with differing life stages.

To fulfill the analytical aims of the study, correlation relationships were scrutinized between age and both thyroid hormones and vitamin D. Furthermore, interrelationships among thyroid hormones themselves, alongside their association with vitamin D, were investigated. These relationships were represented through suitable statistical methodologies and illustrative graphs substantiated by statistical equations, which aided in interpreting the directionality and intensity of associations among the examined variables.

A comparative assessment of correlation coefficients between males and females was also performed to discern potential gender-specific variations in the relationships among the study variables. Consequently, the findings were elucidated based on the established normative reference ranges for each hormone and vitamin D across varying age groups, facilitating a precise scientific appraisal of the hormonal and vitamin status of the study participants.

Study Area: The data for the present study were amassed from the Sabratha region during the interval from July 2025 to December 2025.

Data Collection and Analysis: Samples were acquired from patients diagnosed with hypothyroidism and vitamin D deficiency (n = 133): (53) males and (80) females were included in this research. The patients were segmented into seven age groups. Data were analyzed with the aid of Microsoft Excel. The mean, standard deviation, correlation coefficient, and regression analysis were computed to evaluate the interrelationships among the study variables.

Results

In this particular segment of the comprehensive study, the findings are meticulously delineated with respect to the research that was specifically designed to assess the concentrations of vitamin D and its intricate associations with thyroid hormones, namely Thyroid Stimulating Hormone (TSH), Triiodothyronine (T3), and Thyroxine (T4), within the cohort that was subjected to analysis. The resultant data underwent a thorough statistical examination and were subsequently organized and displayed in various tables along with illustrative figures, thereby enhancing the clarity and comprehension of the variances and interrelationships that exist among the diverse variables under investigation.

Table (1): Numerical and Percentage Distribution of the Study Sample by Sex.

Sex	Frequency	Percentage
Females	80	60.15%
Male	53	39.84%
Total	133	100%

Table (2): Mean Levels of Triiodothyronine (T3) by Age Groups in Males.

Age Group	Frequency	T3	Reference Range
0_-_10	9	2.28±0.74	1.30 – 3.10 Nmol/L
11 – 20	6	1.93±0.63	
21 – 30	6	1.77±0.48	

31 – 40	13	1.73±0.13	
41 – 50	4	1.68±0.63	
51 – 60	6	1.80±0.63	
61 Or More	9	1.60±0.25	
Total	53		

Table (2) provides a comprehensive illustration of the mean concentrations of Triiodothyronine (T3) hormone levels in males categorized according to various age brackets, thereby allowing for an analytical understanding of the hormonal fluctuations that occur throughout the lifespan. The empirical data elucidate that the age group of 0–10 years exhibits the highest mean T3 level, which is quantitatively recorded at an approximate value of 2.28 ± 0.47, thereby suggesting a period of relatively elevated thyroid activity during the early developmental stages of life. In stark contrast, the age demographic of individuals aged 61 years and above presents the lowest mean T3 measurement, which is observed to be around 1.60 ± 0.25, thus reflecting a notable and gradual decline in hormone concentrations as individuals progress into older age brackets. It is imperative to note that despite the evident variability of T3 levels observed across the different age cohorts, all recorded values are within the established reference range for T3, which spans from 1.30 to 3.10, thereby indicating that the hormone levels present within the studied sample population were deemed to be normal and did not suggest any discernible thyroid dysfunction that would warrant further clinical investigation.

Table (3): Mean Levels of Thyroxine (T4) by Age Groups in Males.

Age Group	**Frequency**	**T4**	**Reference Range**
0 – 10	9	120.22±27.67	66 – 181 Nmol/L
11 – 20	6	102.73±30.96	
21 – 30	6	101.58±32.02	
31 – 40	13	105.92±26.61	
41 – 50	4	111.81±34.79	
51 – 60	6	100.70±31.77	
61 Or More	9	107.11±15.67	
Total	53		

Table (3) presents a comprehensive illustration of the mean concentrations of Thyroxine (T4) specifically in the male demographic, categorized according to distinct age brackets. The findings elucidate a notable variation in the mean T4 concentrations that is evident across the various age categories, which is characterized by a discernible trend of fluctuation correlated with the aging process. The age group encompassing individuals aged 41 to 50 years exhibited the highest mean T4 concentration, which was quantified at approximately 111.81 ± 34.79, thereby indicating a comparatively elevated level of this hormone within this specific cohort when juxtaposed with the other age classifications. Conversely, the age group comprising individuals aged 61 years and older manifested the lowest mean T4 concentration, measured at around 107.11 ± 15.67, thereby reflecting a quantifiable decline in hormone levels as one progresses into the older age strata. Notwithstanding this observable variability, it is imperative to note that all recorded mean values remain comfortably within the established reference range

for T4, which spans from 66 to 181, thereby suggesting that the hormonal levels among the male subjects examined in this study were within normal limits and did not indicate any apparent thyroid dysfunction or related health issues.

Table (4): Mean Levels of Thyroid-Stimulating Hormone (TSH) by Age Groups in Males.

Age Group	Frequency	TSH	Reference Range
0 – 10	9	2.11±1.09	(0-12month)1.30-8.8 (1-6year)0.85-6.5 (7-12year)0.28-4.3 (12>year)0.35-4.6 MLU/mL
11 – 20	6	2.88±1.85	
21 – 30	6	1.71±0.69	
31 – 40	13	1.75±0.66	
41 – 50	4	2.17±2.07	
51 – 60	6	2.41±0.85	
61 Or More	9	3.06±1.90	
Total	53		

Table (4) meticulously delineates the average concentrations of Thyroid-Stimulating Hormone (TSH) specifically within the male demographic, systematically categorized according to various age cohorts. The outcomes derived from this analysis unequivocally illustrate a pronounced disparity in the average TSH concentrations when juxtaposed across the delineated age groups, revealing an absence of a uniform trend of either escalation or reduction as one progresses further into older age brackets. Notably, the apex of the mean TSH value was documented in the demographic of individuals aged 61 years and older, which registered at an approximate measurement of 3.06 ± 1.90, thereby signifying a comparatively elevated level of this hormone in the older adult population in relation to their younger counterparts. Conversely, the nadir of the mean TSH concentration was identified within the 31–40 years age category, where it was recorded at roughly 1.75 ± 0.66, thereby illustrating a comparatively diminished level of the hormone within this particular age segment. In spite of the observable fluctuations in TSH levels, it is crucial to note that the mean TSH values across all the examined age groups remain comfortably situated within the established reference ranges that are pertinent to each specific age category, thereby suggesting that the thyroid functionality within the studied sample population was predominantly normal and did not exhibit any discernible signs of thyroid dysfunction.

Table (5): Mean Levels of Vitamin D by Age Groups in Males.

Age Group	Frequency	VD	Reference Range
0 – 10	9	28.31±21.56	Sufficient:30-70ng/ml Insufficient:20-30ng/ml Deficient:<20ng/ml
11 – 20	6	25.99±9.13	
21 – 30	6	21.77±10.15	
31 – 40	13	29.3±9.63	
41 – 50	4	21.05±9.53	
51 – 60	6	21.69±7.17	
61 Or More	9	27.82±8.69	
Total	53		

Table (5) presents a comprehensive depiction of the average concentrations of Vitamin D among males categorized by distinct age brackets, allowing for a thorough examination of the data. The findings elucidate a notable disparity in the average levels of Vitamin D across the various age classifications, highlighting the dynamic nature of this essential nutrient's presence in the human body as it correlates with age. Specifically, the most elevated average concentration of Vitamin D was documented within the age group spanning from 0 to 10 years, which exhibited an impressive mean of approximately 28.31 ± 21.56, thereby suggesting a comparatively higher status of Vitamin D levels when juxtaposed with the other examined cohorts. Conversely, the age group ranging from 51 to 60 years manifested the most diminished mean concentration of Vitamin D, registering an approximate average of 21.69 ± 7.17, which unequivocally signifies the lowest recorded average amongst all the age segments that were scrutinized in this study. Furthermore, it is imperative to note that a substantial majority of the age groups analyzed appear to reside within the insufficient or deficient spectrum of Vitamin D levels, particularly highlighting the concerning trends observed in middle-aged and elderly populations, a phenomenon that may be indicative of various factors such as restricted exposure to sunlight, dietary inadequacies, or lifestyle choices that often accompany the aging process.

In summary: The results indicate that younger individuals have the highest Vitamin D levels, while these levels gradually decrease with age, reaching their lowest point in the 51–60 years age group.

Table (6): Mean Levels of Triiodothyronine (T3) by Age Groups in Females.

Age Group	Frequency	T3	Reference Range
0 – 10	4	2.38±0.33	1.30 – 3.10 Nmol/L
11 – 20	20	1.89±0.63	
21 – 30	7	1.86±0.43	
31 – 40	12	2.28±4.03	
41 – 50	22	1.77±0.18	
51 – 60	11	1.91±0.44	
61 Or More	4	1.67±0.34	
Total	80		

Table (6) provides a comprehensive overview of the average concentrations of Triiodothyronine (T3) specifically in the female demographic, categorized meticulously according to distinct age brackets. The findings elucidate a pronounced disparity in the average T3 concentrations that exists among the various age cohorts analyzed. Notably, the peak average T3 value was documented in the age group encompassing individuals aged 31 to 40 years, where the recorded level was approximately 2.28 ± 4.03, a figure that significantly surpasses the values observed in the other age categories under consideration. Conversely, the lowest mean T3 concentration was identified in the age group of 41 to 50 years, where the value was approximately 1.77 ± 0.18, thus representing the nadir of T3 levels captured in the data table. Furthermore, it is imperative to highlight that the majority of the average T3 values across the varying age demographics tend to reside at or marginally below the established normal reference range, which is delineated as being between 1.30 and 3.10, with a conspicuous decline noted in certain cohorts, particularly amongst the older population segments.

In Summary: The findings suggest that the apex of T3 concentrations in the female population is observed during the middle-aged years, specifically between 31 and 40 years, while there is a discernible reduction in these levels, reaching their lowest point within the 41 to 50 years age group, a phenomenon that may be indicative of the physiological impacts resulting from age-associated hormonal fluctuations.

Table (7): Mean Levels of Thyroxine (T4) by Age Groups in Females.

Age Group	Frequency	T4	Reference Range
0 – 10	4	122.5±12.65	66 – 181 Nmol/L
11 – 20	20	100.14±9.97	
21 – 30	7	102.84±16.37	
31 – 40	12	102.22±73.93	
41 – 50	22	96.31±25.34	
51 – 60	11	96.56±22.28	
61 Or More	4	92.62±3.22	
Total	80		

Table (7) provides a comprehensive illustration of the mean concentrations of Thyroxine (T4) in female subjects categorized according to various age segments, thereby enabling a thorough comparative analysis of hormonal levels across different life stages. A distinct and significant variation in the mean values of T4 among these specified age groups is clearly evident upon examination of the data presented. The age group of individuals ranging from 31 to 40 years showcases the highest recorded mean level of T4, which was found to be approximately 102.22 ± 73.93, a figure that markedly surpasses the average levels observed in the other age categories included in the analysis. Conversely, the age group encompassing individuals aged 61 years and older exhibited the lowest mean T4 level, calculated at approximately 92.62 ± 3.22, thereby signifying the lowest value recorded within the confines of the referenced table. Furthermore, the results derived from this analysis indicate that the majority of the mean T4 levels are situated either within or below the established normal physiological range (66–181), with a distinctly observable decline in these levels as age increases, thereby suggesting a potential correlation between thyroid activity and the aging process.

In Summary: The data meticulously suggest that the highest concentrations of T4 in female subjects were observed within the age group of 31 to 40 years, whereas the lowest concentrations were noted in the group of individuals aged 61 years and above, which reflects the hormonal alterations that occur in relation to aging.

Table (8): Mean Levels of Thyroid-Stimulating Hormone (TSH) by Age Groups in Females.

Age Group	Frequency	TSH	Reference Range
0 – 10	4	5.53±5.10	(0-12month)1.30-8.8 (1-6year)0.85-6.5 (7-12year)0.28-4.3 (12>year)0.35-4.6 MLU/mL
11 – 20	20	2.03±1.56	
21 – 30	7	8.82±4.01	
31 – 40	12	7.50±2.94	
41 – 50	22	19.22±59.04	
51 – 60	11	16.99±7.45	
61 Or More	4	11.04±3.85	

Total	80	

Table (8) presents an informative depiction of the mean levels of Thyroid-Stimulating Hormone (TSH) specifically in the female population, systematically categorized across various age groups, thereby offering a comprehensive overview of hormonal variations. The empirical results derived from this data indicate a significant and discernible variation in TSH levels when analyzed across the different age demographics, suggesting that age is a crucial factor influencing hormonal balance. The most elevated mean TSH value was meticulously recorded within the 41–50 years age group, where it measured an impressive 59.04 ± 19.22, which underscores a remarkable increase in hormone levels in this particular demographic when juxtaposed against those of the other age cohorts. Conversely, the lowest mean TSH value was observed in the 11–20 years age group, where it was noted to be a mere 1.56 ± 2.03, thus representing the absolute lowest value documented in this comprehensive table of findings.

In summary, the overall results derived from this analysis illustrate a clear trend indicating that TSH levels are generally lower in younger individuals, subsequently exhibit an upward trajectory with the progression of age, reaching their zenith during the middle-aged phase, and are followed by noticeable fluctuations in the older age brackets.

Table (9): Mean Levels of Vitamin D by Age Groups in Females.

Age Group	Frequency	VD	Reference Range
0 – 10	4	27.87±11.88	Sufficient:30-70ng/ml Insufficient:20-30ng/ml Deficient:<20ng/ml
11 – 20	20	18.97±3.71	
21 – 30	7	19.67±16.33	
31 – 40	12	24.59±9.40	
41 – 50	22	21.79±8.32	
51 – 60	11	22.54±6.65	
61 Or More	4	21.29±10.91	
Total	80		

Table (9) provides a comprehensive overview of the mean concentrations of Vitamin D among female participants, categorized meticulously according to distinct age groups, and juxtaposed with the previously established normative range that serves as a benchmark for comparison. Notably, the highest recorded mean level of Vitamin D was identified within the demographic segment of individuals aged 21 to 30 years, achieving a mean value of 16.33 ± 19.67, which, while representing the peak among all evaluated age categories, remains regrettably within the insufficient range as defined by the established normal limits for optimal health. Conversely, the lowest observed mean level of Vitamin D was documented in the younger age cohort of 11 to 20 years, revealing a concerning mean of 3.71 ± 18.97, thereby underscoring a significant and alarming deficiency prevalent within this particular group.

In summary, the analysis of the data reveals a consistent pattern across all age demographics, wherein each group demonstrates Vitamin D levels that fall short of the sufficient range, specifically the established threshold of 30 to 70, while also exhibiting notable

relative variations that correlate with age. Most strikingly, the deficiency of Vitamin D appears to be markedly more severe in the younger age cohorts, with some degree of relative enhancement observed in the 21 to 30 year groups; nevertheless, it is imperative to note that even this group's levels remain beneath the normative range that is deemed adequate for maintaining optimal health and well-being.

Table (10): Correlation Matrix between Age, Thyroid Hormones, and Vitamin D in Males

	Age	**T3**	**T4**	**TSH**	**VD**
Age	1	-0.42	-0.12	+0.17	-0.001
T3	X	1	+0.46	-0.10	-0.009
T4	X	+0.46	1	-0.09	+0.04
TSH	X	-0.10	-0.09	1	-0.11
VD	X	-0.009	+0.04	-0.11	1

Table (10) presents an extensive analysis of the correlation coefficients that exist between the variable of age and the levels of thyroid hormones, specifically TSH, T3, and T4, as well as the levels of Vitamin D among male participants in the study. The findings derived from this analysis reveal a moderate negative correlation between advancing age and the levels of T3, characterized by a correlation coefficient of r = -0.42, which implies a significant decline in T3 hormone levels as age progresses and individuals grow older. Furthermore, a moderate positive correlation was identified between T3 and T4, denoted by a correlation coefficient of r = +0.46, which underscores the typical physiological relationship that exists between these two hormones within the context of human biology. In stark contrast to the aforementioned relationships, the correlation coefficients that were calculated for Vitamin D in relation to the thyroid hormones indicated a markedly weak association or values that were almost negligible, thereby suggesting the absence of a discernible relationship between Vitamin D levels and those of the thyroid hormones in the male subjects who comprised the sample population of this study.

Table (11): Correlation Matrix between Age, Thyroid Hormones, and Vitamin D in Females.

	Age	**T3**	**T4**	**TSH**	**VD**
Age	1	-0.09	-0.10	+0.16	+0.01
T3	X	1	+0.63	-0.18	+0.12
T4	X	+0.63	1	-0.45	+0.26
TSH	X	-0.18	-0.45	1	-0.10
VD	X	+0.12	+0.26	-0.10	1

Table (11) presents a comprehensive analysis of the correlation coefficients that elucidate the intricate relationships between age and the levels of thyroid hormones, specifically T3 and T4, as well as Vitamin D concentrations in females. The findings of this analysis reveal the existence of a relatively strong positive correlation between the thyroid hormones T3 and T4, as evidenced by the correlation coefficient of r = +0.63, which unmistakably reflects a clear and direct relationship between these two critical hormones that play essential roles in metabolic regulation. Furthermore, a moderate negative correlation was discerned between TSH and both

T3 and T4, which aligns seamlessly with the established negative feedback mechanism inherent to the functioning of the thyroid gland, thereby highlighting the regulatory interplay between these hormonal levels. In terms of the role of Vitamin D in the modulation of thyroid function among females, it is noteworthy that the observed correlations remain weak and ultimately inconclusive, thereby indicating a lack of robust evidence to support a definitive relationship between Vitamin D levels and thyroid function in this demographic.

Discussion

The results of the study indicated that the levels of triiodothyronine (T3) in male subjects exhibit a gradual decline as one progresses through the various stages of aging, a phenomenon that is further complemented by a positive correlation with thyroxine (T4) levels, thereby supporting the assertions made by Braverman and Cooper in their 2013 study, which posited that alterations associated with aging significantly influence both the synthesis and the metabolic conversion of thyroid hormones within the human body. Furthermore, the findings elucidated that the relationship between Vitamin D and thyroid hormones in the male population is characterized by a lack of strength and clarity, which is only partially in agreement with **Holick, 2007** conclusions, wherein he proposed that the influence of Vitamin D on thyroid functionality is likely to be constrained under typical physiological circumstances, particularly in the absence of severe deficiency states.

In the female demographic, the concentrations of T3 and T4 hormones attained their peak levels within the age bracket of 31 to 40 years, after which a decline was observed as age increased, while the levels of thyroid-stimulating hormone (TSH) exhibited an elevation during middle age, a phenomenon that reflects the intricate negative feedback mechanism inherent to the functioning of the thyroid gland, as discussed by **Guyton and Hall 2021**. Additionally, the results revealed that a significant proportion of female participants were experiencing Vitamin D deficiency or insufficiency, particularly among the younger cohorts, and a weak inverse relationship was noted between Vitamin D levels and TSH concentrations, whereas no definitive impact was discerned on T3 and T4 levels; this observation is only partially aligned with the findings of Sheryl Huggins Salomon in 2022, who documented a limited correlation between Vitamin D deficiency and the prevalence of thyroid-related disorders. The relationship between vitamin D and thyroid hormones changes with age. In younger individuals, high vitamin D levels are associated with low TSH levels, while in older adults, the correlation can become positive **(Chailurkit *et al.*, 2013b, Zhang *et al.*, 2014)**. In the 20-60 years age group, a negative correlation between thyroid hormone sensitivity indices and vitamin D levels is observed, which turns positive in the 60-80 years age group **(Li *et al.*, 2023).**

In summation, these findings lend credence to the established physiological correlation that exists between T3 and T4 hormones, as well as their inverse relationship with TSH levels, while simultaneously suggesting that the influence of Vitamin D on thyroid function remains weak or indirect within healthy populations, thereby indicating that the ramifications of Vitamin D deficiency may become significantly more pronounced under pathological conditions or in scenarios where hormone levels are exceedingly low.

Conclusion

The present study demonstrated significant age-related variations in thyroid hormone levels and Vitamin D concentrations among both males and females. While T3 and T4 levels generally showed a tendency to decline with advancing age, most values remained within normal reference ranges, indicating preserved thyroid function across the study population. TSH levels exhibited fluctuations without a consistent age-dependent pattern. Vitamin D deficiency or insufficiency was prevalent in most age groups, particularly among adults and older individuals, suggesting a potential public health concern. Correlation analyses confirmed expected physiological relationships among thyroid hormones but revealed only weak associations between Vitamin D and thyroid function.

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