AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 6. No 02. February ,2026

PHYSIOLOGICAL MECHANISMS OF BONE METABOLISM IN OSTEOPOROSIS

Saidova Sarvinoz,

a student at the Faculty of Pediatrics of the Bukhara State

Medical Institute named after Abu Ali Ibn Sino

Abstract: Osteoporosis is a metabolic bone disease characterized by a decrease in bone mass and an increased risk of fractures. Bone tissue is a living structure that undergoes continuous remodeling through a balance between bone formation and bone resorption. Under normal physiological conditions, this balance helps maintain bone strength and mineral homeostasis. However, in osteoporosis, normal bone metabolism is disrupted, leading to excessive bone loss.

This article aims to explain the physiological mechanisms of bone metabolism and how their disturbance contributes to the development of osteoporosis. The roles of bone remodeling, osteoblast and osteoclast activity, calcium and phosphorus balance, and hormonal regulation are discussed in a step-by-step manner. Special attention is given to age-related and hormonal changes that affect bone physiology.

Understanding the normal physiological processes of bone metabolism provides a basis for explaining the pathogenesis of osteoporosis. In addition, this knowledge highlights the importance of preventive measures such as adequate nutrition, physical activity, and hormonal balance, as well as general principles of treatment aimed at restoring bone remodeling balance.

Keywords: Osteoporosis, bone metabolism, bone remodeling, osteoblasts, osteoclasts, calcium homeostasis.

Introduction: Bone tissue plays a crucial role in providing structural support to the body and maintaining mineral balance. Unlike inert structures, bone is a dynamic tissue that continuously undergoes metabolic activity throughout life. This constant renewal allows the skeleton to adapt to mechanical stress, repair microscopic damage, and regulate calcium and phosphorus levels in the body.

Under normal physiological conditions, bone metabolism is maintained through a balanced process known as bone remodeling. During this process, old bone tissue is resorbed and replaced with newly formed bone. The coordinated activity of bone-forming cells and bone-resorbing cells ensures that bone mass and strength remain stable, especially during early and middle adulthood.

Osteoporosis develops when this physiological balance is disrupted. The rate of bone resorption exceeds the rate of bone formation, leading to a gradual loss of bone mass and deterioration of bone microstructure. As a result, bones become fragile and more susceptible to fractures, even under minimal stress. These changes often occur silently over many years before clinical symptoms appear.

Understanding osteoporosis requires a clear knowledge of normal bone metabolism and its regulatory mechanisms. Factors such as aging, hormonal changes, and disturbances in mineral

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 02. February ,2026

homeostasis significantly influence bone physiology. Therefore, studying the physiological mechanisms underlying bone metabolism is essential for explaining the development of osteoporosis and for identifying effective strategies for prevention and treatment.

Bone metabolism depends not only on the balance between osteoblasts and osteoclasts but also on the careful regulation of minerals and hormones in the body. Calcium and phosphorus are the main minerals required for bone formation and strength. The body maintains their levels through a combination of intestinal absorption, storage in bones, and excretion by the kidneys. Vitamin D is crucial for helping the intestines absorb calcium and for supporting proper bone mineralization. Without enough vitamin D, bone formation slows and bones become weaker over time.

Hormones play an equally important role. Parathyroid hormone and calcitonin help regulate calcium levels in the blood, ensuring that bones are neither over-resorbed nor under-mineralized. Sex hormones, particularly estrogen and testosterone, influence the activity of both osteoblasts and osteoclasts. Estrogen, for example, normally suppresses excessive bone resorption. When estrogen levels decline, such as during menopause, bone loss can accelerate. Similarly, aging and hormonal changes in men can gradually reduce bone density.

This complex interaction of cells, minerals, and hormones keeps bone remodeling in balance during healthy adulthood. Disruption of any of these physiological factors—whether due to inadequate nutrition, hormonal imbalance, or aging—can slowly tip the balance toward bone loss. Understanding these mechanisms helps explain why osteoporosis develops and why preventive measures such as sufficient calcium intake, vitamin D, physical activity, and hormonal health are so important for maintaining bone strength.

Osteoporosis develops when the normal balance between bone formation and resorption is disturbed over time. In this condition, osteoclast activity exceeds osteoblast activity, causing a gradual loss of bone mass and deterioration of bone microstructure. Aging is a major contributing factor, as bone formation naturally slows while resorption continues. Hormonal changes, such as the decline of estrogen in postmenopausal women, further accelerate bone loss. Nutritional deficiencies, especially low intake of calcium and vitamin D, and insufficient physical activity also weaken bones and disrupt normal remodeling.

Other physiological factors include reduced efficiency of the kidneys and intestines in maintaining mineral balance, as well as chronic low-grade inflammation that can increase bone resorption. These subtle, long-term changes often occur without noticeable symptoms until bones become fragile and fractures occur even after minor stress. Understanding this step-by-step disruption of normal physiology explains why osteoporosis is often called a “silent disease.”

Preventive strategies focus on maintaining the natural balance of bone metabolism. Adequate nutrition, including sufficient calcium and vitamin D, supports mineral availability for bone formation. Regular weight-bearing and resistance exercises stimulate osteoblast activity and help maintain bone strength. Hormonal health, such as monitoring estrogen levels in women and testosterone in men, also plays a critical role. While medical treatments may be used to restore balance in severe cases, supporting the body’s own physiological processes remains the cornerstone of osteoporosis prevention. Osteoporosis develops gradually as the normal physiological balance of bone metabolism shifts. Over time, the rate of bone resorption begins to exceed the rate of bone formation. This imbalance leads to a progressive loss of bone mass and a

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 02. February ,2026

weakening of the bone structure, making bones more fragile and susceptible to fractures. Aging is a natural contributor, as the activity of osteoblasts decreases while osteoclast activity may remain the same or even increase slightly. Hormonal changes, particularly the decline of estrogen in postmenopausal women and testosterone in older men, further accelerate this process.

Nutritional factors also play a role: insufficient calcium or vitamin D intake reduces the raw materials necessary for bone formation, while lack of physical activity limits the mechanical stimulation that encourages bones to remain strong. Even subtle disturbances in kidney or intestinal function can affect mineral balance, slowly undermining the stability of the skeletal system.

Despite these changes, osteoporosis often progresses silently, with no noticeable symptoms until a fracture occurs. Understanding the physiological processes behind this imbalance helps explain why bones become weak over time and highlights the importance of early preventive measures. Supporting natural bone remodeling through proper nutrition, regular exercise, and attention to hormonal health can slow the progression of bone loss and maintain skeletal strength. Over time, the gradual changes in bone metabolism can lead to noticeable effects on skeletal strength. When the normal cycle of bone renewal is disrupted, bones become less dense and their internal structure becomes fragile. This process does not happen overnight; it develops slowly as the cumulative effects of aging, minor hormonal shifts, and insufficient nutrient supply take place.

Even small deficiencies in calcium or vitamin D, combined with limited physical activity, can subtly weaken bones. Hormonal variations, such as decreased estrogen or testosterone, further reduce the efficiency of bone formation. As these factors accumulate, bones lose resilience, making fractures more likely even under minor stress or everyday movements.

By studying these physiological changes, it becomes clear that osteoporosis is the result of multiple interconnected processes rather than a single cause. Recognizing the early signs of imbalance allows for interventions that support the body’s natural remodeling processes, helping to maintain bone density and reduce the risk of fractures.

In conclusion, osteoporosis develops when the natural balance of bone metabolism is disrupted. When bone formation slows or bone resorption increases, bones gradually lose density and become more fragile. Aging, hormonal changes such as reduced estrogen or testosterone, insufficient calcium and vitamin D intake, and low physical activity all contribute to this imbalance.

Understanding the physiological mechanisms of bone remodeling and mineral regulation shows that osteoporosis is a result of multiple interacting factors rather than a single cause. Supporting bone health through proper nutrition, regular exercise, and attention to hormonal balance can help maintain bone strength and reduce the risk of fractures. By focusing on these preventive measures, it is possible to slow bone loss and preserve skeletal resilience throughout life.

References

1. Elahmer N., Wong S.K., Mohamed N. et al. Mechanistic Insights and Therapeutic Strategies in Osteoporosis: A Comprehensive Review. Biomedicines. 2024

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 02. February ,2026

2. Yang D., Gong G., Song J. et al. Ferroptosis-mediated osteoclast-osteoblast crosstalk: signaling pathways governing bone remodeling in osteoporosis. J Orthop Surg Res. 2025

3. Elahmer N.E., Mohamed N.M., Wong S.K. et al. The canonical Wnt pathway in osteoporosis: a scoping review of key compounds and proteins modulating Wnt-induced osteogenesis. Front Pharmacol. 2025

4. Leszczyńska D., Szatko A., Toboła A. et al. Novel aspects of biochemical assessment of bone remodeling and mineralization. Front Endocrinol. 2025

5. Wang X., Zhang C., Zhao G. et al. Obesity and lipid metabolism in the development of osteoporosis. Int J Mol Med. 2024

6. Yakubov D.J., Turobov B.U., Berdiqulov A.R. Osteoporoz va suyak zichligini baholashda raqamli rentgenografiya: yangi indekslar va algoritmlar. Healthway. 2025

7. Aibar-Almazán A., Voltes-Martínez A., Castellote-Caballero Y. et al. Osteoporosis diagnosis and clinical features: review of current approaches. (From the article on new diagnostic approaches). 2022

8. Scheiner S., Pivonka P., Hellmich C., Smith D.W. Mechanobiological regulation of bone remodeling: coupled systems biology and micromechanics. (Theoretical model article). 2012