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The Role of Sport in Human Health: Prevention and Treatment of Osteoporosis

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ABSTRACT

Introduction and purpose

Osteoporosis is the most prevalent metabolic bone disease, characterized by diminished bone mineral density, compromised bone microarchitecture, and geometry, culminating in diminished bone strength and susceptibility to fractures. Physical activity posits potential as a preventive measure and therapeutic approach for osteoporosis. The aim of this study was to assess the impact of physical activity on the prevention and treatment of osteoporosis.

Materials and method

In order to curate appropriate sources for this article, a comprehensive search was conducted within the PubMed and Google Scholar databases.

A brief description of the state of knowledge

One of the risk factors for osteoporosis is a lack of physical activity. For this reason, many scientists have decided to conduct some research to determine whether physical activity will have a beneficial impact on both the prevention and treatment of osteoporosis. These studies show that physical activity can benefit people with osteoporosis by improving bone density, balance, strength, and overall physical function. Regular and long-term exercise is essential to maximize these benefits.

Summary

The studies conducted so far provide promising results and confirm the beneficial impact of physical exercises on people with osteoporosis as well as on the prevention of this disease. Exercises should be performed regularly and persistently.

Keywords: osteoporosis, physical activity, bone mineral density, exercises

INTRODUCTION AND PURPOSE

Physical inactivity is an adjustable risk factor for an array of diseases such as cardiovascular disease, diabetes mellitus, hypertension, osteoarthritis, and osteoporosis [1]. Physical activity represents a widely accessible, cost-effective, and highly adaptable factor that contributes significantly to bone health. During exercise, the skeleton experiences the transmission of forces, leading to the generation of mechanical signals, like bone strain, which are identified by osteocytes. In healthy biological systems, these signals trigger a series of biochemical responses at local and systemic levels, ultimately enhancing bone turnover, resulting in a net gain in bone mass. Hence, esteemed organizations like the International Osteoporosis Foundation advocate weight-bearing exercises for osteoporosis prevention [2, 3]. Regular physical activity confers numerous advantages for bone health in individuals of all ages. These benefits include the development of strong bones in children, as well as the strengthening of bones and muscles in both adults and children. Physical activity also aids in preventing bone loss in adults, enhancing bone density, improving coordination and balance, and reducing the risk of falls, fractures, and osteoporosis [4]. The aim of this article was to assess the impact of physical activity on the prevention and treatment of osteoporosis.

STATE OF KNOWLEDGE

Osteoporosis is characterized by a reduction in bone mineral density, due to the alteration of bone microstructure and leading to an increased risk of low-impact, fragility fractures [5,6]. This disease presents a significant and escalating global health concern and affects more than 200 million people globally [7, 8, 9].

Risk factors

Osteoporosis predominantly affects older females, although it also poses a significant risk to certain males [10, 11]. Identified risk factors in both genders encompass age surpassing 65 years, inherited tendency for fractures, smoking, and body mass index at both low and high ends, particularly in males. Secondary etiologies of osteoporosis encompass prolonged

administration of glucocorticoids, diabetes mellitus, gastrointestinal disorders, rheumatoid arthritis, hepatic pathology, celiac disease, and some hematologic conditions like multiple myeloma. Nonetheless, primary osteoporosis predominantly emanates from postmenopausal estrogen depletion or degeneration of skeletal microarchitecture related to age, primarily attributable to uncoupling within the bone remodeling unit. The decline in bone formation associated with aging is likely a result of reduced differentiation of stem cells into osteoblasts, leading to an increase in adipogenesis within the bone marrow. Many types of osteoporosis are also characterized by increased bone resorption, with multifactorial etiology. This imbalance between formation and resorption is often attributed to changes in systemic and local growth factors. Furthermore, changes in bone formation during growth years can contribute to low bone density and increased susceptibility to fractures later in life [12, 13, 14].

Modifable risk facors	**Fixed risk factors**
Insufficient exercise	Female gender
Poor nutrition – low dietary calcium intake	Age
Vitamin D deficiency	Oestrogen deficiency and amenorrhea
Smoking	Ethnicity
Alcohol	Family history of osteoporosis
Low body mass index	Previous fracture
Frequent falls	Height loss
Eating disorders	Menopause and hysterectomy

Table 1. Osteoporosis risk factors. The data needed to create the table come from https://www.osteoporosis.foundation/

Pathophysiology

Osteoporosis arises from an imbalance between bone remodeling and bone resorption, resulting in diminished skeletal mass. Typically, peak bone mass occurs in the third decade of life, and then bone resorption surpasses bone formation. If an individual fails to achieve normal peak bone mass or experiences accelerated bone loss, it can lead to osteoporosis [5].

Diagnosis

The diagnosis of osteoporosis relies on the evaluation of bone mineral density (BMD). Dual-energy X-ray absorptiometry called DXA is the most commonly employed technique for this purpose. Osteoporosis is identified by a bone mineral density that drops 2.5 standard deviations or more below the mean peak bone mass of a 25-year-old person [15, 16].

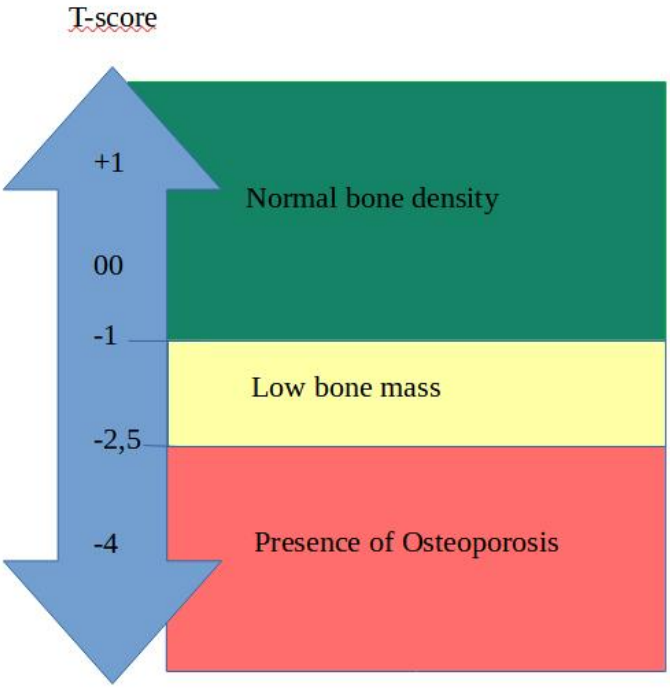

Figure 1. Interpretation of bone density test results

Fragility fractures

Osteoporosis predisposes individuals to fragility fractures, which are often precipitated by minor trauma, like falling from a standing height or less [17]. The incidence of these fractures increases markedly with advancing age and predominantly involves the spine, distal forearm, or hip. Hip fractures carry a significant risk of morbidity and mortality and they are the most serious from osteoporosis fracture. Vertebral compression fractures represent the most prevalent osteoporotic fractures, frequently remaining asymptomatic and incidentally identified during imaging procedures conducted for unrelated purposes. Nonetheless, these

fractures are associated with considerable morbidity, including height loss, restrictive lung disease, functional impairment, kyphosis, and back pain. A history of vertebral fractures confers a fivefold increased risk for subsequent vertebral fractures and a twofold to threefold increased risk for other fragility fractures [18, 19, 20].

Impact of physical activity on osteoporosis

Horacio Sanchez-Trigo et. al tried to look at physical activity as a potential prevention of osteoporosis. Their investigation sought to assess the impact of an mHealth intervention that administered and monitored an unsupervised exercise program on BMD. Sixty premenopausal women, with an age range of 35-50 years, were segregated into two distinct cohorts: an intervention group and a control group. The intervention group embarked on a 6-month program aimed at augmenting osteogenic physical activity. They were instructed to achieve daily targets of walking a minimum of 10,000 steps and generating sixty impacts over 4 g of acceleration. These objectives were monitored through the utilization of a wearable accelerometer synced to an mHealth application. Conversely, the control group adhered to their customary lifestyle and used the accelerometer without receiving any feedback. The assessment of BMD was conducted via DXA scans at the onset and culmination of the 6-month period, with group-by-time analyses executed using ANCOVA. Additionally, the intervention's effects on physical fitness and activity habits were subject to evaluation. The intervention group demonstrated significant enhancements in femoral neck BMD, total hip BMD, and trochanter BMD compared to the control group. Furthermore, the intervention group exhibited noteworthy improvements in physical fitness parameters, including power and peak torque across various positions and speeds. The unsupervised physical activity intervention, implemented through an mHealth application and wearable technology, yielded significant improvements in BMD, suggesting its potential to contribute to osteoporosis prevention [21].

In a different approach J Iwamoto et. al approached the influence of physical activity on osteoporosis quite differently. They did not evaluate the role of exercise in the prevention of osteoporosis but instead considered patients already diagnosed with osteoporosis and investigated whether exercise could also bring some beneficial effects to them. They

conducted the study to assess the impact of exercise training and detraining on BMD in women after menopause diagnosed with osteoporosis. The results show that an exercise training program resulted in a notable increase in lumbar bone mineral density among women after menopause with osteoporosis compared to the control group. However, upon cessation of the training, the BMD regressed towards a level that did not significantly differ from the control group. Sustained exercise training is necessary to uphold the bone mass accrued through the exercise regimen [22].

Expanding on the theme of exercise's impact on osteoporosis, Steven L. Watson et al. conducted a trial to evaluate the efficacy of high-intensity resistance and impact training in reducing fracture risk factors in women after menopause with low bone mass. They found that high-intensity resistance and impact training proved to be effective and did not result in any adverse events when conducted under closely supervised conditions for their cohort of otherwise healthy women after menopause with low or very low bone mass. The study determined that high-intensity resistance and impact training outperformed a home-based, low-intensity exercise program in enhancing bone mass, physical function, and femoral neck geometry [23].

Similarly, Teresa Y. L. Liu-Ambrose et al. examined the effects of group-based agility and resistance training on bone density in women aged 75-85 with low bone mass. The study involved randomizing women into three experimental groups: agility training, resistance training, or stretching (sham exercise). BMD at the femoral neck, total hip, and trochanter were assessed using DXA, alongside peripheral quantitative computed tomography (pQCT) measurements at the radius and tibia. Upon completion of the trial, it was observed that the agility training group exhibited a significant increase in cortical bone density at the shaft of the tibia compared to a modest decline in the stretching group. Similarly, the resistance training group demonstrated a notable increase in cortical bone density at the shaft of radius, while the agility training group displayed a modest decline. No statistically significant disparities between the groups were documented in the other bone outcome measures [24].

The impact of physical activity on patients with osteoporosis was also investigated by Tamara N. Filipović et al. Their study assesses the impact of a 12-week exercise program on the functional outcomes of women after menopause diagnosed with osteoporosis through densitometry. Two groups of patients were allocated randomly into the exercise group and the control group. The exercise group underwent a 12-week exercise program comprising balance exercises, resistance training, and aerobic exercise. In contrast, the control group did not partake in any structured exercise program throughout the intervention period. Functional outcomes were measured using the Time Up and Go Test, Sit To Stand test, and One Leg Stance Test at baseline, 4 weeks, and also 12 weeks post-treatment. Furthermore, the Fall Efficacy Scale and Knowledge About Osteoporosis Questionnaire were evaluated at the beginning and after 12 weeks, respectively. Statistically significant improvements were observed in all measurements within the experimental group. A comparative analysis between the experimental and the control group revealed statistically significant differences in all functional outcomes over the observed periods [25].

The primary cause of osteoporotic fractures is attributed to falls, particularly prevalent among the elderly, and often associated with diminished balance and decreased muscular strength. In the elderly population, possessing robust lower limb strength and proficient balance are essential prerequisites for maintaining independence and performing routine activities. Consequently, enhancing strength and balance through regular physical exercise represents a paramount preventive strategy and plays a pivotal role in mitigating the risk of falls, as substantiated by various studies [26, 27, 28, 29]. Montserrat Otero et. al conducted a study to assess the impact of a basic exercise regimen on the strength and balance of postmenopausal women diagnosed with osteoporosis. The study provides evidence indicating that an exercise program focused on strength and balance exercises, utilizing easily accessible equipment, yields significant improvements in the balance and strength of women diagnosed with osteoporosis [29].

Balance was also one of the assessed factors in the study conducted by Alexandra Halvarsson et. al. The objective of this study is to assess the impact of a comprehensive balance training program, integrating dual-task and multi-task exercises, on fear of falling, fall-related self-

efficacy, physical function, and balance and gait performance in older people diagnosed with osteoporosis and identified as having an elevated risk of falling. Furthermore, this study aims to investigate the potential additional benefits of incorporating supplementary physical activity into the program to further enhance its efficacy. This program of balance training demonstrates improvements in balance performance, fall-related self-efficacy, physical function, and gait speed, among elderly individuals diagnosed with osteoporosis [30].

SUMMARY

Osteoporosis is a prevalent bone disorder characterized by diminished bone mass and manifestations of degeneration, resulting in the typical fragility associated with this pathology. Osteoporosis risk factors are multifaceted and diverse and one of them is physical inactivity. Physical activity serves as a crucial tool for preventive measures and supplementary treatment. According to the cited research, physical exercises can bring numerous benefits for people with osteoporosis. They improve bone mineral density, balance and strength, fall-related self-efficacy, gait speed, and physical functions. To fully maximize the advantages of physical exercise, it is essential for individuals to consistently adhere to a long-term regimen.

DISCLOSURE

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