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Review Article

Comparative Review of Osteoporosis in Postmenopausal Women

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ABSTRACT

Osteoporosis is a condition where bones become weak and fragile, making them more likely to break. Postmenopausal women are particularly vulnerable to osteoporosis due to the rapid decrease in estrogen levels following menopause, which accelerates bone loss. Osteoporosis has a major impact on women's lives, reducing their quality of life, increasing their risk of fractures, and lowering their overall well-being. In fact, one in three women over the age of 50, and one in five men, will experience osteoporosis in their lifetime. In postmenopausal women, osteoporosis is mainly caused by a drop in estrogen levels and the reduction in egg production by the ovaries as they age. To prevent osteoporosis, all women should be educated about the condition and encouraged to lead a healthy lifestyle. This review examines the pathophysiology, risk factors, diagnosis, and management of osteoporosis in postmenopausal women. Factors such as aging, low body weight, family history, and lack of physical activity increase the risk of osteoporosis, while modifiable factors like diet, calcium and Vitamin D intake, and smoking can help reduce risk. Early diagnosis, often through dual-energy x-ray absorptiometry (DEXA) scanning, plays a key role in managing the disease, but access to diagnostic tools remains limited in some regions. Preventive strategies, including regular weight-bearing exercise, a balanced diet rich in calcium and Vitamin D, and lifestyle changes, are essential in reducing the incidence of osteoporotic fractures. This review highlights the importance of early intervention and public health education to improve bone health and quality of life for postmenopausal women.

INTRODUCTION

Osteoporosis is a prevalent and significant public health concern, particularly among postmenopausal women. This condition,

characterized by reduced bone mass and micro architectural deterioration, leads to increased bone fragility and susceptibility to fractures. Postmenopausal women are at an elevated risk due

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to the hormonal changes that accompany menopause, most notably the decline in estrogen levels, which plays a central role in bone metabolism. As estrogen deficiency accelerates bone resorption and decreases bone formation, postmenopausal women experience a marked increase in bone loss, often without symptoms until a fracture occurs. (Black & Rosen, 2016) Osteoporosis is a long-term bone condition where bones become weak and brittle, making them more likely to break. The World Health Organization (WHO) defines menopause as the point when a woman's menstrual periods stop for at least 12 months, usually around the age of 50. Menopause is a natural phase in a woman's life, during which the body undergoes various changes, including a decrease in estrogen levels. One of the major effects of menopause is a significant drop in bone density. In the first 5 to 10 years after menopause, women can lose 25% to 30% of the bone in their spongy (trabecular) bone and about 10% to 15% of the bone in their outer (cortical) bone. Because of this rapid bone loss, postmenopausal women are at a much higher risk of developing osteoporosis and experiencing bone fractures. (Compston et al., 2013) Osteoporotic fractures in postmenopausal women can result in substantial morbidity, disability, and decreased quality of life. Hip, spine, and wrist fractures are among the most common, often leading to chronic pain, loss of independence, and even increased mortality. Despite the availability of pharmacologic and non-pharmacologic interventions, osteoporosis remains under diagnosed and undertreated in this population. This review aims to summarize the pathophysiology, risk factors, diagnostic strategies, and current therapeutic approaches for osteoporosis in postmenopausal women, highlighting the importance of early detection and effective management to mitigate the impact of this condition on women's health.(Bijelic et al., 2017) Diagnosing osteoporosis with a DEXA

(dual-energy x-ray absorptiometry) scan can be challenging, especially in rural areas of Asian countries, where this test is not easily available. Without access to early diagnosis, preventing fractures in people at high risk becomes difficult. Osteoporosis has both non-modifiable and modifiable risk factors. Non-modifiable factors are things that can't be changed, such as age, height, weight, body mass index (BMI), and menopause. These factors increase the risk of developing osteoporosis. On the other hand, modifiable risk factors are lifestyle-related and can be controlled. These include factors like calcium intake, exposure to sunlight, smoking, alcohol use, and physical activity.(Meunier et al., 1999) Diet plays a crucial role in maintaining bone health, especially in postmenopausal women, who experience increased bone loss due to the decline in estrogen levels. Proper nutrition can help prevent or slow the progression of osteoporosis, reduce fracture risk, and improve overall bone strength. For postmenopausal women, adopting a diet that supports bone health is essential in preventing and managing osteoporosis. This includes ensuring adequate intake of calcium, vitamin D, protein, magnesium, and other bone-supporting nutrients. Alongside dietary changes, weight-bearing exercises, lifestyle modifications, and, if necessary, supplementation are critical components of osteoporosis prevention and management. Education on these dietary factors can help empower postmenopausal women to reduce their risk of osteoporosis and improve their overall quality of life.

Etiology-

Osteoporosis- Osteoporosis is a condition where the bones become weak and fragile due to changes in bone structure, loss of bone tissue, and low bone mass. This makes bones more likely to break or fracture. It can have serious effects on a person's body, mind, social life, and even the economy. As we age, osteoporosis tends to develop naturally,



but certain health conditions or diseases can also cause it. For women after menopause, a lack of estrogen contributes to osteoporosis. This hormone deficiency increases the activity of cells that break down bone (called osteoclasts), which weakens the bone structure and raises the risk of fractures. Osteoporosis in postmenopausal women refers to a condition where women, after going through menopause, experience a significant reduction in bone density and strength, making their bones more fragile and prone to fractures. This is mainly due to a drop in estrogen levels, a hormone that helps maintain bone health.(Black & Rosen, 2016)

Osteoporotic fracture-

An osteoporosis fracture in postmenopausal women refers to a bone fracture that occurs due to weakened bones from osteoporosis, a condition where bone density and strength are reduced. Osteoporosis is particularly common in postmenopausal women because of the decline in estrogen levels after menopause. Estrogen plays a key role in maintaining bone density, and its decrease accelerates bone loss. Weakened Bones In osteoporosis is the bones which become porous and fragile, making them more susceptible to fractures even from minor falls or injuries that would not normally cause harm to healthy bones.

Types of Fractures Common in Osteoporosis

1. **Vertebral Fractures (Spinal Compression Fractures)**-These fractures occur in the bones of the spine (vertebrae) and are one of the most common types of fractures in osteoporosis. A vertebral fracture can occur with minimal or no trauma (such as bending over or lifting a light object). Compression fractures can lead to pain, loss of height, and changes in posture (e.g., a hunched back, known as kyphosis). Over time, multiple spinal fractures can lead to a stooped or "dowager's hump."
2. **Hip Fractures**-Hip fractures are among the most serious and debilitating fractures in

osteoporosis. They typically occur from a fall, and surgery is often required for treatment. Hip fractures are associated with high morbidity and mortality, particularly in older adults, as they often lead to complications like immobility, infections, or blood clots.

3. **Wrist Fractures**-Wrist fractures often happen when a person falls and tries to break the fall with their hands. The distal radius bone in the forearm is most commonly affected in such injuries. While wrist fractures can heal with appropriate treatment, they still represent a significant risk for postmenopausal women with osteoporosis, especially if falls are frequent. (de Villiers, 2009) In summary, osteoporosis fractures in postmenopausal women result from weakened bones due to decreased estrogen levels, leading to an increased risk of fractures, especially in the spine, hip, and wrist. Preventing bone loss through medication, nutrition, and exercise is key to managing osteoporosis and reducing the risk of fractures.

Role of Estrogen-

Estrogen plays a critical role in maintaining bone health, and its deficiency after menopause is a primary factor in the development of osteoporosis in postmenopausal women. Estrogen helps to regulate bone metabolism by balancing the processes of bone resorption (breakdown) and formation. When estrogen levels decline after menopause, bone loss accelerates, leading to weaker, more fragile bones that are more prone to fractures. Estrogen also stimulates osteoblast activity, promoting the formation of new bone tissue, although this effect is less significant compared to its inhibitory effect on osteoclasts. The net effect of estrogen is to maintain bone mass and ensure bone strength by reducing excessive bone breakdown while supporting bone formation. (Bijelic et al., 2017) Estrogen levels drop significantly after menopause, leading to an

imbalance in bone remodeling. Without estrogen's protective effect on osteoclasts, their activity increases, leading to more bone resorption than bone formation. This results in a gradual loss of bone mass. The greatest bone loss occurs in the first 5–10 years after menopause, with some women losing up to 20–30% of their bone mass during this period. This is why postmenopausal women are particularly at risk for osteoporosis. The loss of bone mass is most pronounced in trabecular bone (the spongy bone in the spine, hips, and wrists), which is more metabolically active and more sensitive to changes in estrogen levels. (Genant et al., 1989)

Risk factors-

Non-Modifiable Risk Factors-

Several factors significantly influence the likelihood of developing osteoporosis, although they cannot be changed. Age is a primary factor, as bone density naturally declines with age, and the risk of osteoporosis increases as people grow older. This risk is particularly high after the age of 50, especially in women following menopause. Sex is another key factor, with women being at much higher risk for osteoporosis compared to men. This is mainly due to the hormonal changes during menopause, where the drop in estrogen accelerates bone loss. Women generally have lower bone mass to begin with and experience greater bone loss as they age. Menopause and estrogen deficiency play a critical role in osteoporosis, as the decrease in estrogen after menopause is the most significant hormonal factor contributing to the condition. Estrogen is essential for maintaining bone density, and its decline leads to increased activity of osteoclasts, the cells responsible for breaking down bone, which results in more bone loss than formation. Lastly, a family history of osteoporosis or fractures can increase a woman's risk. Genetics play a role in bone mass and strength, and women with close relatives, especially mothers or sisters, who have had

osteoporosis are at a higher risk themselves. (Bijelic et al., 2017)

Modifiable Risk Factors

There are several factors that can be controlled or managed to reduce the risk of developing osteoporosis. One of the key factors is ensuring adequate intake of calcium and vitamin D, which are essential for bone health. Calcium serves as the primary building block of bone, while vitamin D helps the body absorb calcium. A deficiency in either can lead to weaker bones and a higher risk of osteoporosis. For postmenopausal women, the recommended daily intake is around 1,200 mg of calcium and 800–1,000 IU of vitamin D, though individual needs may vary. Physical inactivity also plays a significant role in bone health. Lack of weight-bearing and resistance exercises can contribute to bone loss. Regular physical activity, particularly weight-bearing exercises like walking, jogging, dancing, and strength training, helps maintain bone density and prevent osteoporosis. In addition, smoking is a major risk factor for osteoporosis. Smoking accelerates bone loss by interfering with estrogen production and reducing calcium absorption. Smokers tend to have lower bone mass and higher fracture rates. (Roush, 2011) Excessive alcohol consumption is another risk factor. Drinking more than 2–3 alcoholic beverages per day can weaken bones by disrupting calcium balance and impairing the function of osteoblasts, the bone-forming cells. Poor diet and eating disorders, such as anorexia nervosa, can also contribute to osteoporosis. A diet low in calcium, vitamin D, and other essential nutrients, combined with low body weight, can increase the risk of bone loss and fractures. Certain medications can also elevate the risk of osteoporosis, particularly when used long-term. Corticosteroids, such as prednisone, which are commonly prescribed for conditions like asthma, arthritis, and autoimmune disorders, can significantly reduce bone density over time.



Similarly, proton pump inhibitors (PPIs), which are used to treat acid reflux, can interfere with calcium absorption and increase the risk of osteoporosis. Managing these factors through lifestyle changes and medical supervision can help reduce the likelihood of developing osteoporosis.

Dietary Plans for Osteoporosis-

Osteoporosis is a condition characterized by reduced bone mass and deterioration of bone tissue, which increases the risk of fractures. It is particularly common in postmenopausal women due to hormonal changes associated with menopause, which lead to decreased bone mineral density (BMD). Since osteoporosis often remains asymptomatic until a fracture occurs, managing the condition proactively through lifestyle interventions, including diet, is essential. A dietary approach to osteoporosis aims to enhance bone health, slow bone loss, and reduce fracture risk.(Eastell, 1998)

1. Calcium- Calcium is a key mineral for bone health, as it forms the structural component of bones and teeth. In postmenopausal women, calcium intake becomes especially important due to the loss of estrogen, which accelerates bone resorption. The National Osteoporosis Foundation (NOF) recommends a daily calcium intake of 1,200 mg for postmenopausal women. Good dietary sources of calcium include dairy products like milk, yogurt, and cheese, as well as leafy green vegetables such as kale and collard greens, fortified foods like tofu and cereals, and fish with edible bones such as sardines and salmon. If dietary intake is insufficient, calcium supplements may be necessary, but care should be taken not to exceed the upper limit of 2,000 mg per day.

2. Vitamin D-Vitamin D is crucial for calcium absorption and bone mineralization. Low vitamin D levels are associated with increased fracture risk and worsened bone health. The NOF recommends 800-1,000 IU of vitamin D daily for postmenopausal women, though higher doses may

be needed for those with low blood levels. Vitamin D can be obtained through sunlight exposure, fatty fish like salmon and mackerel, and fortified dairy and plant-based milk. Supplementation may be necessary in cases of deficiency, with periodic blood monitoring recommended.

3. Protein-Protein is another important component of bone health as it supports bone matrix structure, repair, and remodeling. Adequate protein intake also helps prevent muscle wasting and maintain physical function, reducing fall risk in older adults. Postmenopausal women typically require between 1.0 to 1.2 g of protein per kg of body weight daily. Protein-rich foods include lean meats, poultry, fish, eggs, dairy products, legumes, nuts, seeds, and plant-based protein sources like tofu and tempeh.

4. Magnesium-Magnesium is involved in over 300 biochemical reactions, including those related to bone health. Magnesium deficiency may impair bone mineralization and increase fracture risk. The recommended intake for postmenopausal women is 320 mg per day. Good sources of magnesium include whole grains, green leafy vegetables like spinach and chard, legumes, nuts such as almonds and cashews, seeds, and avocados.

5. Vitamin K-Vitamin K plays an essential role in bone metabolism by regulating osteocalcin, a protein involved in bone mineralization. Deficiency in vitamin K can lead to impaired bone health and increased fracture risk. The recommended intake is 90 µg/day for postmenopausal women. Sources of vitamin K include leafy green vegetables like kale and spinach, fermented foods like natto and sauerkraut, and dairy products.

6. Phosphorus- Phosphorus is an important mineral found in bones and contributes to bone health. However, excessive phosphorus intake, especially from processed foods and soft drinks, may disrupt calcium metabolism and negatively impact bone health. The recommended intake for



postmenopausal women is 700 mg per day. Phosphorus is found in foods such as meat, poultry, fish, eggs, dairy, nuts, seeds, and legumes.

7. Boron- Boron, a trace mineral, supports bone health by influencing the metabolism of calcium, magnesium, and phosphorus and may help balance estrogen levels, which is crucial for bone health after menopause. Boron-rich foods include fruits like apples, pears, and grapes, as well as vegetables like broccoli and carrots, along with nuts and legumes.

8. Omega-3 fatty acids- Omega-3 fatty acids are known for their anti-inflammatory properties and may help protect against bone loss by reducing osteoclast (bone-resorbing cell) activity. Regular intake of omega-3s can help maintain bone mineral density and reduce fracture risk. Omega-3 fatty acids are found in fatty fish such as salmon and mackerel, as well as in flaxseeds, chia seeds, walnuts, and omega-3 enriched eggs. In conclusion, diet plays a significant role in the prevention and management of osteoporosis in postmenopausal women. A balanced, nutrient-dense diet rich in calcium, vitamin D, protein, magnesium, and other bone-healthy nutrients is essential for maintaining bone density, preventing fractures, and promoting overall health. Postmenopausal women should aim to include a variety of whole foods from different food groups to support bone health. In cases where dietary intake is insufficient, supplementation can be considered under the guidance of a healthcare provider. Along with a proper diet, other osteoporosis management strategies such as weight-bearing exercise, fall prevention, and pharmacotherapy can significantly reduce fracture risk and improve quality of life for postmenopausal women.

Diagnosis--

Until 1993, there were no reliable methods to diagnose osteoporosis. The only way doctors could identify osteoporosis was when patients

experienced fragility fractures (fractures that happen from a fall or injury that would not normally cause a break). In 1994, the World Health Organization (WHO) introduced specific definitions for osteoporosis to help doctors and researchers better classify the level of bone loss in patients. (Meunier et al., 1999) The diagnosis of osteoporosis in postmenopausal women typically involves a combination of medical history, physical examination, and diagnostic tests. One of the most common and effective methods for diagnosing osteoporosis is a bone mineral density (BMD) test, usually performed using dual-energy X-ray absorptiometry (DEXA). This test measures the density of bones, particularly in the spine and hip, and compares it to the average bone density of a healthy young adult, providing a T-score. A T-score of -2.5 or lower indicates osteoporosis, while a score between -1.0 and -2.5 suggests osteopenia, a condition of lower-than-normal bone density that may progress to osteoporosis. (Compston et al., 2013) In addition to BMD testing, the diagnosis may take into account a patient's clinical history, including risk factors such as family history of osteoporosis, previous fractures, smoking, alcohol use, physical inactivity, and nutritional status. A fracture risk assessment tool, like the FRAX tool, may be used to estimate the 10-year probability of fractures based on clinical risk factors and BMD scores. If osteoporosis is suspected or confirmed, further assessments might be done to rule out other underlying conditions or diseases, such as hormonal imbalances or other metabolic disorders, that can also affect bone health. Early diagnosis is essential in postmenopausal women because bone loss accelerates after menopause due to a drop in estrogen levels, making them more susceptible to fractures. Regular monitoring and timely intervention can help manage the condition and reduce fracture risk. (Kanis et al., 2008)

Management-

General Management-



To manage osteoporosis and reduce the risk of fractures, several lifestyle changes are recommended. A balanced diet with adequate protein and calcium is essential, with the National Osteoporosis Foundation (NOF) advising women to consume 1200 milligrams of calcium daily. Calcium plays a critical role in bone health, muscle function, nerve signaling, and overall body function. Regular exercise, particularly weight-bearing exercises, is also crucial for maintaining strong bones, especially during the menopausal transition (MT), when hormonal changes can affect bone density. Exercise helps mitigate the risks associated with the decline in estrogen levels during menopause. Activities like walking improve balance and can boost hip bone density, while resistance training and other weight-bearing exercises help increase bone density in the spine and hips. Yoga, when practiced under the guidance of a qualified instructor, can also support bone health and improve posture. In addition to exercise, avoiding smoking and alcohol is vital, as both can weaken bones and raise the risk of fractures. (Kanis et al., 2008)

1. Balanced Diet-

A diet rich in calcium and protein is essential for maintaining bone health. The National Osteoporosis Foundation (NOF) recommends that women consume 1200 milligrams of calcium daily, as calcium plays a critical role in bone structure, muscle function, nerve signaling, and overall health. Additionally, ensuring adequate protein intake is crucial, as it supports bone density. Postmenopausal women are advised to consume 1.1–1.2 grams of protein per kilogram of body weight daily. (Meunier et al., 1999) Along with calcium and protein, vitamin D is equally important. Vitamin D aids the body in absorbing calcium and is essential for bone health. Deficiency in vitamin D is common, especially in countries with limited sunlight exposure, such as India, where over 70% of the population may be

affected. Cholecalciferol, a form of vitamin D, is commonly recommended for postmenopausal women, typically in a dose of 60,000 units every 1-2 months.

2. Exercise-

Regular physical activity is crucial for managing osteoporosis, particularly weight-bearing exercises that help stimulate bone formation. Weight-bearing exercises such as walking, jogging, and dancing can improve balance and hip bone density. Additionally, resistance training (e.g., lifting weights) strengthens bones, especially in the spine and hips. Yoga, when practiced under the guidance of a qualified instructor, also supports bone health by improving posture and flexibility. (Daly et al., 2019)

3. Lifestyle Modifications-

Avoiding smoking and excessive alcohol consumption is essential for bone health, as both are known to weaken bones and increase the risk of fractures. Smoking, in particular, accelerates bone loss, while alcohol can impair calcium absorption and disrupt bone remodeling.

4. Supplements-

In addition to dietary sources, calcium and vitamin D supplements are often recommended for postmenopausal women to ensure they are getting enough of these crucial nutrients. For those with low stomach acid, calcium citrate maleate is preferred, as it is better absorbed than other forms of calcium in people with reduced stomach acidity.

Pharmacological Management-

Pharmacological management of osteoporosis is essential for postmenopausal women who are at high risk of fractures. This risk is typically determined using the T-score from bone mineral density (BMD) testing, with a score of -2.5 or lower indicating osteoporosis. The Fracture Risk Assessment Tool (FRAX) is commonly used to evaluate a patient's 10-year risk of experiencing hip or other major osteoporotic fractures, taking into account factors like age, gender, smoking



habits, alcohol consumption, and previous fractures. Treatment is generally recommended for women with a FRAX score above 5%, particularly those at higher fracture risk, such as older women. For patients with a score below 5%, pharmacological intervention may not be necessary. (Eastell et al., 2019)

❖ Categories of Pharmacological Treatment

The pharmacological treatment of osteoporosis in postmenopausal women falls into three main categories: anabolic drugs, anti-resorptive agents, and estrogen-based hormone replacement therapy (HRT). Each class of drugs serves different roles in managing bone health.

1. Anabolic Drugs (Bone Formation)-

Anabolic drugs promote bone formation, increasing bone density and strength. Among the most commonly used anabolic treatments is teriparatide, a recombinant form of parathyroid hormone (PTH). Teriparatide stimulates osteoblast activity, which promotes new bone formation. Studies have shown that teriparatide significantly reduces fractures, especially in high-risk patients. However, it is generally reserved for patients at very high risk due to concerns about potential side effects, such as osteosarcoma in animal studies. Though this risk has not been confirmed in humans, its use is typically limited to short-term treatment (up to two years). (Shoback et al., 2020) An alternative to teriparatide is abaloparatide, a PTH-related peptide analog that offers similar benefits in terms of bone formation but may have a lower risk profile.

2. Anti-Resorptive Agents (Bone Loss Prevention)-

Anti-resorptive drugs focus on slowing down or inhibiting bone resorption (the process by which bone is broken down). The most common anti-resorptive medications include bisphosphonates and denosumab.

1. Bisphosphonates: These drugs, which include **zoledronic acid, alendronate, ibandronate**, and

risedronate, are widely used to reduce the risk of fractures by inhibiting bone resorption. Zoledronic acid, for example, has been shown to reduce vertebral fractures by up to **70%**, while alendronate and ibandronate also provide significant reductions in fracture risk. Bisphosphonates are typically taken orally or intravenously, depending on the specific drug and dosing regimen. Side effects can include **gastrointestinal issues** (e.g., esophageal irritation) and **bone pain**.

2. Denosumab-This **monoclonal antibody** targets **RANKL** (Receptor Activator of Nuclear Factor Kappa-B Ligand), a key protein involved in bone resorption. Denosumab inhibits RANKL, leading to a reduction in bone resorption and a significant reduction in vertebral fractures (up to 68%). While denosumab is effective in preventing fractures, it can also have side effects such as **hypocalcemia** and **skin infections**.

3. Estrogen-Based Hormone Replacement Therapy (HRT)-

Estrogen therapy can help maintain or even increase bone mineral density (BMD) in postmenopausal women, particularly those under 60, who may be at risk for fractures due to the rapid decline in estrogen levels after menopause. Estrogen helps reduce bone resorption and maintains bone strength. However, long-term use of estrogen is associated with risks, such as breast cancer and cardiovascular issues, which has led to more selective use. Estrogen therapy is typically recommended for women within 10 years of menopause or those who experience early menopause. For women with a uterus, progesterone is usually added to the treatment to mitigate the risk of endometrial cancer, which can result from unopposed estrogen. (Genant et al., 1989)

CONCLUSION-

Osteoporosis is a significant health concern for postmenopausal women due to the rapid decline in



estrogen levels, which accelerates bone resorption and decreases bone density. This condition increases the risk of fractures, especially in the spine, hips, and wrists, leading to considerable morbidity and mortality. Early detection through bone density testing and risk assessment is crucial for effective management. Preventive measures, including adequate calcium and vitamin D intake, weight-bearing exercise, and lifestyle modifications, play an important role in reducing the risk of osteoporosis. Pharmacologic treatments, such as bisphosphonates, selective estrogen receptor modulators (SERMs), and newer agents like denosumab or romosozumab, are also essential for improving bone density and preventing fractures. A multidisciplinary approach to managing osteoporosis, combining prevention, monitoring, and treatment, can help postmenopausal women maintain bone health and quality of life.

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