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**Prevention and Management of Osteoporosis**

**Objectives:**

**The reader should be able to:**

1. Describe osteoporosis and give a general overview of the bone condition;

2. Describe who is at risk for osteoporosis;

 3. Describe the impact of diet, supplements, and medication on preventing or managing osteoporosis;

 4. Describe how physical activity can be beneficial in prevention of osteoporosis and management of osteoporosis once diagnosed;

 5. Discuss how osteoporosis is managed in post-menopausal women: hormone replacement therapy and physical activity;

 6. Discuss how physical therapy plays a role in osteoporosis management and identification;

 7. Describe the common fractures in people with osteoporosis and the associated implications

### What is Osteoporosis?

 Osteoporosis is a disease of the bones causing one’s body to resorb too much bone, produce too little bone, or both.1 Characterized by low bone mass and fragility, people affected are at an increased risk of fracture, especially of the hip, spine, and wrist.2 Around ten million Americans have osteoporosis, putting them at a high risk of these fractures.1 The seriousness of breaking a bone is a concern for many older adults with osteoporosis. Breaking a bone can cause stooped or hunched posture, severe pain, debility with daily activities, long hospital stays and costs, and can lead to other complications.1 According to the National Osteoporosis foundation, twenty percent of adults over 65 who break their hip die within one year and those that do not die may need long-term nursing home care.1 Risk identification, prevention, and management are all important aspects of keeping this disease under control from the perspectives of the patient and the therapist.

 Physical therapists, specifically, see patients frequently who have osteoporosis or people who are at risk for osteoporosis. Often times, osteoporosis is undiagnosed because it is such a silent and slow progressing disease.2 A patient that is at risk may have genetic factors linking them to osteoporosis, lifestyle practices, medications, other diseases predisposing them to osteoporosis.2 Some common examples of risk factors involving these categories are advanced age, family history, post-menopause, decreased physical activity, alcohol, vitamin D deficiency, smoking, corticosteroids, heparin, endocrine disorders, rheumatologic conditions to name a few.2,3 Some of these risk factors are modifiable, while others are not. Being able to decrease the effects of the contribution from non-modifiable risk factors by altering modifiable risk factors will help with prevention and management of osteoporosis.2

***Fractures:***

Common fractures are at the spine and hip for people with osteoporosis due to their weight-bearing components. Clinically, patients with back pain, vertebral deformities, or loss of height may have a vertebral fracture. However, almost three fourths of all vertebral deformities are asymptomatic which is why imaging is necessary to diagnose them.4 Hip fractures are very serious due to the high rate of mortality, associated morbidity, and financial cost.4 In fact, a year after hip fracture, approximately forty percent of the patients that have survived regain their previous level of function while 31,000 excess deaths can result within six months of the fracture in the United States.4 According to a study by Augat et al. of 233 women aged fifty years or older, the majority of fractures occurred after a minor traumatic event and more than a third of these patients were diagnosed with osteoporosis.5

***Diet:***

Diet is a modifiable risk factor that plays an important role in the prevention or contribution to osteoporosis.6 Throughout one’s life, diet has an influence on bone health. Positive bone health diets include protein, calcium (Ca), vitamin D, fruits, and vegetables, while a negative bone health diet involves a high intake of calories, heavy caffeine and/or significant alcohol consumption.6,7 Because peak bone mass is a major factor in osteoporosis risk, diet at a young age is very important.8 Ca is a main mineral component of bone and is needed at all stages of life to maintain bone health.8 Studies involving Ca consumption with controlled trials in young healthy subjects have shown that the subjects given Ca for 1-7 years have greater gains than controls.8 Having insufficient calcium intake creates an increase in bone turnover and acceleration in bone loss due to secondary hyperparathyroidism.6 Recommended daily dosage range from 700mg to 1300mg. According to an assessment, both men and women aged fifty and older have a median intake that is much lower than the recommended dosage in the United States. One prospective longitudinal study followed 61,000 women and their dietary intake with food questionnaires. Results were that a daily intake below 700mg was associated with increased risk of fracture.6 One review of twenty studies involving Ca supplementation in post-menopausal women concluded that appropriate Ca intake could decrease bone loss by approximately one percent per year.8

 For older adults, the most important nutrients for bone health are Ca and vitamin D. Vitamin D is needed to absorb Ca from the diet. Reduced amounts of Ca or vitamin D can cause lower concentration of ionized Ca, creating a rise in parathyroid hormone levels which alters bone remodeling.8 Some studies show an effect of combined Ca and vitamin D on fracture prevention in older and frailer participants.8 One meta-analysis of twenty-nine randomized controlled trials with participants greater than fifty years of age concluded that Ca alone or in combination with vitamin D is effective for the prevention of osteoporotic fracture.8 Adequate levels of vitamin D generally depend on levels of sun exposure or vitamin supplements because it is not contained in a large amount of foods. The most common dietary sources of vitamin D are vitamin D-fortified milk or milk substitutes, other dairy products, and cereals.6

 In addition to a vitamin D and Ca rich diet playing a role in osteoporosis risk, fruits, vegetables, and protein can affect bone health as well.6 Positives to eating a fruit and vegetable rich diet are that they contain minerals such as potassium, magnesium, and calcium; antioxidants such as polyphenols; phytoestrogens; and vitamins C and K.6 The potassium and magnesium keep dietary acid levels low which keeps osteoclasts stimulation at a minimum and continues to maintain osteoblast activity.6 Antioxidants control oxidative stress which contributes to the development of chronic disease.6 Vitamins C and K are important factors in the synthesis of the bone matrix. Eating fruits and vegetables has been shown through a population based cohort, The Canadian Multicentre Osteoporosis Study, to be associated with a reduced fracture risk independent of other risk factors. Another study of 3,000 Scottish women found that a diet rich in processed foods was linked to a decrease in bone density.6 In addition to fruits and vegetables, protein is important in bone density and fracture risk. Protein is approximately fifty percent of bone volume and one third of bone mass and undergoes remodeling and turnover constantly.8 A prospective cohort determined through a food frequency questionnaire and documentation of bone density changes over ten years that in older men, higher fish intake was associated with smaller amounts of bone loss at the hip.6 Randomized controlled trails are needed to further assess protein and its effects on bone health.8

 Caffeine and Alcohol are two substances that may be involved in one’s diet that can influence osteoporosis risk .6,7 In terms of alcohol, mild to moderate amounts have been associated with high bone density; however, alcoholism and high consumption is associated with osteoporosis risk and falls.6 With high, chronic alcohol consumption, a reduction in osteoblast number and activity, inhibition of osteoblast proliferation, increased osteocyte apoptosis, can be seen which results in decreased bone formation.6 Caffeine is a subject of debate in terms of its role in bone loss.7 Previous studies have shown that it can decrease bone mineral density, increase hip fracture risk, and has negative effects on calcium retention.7 One study by Hallström et al. observed that men that had four cups or more per day of coffee had a four percent lower bone density at the femur than men who drank little to no coffee.9 In females that have not undergone menopause (ages 14-40) and self-reported drinking greater than 200mg of caffeine, there was no associated bone mineral density loss.10 For women that are postmenopausal, greater than 300mg of caffeine per day could do irreparable damage to their bone density, creating a greater rate of bone loss.11

 ***Supplements:***

 Supplementation can be used to boost Ca and vitamin D levels if the person is not meeting the recommended daily values through other avenues. These recommended values are 400IU for vitamin D for adults between 51 and 70 years and 600 IU for adults 70 years or older.12 Recommended values for calcium intake from the Institute of Medicine of the National Academy of Sciences are 800mg/day for children ages 4-8 years, 1300 mg/day for 9-18 years, 1000 mg/day for 19-50 years and 1200 mg/day older than 51 years.13 The targeted population for supplementation are individuals at an increased risk of fracture (over 65 years old), osteopenic, and/or proven calcium and/or vitamin D insufficiency with a younger age. Generally, vitamin D and calcium dietary intake reduces with age. Production of vitamin D decreases due to decreased sunlight exposure and the diminished ability of cutaneous synthesis.12 As for Ca, absorption through the intestines as well as renal tubes decreases with age. For women under the age of 65 years, if calcium insufficiency is proven, recommendations for supplementation are usually made. The majority of studies that have investigated combining vitamin D and calcium in the form of supplementation in postmenopausal women have shown that with sufficient patient compliance, there is a reduced fracture risk.12

***Medications:***

Medications can play a role in increasing the risk of osteoporosis as well as a role in the management of osteoporosis. One set of drugs that increases osteoporosis risk are glucocorticoids due to their negative effects on BMD.3 Common medical conditions that are associated with these medications are rheumatoid arthritis and ankylosing spondylitis.3 Other medications that should be considered risk factors are long-term thyroid medications, diuretics, anticonvulsants, methotrexate, heparin, coumadin, cyclosporine, cholestyramine, and gonadotropin-releasing hormones.2 It is important to recognize if a patient is on one or more of these medications, especially long-term, that they may be at risk for osteoporosis.

 Some medications to manage osteoporosis post-menopause are estrogen therapy which is discussed below, bisphosphonates, salmon calcitonin, and raloxifene.4 Two bisphosphonates are risedronate and alendronate. These two medications have been proven effective in reducing the risk of fractures through several large, placebo-controlled, randomized clinical trials.4 Salmon calcitonin via nasal spray significantly reduced 5-year vertebral fracture risk by thirty-three percent in 1255 post-menopausal women when compared to a placebo. Risk was not reduced after just one year of therapy.4 Raloxifene, when given for three years, reduced vertebral fracture risk by thirty percent when compared to a control in 7705 postmenopausal women and was continued through a fourth year.6 Hip fracture risk was not reduced considerably with this type of therapy.4 All of these medications work to suppress bone turnover, creating modest surges in BMD, with bisphosphonates yielding the most prompt anti-resorptive properties.4 Biphosphonates have demonstrated risk reduction of hip and nonvertebral fractures as compared to salmon calcitonin and raloxifine, which have not generated these outcomes.4

***Physical activity:***

 Physical activity is a natural non-pharmacological way to prevent or ameliorate osteoporosis.13 Increasing exercise volume and intensity can raise the accumulation of peak bone mass in women.13 With that being said, when exercise competes with nutritional availability by too much volume and intensity, it can have an inhibitory influence on bone growth and mass accumulation.13 This can be observed in studies examining elite young female athletes vs. same-aged sedentary adolescents. The mechanisms to which physical activity act are stimulation of the bone through high amplitude movements causing recurrent mechanical stresses as well as small amplitude vibrations which in turn stimulates bone growth.13 Exercise also increases pulsatile hormone delivery of growth hormone, which stimulates cell proliferation in the bone. Another positive of physical activity is that it increases the blood supply to muscles which increases the supply of nutrients, hormones, and oxygen to bones.13

 At an early age physical activity can be positive or negative in terms of bone growth. Positives involve sports containing high applications of ground reaction forces. Some sports such as gymnastics, tennis, squash, or running have shown to result in significantly higher lumbar spine BMD in young female athletes prior to puberty and through the end of adolescence as compared to a reference population that are not athletes.13 At age 16 years, BMD begins to plateau at the hip joint or decline in non-athletic populations. In athletic populations participating in gymnastics and racket supports that load the hip joint show an increased BMD in the proximal femur.13 As women increase in age and reach their 20’s, longitudinal studies show little impact of exercise training on increasing bone mass or BMD.13

 In the years just prior to menopause, physically active women, have shown positive correlations between level of activity and bone status. These status measures are bone mineral content, BMD, body calcium, and body potassium. Through a regression analysis of a multitude of studies, physical activity can increase BMD by 12 mg/cm2 for the lumbar spine, 3.8 mg/cm2 for the distal radius, and 3.5 mg/cm2for the radial shaft for each 100 Kcal increase in energy expenditure.13

***Osteoporosis and post-menopause:***

 Menopause usually begins between the ages of 45 and 55 years and is associated with a decline in bone mass. These rates range from 0.3% to 1.5% of bone loss per year, detectable after the age of forty.13 Withdrawal of estrogen and progesterone levels begin in the early phase and are marked by rapid bone loss, an increase in plasma calcium concentration, and renal calcium excretion.13 Previous reviews (prior to the year 2000) looking at exercise and osteoporosis in postmenopausal women have concluded that all exercise programs involving aerobic exercise, resistance exercise, or walking are effective at one year or greater in decreasing the rate at which BMD is lost.14 Fast walking was recommended as the best treatment strategy in this population due to its relevance with activities of daily living as well as its high compliance.5 A current review included seven studies, three of which are randomized controlled trials. The results were that the risk of hip fracture decreases with physical activity as well as bone loss rates slow in a dose-dependent manner.14 Also concluded was that exercise programs may increase BMD in post-menopausal women.14

 In addition to physical activity having a positive impact on BMD in postmenopausal women, hormone replacement therapy (HRT) has been shown as an effective method to combat bone loss. HRT involves decreasing the rate of triggering of bone remodeling and may correct the disparity between resorption and formation in the remodeling cycle by increasing estrogen levels.15 Studies have shown an increase in bone mass after one to two years and a reduced rate of bone loss. Other studies have shown prevention of vertebral and hip fractures.15 A meta-analysis of twenty-two randomized controlled trials involving HRT and fracture data determined that HRT does prevent fractures with the relative risk reduction being thirty-five percent for vertebral fractures and fifty percent for hip fractures in women initiate therapy before sixty years of age.16 None of the studies in this meta-analysis showed statistical significance of HRT on fractures in women that started HRT when older than sixty years of age.16

 Although benefits of HRT on osteoporosis in postmenopausal women have been proven, there are risks involved. According to the National Osteoporosis Society, a study by the Women’s Health Initiative (WHI) concluded that the risks outweighed the benefits with seven coronary heart disease events, eight strokes, eight pulmonary emboli, and eight breast cancers per 10,000 women years’ treatment of HRT.17 The benefits from this study were that for the same amount of years, five hip fractures and six colon cancers were prevented.17 After much research, a position statement was formulated from the National Osteoporosis Society stating the positives and negatives of HRT. Included in this was the recognition of it being an effective treatment for menopausal symptoms and protection against fractures of the hip and spine, however it is not considered suitable to start after the age of sixty years.17 This statement also says that the risks associated with HRT are low if a postmenopausal women below the age of sixty does not exhibit risk factors for breast cancer, heart disease, stroke or venous thromboembolism16 Lastly, an important part of the statement says that HRT is recommended for women who have undergone menopause early whether it be naturally or surgically until the normal age of menopause (around fifty years of age) to avoid symptoms of sustained estrogen deficiency as well as reduce bone loss.16

***Osteoporosis and men:***

Although much of the focus of osteoporosis relates to postmenopausal women, men are at risk too. According to the National Osteoporosis Foundation, one in four men over 50 years of age will have a fracture due to osteoporosis.1 In fact, the chances of breaking a bone due to osteoporosis is higher than getting prostate cancer.1 The majority of the risk factors are the same as women and can be managed in similar ways.1

***Clinical Relevance and the role of physical therapy:***

 A physical therapist encounters patients frequently who are at risk for osteoporosis. Recognition and assessment through history, screening, observation of movements and positioning should be incorporated in the evaluation so that interventions can be safe and so that the patient is aware of the risks of the disease.2 Meeks describes a decision tree involving a history with questions about modifiable and non-modifiable risk factors as well as recent falls, daily habits, analysis of their DEXA scan if available (osteoporosis screening tool), information on pain, body height, posture, balance, gait, functional activities, and restriction patterns.2 Cardinal signs of low bone mass are body height loss, postural changes usually involving an increase in thoracic kyphosis, or a fracture after the age of fifty.2

 Once recognition has been made that a patient either has osteoporosis or may be at risk, a safe treatment intervention is necessary to minimize the risk of fracture. Weight-bearing and resistance exercises are recommended for people with osteoporosis with the challenge of providing the right amount of loading so that the bone is not overloaded, yet is loaded just enough to maintain or increase density and strength.2 Under loading the bone is also a problem due to more bone loss. Exercises involved in an intervention should be focused on body alignment so that the forces of muscle contraction and weight bearing are transferred through the correct anatomical alignment of the bone.2

### Conclusions:

 Due to the fact that osteoporosis is such a common disease, it is vital to know its prevention and management as a person at risk and as a provider. Fractures as a result of osteoporosis can be severely debilitating and are associated with negative outcomes. Physical therapists should be educated so that they can inform patients about how they can decrease their risk of osteoporosis by decreasing the contribution of modifiable risk factors. Knowing the ways to battle this disease through diet, medications, supplements, and physical activity can significantly reduce the risk or impacts of osteoporosis, thus reducing risk of fracture.

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