
Academia Open



By Universitas Muhammadiyah Sidoarjo

Table Of Contents

Journal Cover	1
Author[s] Statement	3
Editorial Team	4
Article information	5
Check this article update (crossmark)	5
Check this article impact	5
Cite this article	5
Title page	6
Article Title	6
Author information	6
Abstract	6
Article content	7

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13831

Originality Statement

The author[s] declare that this article is their own work and to the best of their knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the published of any other published materials, except where due acknowledgement is made in the article. Any contribution made to the research by others, with whom author[s] have work, is explicitly acknowledged in the article.

Conflict of Interest Statement

The author[s] declare that this article was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright Statement

Copyright © Author(s). This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at <http://creativecommons.org/licences/by/4.0/legalcode>

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13831

EDITORIAL TEAM

Editor in Chief

Mochammad Tanzil Multazam, Universitas Muhammadiyah Sidoarjo, Indonesia

Managing Editor

Bobur Sobirov, Samarkand Institute of Economics and Service, Uzbekistan

Editors

Fika Megawati, Universitas Muhammadiyah Sidoarjo, Indonesia

Mahardika Darmawan Kusuma Wardana, Universitas Muhammadiyah Sidoarjo, Indonesia

Wiwit Wahyu Wijayanti, Universitas Muhammadiyah Sidoarjo, Indonesia

Farkhod Abdurakhmonov, Silk Road International Tourism University, Uzbekistan

Dr. Hindarto, Universitas Muhammadiyah Sidoarjo, Indonesia

Evi Rinata, Universitas Muhammadiyah Sidoarjo, Indonesia

M Faisal Amir, Universitas Muhammadiyah Sidoarjo, Indonesia

Dr. Hana Catur Wahyuni, Universitas Muhammadiyah Sidoarjo, Indonesia

Complete list of editorial team ([link](#))

Complete list of indexing services for this journal ([link](#))

How to submit to this journal ([link](#))

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13831

Article information

Check this article update (crossmark)



Check this article impact ^(*)



Save this article to Mendeley



^(*) Time for indexing process is various, depends on indexing database platform

Investigation of Biomarkers Associated with Osteoporosis Among Women Patients: Penelitian Biomarker yang Terkait dengan Osteoporosis pada Pasien Wanita

Al- anbaki , ali.abdulameer@iu-diwaninya.edu.iq (*)

Medical Laboratory Technique department, The Islamic University of Al Diwaniyah, Iraq

Ali Abdulameer, ali.abdulameer@iu-diwaninya.edu.iq

D.Sc., Zoology, Dept. Biology, College of Education, Al-Qadisiyah, Univ. Iraq, Iraq

(*) Corresponding author

Abstract

Background: Biochemical indicators and endocrine factors, particularly thyroid hormones and sex hormones, are closely related to bone metabolism and skeletal regulation in women. **Knowledge Gap:** Although several biomarkers are known to participate in bone metabolism, the combined profile of biochemical and hormonal parameters associated with osteoporosis in women remains insufficiently documented in certain regional populations. **Aims:** This study investigated selected biochemical and hormonal biomarkers in women diagnosed with osteoporosis in Al-Diwaniyah Governorate. **Results:** A total of 76 women aged 25–45 years participated in the study and were divided into an osteoporosis group (46 patients) and a healthy control group (30 individuals). Statistical analysis showed significant reductions in body mass index, serum calcium, and vitamin D levels in osteoporotic women compared with controls. In contrast, thyroid-related hormones, including thyroid-stimulating hormone and thyroxine, were significantly elevated in the patient group. Additionally, estrogen and follicle-stimulating hormone concentrations were significantly lower in women with osteoporosis. **Novelty:** The study provides an integrated evaluation of biochemical and endocrine biomarkers related to bone metabolism among women within the studied population. **Implications:** These findings highlight the importance of hormonal and biochemical assessment in understanding metabolic alterations associated with osteoporosis and may support clinical laboratory monitoring strategies for women at risk of bone metabolism disorders.

Keywords: Osteoporosis, Bone Metabolism, Thyroid Hormones, Vitamin D, Women

Key Findings Highlights

Reduced calcium, vitamin D, and body mass index detected in affected participants.

Elevated thyroid-related hormones identified in the patient group.

Lower estrogen and follicle-stimulating hormone concentrations observed in osteoporotic women.

Published date: 2026-03-03

Introduction

Osteoporosis is a progressive disease that weakens bones, increasing their susceptibility to fractures. Typically associated with a gradual loss of bone density with age or due to deficiencies in certain nutrients, this widespread health problem can often be prevented or managed through early intervention and a healthy lifestyle.

Osteoporosis is a highly prevalent condition among older women, even in the absence of identifiable predisposing risk factors. This condition represents a major public health concern, as it significantly compromises bone strength and increases susceptibility to fractures. Understanding osteoporosis in women requires comprehensive knowledge of both modifiable and non-modifiable risk factors, as well as insight into the underlying pathophysiological mechanisms. In addition, effective management strategies rely heavily on pharmacological interventions and lifestyle modifications, underscoring the essential role of a multidisciplinary healthcare team in the accurate diagnosis and optimal management of osteoporosis [1]. Osteoporosis exerts substantial adverse effects on the physical, psychological, and emotional well-being of postmenopausal women. Epidemiological evidence indicates that osteoporosis affects approximately one in three women and one in five men over the age of 50, classifying it as a chronic and widespread disease [2]. The condition is characterized by a progressive reduction in bone mass and deterioration of bone microarchitecture, resulting in decreased bone strength and an elevated risk of fractures. Consequently, individuals with osteoporosis are more susceptible to fractures, even following low-impact events such as minor falls. According to the World Health Organization, osteoporosis is diagnosed when bone mineral density falls 2.5 standard deviations or more below the average value observed in healthy individuals of the same age and sex [3].

The present study was designed to investigate the effects of osteoporosis on women in Al-Diwaniyah Governorate by assessing several biomarkers, including thyroid hormone (T4, TSH), estrogen (E2), follicle-stimulating hormone (FSH), calcium (Ca), and vitamin D levels.

2- Materials and Methods

3-2 Sample Collections

Samples were collected from December 2024 to January 2025 from female patients with osteoporosis at Diwaniyah Teaching Hospital and other laboratories in the governorate center. The sample totals consisted of (76) women aged between (25-45) years. The samples were categorized into two groups; the first group consisted of healthy women and served as the control group, consisted of (30) individuals, and the second group, representing women with osteoporosis (Patients women), consisted of (46) individuals. Women with other diseases were also excluded.

3-3 Blood Draw

Venous blood (5 mL) was collected from the brachial vein for each individual enrolled in the study, participant and distributed into two types of plastic tubes. For biochemical analyses, a portion of the blood was transferred into plain tubes without anticoagulants. The samples were then centrifuged at 3,000 rpm for 15 minutes to separate the serum for subsequent analysis. Serum was then withdrawn using a micropipette and transferred to clean, sterile tubes. The tubes were stored at -20°C until the study could be carried out later.

3-4 Parameters Study

3-4-1 Biochemical Parameters

1- Vitamin D Measurement

Serum vitamin D3 levels were determined using the ELISA kit provided by [4].

2- Measurement of Calcium Concentration

The concentration of calcium ions in serum was measured according to [5] using a spectrophotometer, reading it at a wavelength of 570 nm.

3- Measurement of Thyroid, FSH and Estrogen Hormone

Thyroid hormones (TSH, T4, FSH and Estrogen) were measured using a modern automated quantitative VIDAS device, according to the methods used for serum analysis using the Enzyme Linked Fluorescent Assay (ELFA) technique [6].

4-5 Statistical Analysis

Statistical analysis was performed using SPSS version 23, and differences between group means were assessed using the t-test.

4 . Results and Discussions

1- Body Max index (BMI)

Results showed that those with osteoporosis women had (BMI) decrease compared to the healthy control group with the percentages reaching (28.75) 58% and (20.53)42%, respectively, as shown in Figure (1) .

Variables such as BMI, sex, and age have been shown to significantly influence the incidence of vitamin D3 deficiency . A low body mass index (BMI) has been consistently identified as a major determinant of osteoporosis risk [7]. This effect is largely mediated by the strong link between body weight and bone mass. Population-based studies have shown that increased body weight contributes to higher bone mineral density and a decreased likelihood of fragility fractures, especially among older women, whereas low BMI is associated with a greater risk of hip fractures , even before adjustments for bone mineral density are taken into account. Furthermore, postmenopausal women present additional challenges: thinner skin, reduced capacity to synthesize vitamin D, decreased intestinal absorption of vitamin D, and reduced hydroxylation in the liver and kidneys. These metabolic changes are further compounded by lower levels of outdoor activity and insufficient dietary vitamin D intake [8].

2- Calcium and vitamin D Levels

The results summarized in Table (1) indicate a significant decrease ($P \leq 0.05$) in calcium and vitamin D concentrations among women with osteoporosis relative to the control group. The findings of this study contradict those of other research in the field, such as the study by Catalano [9], which reported no change in calcium levels in individuals with osteoporosis. Calcium plays a crucial role as a reservoir in bones, serving multiple vital functions, including supporting bone cell development, heart functions, and various other physiological processes. When blood calcium levels decrease, the body compensates for the deficiency by drawing from calcium reserves in the bones as in figure (2) .

Vitamin D deficiency represents one of the primary causes of hypocalcemia, given its essential role in promoting intestinal calcium absorption and regulating calcium incorporation into bone tissue [10]. Insufficient dietary intake or untreated deficiency may disturb calcium homeostasis and negatively affect bone metabolism. These observations are in agreement with the findings of [11], who reported significantly reduced serum vitamin D concentrations in osteoporotic individuals compared with healthy controls.

Furthermore, the present study emphasizes the clinical relevance of assessing Serum level of 25-hydroxyvitamin D [25(OH)D] in postmenopausal women with osteoporosis on a global scale. Variations in vitamin D status have been documented across different populations and geographical regions, influenced by factors such as seasonal changes, latitude, and sun exposure, which contribute to significant differences in vitamin D levels among countries.

Although cutaneous synthesis following sunlight exposure is considered the primary source of vitamin D, additional factors—including dietary intake and supplementation—substantially influence serum 25(OH)D concentrations [12]. Several studies have highlighted the importance of consuming vitamin D-rich foods, particularly oily fish such as mackerel, herring, sardines, and salmon, which are among the most potent natural dietary sources of this vitamin. Previous research has shown that approximately 60% of individuals using cod liver oil supplements achieved sufficient vitamin D levels. Seasonal variation also plays a role, with higher proportions of adequate vitamin D status observed during summer months compared to winter, where deficiency rates markedly increase [13].

Vitamin D supplementation is therefore essential for a considerable proportion of postmenopausal women with osteoporosis, particularly during periods of limited sunlight exposure. It has been reported that approximately 25% of affected women require supplementation during winter, while up to 35% may need it during summer. Therapeutic regimens including daily doses of up to 10,000 IU or weekly doses not exceeding 50,000 IU have been shown to effectively correct 25(OH)D deficiency and produce significant clinical improvements in osteoporotic patients [12], [13].

3- Thyroid hormones level

In contrast, the results of this study, shown in Table (1), revealed a significant increase ($P < 0.05$) in thyroid function levels, particularly thyroxine (T4) hormone, along with a significant decrease in the level of thyroid-stimulating hormone (TSH) in women with osteoporosis compared to the healthy group , as illustrated in Figure (2). Thyroid function plays a fundamental systemic role in the regulation of bone mineral metabolism, and abnormalities in thyroid hormone secretion are well recognized as an important cause of secondary osteoporosis [14].

Thyroid hormones are key regulators of bone remodeling and mineral homeostasis in adults. The hormonal pattern observed in this study—elevated T4 levels accompanied by suppressed TSH—indicates a state of increased thyroid hormone activity. Such a condition is known to accelerate bone turnover and promote bone resorption through the activation of T3 receptors expressed in chondrocytes and osteoblasts [15]. Enhanced thyroid hormone activity stimulates osteoclast differentiation and function, ultimately leading to a decline in bone mineral density and a higher risk of osteoporosis. Moreover, TSH itself has been shown to exert a protective effect on skeletal health by inhibiting osteoclast formation and activity, thereby supporting the maintenance of bone mass and microstructural integrity [16]. Consequently, the reduced TSH levels detected in the osteoporosis group may further contribute to excessive osteoclastic resorption and disruption of normal bone homeostasis. In addition, thyroid hormones exert direct catabolic effects on bone mineral balance, and elevated circulating levels can increase renal calcium excretion, exacerbating bone demineralization [17].

Both thyroid-stimulating hormone (TSH) and triiodothyronine (T3) are key regulators of bone remodeling, exerting their

influence by regulating the activity of osteoblasts and osteoclasts. TSH, in particular, stimulates the production of osteoprotein (OPG), a protein that inhibits osteoclast-mediated bone resorption and supports skeletal homeostasis [18]. A study by [19] indicated that thyroid hormone imbalances, characterized by elevated T4 and low TSH levels, may be closely associated with impaired bone turnover, decreased bone mineral density, and exacerbation of osteoporosis in women. These hormonal imbalances disrupt bone regulation at the cellular level, ultimately leading to increased bone loss.

4- Follicle stimulating hormone (FSH) and Estrogen (E2) Levels

The current study, shown in Table (1), demonstrated a significant decrease ($P \leq 0.05$) in estrogen (E2) and FSH levels in women with osteoporosis compared to healthy controls women as in figure (2), Several studies in this area support these findings [20] [21].

The reduced FSH levels in the osteoporosis group may be attributed to differences in menopausal status, age distribution, hormonal therapy, or metabolic and inflammatory changes that alter pituitary feedback regulation. These factors can collectively suppress FSH secretion and explain the lower levels observed in this study. The primary purpose of FSH is believed to be to promote estrogen production and ovarian follicle development. While the reproductive function of FSH is widely recognized, The relationship between elevated blood levels of follicle-stimulating hormone (FSH) and bone loss remains controversial [22]. Evidence from studies involving premenopausal and perimenopausal women suggests that elevated FSH concentration, even before menopause, is associated with decreased bone mineral density, increased bone resorption indices, and decreased estradiol levels [23]. Confirming this observation, a meta-analysis of ten prospective studies showed that the rate of spinal bone mineral loss during perimenopause—when estrogen levels are relatively high—was greater than that observed in postmenopausal women, despite the significantly lower estrogen concentration in the latter group [24]. Experimental evidence further complicates this relationship; using a genetically modified mouse model expressing human FSH, [25] demonstrated that increased FSH activity in vivo, via ovarian pathways, is associated with increased bone mass. This effect appears to be indirect, as increased bone mass has been observed even in the absence of a direct stimulatory effect of FSH on bone tissue. Furthermore, FSH-related bone changes have been linked to ovarian testosterone secretion, FSH-stimulated inhibitory factors that suppress FSH secretion from the pituitary gland, and immune cell changes occurring during perimenopause [25].

Estrogen is a very important hormone for bone health, Estradiol is a major estrogen receptor and a key female sex hormone. This hormone plays a crucial role in regulating bone metabolism. Primarily produced in the ovaries, its levels remain within the normal range during the premenopausal period and then gradually decline with age [26]. After menopause, estradiol levels drop sharply, and this decline is closely associated with decreased bone mineral density. The marked decrease in estradiol negatively impacts bone strength and increases the risk of osteoporosis [27].

Groups	Healthy Control (N = 30)	Women Patients(N = 46)
Ca	8.90 ± 0.62 *	6.21 ± 0.63
Vitamin D	33.45 ± 3.70 *	24.25 ± 3.90
E2 (µg/L)	30.04 ± 1.45 *	25.72 ± 1.96
FSH (mU/ml)	10.30 ± 0.61 *	6.30 ± 0.72
TSH (U/ml)	3.31 ± 0.16	2.20 ± 0.13 *
T4 (pg/ml)	34.2 ± 0.64	51.80 ± 1.82*

Table 1. **Table (1) : Shows the comparison between control (healthy) and osteoporosis women (Patients) for Body mass index (BMI), FSH, E2, T4, TSH, and Calcium (Ca).**

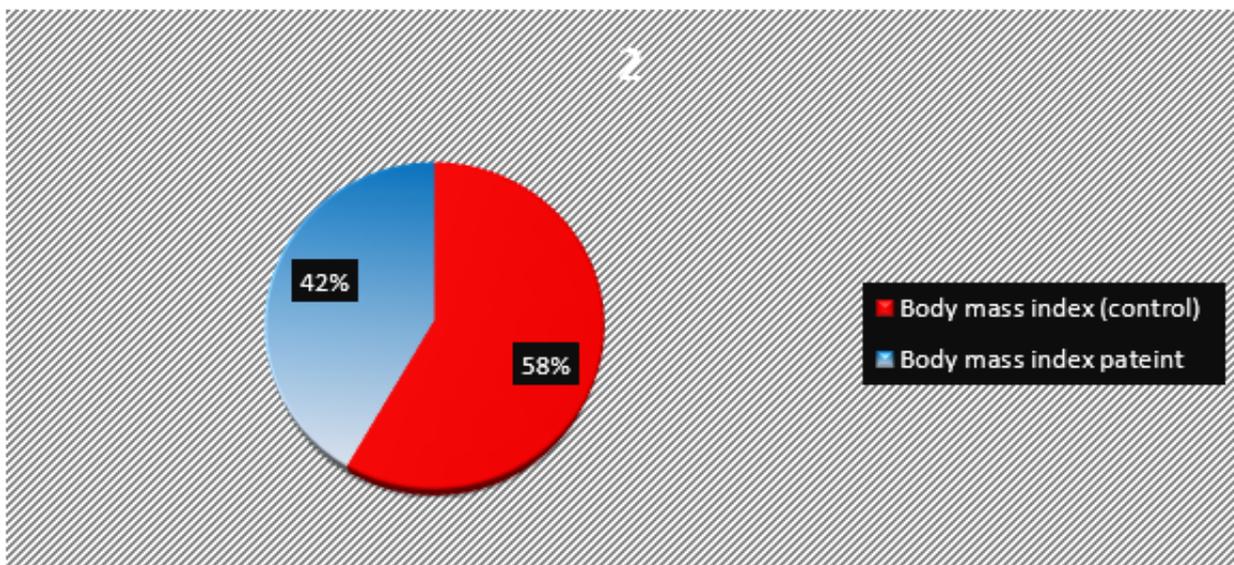


Figure 1. **Figure (1)** : Shows the comparison between control (healthy) and osteoporosis women (Patients) for Body Mass Index (BMI) .

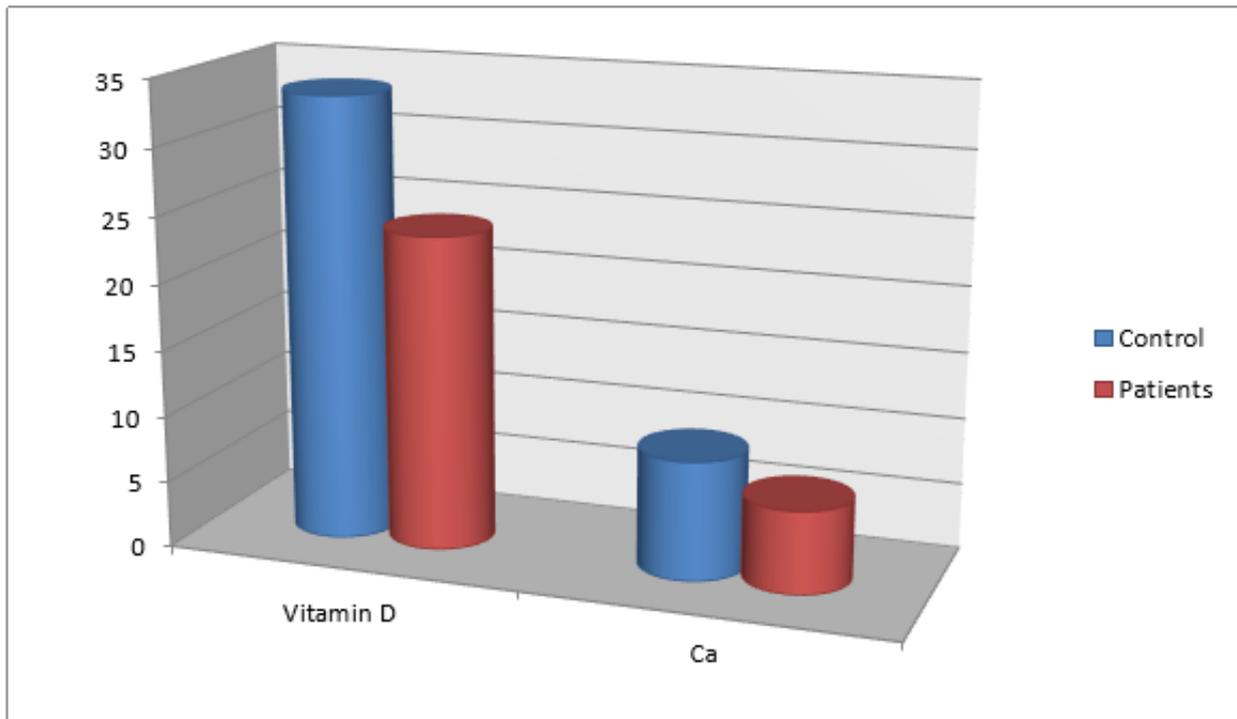


Figure 2. **Figure (2)** : Shows the comparison between control (healthy) and osteoporosis women (Patients) for Vitamin D, and Calcium (Ca) .

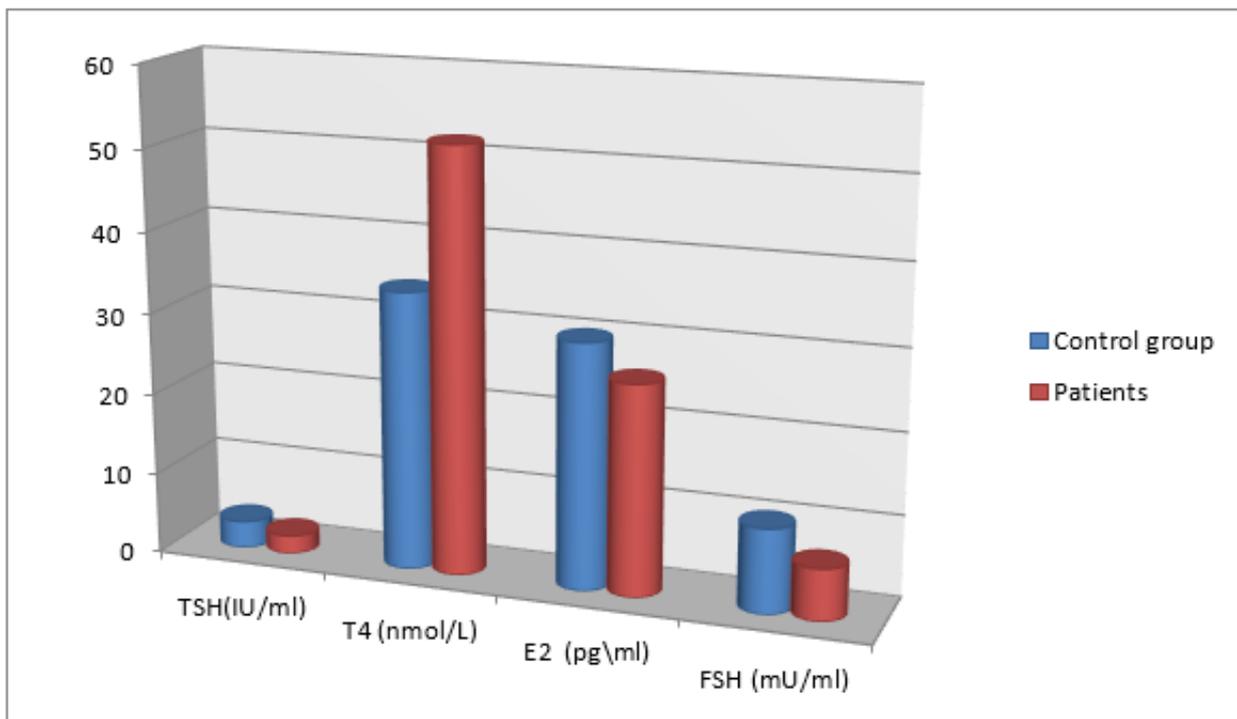


Figure 3. **Figure (2)** : Shows the comparison between control (healthy) and osteoporosis women (Patients) for thyroid hormones (TSH, T3), Estrogen (E2), follicle-stimulating hormone(FSH), Vitamin D, and Calcium (Ca) .

Conclusion:

This research concludes that osteoporosis in the context of thyroid hormonal imbalance is statistically correlated with a significant downregulation of bone-regulating markers. This includes a marked decrease in Vitamin D and calcium, as well as an observed reduction in systemic estrogen and FSH levels and thyroid hormones.

References

1. C. Trevisan et al., "The Impact of Smoking on Bone Metabolism, Bone Mineral Density and Vertebral Fractures in Postmenopausal Women," *Journal of Clinical Densitometry**, 2020.
2. T. Mitek, L. Nagraha, J. Deszczynski, M. Stolarczyk, E. Kuchar, and A. Stolarczyk, "Genetic Predisposition for Osteoporosis and Fractures in Postmenopausal Women," *Medical and Biological Sciences**, New York, 2019.
3. M. Hiligsmann and D. Cornelissen, "Consequences and Potential Solutions to Poor Adherence to Anti-Osteoporosis Treatment," *Osteoporosis International**, vol. 30, 2019.
4. M. F. Holick, "Vitamin D Status: Measurement, Interpretation, and Clinical Application," *Annals of Epidemiology**, vol. 19, pp. 73-78, 2009.
5. J. Stern and W. H. P. Lewis, "The Colorimetric Estimation of Calcium in Serum With O-Cresolphthalein Complexone," *Clinica Chimica Acta**, vol. 2, no. 6, pp. 576-580, 1957.
6. S. R. Freidberg et al., "Intraoperative Computerized Tomography Scanning to Assess the Adequacy of Decompression in Anterior Cervical Spine Surgery," *Journal of Neurosurgery: Spine**, vol. 94, no. 1, pp. 8-11, 2001.
7. C. A. Usoro, C. U. Onyeukwu, and A. C. Nsonwu, "Biochemical Bone Turnover Markers in Postmenopausal Women in Calabar Municipality," *Asian Journal of Biochemistry**, vol. 2, no. 2, pp. 130-135, 2007.
8. H. J. Qureshi et al., "Calcium Status in Premenopausal and Postmenopausal Women," *Journal of Ayub Medical College Abbottabad**, vol. 22, no. 2, pp. 143-145, 2010.
9. A. Catalano et al., "Pulsed Electromagnetic Fields Modulate Bone Metabolism via RANKL/OPG and Wnt/ β -Catenin Pathways in Women With Postmenopausal Osteoporosis: A Pilot Study," New York, 2018.
10. R. Bouillon and T. Suda, "Vitamin D: Calcium and Bone Homeostasis During Evolution," *BoneKey Reports**, 2019.
11. N. O. Kuchuk et al., "Relationships of Serum 25-Hydroxyvitamin D to Bone Mineral Density and Serum Parathyroid Hormone and Markers of Bone Turnover in Older Persons," *Journal of Clinical Endocrinology and Metabolism**, vol. 94, no. 4, pp. 1244-1250, 2009.
12. U. Lehmann et al., "Efficacy of Fish Intake on Vitamin D Status: A Meta-Analysis of Randomized Controlled Trials," *American Journal of Clinical Nutrition**, vol. 102, no. 4, pp. 837-847, 2015.
13. F. H. Chen, T. Liu, L. Xu, L. Zhang, and X. B. Zhou, "Association of Serum Vitamin D Level and Carotid Atherosclerosis: A Systematic Review and Meta-Analysis," *Journal of Ultrasound in Medicine**, vol. 37, no. 6, pp. 1293-1303, 2018.
14. D. K. Dhanwal, "Thyroid Disorders and Bone Mineral Metabolism," *Indian Journal of Endocrinology and Metabolism**, vol. 15, Suppl. 2, pp. S107-S112, 2011.
15. G. R. Williams, "Thyroid Hormone Actions in Cartilage and Bone," *European Thyroid Journal**, vol. 2, no. 1, pp. 3-13, 2013.
16. W. Zhang et al., "Thyroid-Stimulating Hormone Maintains Bone Mass and Strength by Suppressing Osteoclast Differentiation," *Journal of Biomechanics**, vol. 47, no. 6, pp. 1307-1314, 2014.
17. M. Modi and M. Daveswar, "Study of Histopathological Pattern of Thyroid Lesions," *International Journal of Biomedical and Advanced Research**, vol. 9, no. 1, pp. 27-36, 2018.
18. R. Baliram et al., "Hyperthyroid-Associated Osteoporosis Is Exacerbated by the Loss of TSH Signaling," *Journal of Clinical Investigation**, vol. 122, no. 10, pp. 3737-3741, 2012.
19. F. R. Freitas et al., "The Thyroid Hormone Receptor β -Specific Agonist GC-1 Selectively Affects the Bone Development of Hypothyroid Rats," *Journal of Bone and Mineral Research**, vol. 20, no. 2, pp. 294-304, 2005.
20. L. Li and Z. Wang, *Ovarian Aging and Osteoporosis**, New York: Aging and Aging-Related Diseases Press, 2008.
21. K. Jamka, P. Adamczuk, A. Skowronska, I. Bojar, and G. Raszewski, "Assessment of the Effect of Estradiol on Biochemical Bone Turnover Markers Among Postmenopausal Women," *Annals of Agricultural and Environmental Medicine**, 2021.
22. M. Abedinzade, S. Nasri, M. J. Omodi, E. Ghasemi, and A. Ghorbani, "Efficacy of *Trigonella Foeniculum-Graecum* Seed Extract in Reducing Metabolic and Inflammatory Alterations Associated With Menopause," *Iranian Red Crescent Medical Journal**, vol. 17, no. 11, p. e26685, 2015.
23. M. R. Sowers, J. S. Finkelstein, B. Ettinger et al., "The Association of Endogenous Hormone Concentrations and Bone Mineral Density Measures in Pre- and Perimenopausal Women of Four Ethnic Groups: SWAN," *Osteoporosis International**, New York, 2003.
24. S. Herrero et al., "Low Bone Density With Normal Bone Turnover in Ovariectomized and Streptozotocin-Induced Diabetic Rats," *Calcified Tissue International**, vol. 62, no. 3, pp. 260-265, 1998.
25. C. M. Allan, R. Kalak, C. R. Dunstan et al., "Follicle-Stimulating Hormone Increases Bone Mass in Female Mice," *Proceedings of the National Academy of Sciences of the United States of America**, 2010.
26. S. H. Ko and Y. Jung, "Energy Metabolism Changes and Dysregulated Lipid Metabolism in Postmenopausal Women," *Nutrients**, 2021.
27. F. Fakili, I. V. Duzen, M. Kaplan, and N. G. Bayram, "A 24-Year-Old Woman With Dyspnea, Chest Pain, and Dry Cough," *Chest**, vol. 160, no. 5, pp. e503-e506, 2021.