

# Multidisciplinary Approach to Management Osteoporosis: Clinical Manifestations, Diagnostic Tools, Nutrition, Lifestyle Modification and Current Treatment Options

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## Abstract

**Background:** A multidisciplinary approach to osteoporosis management involves integrating various healthcare disciplines to address the complex needs of patients with osteoporosis, aiming to prevent fractures and improve overall bone health. This approach is crucial given the high prevalence of osteoporosis and the significant risk of fractures, particularly in aging populations. The integration of different specialties ensures comprehensive care, from diagnosis to treatment and follow-up. **Objective:** an overview of osteoporosis management. **Method:** The PUBMED And Google Scholar Search Engines Were the Main Databases Used For The Search Process, With Articles Collected From 1980 To 2024. **Conclusion:** the pathophysiology of osteoporosis involves various factors such as hormonal changes, aging, and bone tissue deterioration. Recognizing these mechanisms is vital for creating preventive and treatment measures, especially for high-risk groups like postmenopausal women. While age and gender are non-modifiable risk factors, diet and lifestyle choices can be modified to lower osteoporosis risk. By adjusting these modifiable factors, individuals can improve their bone health and prevent osteoporosis. Understanding both non-modifiable and modifiable risk factors is crucial for effective management and prevention of this condition.

**Keywords:** Osteoporosis, Pathophysiology, Risk Factor, Diagnosis, Treatment, Nutrition, Lifestyle, Physiotherapy.

## Introduction

Osteoporosis is a prevalent age-related disorder characterized by low bone mass and microarchitectural deterioration of bone tissue [Figure 1], which significantly increases the risk of skeletal fractures, particularly in the hip, spine, and distal forearm. (1, 2) This condition is often called a "silent disease" because it typically remains asymptomatic until a fracture occurs, making early diagnosis crucial. (3) The lifetime fracture risk for individuals with osteoporosis can be as high as 40%, with fractures leading to severe complications, including increased mortality and loss of mobility. (4) Additionally, osteoporosis can be classified into primary and secondary types [Figure 2]. Primary osteoporosis is the most common form, often linked to aging and hormonal changes, while secondary osteoporosis arises from various underlying conditions or medications.

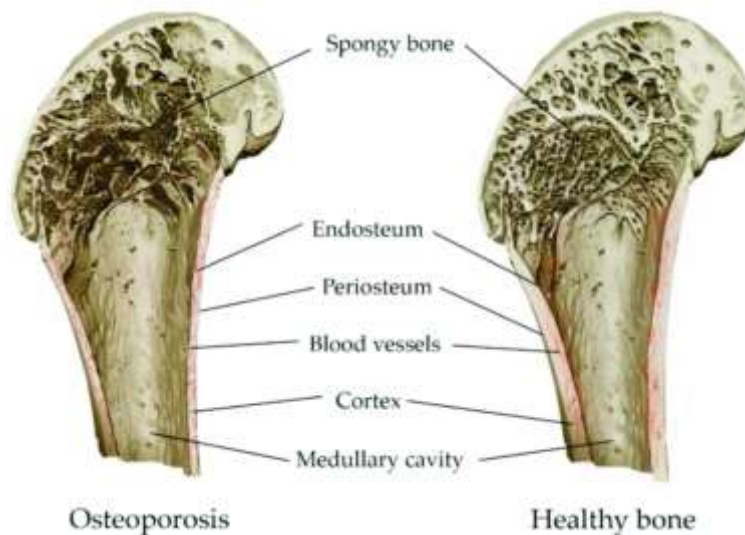


Figure 1: Demonstrates the disparity between normal and osteoporotic bone, showing a decrease in bone density and thinning of bone structures as a result of osteoporosis (5).

Osteoporosis is a multifactorial disorder characterized by a pathologically negative bone balance, where bone resorption exceeds bone formation, leading to reduced bone mass and increased fracture risk. (6) The pathophysiology of osteoporosis involves several interconnected mechanisms, including microarchitectural deterioration, hormonal imbalances, and age-related changes in bone metabolism. One of the primary contributors to osteoporosis is the deficiency of osteoblast activity, particularly in older adults. This deficiency arises from a reduced proliferating cell pool of bone tissue, which impairs the formation of new bone. Additionally, reduced bone mineral density serves as a significant predictor of genetically caused osteoporosis, highlighting the importance of both genetic and environmental factors in the disease's development. (7) In younger individuals, low bone mineral density and structural changes can indicate a predisposition to osteoporosis, while in older adults, the cumulative effects of aging exacerbate these issues. (2, 7) Hormonal changes, particularly during menopause, play a crucial role in the pathophysiology of osteoporosis. The decline in estrogen levels significantly affects bone density, leading to accelerated bone loss. (2) This hormonal imbalance, combined with age-related bone loss, results in a situation where the rate of bone resorption often surpasses that of bone formation, particularly in postmenopausal women. Moreover, excessive bone remodeling rates contribute to the net loss of bone mass. This accelerated turnover can lead to compromised bone strength and increased skeletal fragility, further heightening the risk of fractures. (8) Defects in the microarchitecture of trabecular bone also play a significant role, as these structural abnormalities can weaken the overall integrity of the bone.

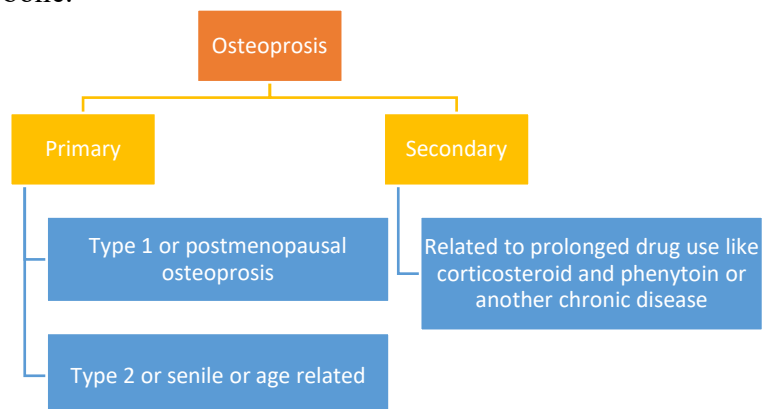


Figure 2: Classification of Osteoporosis.

## **Risk Factors for Osteoporosis**

Osteoporosis influenced by both non-modifiable and modifiable risk factors. Understanding the risk factors associated with osteoporosis is crucial for prevention and management [Figure 3]. Non-modifiable risk factors include age, gender, and family history. Age is a significant determinant, as bone density typically decreases with advancing age, particularly after 65 years. Gender also plays a significant role, with women, especially postmenopausal women, being at a higher risk. The loss of estrogen after menopause significantly contributes to bone density reduction, leading to primary osteoporosis. This hormonal change accelerates bone loss, making women more vulnerable to fractures compared to men. Additionally, a family history of fractures or osteoporosis can indicate a genetic predisposition to lower bone density, making individuals more susceptible to osteoporosis. (9) Furthermore, ethnicity is a significant factor; Caucasian and Asian women are at the highest risk for developing osteoporosis, while African American and Hispanic women have a lower, yet notable, risk. (10) Previous fractures, especially those occurring after the age of 50, are also strong indicators of increased risk, as they suggest underlying bone fragility. (11) This variation suggests that genetic and environmental factors may interact differently across populations, influencing overall risk levels.

In contrast, modifiable risk factors present opportunities for intervention. Several dietary and lifestyle factors can be adjusted to mitigate the risk of developing this condition. Key dietary factors include low calcium and vitamin D intake, which are critical for maintaining bone health. Insufficient calcium can lead to decreased bone mass, while low vitamin D levels impair calcium absorption, both contributing to osteoporosis. Furthermore, protein intake plays a vital role; both low and excessively high protein consumption can negatively affect bone density. Additionally, increasing potassium intake has been associated with improved bone metabolism, further supporting the need for a balanced diet rich in essential nutrients. (12) Similarly, high alcohol consumption can lead to decreased bone density, compounding the risk of osteoporosis. The intake of carbonated beverages has also been associated with lower bone mineral density, suggesting that dietary habits can be adjusted to mitigate risk. (12) Lifestyle choices also significantly impact osteoporosis risk. Smoking is a well-documented risk factor that adversely affects bone health, increasing fracture risk. (13) Physical activity is another crucial modifiable factor. Regular weight-bearing exercises enhance bone strength and density, while a sedentary lifestyle can lead to increased osteoporosis risk. Additionally, managing present illnesses and maintaining a healthy body mass index (BMI) are important, as both low BMI and certain health conditions can elevate the risk of developing osteoporosis.

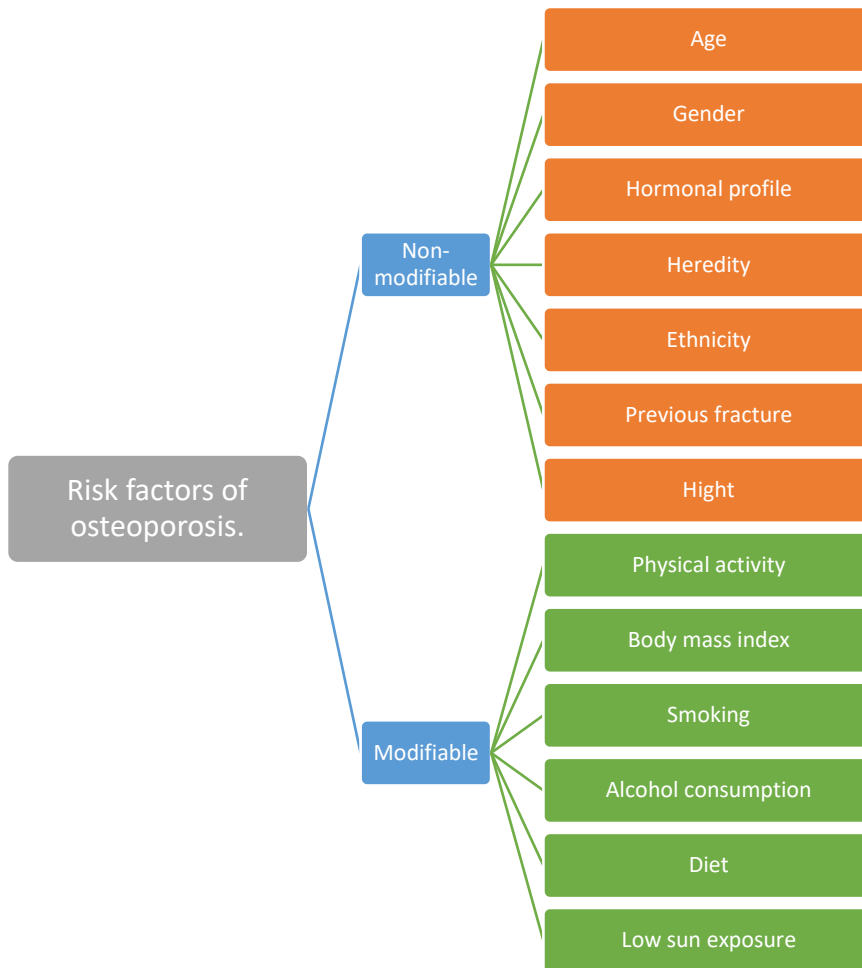


Figure 3: Risk factors of osteoporosis.

### **Clinical Manifestations of Osteoporosis**

Osteoporosis is a clinical syndrome characterized by low bone mass and an increased risk of fractures, which are its most common clinical manifestations. Patients with osteoporosis often experience pain and disability, which escalate with the number and severity of fractures. This pain can persist for years, significantly impacting the quality of life. (14) The primary sites for these fragility fractures include the hip, spine, and distal radius, with each site presenting unique implications for patient health and quality of life. Hip fractures are particularly concerning, as they often result from minor falls and can lead to significant morbidity and mortality. Approximately 40% of all deaths from trauma in individuals over 75 are attributed to hip fractures, and many patients do not return to their previous level of activity post-injury. (15) The loss of cortical bone is a critical factor contributing to the occurrence of hip fractures, highlighting the importance of maintaining bone density. In addition to hip fractures, osteoporosis can lead to vertebral compression fractures, which are common and can result in severe back pain and a gradual loss of height over time. These fractures often occur due to the rapid loss of trabecular bone, leading to vertebral collapse, which can significantly affect a patient's posture and overall mobility. These fractures often occur due to the rapid loss of trabecular bone, leading to vertebral collapse, which can significantly affect a patient's posture and overall mobility. The development of a stooped posture is a visible manifestation of this condition, further impacting the individual's quality of life. (16)

Moreover, distal forearm fractures are another significant manifestation of osteoporosis, often occurring in individuals with low bone mass. (16) These fractures, along with those in the spine and hip, underscore the critical need for early detection and management of osteoporosis, particularly in populations at risk, such as the elderly and those with mood disorders that may

exacerbate bone loss. (17) As the population ages and life expectancy increases, the incidence of osteoporosis-related fractures is expected to rise, necessitating a proactive approach to prevention and treatment. (15) it is essential to recognize that while low bone mass is a key sign, other intrinsic factors, such as microdamage accumulation, and extrinsic factors, like poor coordination, can also contribute to the risk of fractures. (16) The psychosocial implications of these symptoms are profound, as many patients may not openly discuss their emotional struggles related to living with osteoporosis. The consequences of fractures, including chronic pain and physical limitations, can lead to a diminished psychosocial status, which is an important aspect of patient care that requires attention. (14)

### **Diagnostic Tools and Techniques**

Osteoporosis is a significant health concern, necessitating effective diagnostic tools to assess bone health. One of the most widely used methods for measuring bone mineral density (BMD) is Dual-Energy X-ray Absorptiometry (DXA), which is recommended for diagnosing osteoporosis and evaluating fracture risk. DXA provides a comprehensive assessment of BMD, which is a critical factor in determining osteoporosis risk. In addition to DXA, various advanced imaging techniques have emerged. The interpretation of established by World Health Organization (WHO) a standardized method for interpreting DXA results through the T-score, which compares an individual's BMD to that of a healthy young adult. A T-score of -2.5 or lower indicates osteoporosis, while scores between -1.0 and -2.5 suggest osteopenia, or low bone mass. The introduction of the WHO FRAX<sup>®</sup> algorithm has significantly enhanced the clinical utility of DXA scans. This algorithm combines clinical risk factors with hip DXA results to predict a patient's 10-year risk of experiencing an osteoporotic fracture. By integrating these factors, clinicians can make more informed decisions regarding the management and treatment of osteoporosis. The FRAX tool emphasizes the importance of a quantitative evaluation of fracture risk, which should be the standard approach in interpreting DXA examinations, particularly for postmenopausal women and older men. DXA scans are recognized as the reference method for measuring BMD due to their accuracy, precision, and ability to assess multiple skeletal sites. The procedure is non-invasive, involves minimal radiation exposure, and can be completed in a short time, making it accessible for patients at risk of osteoporosis. (18) However, while BMD is a critical factor in assessing fracture risk, it is not the sole determinant. Other parameters, such as bone microarchitecture, can also influence bone strength and susceptibility to fractures.

Quantitative CT (QCT) is one such method that offers detailed measurements of bone density, making it a valuable tool for osteoporosis assessment. Peripheral QCT, a specialized form of QCT, focuses on measuring bone density in peripheral sites, enhancing the diagnostic capabilities for osteoporosis. Furthermore, quantitative MRI provides insights into both bone density and microstructure, contributing significantly to the evaluation of osteoporosis. Another innovative approach involves the use of micro-CT, which allows for high-resolution imaging and quantification of the three-dimensional structure of trabecular bone. This technique is particularly relevant for assessing the micro-architectural changes associated with osteoporosis. Similarly, magnetic resonance microscopy offers precise imaging capabilities to analyze bone microstructure, further aiding in the evaluation of osteoporosis. (19) For specific applications, the osteoporosis calcaneus bone test device utilizes ultrasonic probes to directly measure BMD in the calcaneus, providing a targeted diagnostic tool for osteoporosis. (20) This device is particularly significant given the rising prevalence of osteoporosis among the aging population, emphasizing the need for effective diagnostic methods. Lastly, a compact MRI system has been developed to facilitate the diagnosis and follow-up of osteoporosis, utilizing a compact magnet and RF probe to accommodate human extremities. This system measures proton density in bone marrow, which can be used to compute trabecular bone volume fraction, further supporting osteoporosis diagnosis.

(21)

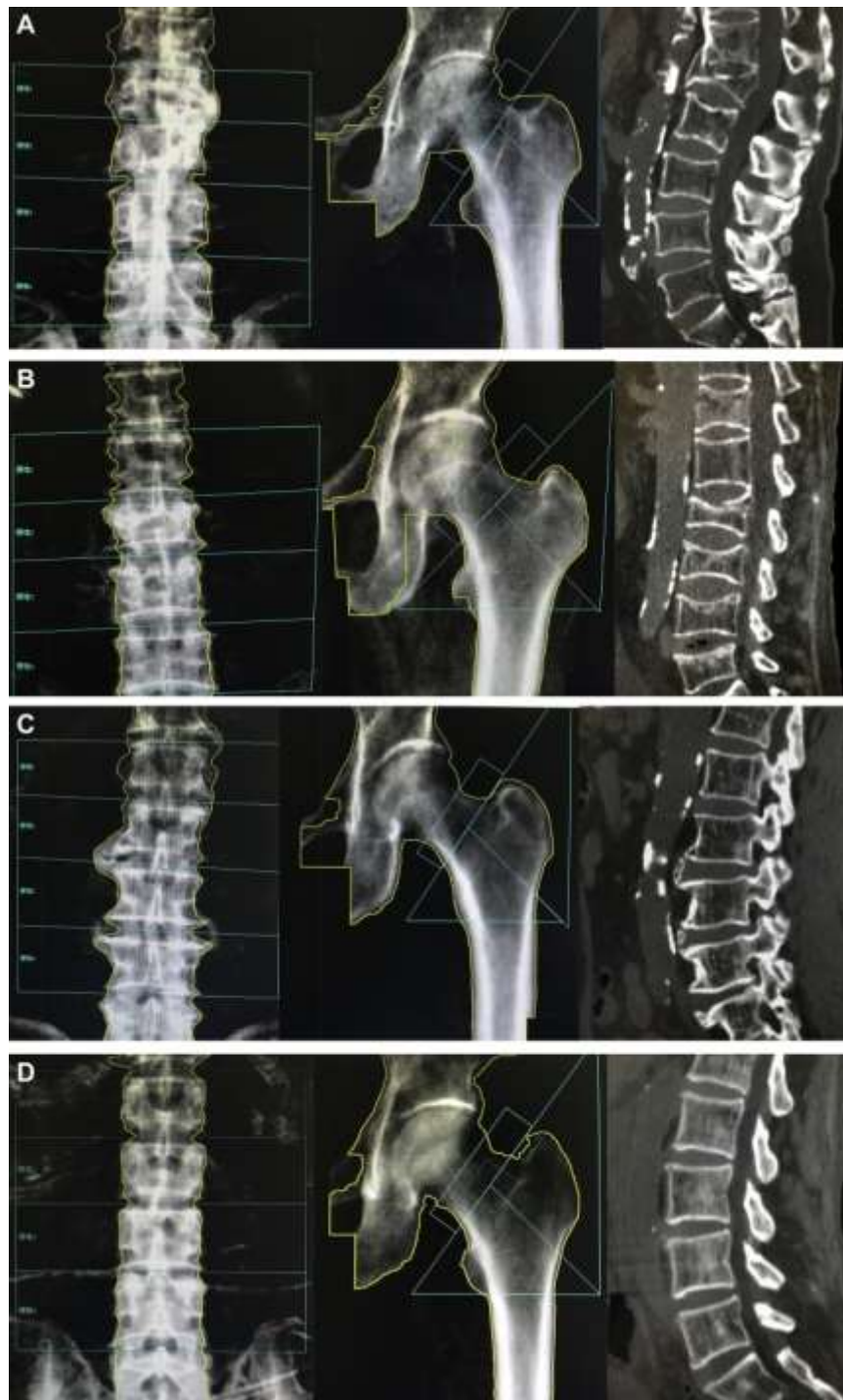


Figure 4: Diagnostic tools for osteoporosis (22). (A) An 82-year-old patient; the T-scores for lumbar spine DXA and hip DXA were recorded at 1.45 and  $-2.35$ , respectively, leading to a diagnosis of osteopenia based on DXA. The BMD assessed by QCT was  $34.0 \text{ mg/cm}^3$ , resulting in a diagnosis of osteoporosis by QCT, with a minor discordance in the diagnostic findings. The QCT images revealed a compression fracture of L1 along with abdominal aortic calcification (AAC). (B) A 70-year-old patient; the T-scores for lumbar spine DXA and hip DXA were  $-1.36$  and  $-1.92$ , respectively, indicating a diagnosis of osteopenia as per DXA results. The BMD determined through QCT measured  $37.5 \text{ mg/cm}^3$ , leading to a diagnosis of osteoporosis via QCT, with a minor discordance in the diagnostic evaluation. The QCT images displayed multiple vertebral compression fractures along with AAC. (C) An 81-year-old patient; the T-scores for lumbar spine DXA and hip DXA were noted at 1.01 and 0.38, respectively, resulting in a diagnosis

of normal bone density according to DXA. The BMD evaluated by QCT was 76.2 mg/cm<sup>3</sup>, which led to a diagnosis of osteoporosis based on QCT findings, showing major discordance in diagnosis. The QCT images exhibited osteophytes, ossification of the anterior longitudinal ligament, and AAC. (D) A 72-year-old patient; the T-scores for lumbar spine DXA and hip DXA were recorded at -1.52 and -2.65, respectively, resulting in a diagnosis of osteoporosis according to DXA. The BMD ascertained by QCT was 126.2 mg/cm<sup>3</sup>, leading to a diagnosis of normal bone density via QCT, with major discordance in the diagnostic interpretation. AAC = abdominal aortic calcification; BMD = bone mineral density; DXA = dual-energy X-ray absorptiometry; QCT = quantitative computed tomography.

### Current Treatment Options

Current pharmacological interventions for osteoporosis encompass a range of therapies aimed at either inhibiting bone resorption or promoting bone formation. The landscape of osteoporosis treatment has evolved significantly, introducing several effective agents that cater to different patient needs. One of the most notable drugs is **Strontium ranelate**, which uniquely increases osteogenesis while simultaneously decreasing bone resorption, making it a dual-action agent in osteoporosis management. This drug has been shown to halve the risk of vertebral fractures within months of treatment. Another important agent is **Teriparatide**, a parathyroid hormone analog that primarily stimulates osteoblast activity, thereby enhancing bone formation. (23) Both of these agents represent a shift towards more effective treatments that address the underlying mechanisms of osteoporosis. **Bisphosphonates**, such as Alendronate and Risedronate, remain a cornerstone of osteoporosis therapy. They work by inhibiting bone resorption, thus reducing the rate of bone remodeling and lowering fracture risk, although they do not increase bone mass. These agents have become increasingly popular due to their efficacy and the development of less frequent dosing regimens. **Denosumab**, a monoclonal antibody that inhibits osteoclast formation, has also gained prominence. Administered biannually, it significantly increases bone mineral density and reduces the risk of fractures over extended periods. (24) Emerging therapies, including **Romosozumab**, a sclerostin inhibitor, and **Abaloparatide**, a PTH-related peptide analog, are currently in advanced clinical evaluation and show promise in promoting bone formation while also reducing resorption. (25) In addition to these newer agents, traditional therapies such as **Estrogen therapy** and **Raloxifene**, a selective estrogen receptor modulator (SERM), continue to play a role, particularly in postmenopausal women. While estrogen therapy effectively maintains bone density, it carries risks such as blood clots and cancer. (26) Raloxifene offers a safer alternative by mimicking estrogen's protective effects on bone without some of the associated risks. (24) Lastly, **Calcitonin**, although not a first-line treatment, is available as a nasal spray or injection and helps prevent bone loss. (24, 26) The combination of these various pharmacological interventions provides a comprehensive approach to managing osteoporosis, addressing both prevention and treatment in diverse patient populations. As research continues, the development of new agents and combinations promises to enhance the effectiveness of osteoporosis management further.

### Nutrition and Lifestyle Modification Role for Osteoporosis

Nutritional recommendations for osteoporosis focus on ensuring adequate intake of calcium and vitamin D, as both are crucial for maintaining bone health and preventing fractures. Dietary calcium is a significant part of a lifestyle prescription aimed at reducing fracture risk in later life, particularly for elderly individuals who are at a higher risk of falls and subsequent fractures. (27) It is essential to incorporate foods rich in calcium, such as milk and dairy products, which not only provide calcium but also enhance its absorption. These products are beneficial due to their additional functional compounds, such as milk basic protein (MBP), which contribute positively to bone health. (28) Moreover, maintaining an adequate vitamin D status is vital, especially for older adults, as it plays a key role in calcium metabolism and bone health. A balanced diet that includes sufficient calcium, vitamin D, and other essential nutrients is necessary for osteoporosis

prevention throughout life. (29) To effectively manage osteoporosis, several lifestyle modifications are recommended. First and foremost, engaging in regular physical activity is crucial. This not only helps improve or maintain bone health but also reduces the risk of fractures associated with osteoporosis. (29) Additionally, avoiding a sedentary lifestyle is essential, as inactivity can exacerbate bone density loss. Moreover, lifestyle choices such as avoiding excessive alcohol consumption are critical, as alcohol can negatively impact bone density and increase fracture risk. By integrating these recommendations—regular physical activity, a balanced diet rich in calcium and vitamin D, and avoiding harmful habits—individuals can significantly enhance their bone health and reduce the likelihood of osteoporotic fractures. These multifaceted strategies are essential for both prevention and management of osteoporosis, addressing the disorder's complex nature and its socioeconomic implications

### **Physical Therapists**

Physical therapists play a crucial role in the management and rehabilitation of osteoporosis. Their expertise is essential in developing customized exercise programs tailored to the specific needs of individuals with osteoporosis, ensuring that these regimens are both safe and effective. A key component of these programs includes weight-bearing exercises, which are vital for building and maintaining bone density. Additionally, resistance training is often recommended to improve muscle strength, further aiding in fracture prevention. Physical therapists also implement fall prevention strategies, which are critical in reducing the risk of falls that can lead to fractures in this vulnerable population. The comprehensive management of osteoporosis requires a multidisciplinary approach, where physical therapists collaborate with other health professionals to address not only the physical aspects of the disease but also the psychological and social factors that may affect patients, such as pain, decreased mobility, and social isolation. (30, 31) By integrating physical therapy with pharmacological treatments and lifestyle modifications, therapists can significantly enhance the quality of life for individuals suffering from osteoporosis, promoting better health outcomes and reducing the incidence of fractures

### **Conclusion**

the pathophysiology of osteoporosis involves various factors such as hormonal changes, aging, and bone tissue deterioration. Recognizing these mechanisms is vital for creating preventive and treatment measures, especially for high-risk groups like postmenopausal women. While age and gender are non-modifiable risk factors, diet and lifestyle choices can be modified to lower osteoporosis risk. By adjusting these modifiable factors, individuals can improve their bone health and prevent osteoporosis. Understanding both non-modifiable and modifiable risk factors is crucial for effective management and prevention of this condition.

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Each author contributes to the paper's editing, collects pertinent material, and approves the final submission to the journal. The corresponding author oversaw the first author's drafting of the paper.

### **Conflict of Interest**

The authors declare they don't have any conflicts of interest.

### **Ethical Approval**

Not Applicable

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