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The influence of non-pharmacological methods in osteoporosis treatment

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Abstract

Introduction

Osteoporosis is a systemic skeletal disorder which results from an imbalance in bone remodeling. The disease can occur because of failure to achieve peak bone mass and/or excessive bone resorption and/or decreased bone formation during remodelling. Multiple pathogenetic and regulatory mechanisms are responsible for these changes. In the above review, selected non-pharmacological therapies in osteoporosis are described.

Material and methods

Articles in the EBSCO database have been analyzed using keywords: osteoporosis, osteopenia, treatment. The available literature is subjectively selected. Then, the newest version of every paper was searched for.

Results

Results of researches on osteoporosis pathomechanism, quality of life in patients, comorbidities, non-pharmacological methods for treatment of osteoporosis, the impact of physical exercise, role of diet as adjunctive therapy in osteoporosis were described.

Conclusions

Osteoporosis and treatment influence on the patient's functioning and subjective assessment of the quality of life. Medical doctors need to take into account high occurrence of multimorbidity in adults with osteoporosis to be able to propose comprehensive treatment. The treatment of the affected patients should be improved to offer early or even preventive care for other diseases that coexist with osteoporosis. Non-pharmacological interventions, such as diet, seem to be effective in osteoporosis. Effects of physical exercise could be beneficial in osteoporosis patients, however further studies are needed to determine specifics of the most effective program.

Key words: osteoporosis; diet; physical exercise; resistance training

Introduction

Osteoporosis is a systemic skeletal disorder which results from an imbalance in bone remodeling. The disease can occur because of failure to achieve peak bone mass and/or excessive bone resorption and/or decreased bone formation during remodelling. As a result, bone microarchitecture is disturbed, which promotes the occurrence of fractures. People with osteoporosis have worse bone mineral density (BMD) and bone quality [1]. Multiple pathogenetic and regulatory mechanisms are responsible for these changes. These include genetic factors contributing to the acquisition of peak bone mass, illnesses affecting skeletal growth and development, sex steroid deficiency following the menopause in women and with aging in men, and intrinsic, age-related changes in bone metabolism [2].

The occurrence of osteoporosis in the family is associated with its increased risk in subsequent generations, which indicates its close relationship with its genetic pool, but monogenic forms of bone fragility have also been identified, which are the result of a single mutation in the gene that plays an important role in skeletal biology [3].

Hormonal changes also have an impact on the onset of osteoporosis. Recent data suggest that follicle-stimulating hormone (FSH) levels are closely related to bone loss. This is due to the fact that FSH is involved in stimulating bone resorption, acting to increase osteoclast formation. Other hormones, e.g. TSH, also have an impact on the occurrence of osteoporosis, but their importance is smaller than FSH. Also calcium and vitamin D have an important role in the occurrence of osteoporosis due to their effect on maintain bone homeostasis [4].

Drug-induced osteoporosis is a significant health problem. While glucocorticoids are most commonly associated with drug-induced osteoporosis, the use of several other therapeutic agents increase the risk of significant bone loss and fracture [5]. These medications include proton pump inhibitors, selective serotonin receptor inhibitors (SSRI), thiazolidinediones, anticonvulsants, medroxyprogesterone acetate, hormone deprivation therapy, calcineurin inhibitors, chemotherapies, and anticoagulants [6, 7, 9, 9].

The pathomechanism of osteoporosis is always complex and is never determined by one factor.

Material and methods

Articles in the EBSCO database have been analyzed using keywords: osteoporosis, osteopenia, treatment. The available literature is subjectively selected. Then, the newest version of every paper was searched for.

Results

3.1 Pathomechanism

Cells involved in bone remodeling

Bone is a dynamic organ that is constantly rebuilt throughout the life [10]. The bone remodeling process occurs in basic multicellular units (BMU). This unit includes osteoclasts, osteoblasts and osteocytes [11]. The growth hormone (GH) is the main stimulus for bone growth regulation by activating osteoblast differentiation [12].

Osteoblasts are derived from mesenchymal stem cells (MSCs) in the bone marrow [10]. The role of osteoblasts is not only limited to bone formation. What is more, they play a significant role in coordinating bone remodeling. Osteoblasts are also responsible for initiating the bone resorption process. Osteoblast produces the necessary stimuli that are affecting osteoclast activity. These reactions occur through cell-cell interaction [11]. In bone marrow, osteoblasts affecting cytokines having a key impact on the transformation of the progenitor cell into osteoclast. These are NF- κ B ligand activator (RANKL) and osteoprotegerin (OPG) [13].

RANK stimulates osteoclast fusion. It is also responsible for the penetration of osteoclasts into the bones and increases their survival by reducing apoptosis. OPG is a protein synthesized by stromal cells and osteoblasts. It blocks the binding of RANK to the RANK receptor, inhibiting the function of these cells. It reduces the number of osteoclasts by increasing apoptosis [14].

Osteoclasts are the main cells responsible for bone resorption. Their structure and biochemical properties have been well described.

The first stage involves the recruitment and dissemination of osteoclast precursors in bone. Progenitor cells are recruited from the bone marrow and bone marrow tissue where they are transported to the bone along with the blood. The proliferation and differentiation of progenitor cells occurs through the mechanism of interaction of these cells with osteoblast stromal cells [13]. Osteocytes are formed under the influence of alkaline phosphatase as a result of calcification of the osteoblast matrix. They participate in the transmission of signals to osteoclasts and osteoblasts during each mechanical load on the bone [10].

3.2. Quality of life in osteoporosis and osteopenia patients

Quality of life assessment is an important element in the study of chronically ill people, including osteoporosis. Over the years, many definitions of quality of life have been created. One of the widest definitions was created by the World Health Organization. According to WHO, the quality of life is its perception by an individual through cultural conditions and a system of values in relation to their own goals, expectations, principles and fears [15]. In medicine, the definitions of quality of life refer to the individual's state of health. According to Berzon et al. [16] is the impact of the disease and treatment on the patient's functioning and subjective assessment of the quality of life. The quality of life is most often considered in four domains: somatic, psychological, social and environmental.

The quality of life of people with osteoporosis is decreasing, especially in patients with comorbidities. The main reason for reducing the quality of life in patients with osteoporosis is pain and reduced physical fitness due to fractures, which makes it difficult to perform daily activities [17]. Paul and van Schoor [17] showed in their studies that fractures of the

vertebrae and femoral neck decreased the quality of life of patients. They also showed a decrease in the quality of life along with the increase in the number of broken vertebrae, which limited mobility and activity in everyday life, and also intensified pain [17]. Park [18] showed that the more effective the treatment of osteoporosis, the better the quality of life of women suffering from osteoporosis.

3.3. Fitness level of osteoporosis and osteopenia patients

Researches have shown that muscle strength in younger women positively correlates with BMD [19]. Nevertheless, physical activity of older women should be individually adjusted to their age and general health. Regular physical activity helps to maintain bone health. Admittedly, there are reports that fitness level does not affect BDM levels over time, but women with lower levels of physical fitness had a greater risk of losing BDM, although not all results were statistically significant. In fact, it is important to correctly choose the physical activity because there are reports that heavy and overloaded exercise can contribute to osteoporosis [20].

The results of studies conducted on women suggest that even moderate physical activity should be recommended, because it may help prevent bone loss [19, 20, 21, 22]. Similar studies should be conducted to assess effects in men [22].

3.4. Comorbidities related to osteoporosis and osteopenia

As shown in the “European Prospective Osteoporosis Study” (EPOS) osteoporosis affects 2.4% of men at age 50-60 years and 17% of men older than 70 years. In case of women the percentage is even higher, i.e. 15% of women aged 50-60 years and 45% of women over 70 years of age [23].

Bone fractures, as the most immediate consequences of osteoporosis, are usually the main focus of health problems of the osteoporosis patients. Often little is discussed about other diseases that go along with osteoporosis and equally reduce the patients’ quality of life.

Puth et al. in their study show that over 95% of adults with osteoporosis had at least one comorbidity and around two thirds (65.7%) had three or more comorbid diseases. In case of adults without osteoporosis the numbers were significantly lower, only 80.6% reported at least one chronic condition and 39.2% had three or more different chronic diseases. The study has indicated arthrosis (63.2%) to be the most common comorbidity among participants with osteoporosis, followed by hypertension (51.3%), chronic low back pain (49.6%), hypercholesterolemia (38.6%) and from coronary heart disease (21.0%). For adults not suffering from osteoporosis, the odds for arthrosis, chronic low back pain, arthritis and chronic heart failure, respectively, were more than two times lower than for adults with osteoporosis [24]. Drosselmeyer et al. emphasizes that depression also often follows osteoporosis. Physical disability as an effect of the fractures lowers the capacity for independent living and complicates social participation [25].

3.5. Non-pharmacological methods for treatment of osteoporosis

In the treatment and prevention of osteoporosis, various physical activities are recommended, including exercise programs, which have a positive effect on the skeletal system. In contrast to pharmacological agents, exercise programs can minimize key fracture risk factors in people with osteopenia or osteoporosis, such as muscle strength, dynamic balance or coordination [26]. Scientific research shows that exercises reduce the risk of falls in people with osteoporosis, by improving muscle mass and strength and having a positive effect on the balance of the body [27]. In addition, mechanical loadings during physical activity stimulate the body to osteogenesis of the skeletal system, including the production of osteoblasts [28]. The improvement of the body balance of people with osteoporosis may be influenced by, for

example, aerobic training with the external loading on the treadmill. Roghani et al. carried out research on 36 women who suffered from osteoporosis. They were divided into three groups – one using aerobic training and second having aerobic training in combination with an external loading (which ranged from 4 to 8% of body weight) and a third, a control group. Research has shown that aerobic training both without and with external loading stimulates bone synthesis and reduces their resorption, but better results were obtained by women belonging to the group of aerobic training with external loading [29].

Gunendi et al. conducted research in Turkey on a group of 28 women with osteoporosis who also used aerobic training on the treadmill. Four weeks of this activity resulted in improved static and dynamic balance, which was tested using the Timed Up and Go test, the Four Square Step test and the Berg Balance Scale. For example, the average time to perform the Timed Up and Go test after the intervention was 6.2 seconds compared to the 7.1 seconds before the training [30].

Rehabilitation including treatment and prevention of osteoporosis may also include multimodal programs, which are characterized by a greater amount of activity, where combinations of training programs are used. Weight-bearing activities are combined with balance training or progressive resistance training [31]. For instance, randomized control trials in 162 people conducted by Gianoudis et al. showed that a multicomponent exercise program was effective as it has improved femoral neck and lumbar spine bone mineral density. Traditional and high-velocity progressive resistance training combined with weight-bearing exercises and balance training was used three times a week. Besides an improvement on bone mineral density, dynamic balance measured by Four Square Step Test has improved significantly [32].

All things considered, there are many training programs and other physical activities that are helpful in the treatment and prevention of osteoporosis and its effects, such as problems with balance or falls [33]. It should always be remembered that every rehabilitation of patients with osteoporosis must be appropriately selected and matched to the severity of the disease, so as not to create additional risk of bone fractures [34].

3.5.2.2. The impact of physical exercise

The most commonly used forms of activity in low-intensity training include walking, nordic walking, swimming, gymnastics, Tai-Chi. One of the most popular forms of aerobic training are walking and Nordic walking [35]. These exercises are very well accepted by geriatric patients because in most cases they do not have contraindications, they can be performed alone or in groups and are easy to do. Nordic walking also allows one to not only activate the muscles of the lower limbs and the pelvic girdle, but also strongly activate the muscles of the upper limb together with the shoulder rim. The whole skeleton is evenly loaded. Nordic walking exercises load the bone axially, as opposed to walking or running without sticks [36]. The effects of walking training on BMD were widely considered, but the results were not consistent in most cases during various studies. Meta-analysis showed no improvement in the results of effects on the lumbar spine or femoral neck, the only walking [35, 37]. The analyzed studies also do not confirm the correlation between walking and Nordic walking training and the increase in BMD. Various forms of gymnastic exercises are also often used in the fight against degenerative diseases. Tai-Chi exercises consist mainly of a series of slow, relaxing movements connected together in a fluid and continuous way. This form of activity requires little space and besides due to its simplicity it is suitable for most patients, regardless of age or fitness [38]. It has been shown that Tai-Chi has a beneficial effect on BMD under the influence of training grew or was also maintained at the same level. This has been confirmed in various studies, thus preventing osteoporosis. It is stated that the long-term training program Tai-Chi - maintained for a minimum of one year [34, 38] has a beneficial

effect on the improvement and prevention of osteoporosis. Another option for activating patients with osteoporosis is exercise in water. This form could be applied in cases when exercises on land are impossible or difficult. Most of the analyzed studies show that exercises in water can be useful in at least maintaining different measurements of BMD and even their improvement [39].

3.5.3. Role of diet as adjunctive therapy in osteoporosis

The skeletal system is one of the systems for development and health which is influenced by proper nutrition. Available evidence suggests that increased calcium intake may have a positive effect on bone mass. It is one of the basic ingredients building the skeleton. It is responsible for proper mineralization and keeping it at the proper level, especially in the period of the skeleton formation. The proper supply of calcium in the postmenopausal period is also important when the bone mineral density decreases. It is recommended that increased consumption of dairy products and, if necessary, adequate supplementation [40]. An equally important nutrient is vitamin D3. It also prevents osteoporosis, while its importance lies in the increased absorption of calcium from the gastrointestinal tract, which affects the reduced loss of bone mass [41]. Vitamin D is delivered to the body not only along with the diet, but also in the skin in the process of its synthesis, during exposure to light. This process covers 80% of the need for this vitamin [42]. Another important vitamin in the prevention of osteoporosis is vitamin K. It increases the affinity of calcium ions to glutamic acid, in proteins essential for the proper functioning of the body. These proteins regulate bone mineralization, reducing the risk of fractures [43]. Vitamin C is a factor for the hydroxylation of proline and hydroxyproline in the process of collagen formation [44]. Scientific research proves the existence of a positive relationship between vitamin C and bone mineralization, especially in men over 70 years old and in women after menopause, who also took hormone replacement therapy (HRT) [45]. In addition to the calcium mentioned, also phosphorus is an element that is largely a bone component. However, high phosphorus intake can lead to increased bone loss, especially if it is associated with calcium deficiency in the diet. Moreover, high phosphorus intake may impede the absorption of calcium from the gastrointestinal tract [46]. Magnesium is important in bone metabolism, through its influence on the regulation of parathyroid hormone secretion. Also magnesium competes with calcium for absorption in the gut. Due to this, the increased amount of calcium in the diet leads to magnesium deficiency and vice versa [47].

Conclusions

Osteoporosis and treatment influence on the patient's functioning and subjective assessment of the quality of life. Physicians need to take into account high occurrence of multimorbidity in adults with osteoporosis, to be able to propose comprehensive treatment. The treatment of the affected patients should be improved to offer early or even preventive care for other diseases that coexist with osteoporosis. Non-pharmacological interventions, such as diet, seem to be effective in osteoporosis. Effects of physical exercise program could be beneficial in osteoporosis patients, however further studies are needed to determine specifics of the most effective program.

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