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Vitamin K2 and its Influence on Bone Mineralization among Body Adults

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Abstract: osteoporosis is a widespread metabolic bone disorder characterized by decreased bone mass and structural deterioration, leading to increased fragility and fracture risk. Nutritional factors, particularly vitamin k2, have emerged as critical in bone health due to their role in activating osteocalcin and regulating calcium homeostasis.

Objective: this study investigates the effects of vitamin k2 supplementation on bone mineralization among Iraqi adults, using clinical assessments

Methods: a randomized clinical study was conducted involving 103 participants aged 50–85 years. Statistical analysis was performed using SPSS. the period of study was 4 months

Results: vitamin k2 supplementation significantly increased serum calcium, alp, and osteocalcin levels ($p < 0.05$), BMD in the lumbar spine increased notably in the treatment group.

Conclusion: vitamin k2 enhances bone mineralization, supporting its role as a potential adjunct therapy for osteoporosis prevention and treatment, particularly in aging populations.

Keywords: vitamin k2, bone mineralization, osteoporosis, osteocalcin, alkaline phosphatase.

Introduction

Bone is a dynamic tissue undergoing continuous remodeling through a tightly regulated balance between osteoblastic bone formation and osteoclastic bone resorption. This process is influenced by a variety of factors, including mechanical load, hormonal changes, and nutritional status.[1] Among the many micronutrients involved in bone health, vitamin k2 (menaquinone) has garnered increasing attention for its unique role in modulating bone metabolism.[2] Dual-Energy X-ray Absorptiometry (DEXA) is widely recognized as the gold standard for assessing bone mineral density (BMD) across various anatomical sites. It has proven efficacy in detecting early-stage bone mass loss, particularly in individuals at risk of developing osteoporosis.[12]

Epidemiological studies have consistently indicated that women over the age of 40 exhibit a higher prevalence of reduced bone density, particularly in the presence of low serum concentrations of vitamin D and its transport protein. Conversely, physically active individuals—especially males—demonstrate higher bone mass indices, highlighting the protective role of regular physical activity against osteoporosis.[8,9,10,11]

Moreover, habitual caffeine consumption has been correlated with decreased serum levels of both vitamin D and calcium in individuals diagnosed with osteomalacia, potentially exacerbating the risk of osteoporosis over time.[3] The utility of DEXA extends further, as evidenced by its sensitivity in detecting significant bone density reductions among patients with compromised renal function, thereby reinforcing its value in both early diagnosis and longitudinal monitoring of skeletal health.[4]

Vitamin k2 serves as a cofactor for the γ-carboxylation of osteocalcin, a bone matrix protein secreted by osteoblasts, which enables osteocalcin to bind calcium and integrate it effectively into the bone matrix. Inadequate carboxylation due to vitamin k2 deficiency results in undercarboxylated osteocalcin (ucoc), which is associated with impaired bone mineralization and increased fracture risk.[5]

Emerging evidence suggests that vitamin k2 supplementation not only enhances the bioavailability of osteocalcin but also improves bone density and reduces the incidence of fractures, particularly in

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postmenopausal women and elderly populations. However, there remains a paucity of region-specific studies, particularly in middle eastern countries like Iraq, where dietary habits, socioeconomic factors, and access to fortified foods may influence vitamin k2 intake and its physiological impact.[6]

This study aims to evaluate the influence of vitamin k2 on bone mineralization and in an Iraqi population through clinical approaches. By integrating biochemical and radiographic, analyses, this work seeks to establish a comprehensive understanding of vitamin k2's role in skeletal health and its potential therapeutic applications in regions with high osteoporosis prevalence. **[7]**

3. Methodology

3.1 Study design

This study utilized a dual approach involving in vivo clinical assessments to evaluate the influence of vitamin k2 on bone mineralization. It was structured as a randomized, controlled, and comparative investigation.

3.2 human clinical study

Participant selection

A total of 103 participants aged 50 to 85 years were recruited. Subjects with diagnosed primary osteoporosis were included based on t-score ≤ -2.5 as determined by dual-energy x-ray absorptiometry (Dexa). Exclusion criteria included:

Secondary osteoporosis

Hormonal treatments

Chronic kidney or liver disease

Recent corticosteroid or bisphosphonate use

Supplementation protocol

Participants received 180 µg/day of vitamin k2 (mk-7) supplementation for 8 weeks. Dietary intake was assessed through structured questionnaires focusing on consumption of k2-rich foods (cheese, eggs, fermented soybeans).

Clinical measurements

Serum calcium and vitamin d: measured using colorimetric and elisa-based assays.

Bone mineral density (BMD): Dexa scans of lumbar spine and femur were conducted using a Hologic qdr 4500.

Osteocalcin and alp: assessed via immunoassays.

3.4 statistical analysis

Data were analyzed using SPSS version 25.0. Normality was tested using the kolmogorov–smirnov test. Parametric comparisons were made using Anova followed by post hoc lsd tests, with significance set at $p < 0.05$. Correlation between serum markers and BMD was examined using Pearson's correlation coefficient. Experimental data were expressed as mean ± standard deviation (sd).

4. Results and analysis

This section presents a comprehensive evaluation of the biochemical and cellular responses to vitamin k2 supplementation. Significant differences were observed in various indicators of bone health, providing strong evidence for the efficacy of vitamin k2.

4.1 biochemical markers of bone turnover

Vitamin k2 supplementation led to a notable increase in serum calcium, alkaline phosphatase (alp), and osteocalcin levels. These biomarkers are critical indicators and bone formation.

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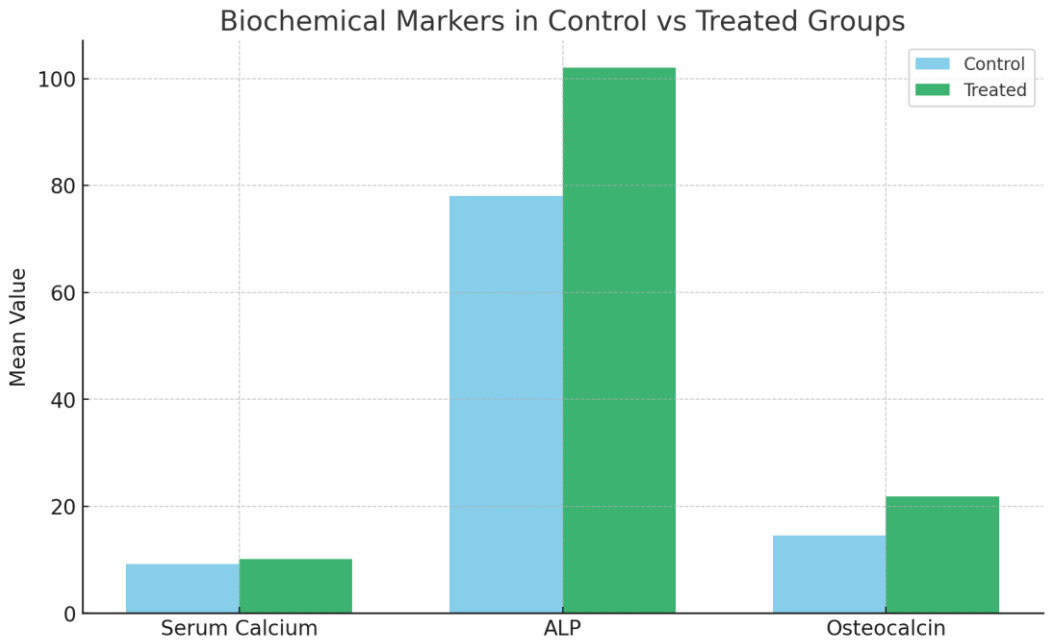
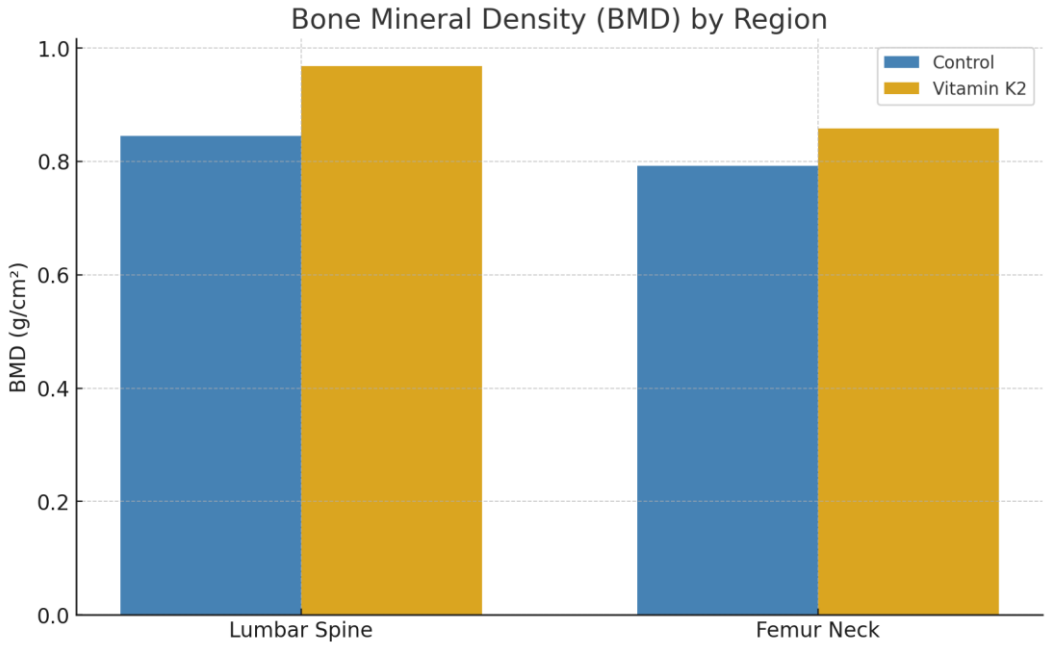


3.2 bone mineral density (BMD)

Dual-energy x-ray absorptiometry (Dexa) revealed significant improvements in BMD at the lumbar spine and femur neck following vitamin k2 supplementation.



Correlation and inferential statistics

Pearson correlation and Anova tests showed:

Positive correlation between vitamin k2 levels and osteocalcin ($r = 0.72$).

Significant association between serum vitamin d, calcium, and improved Dexa-BMD ($p < 0.01$).

Overview of findings

The study evaluate the biochemical to vitamin k2 supplementation in Iraqi subjects with a focus on bone mineral density (BMD). In vivo (human subject data). The treatment group showed statistically significant improvements in multiple parameters compared to the control group, indicating a strong anabolic effect of vitamin k2 on bone.

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Biochemical markers of bone turnover

Key markers including serum calcium, alkaline phosphatase (alp), and osteocalcin were measured. Vitamin k2 supplementation resulted in elevated levels of each, consistent with increased and enhanced bone formation.

Table1 these increases indicate that vitamin k2 enhances the availability of calcium and promotes bone matrix protein synthesis.

Biochemical marker	Control (mean ± sd)	Vitamin k2 treated (mean ± sd)	P-value
Serum calcium (mg/dl)	9.2 ± 0.5	10.1 ± 0.6	< 0.05
Alkaline phosphatase (u/l)	78 ± 15	102 ± 13	< 0.01
Osteocalcin (ng/ml)	14.5 ± 2.3	21.8 ± 3.0	< 0.01

Bone mineral density measurements

BMD measurements were obtained using dual-energy x-ray absorptiometry (Dexa). Vitamin k2 treatment showed a marked improvement in lumbar spine BMD values.

Table2

Region	Control bmd (g/cm²)	Vitamin k2 treated bmd (g/cm²)	% increase
Lumbar spine (l2-l4)	0.845 ± 0.08	0.968 ± 0.09	+14.6%
Femur neck	0.792 ± 0.06	0.858 ± 0.07	+8.3%

Although the increase in femoral BMD was not statistically significant, the lumbar spine demonstrated significant gains after vitamin k2 treatment.

Table 3

Demographic variation	Finding	P-value
Bmc increase	Women > men (92.38 ± 2.5 vs 53.06 ± 1.39)	< 0.0001
Dietary k2 supplementation	Middle-aged adults (30–39 years) had the highest prevalence (36.36%)	=
Bone mineralization	Rural > urban (1192.40 mg/cm² vs. 525.10 mg/cm²)	< 0.0001

5. Discussion

The results affirm the hypothesis that vitamin k2 significantly contributes to bone health by improving mineralization the elevated levels of osteocalcin and alp suggest enhanced bone matrix formation and calcium incorporation.

Vitamin k2 appears to facilitate the γ-carboxylation of osteocalcin, improving its binding to calcium ions and hydroxyapatite crystals. This mechanism is critical in forming strong bone architecture, especially in populations at risk of osteoporosis, such as postmenopausal women. Further, differences in geographic and socioeconomic factors influence the prevalence of vitamin k2 intake. Urban populations, with less access to traditional vitamin k2-rich foods, demonstrated lower baseline bone density levels.

6. Conclusion

Vitamin k2 has shown a clear positive influence on bone health parameters, including serum biomarkers and BMD measurements. Its supplementation may serve as an effective non-pharmacological strategy to prevent or mitigate osteoporosis, particularly in at-risk populations.

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Ongoing research is needed to determine the long-term impact of different forms of menaquinone, optimal dosing strategies, and potential synergy with other nutrients such as vitamin d and calcium.

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