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The Effect of Exercise on Postmenopausal Women with Osteoporosis

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Abstract

Millions of Americans are living with osteoporosis, with nearly one in two women being affected due to their delicate bone structure and decline in estrogen hormone level. Consequently, half of women over the age of 50 will break a bone as a result of osteoporosis. Although osteoporosis is highly prevalent, it is not an inevitable part of aging. Today there is much more knowledge on how to prevent, detect, and manage the disease. Good lifestyle habits, including exercise, can protect bones. The greater a woman's bone density reaching menopause, the lower the chance of developing osteoporosis. On the contrary, poor lifestyle habits can decrease not only bone density and strength but hinder an individual's overall functional ability. A portion of this paper will review a primary care clinic visit with patient, M.J., an elderly postmenopausal woman who suffered a hip fracture from an unprovoked fall requiring surgery and hospitalization. She is a chronic cigarette smoker with a past medical history of chronic obstructive pulmonary disease (COPD) and frequent steroid use. The effect of exercise in postmenopausal women with osteoporosis will be analyzed and evaluated as it relates to M.J.'s case. Weight bearing and/or impact exercise programs with at least 30 minute sessions and frequent weekly attendance has been shown to provide the best bone health.

The Effect of Exercise on Postmenopausal Women with Osteoporosis

Osteoporosis is characterized as a degenerative metabolic bone disease involving systemic osteopenia, microstructure bone deterioration, increased osteopsathyrosis, and decreased bone strength (Dunphy, Winland-Brown, Porter, & Thomas, 2015). The term osteoporosis means 'porous bone' since the bone takes on a honeycomb appearance as it weakens. Osteoporosis is clinically diagnosed in individuals with a bone mineral density (BMD) of 2.5 standard deviations below (>-2.5) the peak mean of an adult. This differs from osteopenia which is a less severe form of decreased BMD (-1.0 to -2.5), and osteomalacia which signifies a decrease in bone mineralization (Dunphy et al., 2015). A dual energy x-ray absorptiometry (DEXA) scan is used to measure BMD in the lumbar spine and hip. The DEXA scan has limited picture and complete patient dynamic, so the Fracture Risk Assessment Tool (FRAX) is also used as a predictor for future fracture risk. Decreased quality of life from a reduction of independence, fragility, increased fracture risk, and decline in physical, social, and mental security are all consequences of osteoporosis.

Background

Osteoporosis is a serious public health concern around the world as it drastically increases both morbidity and mortality in its sufferers. An estimated 54 million Americans in the United States and hundreds of millions on a global scale are affected (NOF, 2019). The development of osteoporosis is largely multifactorial. Genetic factors have been shown to increase susceptibility up to 70%, however there are many contributing features. Lifestyle factors include low body weight, cigarette smoking, excessive alcohol use, and low calcium and vitamin D intake. Certain disease-states increasing risk are thyrotoxicosis, hyperparathyroidism,

Cushing's disease, rheumatoid arthritis, and secondary estrogen deficiency as seen in postmenopausal women. Medications such as glucocorticoids, excessive thyroxine, and long-term phenytoin use are also risk factors that can predispose individuals for BMD variance (Dunphy et al., 2015).

Postmenopausal women are more prone to a rapid decline in BMD due to having smaller, thinner bones than men and decreased circulating estrogen levels. In postmenopausal osteoporosis, also known as Type 1 osteoporosis, there is an increased rate of bone resorption without bone formation, leading to significant bone loss. Type 1 osteoporosis often takes effect within 15 to 20 years of menopause, with the most rapid bone loss occurring the initial five to seven years (Zehnacker & Bernis-Daughtery, 2007). Increased fracture risk is considered a major health concern among the aging population affected by osteoporosis. "A woman just over the age of 50 in the United States has a 3.4%, 5.3%, and 6.8% risk of experiencing a fragility fracture within the next 10 years based on normal, low, and osteoporotic bone mass, respectively evaluated by dual energy X-ray absorptiometry (DXA) T-scores" (Troy, Mancuso, Butler, & Johnson, 2018, p. 1). In 2011, over 1.7 million people were hospitalized due to fragility fracture, with osteoporosis treatment costs just beyond 70 billion dollars in the United States alone (Troy et al., 2018).

Unfortunately, no treatment has been found to fully replenish a reduced BMD caused by osteoporosis. There are many effective pharmaceutical options developed for osteoporosis but preventing bone density decay remains the best option. The National Osteoporosis Foundation and International Osteoporosis Foundation recommend physical activity involving weight-bearing and resistance to contribute to bone health. The information provided in the literature will review M.J., a postmenopausal woman seeking clinical care following a right hip fracture

and repair due to a fall. M.J. has significant risk factors for osteoporosis which will be discussed in more detail as the case unfolds. The purpose of this report is to determine the effects of exercise, with predominate focus on weight-bearing exercises, in postmenopausal women with osteoporotic disease.

Case Report

M.J. is a 72 year old Caucasian female who presents to clinic for a follow-up visit after being discharged from the hospital. M.J. was hospitalized for three days due to a right hip fracture. She underwent an open reduction and internal fiction (ORIF) of her right hip after suffering a fall. She states that her right leg "just went out" while walking in her house causing her to fall to the floor. A popping sound and intense pain to her right hip followed the fall. She was then brought immediately to the Emergency Room for further evaluation.

She denies tripping over a rug or walking on uneven flooring. She rejects alcohol or illicit drug use. She denies dizziness, lightheadedness, room-spinning, change in eyesight, confusion, slurred speech, headache, chest pains, shortness of breath, weakness, or syncope. She denies recent fever or illness, and she has not started on any new medications. She does not use any assistive devices to walk, and she does not have a fall history. Other than the sudden fall she was feeling well. She states her right hip incision is healing nicely, and her hip is functioning like new. She refers to a mild pain rating the pain a two or three (on the zero-to-ten scale) to her right hip with ambulation, but the pain lessens with over-the-counter Tylenol. Otherwise, she has no significant changed arthralgias or myalgias. She has no concerns regarding post-operational ability, and she remains in physical therapy two days a week. She notes she would also like to establish care with this writer when she is able.

M.J. has no known drug allergies. She has a past medical history of chronic obstructive pulmonary disease (COPD), anemia, hypertension, hypercholesteremia, and is a current cigarette smoker. She has no other surgical history beyond the ORIF and an unremarkable family history. She eats a well-balanced diet and consumes at least one glass of two percent milk each day. She is approximately 22 years postmenopausal. She currently smokes one pack per day for the past 45 years. She has tried quitting on several occasions with use of nicotine patches but has not succeeded. She has a history of prednisone use due to COPD flares, and she also uses a daily inhaler (fluticasone propionate and salmeterol 250/50). She denies an increase in inhaler use recently. The last prednisone burst completed one day ago. She feels her breathing is normal currently. She is taking losartan 50 milligram (mg) and metoprolol 50 mg for her hypertension. She is on Lipitor 20 mg for her hypercholesteremia and iron sulfate 325 mg for her anemia. Since being hospitalized, she has felt more tired than usual. M.J. also takes paroxetine 20 mg and quetiapine 200 mg daily and states her mood has been stable and of no concern. She is also taking a daily multivitamin. M.J. is up-to-date on her vaccines except she has not received her yearly influenza vaccine or the pneumonia vaccines. Her activity level is fair, but she does not currently have a regular exercise routine.

Her vital signs are as follows: blood pressure 138/70, heart rate 72, respiratory rate 16, temperature 98.6 degrees Fahrenheit, and oxygen saturation 92%. She is 5 feet, 4 inches tall and 154 pounds with a body mass index (BMI) of 26.4. This would categorize her with an overweight BMI. M.J. is an alert and pleasant female who appears to not be in any acute distress. She has a normal cardiac rate and rhythm, with both S1 and S2 heart sounds heard. No additional heart sounds heard including S3, S4, murmur, rub or gallop. Her lungs are clear to auscultation. She does not appear to be short of breath and her chest expansion is symmetrical and unlabored.

There is no wheezing, rales, or rhonchi heard throughout the lung fields. Her abdomen is soft with equal contour. Bowel sounds are active in all four quadrants. There is no guarding during her abdominal examination and no concern for abdominal tenderness, bloating, swelling, masses, or organomegaly. Her skin color, texture, and turgor is normal. The ORIF surgical incision scar is dark pink in color and is approximated and healing properly. The surrounding skin is free from erythema, swelling, warmth or drainage. She has appropriate right hip range of motion (i.e. abduction and adduction) and no limitation with lifting her right leg. Her bilateral leg strength is symmetrical, her right foot is warm with a capillary refill under three seconds. She has appropriate right leg sensation and her gait is unaffected.

Due to M.J.'s past medical history of advanced age, postmenopausal status, excessive cigarette smoking, frequent inhaled and oral steroid use, and recent unprovoked fall, she poses significant concern for the diagnosis of osteoporosis. Her FRAX score calculation revealed a 40% major osteoporotic fracture risk and a 19% hip fracture risk within 10 years (Centre for Metabolic Bone Diseases, n.d.). Having M.J. undergo a DEXA scan to measure her BMD would be beneficial for her plan of care going forward, including future fracture prevention. Based on her overall DEXA T-score of -2.6, M.J. would be categorized as osteoporotic. Lifestyle management including a weight-bearing exercise class, smoking cessation, limiting tripping hazards, optimal calcium (1,5000 mg/day) and vitamin D supplementation is recommended. She should also be started on pharmacological management such as a bisphosphonate. It was discussed that following up with BMD testing should be in two year intervals. Today she will also receive the influenza and pneumonia (PVC13) vaccine. She was educated that she will need to receive the second pneumonia vaccine (PPSV23) at least a year from now.

Furthermore, we discussed having her be seen in the clinic within the next couple weeks to establish care. Additional encouragement on smoking cessation would be deliberated, as well as obtaining a low dose computed tomography (CT) scan for yearly lung cancer screening due to her smoking history. Also, a lipid profile to monitor her hypercholesteremia, a red blood cell count and hemoglobin to monitor her anemia, and a full physical assessment would be obtained. She should continue her physical therapy as it is scheduled, and counselling on weight-bearing exercise programs to inspire continued functionality as a postmenopausal osteoporotic woman will be provided.

Literature Review

M.J. is among the millions of older adults suffering from osteoporosis, a multifactorial, microarchitectural deterioration of bone tissue that increased her fracture risk. It is estimated that nearly four out of ten osteoporotic women over the age of 50 in the United States will experience a spine, hip, or wrist fracture as they age (Dunphy et al., 2015). With rise in osteoporosis diagnosis and related fractures in today's maturing population, comprehensive prevention, screening, and innovative treatment programs must be utilized to preserve health. This effort will decrease incidence and the cost burden of osteoporosis on individual victims and the nation. The following literature review gives rise to the effects of exercise on osteoporosis. Exercises in many forms has been shown to increase strength, mobility, balance, and ultimately increase BMD.

PubMed and CINHAL were navigated to find sufficient and current evidence-based data. Key terms contained ((exercise)) AND postmenopausal women) AND osteoporosis. To limit the search results, specific limitations were acknowledged such as PDF Full-Text available, English language, limited to the last 10 years, human studies, and evidence-based practice. The article

per Zehnacker & Bernis-Daughtery was included as it was discovered as a related article to the others analyzed. Appropriate articles described exercises' effects on bone remodeling, weighted versus high-intensity resistance versus aquatic exercises, exercise intensity level and duration, balance control, and community-based exercise programs for osteoporosis.

Although not completely curable, osteoporosis is both preventable and partially treatable with exercise playing an important role in overall osteogenesis, the formation of bone. Eighty to ninety percent of peak adult bone mass is accrued by age 16 in women (Troy et al., 2018). By the time a woman is 18 years old their peak bone mass should be attained, with bone growth preserved through their third decade. Failure in reaching and maintaining optimal peak bone mass as an adult is a critical factor in the progression of bone fragility and fracture (Troy et al., 2018). Bone growth during childhood is particularly sensitive to physical activity, resulting in increased bone size and density that persists for many years. Bone adapts its structure to the typical mechanical environment it is exposed to, as if it has a memory. A history of physical activity is linked with beneficial structural features in mature skeletal bone (Troy et al., 2018). Functional adaptation, where bone cells modify their structure in response to loading, lead to greater BMD, greater cross-sectional area of bone, and increased bone inertia resulting in a stronger skeleton (Troy et al., 2018).

After the third decade of life humans begin to lose bone mass. Exercise can help maintain muscle strength, balance, and coordination which ultimately helps prevent falls and fractures (NIH, 2018). Osteoporosis is caused by a disruption between bone formation and resorption. Bones are generated by osteoblasts and bones are broken down by osteoclasts. Bone formation is particularly responsive to mechanical loading exercises, which act on the bones through muscle and ground reaction forces. These actions increase both BMD and bone strength (NIH, 2018).

The two extrinsic forces acting on the skeleton to increase BMD during exercise include 1) supporting the body mass against gravity, and 2) the muscle-tendon unit pulling on the bone during muscular contraction (Zehnacker & Bernis-Daughtery, 2007). Exercise in general leads to an increase in fluid flow, tension, compression, and hydrostatic pressure. Muscular action transmits tension to the bone and the strain leads to anabolic effects by stimulating osteoblast proliferation. These mechanical signals increase the amount of bone marrow mesenchymal stem cells (MSCs), or multipotent cells, that can proliferate into osteoblasts. Exercise involving climbing and swimming regulate bone metabolism through specialized mRNA signaling, increasing osteogenic differentiation of MSCs into osteoblasts (Yuan et al., 2016).

Exercise also causes a series of physiological responses involving the release of growth hormone, prostaglandins, parathyroid hormone, and thyroid hormones. Some of these hormones help stimulate the differentiation of MSCs into osteoblasts (Yuan et al., 2016). Estrogen also plays a large role in bone formation and has been noted to inhibit MSC apoptosis and increases the amount of MSCs. Moderate exercises have been linked to increasing the levels of estrogen in humans and promoting osteogenic differentiation (Yuan et al., 2016). An up-regulation of osteogenic markers (i.e. OCL, Runx2 Osx, BAP, BMP2, and type 1 collagen) and a decrease in bone resorption biomarkers (i.e. tartrate-resistant acid phosphase (TRAP) have been seen in women taking part in an exercise program involving resistance and combined aerobic/resistance exercise. Cyclical stimulation in as little as five-minute daily jumping exercises can significantly inhibit osteocyte apoptosis while improving osteocyte viability, especially in the trabecular bones (Yuan et al., 2016). Conversely, absent physical activity and bedrest produces negative effects on bones by inhibiting osteoblast activity and/or the enhancement of osteoclastic activity (Yuan et al., 2016).

An exercise program for osteoporotic individuals should be gearing towards posture, balance, coordination, gait, and hip and trunk stability. More specifically, exercise therapy for postmenopausal women should focus on increasing muscle mass and function to decrease fall and fracture risk (IOF, 2018). The work out should combine a warm-up, a workout and a relaxation period. Ground weight-bearing and high intensity exercises involve countermovement jumping, box-drops, heel-drops, and stamping (Montgomery et al., 2019). Running variations, rope skipping, and high-impact aerobic dance (i.e. Zumba) have also been incorporated in programs (Kemmler, Bebenek, & von Stengel, 2015). Strength-training exercises involve elastic belts, isometric exercise, dumbbells, and weighted vests. Many programs use hydraulic resistance machines for seated rowing, back extension, and abdominal flexion or bench press (IOF, 2018). In a randomized study of osteoporotic women with a mean age of 80, exercises geared at increases lower limb strength and balance showed a significant reduction in falls (IOF, 2018).

Studies have shown that both ground and aquatic exercises are beneficial to the remodeling of bone tissue (Moreira et al., 2014). The osteogenic effects of walking, which is the most common ground exercise worldwide, revealed that the impact from this activity can slightly improve femoral BMD in postmenopausal women, but there was no positive effects on BMD in the spine (Moreira et al., 2014). BMD changes seen with walking exercise required intervention lasting more than six months and walking as a singular exercise was not enough to stimulate BMD to any large degree. Similarly, postmenopausal women who alternated treadmill walking and step climbing saw improvement in their BMD in the lumbar and femoral neck areas, and those involved in high-impact exercises found increase in lumbar and femoral neck BMD compared to strengthening exercises or sedentary lifestyle (Moreira et al., 2014). Serum

osteocalcin, a bone formation marker, increased, and NTx, a bone resorption marker, decreased in the high-impact group (Moreira et al., 2014). A program of moderate to high intensity, including three to four cycles of eight to twelve repetitions of each exercise achieved two to three times a week improved BMD of the hip and femur in postmenopausal women when maintained for over one year (Moreira et al., 2014).

In a study analyzed by Balsamo et al., 2013, it was found that the concurrent use of hormonal replacement therapy with estrogen along with weight-bearing aquatic exercise in postmenopausal women revealed a higher total body BMD with particular increase in the spine and total hip compared to an untrained group. And surprisingly, there was an insignificant difference in BMD increase between the strength-trained group and the water-trained group (Balsamo et al., 2013). Swimming does not seem to negatively affect bone mass, but it is not often considered to increase bone mass in osteoporotic adults due to the hypo-gravity and low-impact nature. There has been positive effects on postmenopausal physical function after high-intensity aquatic exercise including a reduction in the number of falls (Balsamo et al., 2013). Other variables that significantly improved included increased flexibility, unipedal stance, mobility, handgrip strength, strength of back extensor muscles, hip flexor muscles and knee extensor muscles (Moreira et al., 2014).

Elderly populations often present with joint limitations such as knee problems, osteoarthritis, herniated discs, and vertebral fractures, making impact exercises intolerable. No-impact resistance training is recommended for this population (Moreira et al., 2014). Exercise that best benefit the femoral neck is lower limb no-impact resistance training, and the best benefit for spine is combined resistance and aerobic exercises (Moreira et al., 2014). Water weight-bearing exercises in the elderly has improved not only neuromuscular and functional

health but also has cardiometabolic effects (Balsamo et al., 2013). The reduction of gravity forces when immersed in the water makes this exercise more comfortable for the elderly with joint disease. Also, the environment in the water is encouraging to the development of balance and muscle strength. Waves not only challenge center of gravity but stimulates trunk muscles to control balance (Moreira et al., 2014).

Osteoporosis and related fractures, especially hip fractures, can lead to decreased self-sufficiency, permanent physical disability, increased mortality, and hospitalizations. Fractures to the spine, hip, and wrist are the common in postmenopausal women with osteoporosis. Vertebral compression fractures and hip fractures decrease overall quality of life and increase morbidity. Women with the highest rate of vertebral compression fractures include those greater than 52 years of age, with a BMI of less than 22 kg/m^2, and low exercise frequency (Hsu, Chen, Tsau, & Yang, 2014). Eighty-two percent of the fractures reported in a large study of postmenopausal older women were due to falls (Hsu et al., 2014). Age-related fall risk factors include poor vision, vestibulopathy, impaired gait, reduced muscle strength. Women with osteoporosis have less flexibility and mobility that affects ambulation to a greater capacity than that of men. Postural correction exercises are important for these individuals and has the capacity to reduce vertebral compression fractures. Estrogen-deficient older women who participate in a back extensor strengthening programs show a ten year long benefit (Hsu et al., 2014). Pilates, yoga, and Tai Chi are wonderful core strengthening exercises. These specialties promote functional movement strength and decrease falls but there is low evidence of these practices increasing BMD to a degree of relevance (Hsu et al., 2014).

Unlike pharmacological agents, exercise effects all fracture parameters including fall risk, fall impact, and overall bone strength. When studying long term effects of exercise on BMD,

adherence to an exercise program appeared to be a relevant problem. Less people poorly tolerate bisphosphonates and discontinued therapy compared to quitting physical exercise programs (Kemmler, Engelke, & von Stengel, 2015). Overall, a sophisticated exercise program showed a long term effect on BMD at the lumbar spine and femoral neck sites, slowing the progression up to 16 years compared to a non-exercising control group (Kemmler et al., 2015). Long term pharmacological therapy and mutual exercise have been shown to maintain and even increase BMD. Dual therapy is the most beneficial evidence-based strategy in combating osteoporosis after menopause if the individual is motivated (Kemmler et al., 2015).

Advanced age is one of the key factors found in individuals diagnosed with osteoporosis and unfortunately there is a rather low sports participation in this population. Due to people's low enthusiasm to participate in regular exercise as they age, there has been much analysis on the exercise tolerance and frequency effectiveness among aging individuals, particularly postmenopausal women. An exercise frequency study (ExFreq) looked at 55 early postmenopausal women with osteopenia to help determine the critical dose of exercise that affects bones. It was noted that maintaining adequate exercise participation of at least two sessions per week of at least 30 minutes was essential for affecting BMD in early postmenopausal women (Kemmler, von Stengel, & Kohl, 2016). Additionally, there was a closer relationship found between exercise frequency and BMD in the lumbar spine in these women compared to changes seen in the hip (Kemmler et al., 2016).

Community-based public health programs focused on osteoporosis prevention have been implemented world-wide. The National Institute of Health Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy noted that the disease affects all populations, but it is preventable with achieving maximal BMD through adequate calcium intake and weight-

bearing exercise (Nguyen, 2017). Programs have reported more success in increasing calcium intake than weight-bearing exercises. Only a few of the programs were successful in motivating participants to increase their weight-bearing exercises to the proper extent needed. The reason was unclear other than calcium intake and exercise are vastly different behaviors (Nguyen, 2017). Calcium intake is significantly easier to achieve, especially in the aging population. However, community-based public health programs that incorporated high-intensity weight-bearing exercises showed to significantly increase BMD in osteoporotic individuals that followed the program 80-85% of the time (Nguyen, 2017).

Zehnacker and Bernis-Doughtry (2007), conducted an analysis of several studies focused on the effects of weighted exercises on BMD in postmenopausal women. The studies concluded that the duration of an exercise program for osteoporotic women should be at last one year for notable changes in BMD at the femoral neck and trochanter to be seen (Zehnacker & Bernis-Daughtery, 2007). Bone undergoes a continued process of formation and resorption but as we age the resorption process speeds up. The total time of bone formation at a bone multicellular unit is about four to six months long (Zehnacker & Bernis-Daughtery, 2007). Weight training should be at least two to three times that period, or 12 to 16 months to be in an equalized state. Postmenopausal women require longer periods of high-impact intervention and heavier loads to achieve increased BMD compared to premenopausal women because they are at a point of accelerated bone loss (Zehnacker & Bernis-Daughtery, 2007). Physical therapists should revise their treatment protocol. Women who are postmenopausal with osteopenia have found to benefit from less frequent but longer duration of therapy. Also, dividing exercises into periods of high intensity with regeneration periods help give motivation and avoid injury (Zehnacker & Bernis-Daughtery, 2007).

Given the recent and relevant data presented, it is apparent that weight bearing exercises, those that force an individual to work against gravity such as jumping, jogging, climbing stairs, dancing are best for bone remodeling. Incorporating resistance exercises has also been shown to improve overall functionality (i.e. strength, balance, and coordination) in individuals with osteoporosis. These exercises include lifting weights, elastic bands, and high-intensity aquatic exercises. Both consistency and duration of exercise programs is key for significant improvement in BMD. Best results are seen in motivated individuals who are concurrently on pharmacological management and are in a dedicated exercise program. Participation involves at least two to three times a week of at least a 30 minute design integrating warm up, high-impact activity, stretching, and cool-down phases over a year's time for best results. Exercise in able, unrestricted postmenopausal women aimed at increasing muscle mass and BMD will decrease falls and promote a healthier, happier, safer lifestyle.

Learning Points

- Exercise programs for individuals with osteoporosis should target balance, coordination, posture, and hip and trunk stabilization, and gait.

- Weight bearing and impact exercises are best for bone remodeling. This includes jumping, jogging, stair-stepping, dancing, dumbbells, and tennis/racquetball.

- Walking and aquatics can be beneficial for restricted individuals with cannot exert strong force due to very weak bones or vertebral fracture. Low impact activities provide less BMD increase than high impact activities but are better than sedentary lifestyle.

- Individuals should participate in a guided exercise program at least two to three times a week for at least 30 minutes. Consistency and duration of exercise programs, especially participation for a year or greater provide the best bone health.

- Exercise alone will not positively impact osteoporosis enough for satisfying results. Individuals must adhere to a pharmaceutical plan as well as increase dietary calcium and modify risky lifestyle behaviors.

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