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Investigating the factors that affect osteoporosis in an aging population.

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Abstract

Background: Osteoporosis is a major public health issue that has been a large topic of discussion for the last 20 years. It is largely prevalent in an aging population and primarily in post-menopausal women. Those with osteoporosis experience enhanced bone fragility, contributing to an increased risk of fractures and falls.

Purpose: This narrative review provides a brief overview of osteoporosis and examines the modifiable factors that contribute to the effects of osteoporosis in an aging population. **Methods:** Information was gathered through databases including PubMed, UBC Library, and Google Scholar. **Results:** Adequate consumption of calcium and vitamin D as well as regular exercise are factors that are recommended to increase bone mineral density and reduce the risk of osteoporotic fractures. Additionally, engaging in alcohol consumption, cigarette smoking, and a sedentary lifestyle should be avoided to optimize bone health. **Conclusion:** Lifestyle factors and the consumption of relevant nutrients required for bone health can be modified in order to reduce the risk of developing osteoporosis in an aging population. Further research should aim to investigate the effects of a variety of different levels of physical activity and alcohol consumption, as well as the effects of calcium supplementation on cardiovascular health. **Health & Fitness Journal of Canada 2020;13(2):30-36.**

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Introduction

Osteoporosis is currently defined as a skeletal disorder that is characterized by compromised bone strength which predisposes an individual to an increased risk of bone fracture (Sipos, Pietschmann, Rauner, Kersch-Schindl, & Patsch, 2009). It affects up to 49 million individuals in nine industrialized countries within North America, Europe, Australia, and Japan (Wade, Strader, Fitzpatrick, Anthony, & O'Malley, 2014). In Canada, 19.2% of women and 3.4% of men aged 50 or older reported that they had been diagnosed with osteoporosis by a health care

professional in 2009. These numbers increased to 31.1% and 6.4% of women and men, respectively, for those aged 71 or older (Garriguet, 2011).

Primary osteoporosis occurs as a result of estrogen deficiency, while secondary osteoporosis is defined as low bone mass and micro alterations in bone strength as a result of age-related declines in overall health (Mirza & Canalis, 2015; Sipos et al., 2009). Aging is accompanied by a decline in bioavailable estrogen, increased oxidative stress, and chronic inflammation that decreases bone density (Clowes, Riggs, & Khosla, 2005; Sipos et al., 2009).

Often referred to as a silent disease, osteoporosis commonly goes undetected until a fracture occurs. These fractures happen primarily at the spine, hip, and wrist (Golob & Laya, 2015). In the year 2000, there was an estimated 1.6 million hip, 1.7 million forearm, and 1.4 million vertebral fractures globally (O'Donnell, 2013). Most cases occur in postmenopausal women, with its prevalence rising from 4% in women ages 50 to 59 to 52% in women ages 80+ (Looker et al., 1998). It has been estimated that 50% of women and 20% of men over the age of 50 years will have an osteoporosis related fracture in their remaining lifetime (Sözen, Özışık, & Basaran, 2017). By the year 2025, the cost of direct care for these fractures, including medical office visits, hospital admissions, and nursing home admissions is projected to be a staggering \$25.3 billion (Golob & Laya, 2015).

Other factors such as racial background and prior medical conditions can predispose individuals to osteoporosis. Both type 1 and type 2 diabetes mellitus are associated with an increased risk for osteoporosis-related fractures (Kurra & Siris, 2011). Osteoporosis is also one of the most common comorbidities in systemic lupus erythematosus (SLE), with recent cross-sectional studies demonstrating a high frequency of osteoporosis in SLE (Zhu et al., 2014).

Purpose

This narrative review provides a brief overview of osteoporosis and investigates the factors that affect osteoporosis in an aging population. Through this review, information on lifestyle factors, nutrition, supplementation, and exercise are provided as a resource of knowledge

translation for those who are looking to gain awareness about the topic.

Methods

Information was gathered through the search of relevant articles via electronic databases including PubMed, UBC library, and Google Scholar. This contained contents from 2003 to 2019.

Results

Lifestyle

Lifestyle factors influence 20-40% of adult peak bone mass (Weaver et al., 2016). Other factors that influence adult peak bone mass include family history, age, gender, hormonal levels, and the presence of comorbidities (Beck, Daly, Singh, & Taaffe., 2017). Three lifestyle factors that have been primarily studied in regard to osteoporosis are alcohol consumption, cigarette smoking, and physical activity levels (Weaver et al., 2016).

Alcohol consumption in early adulthood has been found to suppress bone growth, lower bone mineral density, and lead to the failure to reach optimal bone mass (Bultink & Lems, 2013).

Cigarette smoking has been found to have direct effects on osteogenesis including alterations in collagen metabolism and bone angiogenesis (Bultink & Lems, 2013). Indirect effects of smoking may produce alterations in intestinal calcium absorption, as well as dysregulation in sex, adrenal cortical, gonadal and calciotropic hormone production (Bultink & Lems, 2013).

The importance of physical activity has been widely supported across research for optimal bone health. Moderate levels of physical activity have been found to regulate bone maintenance, stimulate bone formation, and reduce the risk of falls and fractures (Borer, 2005; Sinaki & Pfeifer,

2017). Recent human trials have not yet determined the optimal dose of a combination of both aerobic and musculoskeletal exercise for prevention of osteoporotic related fractures. However, a minimum of at least two sessions per week of progressive resistance training as well as three to seven sessions per week of balance and impact activities are recommended (Beck et al., 2017)

Exercise Prescription

Prescriptions for osteogenic exercise and rehabilitation measures need to be individualized (Sinaki et al., 2010). An assessment of each individual's musculoskeletal competence must be done prior to the prescription of an exercise program to improve patient compliance.

This includes, but is not limited to, spine and hip bone mass, cardiovascular health status, age, and past history of physical activity interests (Sinaki et al., 2010). An ideal exercise prescription program should

incorporate weight bearing, resistance training, and balance focused exercises to optimize bone health and aid in the prevention and rehabilitation of osteoporosis (Table 1). Regularly engaging in these exercises can prevent osteoporosis by increasing bone mineral density to build stronger bones and improve balance, stability, and coordination. This, in turn, reduces the risk of falls and subsequent fractures (Hingorjo, Syed, & Qureshi, 2008; Hong & Kim, 2018). The use of progressive balance-focused exercises such as Tai Chi and gait training have been cited as adequate fall prevention strategies (Body et al., 2011). Exercise programs that are shown to be most effective in the prevention of osteoporosis primarily target the spine and hips. Weight bearing exercises, such as walking, are important for maintenance of bone mineral density of the hips and lower extremities. Progressive, resistive back extension exercises can enhance strength of the

Table 1: Outline of exercises to prevent and manage osteoporosis

Type of exercise	Goal	Modality	Guidelines
Weight-bearing exercises	Accumulate bone mineral density ^a	High- to medium- impact: basketball, jumping, skipping rope, tennis, volleyball, and jogging ^b	30-60 min. per day, 3-5 days a week (preferably every day) ^a
		Lower impact: brisk walking, and stair climbing ^b	
Resistance training	Accumulate bone mineral density ^c	Performing work against a load such as free weights, bodyweight, resistance bands, and machines ^c	8-12 reps per set, 3 sets per exercise, 2-3 times per week ^c
			Target major muscle groups on non-consecutive days ^c Progressive overload ^c
Balance-focused exercises	Improve stability, coordination, and posture ^d	Tai chi, balancing on toes/heels, and back extension ^d	15-20 min, 7 days/week ^d

Note: Data are from Fletcher (2013)^a, Todd & Robinson (2003)^b, Hong & Kim (2018)^c, and Hingorjo, Syed, & Qureshi, (2008)^d

spine, increasing its bone mineral density and thus, decreasing the risk of developing osteoporosis (Sinaki et al., 2010).

Nutrition and Supplementation

Adequate consumption of calcium and vitamin D are recommended as a strategy for the prevention of osteoporotic fractures (Garriguet, 2011; Weaver, Bischoff-Ferrari, & Shanahan, 2019). Adaptive bone responses to exercise require abundant calcium and vitamin D availability, as sufficient supplementation will augment exercise programs for optimal musculoskeletal well-being and functioning (Beck et al., 2017; Borer, 2005). In the United States, the daily recommended intake of calcium for women and men aged 51 or older is 1200mg and 1000mg, respectively. (Reid, Bristow & Bolland, 2015; Weaver et al., 2019). However, recent data has suggested that these recommendations are not conclusive. It has been found that calcium intake between 500-1000mg is adequate for bone mineralization in older individuals at risk of osteoporosis (Bolland, Grey, & Reid., 2015; Garriguet, 2011; Reid et al., 2015; Weaver et al., 2019). In spite of this data, recent research has shown adverse effects associated with calcium supplementation such as gastrointestinal effects, kidney stones, and a small increase in the risk of myocardial infarction (Bolland et al., 2015; Harvey et al., 2017; Weaver et al., 2016).

Vitamin D plays a major role in bone health as its presence is required for dietary calcium to be absorbed in the small intestine (Weaver et al., 2019). In the United States, the daily recommended intake for women and men aged 51 or older is 600mg (Weaver et al., 2019). Few foods contain concentrated amounts of vitamin D, making it an under consumed dietary nutrient (Garriguet, 2011; Weaver et al.,

2019). However, exposure of the skin to sunlight initiates endogenous vitamin D synthesis, making it the major source of vitamin D for most humans (Holick, 2011; Weaver et al., 2019).

Discussion

Expanding on the results of the research, lifestyle and risk factors are evidently important in the maintenance of bone health. Chronic alcohol consumption should be avoided at all costs, while further research should aim to discover the effects of moderate alcohol drinking. Additionally, individuals should refrain from smoking and physical inactivity due to their effects on metabolism and overall bone density (Bultink & Lems, 2013; Tremblay, Colley, Saunders, Healy, & Owen, 2010)

Exercise does not have to be strenuous to be effective (Cosman et al., 2014). Physical activity influences bone mass and strength at all ages of skeletal development. Data suggests that regular physical activity optimizes bone geometry and likely promotes bone mass accrual during childhood, aids in the maintenance of bone during adulthood, and mitigates the loss of bone mass and strength during old age (Harding & Beck, 2017). Many trials report benefits of exercise to bone mineral density in adulthood either preventing deficits or promoting gains to bone mineral density by 1-3% following exercise interventions done over the course of 24 and 104 weeks (Beck et al., 2017). Increases in bone mineral density due to load-induced exercise increases bones susceptibility to bending (Beck et al., 2017). Evidence from randomized control trials and meta-analyses show that exercise training involving multi-modal programs that include resistance training, weight-bearing, and balanced focus exercises can improve the bone health of

adolescents, pre-and post-menopausal women, and older men (Beck et al., 2017). Exercise programs including high impact weight bearing activities, progressive resistance training and balance training should address various limitations in clinical or functional capacities of different individuals as some may require a more conservative approach than others with a focus on one type of exercise over another (Beck et al., 2017). An exercise prescription should be highly individualized, taking into account factors such as an individual's current bone mineral density, functional and clinical risk factors for falls and fractures, nutrient deficient diets, as well as comorbidities such as prior stroke, spinal cord injury, and SLE (Beck et al., 2017; Zhu et al., 2014). An individual's current gait, balance, mobility, transfer ability, range of motion, vision, and muscular strength should also be considered as exercise prescription should be tailored to their functional capacity (Beck et al., 2017). Individuals with osteoporosis should consult a health professional before starting a new exercise program (Bonner et al., 2003).

There is conflicting evidence that supports concomitant calcium and vitamin D supplementation in the overall reduction of fractures. Due to inconsistent results and adverse effects of calcium, it is suggested that supplementation be reserved for individuals who are at a high risk of deficiency in these nutrients (Harvey et al., 2017; Reid et al., 2015).

Conclusions

The pervasiveness of osteoporosis and its substantial cost to the health care system has led researchers to investigate the factors that mitigate its effects. Lifestyle factors such as smoking, alcohol consumption, physical inactivity and the

consumption of nutrients required for bone health can be adjusted in order to reduce the risk of developing osteoporosis later on in life. Further research regarding optimal levels of aerobic and musculoskeletal physical activity and the effects of calcium supplementation on cardiovascular health should be conducted, as current findings are inconclusive.

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The authors' qualifications are as follows: Mark Ashamalla, BKin; Walee Malik, BKin; Nicole Cahill-McMahon, BKin; Jasmine Deol, HBSc in Life Sciences; Jadin Sandhu, BKin; Tracy Hu, BKin.

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