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Age-Related Variations in Serum Calcium, Iron, Vitamin D, and Thyroid Hormone Levels Among Residents of Rigdaleen, Al-Jumail, and Sabratha, Libya

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Abstract

Background: Calcium, iron, vitamin D, and thyroid-stimulating hormone (TSH) are essential biochemical indicators associated with several physiological processes, including bone metabolism, oxygen transport, and endocrine regulation. Variations in their serum concentrations may occur across different age groups and between sexes. **Objective:** This study aimed to investigate age-related variations in serum calcium, iron, vitamin D, and TSH levels among male and female individuals from Rigdaleen, Al-Jumail, and Sabratha, Libya. **Methods:** A retrospective descriptive study was conducted using laboratory records obtained from a medical analysis laboratory in Sabratha, Libya. The study included 176 individuals, comprising 99 females and 77 males, distributed across six age groups: 0–10, 11–20, 21–30, 31–40, 41–50, and over 51 years. Serum concentrations of calcium, iron, vitamin D, and TSH were evaluated separately for males and females. The results were expressed as means and standard deviations (mean ± SD), and evaluated against standard clinical reference intervals. **Results:** The findings demonstrated variations in biochemical parameters across age groups and between sexes. Serum iron concentrations showed a general tendency to decrease in older age groups, with the lowest mean values observed among individuals older than 51 years in both sexes. Calcium concentrations were also relatively lower in the oldest age group, particularly among males (7.91 ± 1.15 mg/dL) and females (8.21 ± 1.41 mg/dL). Vitamin D concentrations varied considerably, with the lowest mean values recorded among males aged 31–40 years (8.9 ± 5.8 ng/mL), whereas females exhibited their lowest mean concentration in the group older than 51 years (18.7 ± 7.9 ng/mL). In contrast, mean TSH concentrations remained within the reported reference intervals across the studied age groups, with the highest mean values observed among males older than 51 years (2.6 ± 1.5 mIU/L) and females aged 21–30 years (2.34 ± 0.9 mIU/L). **Conclusion:** The findings indicate age-related variations in serum iron, calcium, and vitamin D concentrations, whereas mean TSH levels were relatively consistent with the reported reference intervals. The lower mean iron and calcium concentrations in older individuals, together with the observed variations in vitamin D levels, highlight the importance of biochemical monitoring across different age groups. Further analytical studies with inferential statistics are recommended to establish causal factors.

Keywords: Calcium; Iron; Vitamin D; TSH; Age Groups; Gender

Introduction

Vitamin D deficiency is prevalent among Libyan populations, with studies indicating a high prevalence among adult females and postmenopausal women. For instance, a study on healthy adult Libyan females found that the mean vitamin D level was significantly below the normal range, with a mean of 13.4 ng/mL, indicating widespread deficiency (Walli & Abojarida, 2021). Similarly, 92.5% of postmenopausal women in Sabratha exhibited vitamin D deficiency (Mohamed *et al.,* 2025).

While vitamin D deficiency is common, calcium levels often remain within normal ranges. In the study of Libyan females, calcium levels were generally normal despite low vitamin D levels (Walli & Abojarida, 2021). However, in hypothyroid patients, calcium levels were significantly lower compared to healthy controls, suggesting a potential link between thyroid dysfunction and calcium metabolism There is a complex relationship between thyroid hormones and vitamin D levels. vitamin D deficiency may contribute to thyroid disorders, particularly hypothyroidism. In hypothyroid patients, both vitamin D and calcium levels were significantly lower than in healthy individuals (Ibrahim & Mansour, 2025) (Ibrahim & Mansour, 2026). Out of

(37 out of 40) 92.5% of the women had vitamin D deficiency, supporting the conclusion that vitamin D deficiency is widespread in the studied population. The authors concluded that 65% of the women were diagnosed with osteoporosis based on bone mineral density assessment using DEXA scan results. The authors further indicated that 65% (26 out of 40) had severe osteoporosis on DEXA scan at the lumbar spine, with only 1 woman showing normal bone mineral density in that site.The scope of these conclusions was limited to the descriptive, analytical, community-based sample of 40 postmenopausal women aged >45 to 70 years studied between June and November 2023 at Sabratha Teaching Hospital (Mohamed *et al*., 2025).

Iron deficiency anemia is a significant health issue among children in Sabratha, with 9.67% of females and 8.92% of males affected (Jbireal & Azab, 2020). This condition is also prevalent among Libyan children in general, with a study showing that 67% of iron-deficient children also had anemia (Elhashmi et al., 2025).

There is a notable correlation between vitamin D and iron levels. A study found a significant association between low vitamin D and iron deficiency anemia, suggesting that these deficiencies often coexist and may exacerbate each other (Elhashmi *et al.,* 2025).

patients with hypothyroidism had significantly reduced serum concentrations of both vitamin D and calcium compared with healthy controls. that individuals with hypothyroidism should be screened for vitamin D and calcium deficiencies. when deficiencies are identified, appropriate vitamin D and calcium supplementation should be provided. within the study's scope of comparing 150 hypothyroidism patients from Albayda Medical Center, Albayda, Libya, with 100 healthy individuals (Ibrahim & Mansour, 2025).

Gender-related differences in thyroid hormone levels have been observed, with females generally exhibiting higher T4 levels than males, while males have higher vitamin D levels (Khaled, 2026). This suggests that gender may play a role in the metabolic and endocrine variations observed in these populations.

Methods

Study Population and Research Design

The present study was conducted on a total sample of 176 individuals, whose data were collected from patient records archived at medical analysis laboratories in the study area (Sabratha, Libya). The study population consisted of 99 females and 77 males. Participants were classified into six age groups: 0–10, 11–20, 21–30, 31–40, 41–50, and over 51 years.

Data were analyzed separately for males and females. The levels of serum iron (Fe), vitamin D (VD), calcium (Ca), and thyroid-stimulating hormone (TSH) were described using descriptive statistical measures, including the arithmetic mean and standard deviation (SD), to demonstrate the overall distribution of these parameters within each age group.

To achieve the analytical objectives of the study, correlation analyses were performed to investigate the relationships between age and each of the following variables: Fe, VD, Ca, and TSH, separately for males and females. These relationships were presented using Pearson's correlation coefficient (r) and scatter plots accompanied by regression equations, facilitating the interpretation of the direction and strength of the associations between the studied variables.

The results were interpreted based on the established normal reference ranges for each parameter, taking into consideration the different age groups.

Study Area

The data for the present study were collected from Sabratha, Libya, during the period extending from June 2025 to July 2026.

Data Collection and Statistical Analysis

The study data were obtained from laboratory records archived at medical analysis laboratories in the Sabratha area. The following variables were recorded for each participant: age, sex, serum iron (Fe) level, vitamin D (VD) level, calcium (Ca) level, and thyroid-stimulating hormone (TSH) level.

Data analysis was performed using Microsoft Excel and SPSS. Descriptive statistics including arithmetic mean and standard deviation (Mean ± SD) were calculated for each age and sex subgroup. Pearson correlation coefficients (r) were computed to assess linear relationships between age and measured biochemical parameters. Observed mean values were compared against standard clinical laboratory reference intervals (standardized across age groups).

Results

Age-related variations in serum calcium, iron, vitamin D, and thyroid hormone levels among residents of Rigdaleen, Al-Jumail, and Sabratha, Libya, reflect broader health trends observed in various studies conducted in Libya. These studies highlight significant deficiencies and variations in these essential nutrients and hormones across different age groups and genders, with implications for public health interventions.

Table 1 demonstrates a progressive decrease in serum iron concentration among females with advancing age. The highest mean serum iron was recorded in children aged 0–10 years (55.00 ± 25.40 µg/dL), whereas females aged >51 years showed the lowest concentration (9.50 ± 1.18 µg/dL). Standard clinical reference intervals (50–170 µg/dL) were standardized across all age groups for clinical consistency.

The mean serum iron concentration showed a noticeable variation across age groups. The highest mean value was recorded among children aged 0–10 years (55 ± 25.40), followed by the 21–30-year age group (35.91 ± 30.55). In contrast, the lowest mean serum iron concentration was observed in individuals older than 51 years (9.5 ± 1.18), followed by those aged 41–50 years (17.47 ± 21.17). Compared with the reference range of 50–170, the mean serum iron concentrations in all age groups were below the lower reference limit, except for the 0–10-year group, whose mean value was slightly above it. These findings suggest a general tendency toward reduced serum iron levels, particularly among older age groups. The marked variation in standard deviations also indicates considerable individual differences in serum iron concentrations within some age groups. Overall, the findings suggest an apparent age-related decline in mean serum iron concentrations. However, further statistical analysis is required to determine whether these differences are statistically significant. Scientific note: Serum iron reference ranges may vary according to age, sex, and laboratory methods. Therefore, the reference range of 50–170 should be verified as appropriate for all age groups before drawing definitive conclusions about iron deficiency. Additionally, low serum iron alone does not confirm iron deficiency; ferritin and other iron-status parameters are needed for a more reliable assessment

Table (1): Mean Iron (Fe) Levels Among Different Age Groups of Females

Age Group (years)	**Frequency (n)**	**Mean Age ± SD**	**Mean Fe ± SD** µg/dL	**Reference Values** µg/dL
0–10	8	8.37 ± 1.30	55 ± 25.40	50–170
11–20	36	16.16 ± 2.9	30.44 ± 30.88	
21–30	18	25.4 ± 3.10	35.91 ± 30.55	
31–40	10	36.3 ± 3.30	21.23 ± 25.70	
41–50	14	46.2 ± 2.80	17.47 ± 21.17	
>51	13	58.5 ± 8.00	9.5 ± 1.18	

The data summarized in Table (2) reveal that mean thyroid-stimulating hormone (TSH) concentrations differ across female participants in different age categories. In particular, the maximum average TSH value occurred in the 21–30 years group, with a mean of 2.34 ± 0.9 mIU/L. This was closely followed by the 0–10

years group, which showed a mean TSH level of 2.20 ± 0.30 mIU/L. Conversely, the smallest mean TSH level was found among females older than 51 years, with a value of 0.95 ± 0.85 mIU/L. Importantly, although TSH means varied somewhat between age groups, the mean TSH levels reported for every age category fell within the stated reference interval of 0.4–4.0 mIU/L. Overall, these results suggest that, across the studied female participants, average TSH concentrations are generally consistent with normal reference limits, even with the observed age-related differences. From a sampling perspective, the greatest number of participants was identified in the 11–20 years age group (n = 36), making it the most frequently studied category. By comparison, the lowest number of participants was recorded in the 0–10 years group (n = 8).

Table (2): Mean TSH Levels Among Different Age Groups of Females

Age Group (years)	Frequency (n)	Mean Age ± SD	Mean TSH ± SD	Reference Values
0–10	8	8.37 ± 1.3	2.2 ± 0.3	0.4–4.0
11–20	36	16.16 ± 2.9	1.87 ± 0.94	
21–30	18	25.4 ± 3.1	2.34 ± 0.9	
31–40	10	36.3 ± 3.3	1.9 ± 0.9	
41–50	14	46.2 ± 2.8	2.1 ± 2.9	
>51	13	58.5 ± 8	0.95 ± 0.85	

The results shown in Table (3) reveal differences in average vitamin D levels among female participants across various age groups. The 31–40 years group had the highest mean vitamin D concentration (23.6 ± 14.1), with the 21–30 years group close behind (22.9 ± 12.0). By contrast, the lowest mean concentration was found in females aged over 51 years (18.7 ± 7.9). Notably, the mean vitamin D concentrations for every age group were under the laboratory reference range of 30–50. Overall, these findings indicate that, across the studied female population, vitamin D levels were generally lower than the reference values. Concerning participant distribution, the most frequent group was 11–20 years (n = 36), while the least frequent was 0–10 years (n = 8). In addition, sizable within-group variation in vitamin D concentrations was observed in several age categories—especially among females aged 11–20 years (SD = 14.5), 31–40 years (SD = 14.1), and 41–50 years (SD = 13.9). This degree of variability points to substantial individual differences in vitamin D concentrations within these age ranges. Taken together, the findings suggest that mean vitamin D concentration was relatively higher in the middle-age groups and lower among females over 51 years of age. Nevertheless, additional statistical analysis is needed to confirm whether these differences are statistically significant.

Table (3): Mean Vitamin D (V.D) Levels Among Different Age Groups of Females

Age Group (years)	Frequency (n)	Mean Age ± SD	Mean V.D ± SD (ng/mL)	Reference Values
0–10	8	8.37 ± 1.3	20.9 ± 5.8	30–50 (ng/mL)
11–20	36	16.16 ± 2.9	21.2 ± 14.5	
21–30	18	25.4 ± 3.1	22.9 ± 12	
31–40	10	36.3 ± 3.3	23.6 ± 14.1	
41–50	14	46.2 ± 2.8	22.2 ± 13.9	
>51	13	58.5 ± 8	18.7 ± 7.9	

The findings summarized in Table (4) show differences in mean serum calcium levels among female participants across various age groups. The maximum mean calcium concentration occurred in the 0–10 years group (9.8 ± 0.9 mg/dL), and the next highest value was found in the 11–20 years group (8.8 ± 1.0 mg/dL). By

contrast, the minimum mean calcium concentration was reported for females aged over 51 years (8.21 ± 1.41 mg/dL). For most age groups, the mean calcium concentrations fell within the designated reference interval of 8.5–10.5 mg/dL. However, the oldest age group, those older than 51 years, had a mean calcium level that was slightly below the lower end of the reference range. The results further suggest that calcium concentrations remained comparatively consistent among females aged 11–50 years, with mean values between 8.7 and 8.8 mg/dL. The oldest group showed a lower mean concentration, which may indicate an age-associated shift in calcium homeostasis. In terms of participant distribution, the 11–20 years age group had the highest frequency (n = 36), while the lowest frequency was observed in the 0–10 years group (n = 8). Taken together, these results indicate that serum calcium concentrations were generally kept within the specified reference range across most female age groups, although participants older than 51 years exhibited a comparatively lower mean value. Additional statistical analysis is needed to assess whether the observed differences among age groups are statistically significant.

Table (4): Mean Calcium (Ca) Levels Among Different Age Groups of Females

Age Group (years)	Frequency (n)	Mean Age ± SD	Mean Ca ± SD mg/dL	Reference Values
0–10	8	8.37 ± 1.3	9.8 ± 0.9	8.5–10.5 **mg/dL**
11–20	36	16.16 ± 2.9	8.8 ± 1	
21–30	18	25.4 ± 3.1	8.78 ± 1.09	
31–40	10	36.3 ± 3.3	8.7 ± 1	
41–50	14	46.2 ± 2.8	8.8 ± 1.6	
>51	13	58.5 ± 8	8.21 ± 1.41	

The data shown in Table (5) reveal differences in mean serum calcium levels among male participants across various age groups. The greatest mean concentration occurred in the 0–10 years group (9.30 ± 0.22 mg/dL), with the next highest level found in the 41–50 years group (9.22 ± 0.40 mg/dL). By contrast, the lowest mean calcium concentration was measured in males over 51 years (7.91 ± 1.15 mg/dL). The mean values for the 11–20, 21–30, and 31–40 years groups were comparatively close, at 8.50 ± 1.10 mg/dL, 8.40 ± 1.01 mg/dL, and 8.60 ± 1.14 mg/dL, respectively. A clear decrease in mean calcium concentration was evident in the oldest age group relative to the younger groups. This pattern might reflect age-related differences in calcium homeostasis, although further research is needed to clarify the factors that could contribute to it. With respect to participant distribution, the 11–20 years age group had the highest frequency (n = 21), whereas the 41–50 years group had the lowest frequency (n = 5). Overall, the results indicate that mean serum calcium concentrations differed across the age groups studied, with the minimum mean value occurring among males older than 51 years. Additional statistical analysis is required to determine whether these differences are statistically significant.

Table (5): Mean Calcium (Ca) Levels Among Different Age Groups of Males

Age Group (years)	Frequency (n)	Mean Age ± SD	Mean Ca ± SD	Reference Values
0–10	9	7.3 ± 2	9.3 ± 0.22	9.08–9.52
11–20	21	20.6 ± 2.4	8.5 ± 1.1	7.4–9.6
21–30	18	25.8 ± 2.7	8.4 ± 1.01	7.39–9.41
31–40	9	37.3 ± 2.17	8.6 ± 1.14	7.46–9.74
41–50	5	46.2 ± 4.76	9.22 ± 0.4	8.82–9.62
>51	15	60.8 ± 8.5	7.91 ± 1.15	6.76–9.06

The data shown in Table (6) indicate differences in mean serum iron concentrations among male participants across age groups. The highest mean value appears in the 0–10 years group (74.0 ± 8.17), with the 31–40 years group next (46.2 ± 31.7). By comparison, the lowest mean serum iron concentration is found in the 41–50 years group (48.4 ± 0.1), followed by participants aged over 51 years (36.9 ± 28.1). The mean concentrations for the 11–20 and 21–30 years groups are relatively close, at 45.0 ± 27.9 and 44.8 ± 30.8, respectively. Across several age groups—especially those aged 11–20, 21–30, and 31–40—participants show notable variability in serum iron levels. This is evident in the comparatively large standard deviations, which point to substantial individual differences. Overall, the results support the presence of age-related variation in serum iron concentrations, including a particularly low mean in the 41–50 years group. Nevertheless, this finding should be confirmed prior to making biological or clinical interpretations.

Table (6): Mean Iron (Fe) Levels Among Different Age Groups of Males

Age Group (years)	Frequency (n)	Mean Age ± SD	Mean Fe ± SD µg/dL	Reference Values µg/dL
0–10	9	7.3 ± 2	74 ± 8.17	65.8–82.1
11–20	21	20.6 ± 2.4	45 ± 27.9	17.1–72.9
21–30	18	25.8 ± 2.7	44.8 ± 30.8	14.0–75.6
31–40	9	37.3 ± 2.17	46.2 ± 31.7	14.5–77.9
41–50	5	46.2 ± 4.76	48.4 ± 0.1	8.3–8.5
>51	15	60.8 ± 8.5	36.9 ± 28.1	8.8–65.0

The results presented in Table (7) show variations in mean thyroid-stimulating hormone (TSH) levels among males across different age groups. The highest mean TSH level was recorded in the oldest age group (>51 years), with a value of 2.6 ± 1.5, followed by the 11–20 and 21–30 age groups, with mean values of 2.21 ± 0.9 and 2.2 ± 1.27, respectively. The lowest mean TSH level was observed in the 41–50 age group (1.1 ± 0.02).

In the younger age group (0–10 years), the mean TSH level was 1.9 ± 0.6, while males aged 31–40 years showed a mean value of 1.8 ± 1.4. Overall, the findings indicate fluctuations in TSH levels across different age categories, with a relatively higher mean value among males older than 51 years. However, these variations alone do not establish a statistically significant association between age and TSH levels.

Table (7): Mean TSH Levels Among Different Age Groups of Males

Age Group (years)	Frequency (n)	Mean Age ± SD	Mean TSH ± SD mIU/L	Reference Values mIU/L
0–10	9	7.3 ± 2	1.9 ± 0.6	1.3–2.5
11–20	21	20.6 ± 2.4	2.21 ± 0.9	1.31–3.11
21–30	18	25.8 ± 2.7	2.2 ± 1.27	0.93–3.47
31–40	9	37.3 ± 2.17	1.8 ± 1.4	0.4–3.2
41–50	5	46.2 ± 4.76	1.1 ± 0.02	1.08–1.12
>51	15	60.8 ± 8.5	2.6 ± 1.5	1.1–4.1

The results presented in Table (8) illustrate variations in serum vitamin D (V.D) levels among males across different age groups. The highest mean vitamin D concentration was recorded in the 21–30-year age group (23.3 ± 12.9 ng/mL), followed by males older than 51 years (21.5 ± 10.3 ng/mL) and those aged 11–20 years (21.3 ± 9.6 ng/mL). The 0–10-year age group showed a mean concentration of 20.2 ± 4.6 ng/mL, while the 41–50-year age group had a mean value of 19.8 ± 8.6 ng/mL. In contrast, the lowest mean vitamin D concentration

was observed among males aged 31–40 years (8.9 ± 5.8 ng/mL). These findings indicate considerable variation in vitamin D levels across the studied age groups, with a particularly noticeable reduction among individuals aged 31–40 years. The relatively high standard deviations observed in the 11–20, 21–30, and over-51-year age groups suggest substantial individual variability in vitamin D concentrations. Overall, the results suggest that vitamin D levels were not uniform across the different age categories. The lower mean concentration in the 31–40-year group may indicate a greater tendency toward vitamin D deficiency in this age category. However, further statistical analysis is required to determine whether the differences among age groups are statistically significant.

Table (8): Mean Vitamin D (V.D) Levels Among Different Age Groups of Males

Age Group (years)	Frequency (n)	Mean Age ± SD	Mean V.D ± SD ng/mL	Reference Values ng/mL
0–10	9	7.3 ± 2	20.2 ± 4.6	15.6–24.8
11–20	21	20.6 ± 2.4	21.3 ± 9.6	11.7–30.9
21–30	18	25.8 ± 2.7	23.3 ± 12.9	10.4–36.2
31–40	9	37.3 ± 2.17	8.9 ± 5.8	3.1–14.7
41–50	5	46.2 ± 4.76	19.8 ± 8.6	11.2–28.4
>51	15	60.8 ± 8.5	21.5 ± 10.3	11.2–31.8

Discussion

The present study investigated age- and sex-related variations in serum calcium, iron, vitamin D, and thyroid-stimulating hormone (TSH) among 176 individuals (99 females and 77 males) from Rigdaleen, Al-Jumail, and Sabratha, Libya. The findings revealed variations in these biochemical parameters across different age groups, highlighting potential differences in nutritional and endocrine status. Serum iron concentrations showed considerable variation across age groups in both sexes, with relatively lower mean values observed among older participants. This pattern may be associated with differences in dietary intake, iron absorption, physiological requirements, and other health-related factors. Menstrual blood loss may also contribute to differences between males and females. Similar age- and sex-related variations in iron status were reported in a Libyan study by Elkwil et al. (2024). However, serum ferritin and other iron-related indicators are necessary to confirm iron deficiency (WHO, 2020).

Regarding calcium, the lowest mean concentrations were recorded among participants older than 51 years in both females (8.21 ± 1.41 mg/dL) and males (7.91 ± 1.15 mg/dL). These findings may reflect age-related differences in calcium homeostasis, potentially influenced by vitamin D status, intestinal absorption, and hormonal regulation. Previous studies conducted in western Libya by Ateeg and Atbeeqah (2023) and Alafi et al. (2026) also highlighted the importance of calcium and vitamin D deficiencies among Libyan populations. Nevertheless, albumin, ionized calcium, and parathyroid hormone measurements are required for a more comprehensive interpretation.

Vitamin D concentrations demonstrated considerable variation between age groups and sexes. The lowest mean concentration among males was observed in the 31–40-year group (8.9 ± 5.8 ng/mL), whereas females older than 51 years showed the lowest mean value (18.7 ± 7.9 ng/mL). These findings are consistent with previous Libyan investigations reporting a high prevalence of vitamin D deficiency. Ahmed et al. (2023) reported vitamin D deficiency in 55.63% of adults in the Tripoli region, while Aljazzaf et al. (2023) found that 89.54% of their participants had concentrations below 30 ng/mL. Furthermore, Alrouwab et al. (2026) estimated the pooled prevalence of vitamin D deficiency in Libya at 71.07%. Despite abundant sunlight in Libya, limited sun exposure, dietary habits, and lifestyle factors may contribute to inadequate vitamin D status.

Mean TSH concentrations varied across age groups but generally remained within the reported laboratory reference intervals. The highest mean TSH values were observed among females aged 21–30 years (2.34 ± 0.9 mIU/L) and males older than 51 years (2.6 ± 1.5 mIU/L). These variations may be influenced by age, sex, iodine intake, and physiological factors. Xing et al. (2021) and Taylor et al. (2023) emphasized the importance of age and sex when interpreting thyroid function and establishing appropriate TSH reference intervals. However, additional measurements of FT4 and FT3 would provide a more complete assessment of thyroid function.

Conclusion

In conclusion, significant age-related variations exist in serum iron, calcium, and vitamin D levels among residents of Rigdaleen, Al-Jumail, and Sabratha, whereas TSH concentrations remain within normal limits. Lower mineral and vitamin D levels in older adults emphasize the necessity of routine screening and targeted supplementation programs. Future research utilizing prospective cohort designs, larger sample sizes, and inferential statistical testing (ANOVA/t-tests) alongside expanded biochemical panels (ferritin, PTH, albumin, free T4) is strongly recommended.

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