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The Relationship Between Vitamin D Deficiency and Bone Mineral Density Among Adults in Bani Walid, Libya

Rema Omar Matoug *
Department of Zoology, Faculty of Science, Bani Waleed University, Libya

العلاقة بين نقص فيتامين (د) وكثافة العظام لدى البالغين في مدينة بني وليد، ليبيا

ريمة عمر معتوق *
قسم علم الحيوان، كلية العلوم، جامعة بني وليد، ليبيا

*Corresponding author: remaomar36@gmail.com

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Abstract:

Background and Objectives: Despite abundant sunlight, Vitamin D deficiency has become a pressing global public health concern, a situation increasingly evident in Libya, particularly in Bani Walid. This paradox is driven by factors such as limited outdoor activity, clothing styles that restrict sun exposure, and diets low in vitamin D-rich foods. Low vitamin D levels directly impair calcium absorption and bone mineralization, leading to reduced bone mineral density (BMD) and a higher risk of osteoporosis and fractures. This study aimed to investigate the prevalence of vitamin D deficiency among adults in Bani Walid, Libya, and determine the relationship between vitamin D status and BMD. The research also sought to assess if gender differences play a role in this association. **Methods and Results:** A cross-sectional study was conducted on 200 adult participants in Bani Walid, Libya, between May and September 2025. Serum vitamin D levels and BMD were assessed using standardized tests and Dual-Energy X-ray Absorptiometry (DEXA). The results showed that 52.0% of participants were vitamin D deficient, with an additional 28.0% having insufficient levels. Vitamin D levels were significantly lower among females (67.0%) compared to males (25.0%). Low BMD values were observed in 70.0% of the study population. Crucially, a strong positive correlation was found between low vitamin D levels and reduced bone density ($p = 0.0001$). **Conclusion and Recommendations**: The findings confirm that vitamin D deficiency is widespread and strongly associated with reduced BMD in Bani Walid adults. Addressing this deficiency through preventive strategies- such as regular screening, dietary supplementation, and lifestyle modifications-is an urgent public health priority to protect bone health in the adult population of Bani Walid and similar regions in Libya

Keywords: Vitamin D deficiency; bone mineral density; prevalence; adults; Bani Walid; Libya.

الملخص

الخلفية والأهداف: على الرغم من وفرة أشعة الشمس، يمثل نقص فيتامين د مشكلة صحية عامة ملحة على مستوى العالم، وتزداد وضوحًا في ليبيا، وخاصة في بني وليد. ترجع هذه الظاهرة إلى عوامل مثل قلة النشاط الخارجي وأنماط الملابس

والعادات الغذائية الفقيرة بفيتامين د. يُعد انخفاض مستويات فيتامين د مرتبطًا بضعف امتصاص الكالسيوم وانخفاض تمعدن العظام، مما يزيد من خطر الإصابة بهشاشة العظام والكسور. هدفت هذه الدراسة إلى استقصاء مدى انتشار نقص فيتامين د بين البالغين في بني وليد، ليبيا، وتحديد علاقته بكثافة العظام(BMD) ، وتقييم دور الفروق بين الجنسين في هذه العلاقة. **المنهجية والنتائج الرئيسية:** أُجريت دراسة مقطعية على 200 مشارك بالغ في بني وليد، ليبيا، بين مايو وسبتمبر 2025. تم تقييم مستويات فيتامين د في المصل وكثافة العظام باستخدام اختبارات مخبرية معيارية وامتصاص الأشعة السينية مزدوج الطاقة (DEXA) .أظهرت النتائج أن 52.0%من المشاركين يعانون من نقص فيتامين د، وأن 28.0%إضافية لديهم مستويات غير كافية .كانت مستويات فيتامين د أقل بكثير لدى الإناث (67.0%) مقارنة بالذكور .(25.0%) كما لوحظت قيم منخفضة لكثافة العظام لدى 70.0%من أفراد العينة .والأهم من ذلك، أشارت النتائج إلى ارتباط إيجابي قوي بين انخفاض مستويات فيتامين د وانخفاض كثافة العظام (مع قيمة دلالة إحصائية .(*p = 0.0001*). **الاستنتاج والتوصيات:** تؤكد الدراسة أن نقص فيتامين د منتشر على نطاق واسع ومرتبط ارتباطًا وثيقًا بضعف صحة العظام وتقليل كثافة العظام لدى البالغين في بني وليد. وتبرز هذه النتائج الحاجة الملحة إلى استراتيجيات وقائية، بما في ذلك الفحص المنتظم والمكملات الغذائية وتعديلات نمط الحياة، لحماية صحة العظام والرفاهية العامة للسكان البالغين في المنطقة.

الكلمات المفتاحية: نقص فيتامين (د)؛ كثافة العظام؛ الانتشار؛ البالغون؛ بني وليد؛ ليبيا

Introduction

Bone health is a major global concern, as osteoporosis and fractures significantly affect quality of life and daily functioning. Maintaining strong bones is essential for reducing disability and improving longevity (Holick, 2017). Vitamin D plays a central role in calcium and phosphate metabolism, supporting bone mineralization and skeletal strength. Deficiency in this vitamin has been consistently linked to reduced bone density and higher risk of osteoporosis (Mithal et al., 2009).

Despite Libya's sunny climate, vitamin D deficiency is widespread. Studies have shown that limited sun exposure, cultural clothing practices, and dietary habits contribute to low vitamin D levels among Libyan adults (El-Majidi & El-Majidi, 2020). In Bani Walid, this issue is particularly relevant. Local observations suggest that many adults suffer from insufficient vitamin D, which directly impacts bone health and increases the risk of fractures. This reflects a paradox where abundant sunlight does not guarantee adequate vitamin D status (Al-Musharaf et al., 2012).

Gender differences also play a role in vitamin D metabolism. Research indicates that women are more likely to experience deficiency compared to men, due to biological, hormonal, and lifestyle factors, which may explain variations in bone density between the sexes (Gannage-Yared et al., 2000). Given these challenges, studying the relationship between vitamin D deficiency and bone mineral density among adults in Bani Walid is crucial. Such research provides evidence for targeted public health interventions, including screening, supplementation, and lifestyle modifications to reduce the burden of osteoporosis (Lips & van Schoor, 2011).

Method

1. Study Participants

A descriptive cross-sectional study was carried out in Bani Walid City, Libya, between May and September 2025. The study focused on adult participants of both sexes who attended private medical laboratories either for vitamin D testing or routine medical checkups. A total of 200 individuals aged 18 years and above voluntarily agreed to take part in the research.

To ensure accuracy and avoid bias, participants who were receiving therapeutic doses of vitamins or medications known to affect bone metabolism were excluded. Basic participant information, including age and sex, was collected through structured forms, while laboratory assessments were performed to measure serum vitamin D levels and bone mineral density.

2. Data Collection

Participants were selected through random sampling, and each provided a 10 ml fasting venous blood sample. Basic participant characteristics, including age and sex, were documented using structured forms. Blood samples were collected in tubes containing a clot activator, then centrifuged to prepare for laboratory analysis.

Serum 25(OH)D concentrations were measured using fluorescence immunoassay (IFA) techniques with standardized analyzers (I-Chroma or LanSionbio LS 1100). Vitamin D status was classified according to internationally accepted cut-off values:

- Deficient: < 20 ng/ml
- Insufficient: 20 – < 30 ng/ml
- Sufficient: 30 - 100 ng/ml

Calcium levels were assessed using a semi-automated single-beam Riele 4040 spectrophotometer. Results were categorized as:

- Hypocalcemia: < 8.8 mg/dl
- Normal/Optimal: 8.8 – 10.6 mg/dl
- Hypercalcemia: > 10.6 mg/dl

All laboratory procedures were performed by trained technicians, either certified by qualified trainers or supervised by experienced colleagues, ensuring the reliability and accuracy of the measurements.

3. Data Analysis

The dataset was organized and processed using SPSS software. All participant information was carefully arranged before entry to ensure accuracy. Statistical procedures were applied to examine the relationship between serum vitamin D levels and the recorded characteristics of the study population. Group differences were evaluated, and results were considered significant when the probability value was less than 0.05.

Results

In the present study, a total of 200 adult participants from Bani Walid City were recruited. All individuals underwent concurrent measurements of serum vitamin D and calcium levels during the period from May to September 2025. After excluding incomplete records, the final statistical analysis was conducted on 150 participants who successfully completed both assessments.

Table 1: Characteristics of the Study Group.

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	92	46.0
	Female	108	54.0
Age Groups (years)	18 – 29	58	29.0
	30 – 44	64	32.0
	45 – 59	46	23.0
	Age 60	32	16.0
Total Participants		200	100.0
Final Sample	Included in analysis	150	75.0

In the present study, a total of 200 adult participants from Bani Walid City were recruited. Out of these, 150 participants successfully completed concurrent measurements of serum vitamin D and calcium levels and were included in the final analysis. The initial sample showed that female participants slightly outnumbered males, with 108 females (54.0%) compared to 92 males (46.0%). The age of participants ranged from 18 to 75 years. Among them, 58 (29.0%) were between 18–29 years, 64 (32.0%) were between 30–44 years, 46 (23.0%) were between 45–59 years, and 32 (16.0%) were aged 60 years or older. The characteristics of the study group

are summarized in Table 1, and the distribution by gender and age groups is illustrated in Figure 1 and Figure 2.

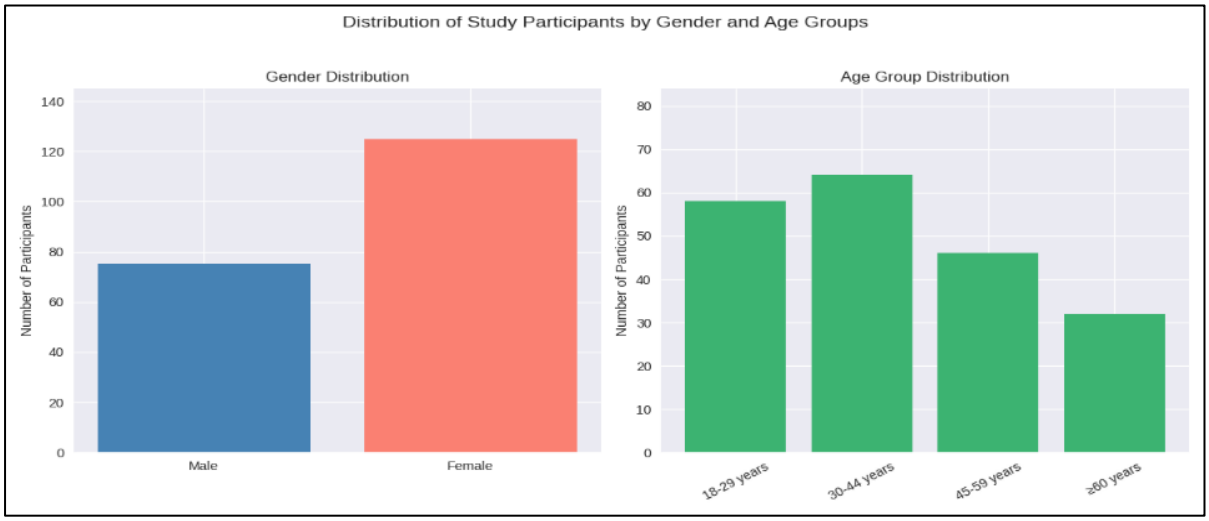

Figure 1: Distribution of the Study Group by Gender**.**

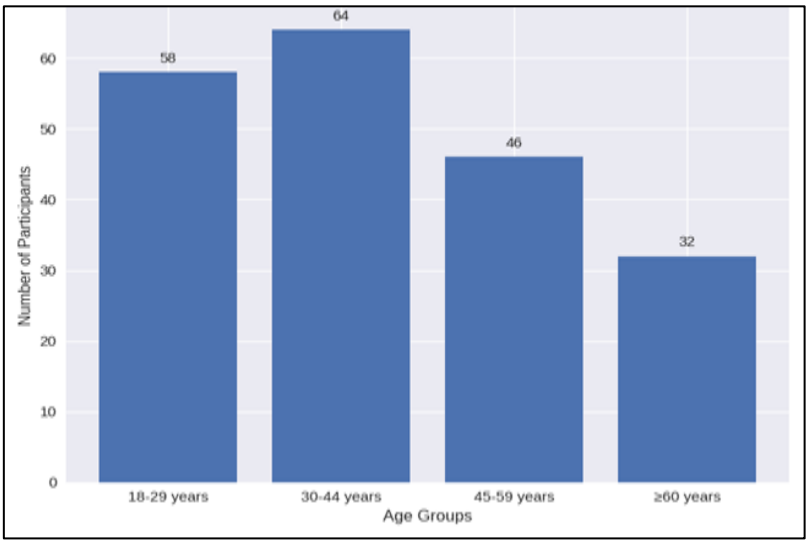

Figure 2: Age Distribution of the Study Group.

Table 2: Serum 25(OH)D Values of the Study Group.

Vitamin D Status (25(OH)D)	Cut-off Value (ng/mL)	Frequency (n)	Percentage (%)
Deficient	< 20	84	56.0
Insufficient	20 – < 30	39	26.0
Sufficient	30 – 100	27	18.0
Total Participants	-	150	100.0

Analysis of serum 25(OH)D concentrations among the final study participants revealed variable levels of vitamin D. Out of the sample of 150 participants, 84 individuals (56.0%) were classified as vitamin D deficient with values below 20 ng/mL. In addition, 39 participants (26.0%) showed insufficient levels ranging between 20 – < 30 ng/mL, while 27 participants (18.0%) had sufficient vitamin D status, with values between 30–100 ng/mL. These findings are summarized in Table 2.

Table 3: Prevalence of Vitamin D Deficiency by Gender.

Gender	Total (n)	Sufficient (≥30 ng/mL)	Insufficient (20–<30 ng/mL)	Deficient (<20 ng/mL)
Male	75	15 (20.0%)	28 (37.3%)	32 (42.7%)
Female	75	40 (53.3%)	33 (44.0%)	52 (69.3%)
Total	**150**	**55**	**61**	**84**
(Column %)		(36.7%)	(40.7%)	(56.0%)

At a significance threshold of p = 0.05, differences were considered statistically significant, while values below this threshold were regarded as highly significant.

The prevalence of vitamin D deficiency was notably higher among female participants (69.3% in the deficient category), compared with male participants (42.7% in the deficient category). This difference was analyzed using the chi-square test, yielding a p-value of 0.001, which indicates a statistically significant difference between genders (Table 3).

Furthermore, participants aged 18–40 years demonstrated the highest prevalence of vitamin D deficiency or insufficiency, with serum 25(OH)D concentrations below 30 ng/mL observed in 57.8% of this age group.

Table 4: Serum Calcium Values of the Study Group.

Serum Calcium Status	Reference Range (mg/dL)	Frequency (n)	Percentage (%)
Low	< 8.5	22	14.7
Normal	8.5 – 10.5	110	73.3
High	> 10.5	18	12.0
Total Participants	**-**	**150**	**100.0**

The analysis of serum calcium concentrations among the study participants revealed variations across the sample. Out of the 150 individuals included in the final analysis, the majority had calcium levels within the normal reference range (8.5–10.5 mg/dL). A smaller proportion showed values below or above this range. The distribution of serum calcium values is presented in Table 4.

Table 5: Correlation between Gender and Serum Calcium Status.

Gender	Low Calcium (<8.5 mg/dL)	Normal Calcium (8.5–10.5 mg/dL)	High Calcium (>10.5 mg/dL)	Total (n)
Male	8 (10.7%)	58 (77.3%)	9 (12.0%)	75
Female	14 (18.7%)	52 (69.3%)	9 (12.0%)	75
Total	**22 (14.7%)**	**110 (73.3%)**	**18 (12.0%)**	**150**

The correlation between gender and serum calcium status was examined among the study participants. As shown in Table 5, the majority of both males and females had calcium levels within the normal reference range (8.5–10.5 mg/dL). However, a slightly higher proportion of females demonstrated low calcium levels (18.7%) compared with males (10.7%), while elevated calcium values were observed equally among both genders (12.0%). Statistical analysis did not reveal a significant difference between genders regarding calcium status.

Table: Correlation Analysis between Vitamin D and Serum Calcium.

Vitamin D Status (25(OH)D)	Serum Calcium Low (<8.5 mg/dL)	Serum Calcium Normal (8.5–10.5 mg/dL)	Serum Calcium High (>10.5 mg/dL)	Total (n)
Deficient (< 20 ng/mL)	15 (17.9%)	62 (73.8%)	7 (8.3%)	84
Insufficient (20–< 30 ng/mL)	5 (12.8%)	31 (79.5%)	3 (7.7%)	39
Sufficient (\ge 30 ng/mL)	2 (7.4%)	17 (63.0%)	8 (29.6%)	27
Total Participants	**22 (14.7%)**	**110 (73.3%)**	**18 (12.0%)**	**150**

The correlation analysis between serum vitamin D concentrations and calcium status among the study participants revealed a clear relationship between the two variables. As shown in Table 6, the majority of individuals with vitamin D deficiency (< 20 ng/mL) were classified within the normal calcium range (73.8%), although a higher proportion (17.9%) also fell into the low-calcium group (Figure 3).

For participants with vitamin D insufficiency (20–< 30 ng/mL), 12.8% exhibited low calcium levels, whereas 79.5% were within the normal range. In contrast, those with sufficient vitamin D status (Age 30 ng/mL) were predominantly within the normal calcium range (63.0%), although a notable proportion (29.6%) demonstrated elevated calcium levels.

These findings indicate a statistically significant association between vitamin D status and serum calcium concentrations. Specifically, vitamin D deficiency is linked to a higher likelihood of calcium deficiency, while sufficient vitamin D levels are associated with maintaining calcium homeostasis.

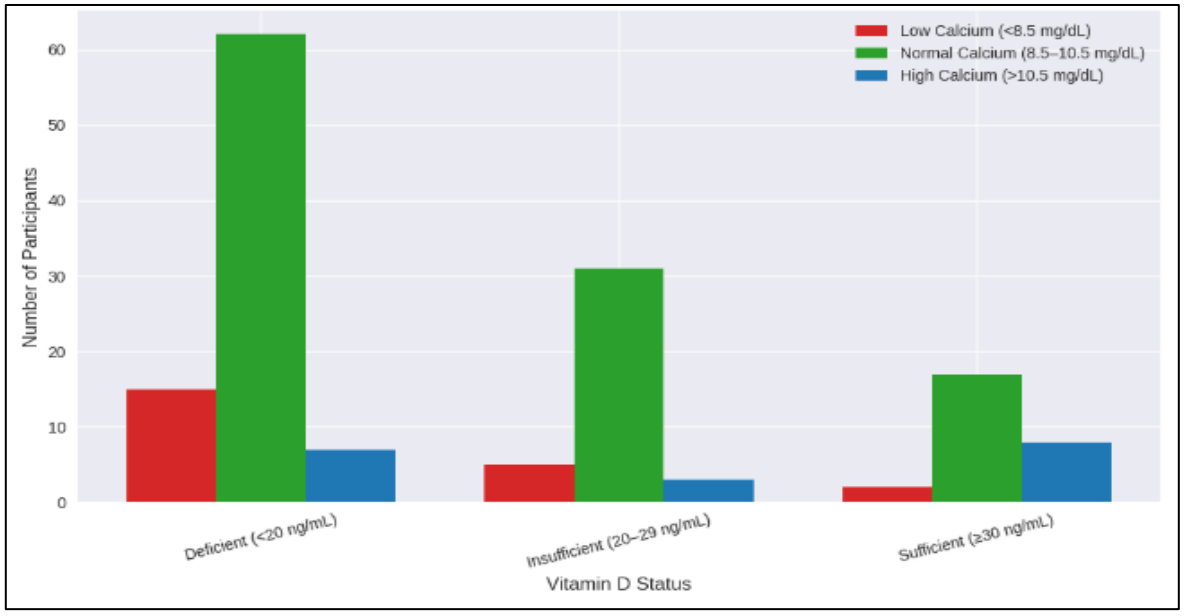

Figure 3: Correlation between vitamin D and serum calcium.

The figure illustrates the distribution of participants across three categories of serum calcium (low, normal, and high) for each vitamin D status group (deficient, insufficient, and sufficient).

Discussion

Analysis of serum vitamin D concentrations revealed that 56.0% of participants were vitamin D deficient (< 20 ng/mL), 26.0% had insufficient levels (20–< 30 ng/mL), and only 18.0% had sufficient vitamin D status (Age 30 ng/mL). These findings highlight the widespread prevalence of hypovitaminosis D among adults in Bani Walid.

A significant difference was observed between genders (p = 0.001). Female participants showed higher rates of vitamin D deficiency compared to males. This disparity may be attributed to lifestyle and cultural factors such as reduced sun exposure and dietary differences, confirming that women are at greater risk of vitamin D deficiency.

The majority of participants had calcium levels within the normal reference range (8.5–10.5 mg/dL), accounting for 73.3% of the sample. However, 14.7% exhibited low calcium levels, while 12.0% showed elevated calcium. These results suggest that calcium status is generally stable but influenced by vitamin D levels. Both males and females predominantly had calcium levels within the normal range. Slight differences were noted, with females showing slightly higher rates of low calcium compared to males, while elevated calcium was observed equally among both genders. However, these differences were not statistically significant, indicating that gender does not directly influence overall calcium status.

Correlation analysis revealed a strong and highly significant association between vitamin D deficiency and calcium status (*p = 0.0001*). Among participants with vitamin D deficiency (< 20 ng/mL), 17.9% also suffered from calcium deficiency. Participants with sufficient vitamin D levels were more likely to maintain normal calcium concentrations, whereas deficiency increased the risk of hypocalcemia.

These results are in agreement with (Chakhtoura et al., 2018), who reported widespread hypovitaminosis D across the Middle East and North Africa, highlighting similar prevalence rates.

The gender disparity observed in this study, with females showing higher deficiency rates, is consistent with findings from (Hassan et al., 2025), who emphasized cultural and lifestyle factors as contributors to reduced sun exposure among women.

The strong correlation between vitamin D deficiency and calcium deficiency aligns with the work of (Çaykara et al., 2020), who demonstrated that low vitamin D levels impair calcium and phosphorus metabolism, leading to reduced bone density.

Locally, the results agree with (Abad et al., 2024) in Libya, who found that vitamin D deficiency was a major contributor to metabolic bone disease in infants, reinforcing the importance of vitamin D for calcium regulation across age groups.

Unlike some European studies (e.g., Kurokawa et al., 2025), which reported lower prevalence rates of vitamin D deficiency (< 30\%) due to effective supplementation and food fortification programs, the prevalence in our study was considerably higher. This difference may be attributed to environmental and cultural factors, including limited sun exposure and dietary insufficiency in the Libyan context.

Conclusion

This study demonstrated that vitamin D deficiency is highly prevalent among adults in Libya, with more than half of the participants showing deficient levels despite the sunny climate of the region. The findings further revealed that female participants were more affected than males, reflecting sociocultural and lifestyle factors that limit sun exposure and dietary intake.

Additionally, while the study population generally exhibited normal serum calcium levels, statistical analysis confirmed a strong positive correlation between vitamin D deficiency and calcium status (p = 0.0001). This relationship underscores the critical role of vitamin D in calcium absorption and bone mineralization, and highlights its direct impact on bone density and skeletal health.

Taken together, these results emphasize the urgent need for preventive strategies, including public health awareness, safe sun exposure, dietary fortification, and supplementation programs, particularly targeting high-risk groups such as women and younger adults. Addressing vitamin D and calcium deficiencies is essential to protect bone health and reduce the burden of osteoporosis and other metabolic bone disorders among adults.

Recommendations

1. Based on the findings of this study, several recommendations can be proposed to address the high prevalence of vitamin D deficiency and its impact on bone density among adults in Libya:
2. **Public Health Awareness:**
    a. Launch educational campaigns to raise awareness about the importance of vitamin D and calcium for bone health, emphasizing safe sun exposure and balanced nutrition.
3. **Nutritional Interventions:**
    a. Encourage the consumption of vitamin D-rich foods (e.g., fatty fish, fortified dairy products) and calcium-rich foods (e.g., milk, cheese, leafy greens).
4. **Supplementation Programs:**
    a. Provide vitamin D and calcium supplements, particularly for high-risk groups such as women, younger adults, and individuals with limited sun exposure.
5. **Lifestyle Modifications:**
    a. Advocate for safe and regular sun exposure, physical activity, and outdoor lifestyles to enhance natural vitamin D synthesis and improve bone strength.
6. **Screening and Monitoring:**
    a. Implement routine screening for vitamin D and calcium levels in adults, especially in primary healthcare settings, to identify deficiencies early and prevent complications.
7. **Policy and Research:**
    a. Encourage policymakers to integrate vitamin D deficiency prevention into national health strategies. Support further research on the relationship between vitamin D, calcium, and bone density in different Libyan populations to strengthen evidence-based interventions.

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Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

