

Impact of vitamin D3, calcium and exercise in the management of osteoporosis

Abstract

Osteoporosis is a disease related to bone metabolism disorder. It is characterized by low bone mass and deterioration of the micro architecture, whose consequence is greater bone fragility and an increased risk of fractures. The purpose of this review is to summarize literature review regarding dietary calcium and vitamin d intake and exercise interventions for the treatment of osteoporosis in isolation. Recommendations as adequate amounts of total calcium, vitamin D and protein intake, regular exercise to improve strength and balance to reduce the risk of falls and consequent fractures, are known to be effective strategies for the prevention of osteoporosis, but also an important complement in the treatment.

Keywords: osteoporosis prevention, falls, calcium, vitamin D, exercise, diet

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Introduction

Osteoporosis represents a significant health challenge worldwide. Approximately 9million fractures occur globally every year.¹ By the year 2050, hip fractures are expected to increase 240% over the number in nineteen ninety.

Having a prior fracture, particularly a hip or spinal fracture, increases the risk of a new fracture 2- and 4-fold compared with those patients without a previous fracture, with a higher probability of having a disabling consequence that often includes reduced mobility and greater social and nursing care.^{2,3} Osteoporosis is one of the main conditions that affect older people, and as life expectancy is going up, there is a real need to focus on prevention, which is the key. Preventing fractures and low bone mass consist not only in the use of pharmacological therapies, but also non-pharmacological ones.

To achieve this, Gynecologists and General Practitioners usually recommend adequate calcium (Ca) and vitamin D intake, avoiding smoking and heavy drinking, and also exercising regularly. It is well known that lifestyle factors, vitamin D, Ca and exercise are good for bone health, usually used as a complement of the strategy for the management of osteoporosis. It is critical not to underestimate the important role that controllable lifestyle factors such as diet and physical activity add to the treatment of osteoporosis, individually or in concert.

Back ground

Healthy adults generally reach their peak bone mass by age 20. It is sustained for some years and thereafter begins to decline during the mid-40s, when the menopause transition begins. After menopause, an accelerated period of bone loss occurs, which lasts approximately 6–10 years. Afterwards, bone loss continues until the end of life. The prevention of osteoporosis begins with optimal bone growth and development in childhood. In girls, the bone tissue accumulated during the ages of 11 to 13 approximately equals the amount lost during the 30 years following menopause. It's estimated that a 10% increase in peak bone mass reduces the risk of an osteoporotic fracture during adult life by 50%. Genetic factors play a significant role in

determining whether an individual is at risk of osteoporosis; however, lifestyle factors such as diet and physical activity also influence bone development.⁴

In many countries, bone health could be at risk due to low Ca intake. According to the International Osteoporosis Foundation online map, there are low levels of dietary Ca intake in many countries and regions, as is the case in South America where the average dietary Ca intake is between 400 to 500mg/day, while in other regions of the world, as in Europe, calcium intake is much higher.⁵ Vitamin D deficiency is significant all over the world. This is an important health issue to resolve. Vitamin D is necessary for building strong bones. Older people often have low vitamin D levels due to low sun exposure, low consumption of vitamin D in their diet and less skin synthesis. Therefore, it has been suggested that taking additional vitamin D supplements may help reduce the risk of hip and other bone fractures.

Evidence suggests that the minimum blood level that is optimal for fracture prevention is 70-80nmol/l.⁶ The Daily Recommendation of Vitamin D intake for adults aged 60years and over is 800 to 1000IU/day for falls and fracture protection. Calcium intake for postmenopausal women and older men is 1200mg/day.⁷ Currently, there is a lack of clarity in the literature as to whether there is a definitive difference between the effects of vitamins D2 and D3 in the raising of serum 25-hydroxyvitamin. Tripkovic and colleagues assessed several studies and the analysis showed that the greater absolute change in serum 25(OH)D from baseline favored the cholecalciferol intervention, with a weighted mean difference of 15.23.⁸

This meta-analysis indicates that vitamin D3 is more efficacious in raising serum 25(OH)D concentrations than vitamin D2, and thus vitamin D3 could potentially become the preferred choice for supplementation. However, additional research is required to examine the metabolic pathways involved in oral and intramuscular administration of vitamin D. It has been found that vitamin D3 is approximately 87% more potent in raising and maintaining serum 25(OH)D concentrations and produces 2- to 3-fold greater storage of vitamin D than does D2. Moreover, it induces a quicker response in the production of serum 25(OH) D that is sustained for longer.⁹

As for exercise, recent research that has just been published included data from 358 surveys across 168 countries, including 1.9 million participants. In 2016 the global prevalence of insufficient physical activity was 27.5% (95% uncertainty interval 25.0–32.2), under 150 min of moderate-intensity, or 75 min of vigorous-intensity physical activity per week, or any equivalent combination of the two. For women the prevalence of insufficient physical activity was 31.7%.¹⁰ The recommendation for adults is to accumulate ≥ 150 minutes per week of moderate to vigorous intensity physical activity, including weight-bearing aerobic and resistance exercises.¹¹

Calcium and vitamin D

Clinical trials have assessed the effectiveness of Ca and vitamin D in bone health. Most of them show that calcium alone and vitamin D alone have weak results on fracture, with the impossibility of reducing fractures or increasing BMD. Reid and colleagues, carried out a systematic review and meta analysis to assess the effects of vitamin D on bone mineral density. Results showed a small benefit only at the femoral neck (weighted mean difference 0.8%, 95% CI 0.2–1.4) with heterogeneity among trials ($I^2=67\%$, $p<0.00027$). No effect at any other site was reported.¹²

Also Tai and colleagues, studied whether increasing calcium intake impacts BMD. They concluded that both calcium from dietary sources and supplements produces small non progressive increases in BMD what are improbable to lead to a significant reduction in risk of fracture,¹³ but when Ca is added to vitamin D supplementation, a slightly lower risk of total and hip fractures has been demonstrated in fragile elderly institutionalized women.¹⁴ Supplementation with calcium alone for fracture reduction is not supported by present evidence. The benefits of calcium supplementation is associated when is combine to vitamin D.¹⁵ According to this, an updated meta-analysis from the National Osteoporosis Foundation (NOF) showed that calcium plus vitamin D supplementation produced a statistically significant 15% reduced risk of total fractures (SRRE, 0.85; 95 % confidence interval [CI], 0.73–0.98) and a 30% reduced risk of hip fractures (SRRE, 0.70; 95 % CI, 0.56–0.87).¹⁶

Fall prevention and vitamin D

Falls are the second leading cause of accidental trauma and deaths worldwide.¹⁷ According to Morrison et al, the annual prevalence rate of falls ranges from 30% to 46%, and it frequency increases with age.¹⁸ Falls entail high mortality and morbidity, mainly in the elderly, associated with consequent fractures and high risk of institutionalization. Several studies have reported a statistically significant reduction in falls with vitamin D supplementation.

In a double-blind, placebo-controlled trials, 160 Brazilian postmenopausal women with a history of falls were randomized into two groups: vitamin D3 group (supplementation 1,000IU/day/orally) and placebo group. The isolated supplementation with 1000 IU of vitamin D3 per day significantly reduced the number of falls.¹⁹ The impact of vitamin D on fall frequency appears to be dose-dependent. It has been proposed that higher dose (700 to 1000 IU/day) showed a risk reduction, whereas lower dose (200 to 600IU/day) did not.²⁰

Exercise

It is well known that the risk of osteoporosis is lower for people who are active. Exercise not only increases muscle mass and strength, but also improves balance. It is a common practice to advice patients with osteopenia and osteoporosis to walk as a way of maintaining or

improving bone health. However, walking is unlikely to stimulate an adequate osteogenic response and, as a single intervention to increase BMD and prevent osteoporosis, is not recommended.²¹ Studies have shown that an adequate bone response of exercise are associated with activities that induce mechanical load.²² Resistance exercise proved to be effective in developing muscle mass and increasing strength even in people who are fragile or have a prior fracture.²¹

In 2011, The Cochrane Collaborative found that the most effective type of exercise intervention on BMD for the neck of femur appears to be non-weight bearing high force exercise such as progressive resistance strength training for the lower limbs (MD 1.03; 95% confidence interval (CI) 0.24 to 1.82). The most effective intervention for BMD at the spine was combination exercise programmers (MD 3.22; 95% CI 1.80 to 4.64) compared with control groups.²³ Weight-bearing impact exercise including moderate to high impact and multidirectional activities have been shown to preserve or improve hip and spine BMD not only in premenopausal women, but also in postmenopausal women.²¹ A systematic review and meta-analysis of 10 exercise controlled trials found that exercise training reduced overall fracture number by 51% and vertebral fracture number (three trials) by 44%.²⁴ As for falls, Zhao R and colleagues concluded that exercise reduced the risk of fall-related fractures by 40% in adults aged ≥ 50 years.²⁵

According to the position statement published by Exercise and Sports Science Australia (ESSA) on exercise for the prevention and management of osteoporosis, patients should be classified into three levels of risk of trauma fracture. Depending on the risk classification, the most appropriate exercises are determined.²⁶

- a. **Low-risk individuals** (normal BMD and functional status): The goal is to improve muscle strength and functional capacity. In addition, it is recommended progressively increasing impact activities and multidirectional weight-bearing exercises. Balance training should be suggest to prevent age-related deterioration.
- b. **Moderate-risk individuals** (low bone mass and/or certain clinical or functional risk factors): Perform weight-bearing impact activities and PRT activities, moderate impact activities and progressively challenging balance.
- c. **High-risk individuals** (having osteoporosis, previous fracture, and/or multiple risk factors): The objective is to work on fall prevention programs with a focus on balance and mobility training and high intensity PRT are essential.

Individuals with a prior fracture or diagnosis of osteoporosis should emphasize moderate aerobic exercise, and form and alignment over intensity when it comes to PRT. It is unknown if individuals with established osteoporosis can improve BMD with exercise.

Osteoporosis prevention strategy

The challenge in osteoporosis is to achieve prevention strategies to avoid bone loss and stop disease progress.

Osteoporosis is preventable, but we need to be aware of modifiable risk factors that lead to the disease. Lifestyle management, cessation of smoking, adequate alcohol consumption, a healthy diet (encouraging protein, calcium and vitamin D intake) and exercise are effective interventions. Prevent falls include not only Improving balance and strength in older adults, but also eye exams to check for visual impairment and managing home hazards.

Conclusion

Osteoporosis represents a significant health challenge worldwide. It is a frequent condition related to multiple risk factors. With the aging of the population, the rate of osteoporotic hip fractures is increasing. This is a public health problem due to the high morbidity and mortality that it entails. Because of this, we need to focus on prevention. When we discuss prevention, we have to promote higher dietary calcium intake, avoiding vitamin D deficiency and encouraging regular exercise.

According to the literature review, we can conclude there is no consensus that the supplementation of Ca and Vit D in isolation reduces the rate of osteoporotic hip and lumbar fractures. Most papers cite evidence that the benefit of calcium supplementation exists only when it is combined with vitamin D. In any case, the combination of both options seemed to provide a minimum benefit. We did find consensus on the topic of falls. Most authors affirm that treatment with vitamin D significantly reduced the number of falls in older women and the amount of exercise was related to overall fracture reduction. An exercise program from moderate to high impact, weight bearing activities, high intensity PRT and balance training forms the basis of the current recommendations. The kind of exercise should be performed according to personal individual risk.

As we stated, prevention is the key. We conclude that it should be a strategy that begins at childhood and continues throughout life, ensuring adequate nutrition and calcium consumption, sun exposure for proper synthesis of vitamin D, as well as exercise and advice against smoking and excessive alcohol consumption.

These small actions are the keys to reducing the rate of osteoporotic fractures. There is a need for future research to provide health professionals with specific evidence-based guidelines for safe and effective exercise prescriptions for the prevention and management of osteoporosis.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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