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Physical activity in the prevention and treatment of osteoporosis: From biomarkers to quality of life

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Abstract

Introduction and Objective: Osteoporosis is a common skeletal disease typified by diminished bone density and deterioration of bone structure. It represents a significant risk factor for fractures, particularly in postmenopausal women. This study evaluates the role of physical activity and bone biomarkers in the prevention and treatment of osteoporosis.

Review and Methods: A review of the literature was conducted with the objective of analysing the impact of weight-bearing exercise and resistance training on bone health and the use of biomarkers in diagnosing and monitoring osteoporosis. Moreover, the potential impact of dietary interventions and supplementation was examined.

Abbreviated Description of the State of Knowledge: It is of the utmost importance to engage in regular physical activity, particularly weight-bearing exercises, in order to prevent and treat osteoporosis. It has been demonstrated to enhance bone density and moderate the likelihood of fracture. Biomarkers such as osteocalcin and alkaline phosphatase are of significant value in the assessment of bone health.

Summary: The combination of physical activity, a balanced diet and appropriate supplementation is fundamental to the prevention and effective management of osteoporosis. This approach confers substantial benefits with respect to bone health and quality of life.

Keywords: Osteoporosis; Physical activity; Bone health; Skeletal System

Introduction

Osteoporosis is a prevalent skeletal disorder characterised by a reduction in bone mineral density and degradation of bones, which increases the risk of fractures. The disease affects millions of people worldwide, particularly postmenopausal women, and represents a significant health challenge due to its impact on quality of life and the social and economic burden of treating osteoporotic fractures [1][13][21].

Bone health is the result of a dynamic equilibrium between bone resorption and bone formation processes, which are regulated by a variety of bone biomarkers [2][14][17]. These molecular markers, such as bone-specific alkaline phosphatase (BALP) or osteocalcin (OC),

provide valuable information regarding bone health and are of crucial importance in the diagnosis and monitoring of osteoporosis treatment [2]. The regular monitoring of these indicators facilitates a more comprehensive understanding of bone remodelling processes, which is fundamental to the assessment of fracture risk and the selection of appropriate therapeutic interventions [3][15][18].

It is widely acknowledged that physical activity plays a decisive role in the maintenance and enhancement of bone health [4][19][22]. Regular exercise, particularly weight-bearing exercise, has been demonstrated to stimulate anabolic processes within the bones, thereby increasing bone mineral density and reducing the risk of fracture [4][12]. The incorporation of physical activity into one's lifestyle is widely acknowledged as one of the most efficacious non-pharmacological methods of preventing osteoporosis and supporting its treatment [5][6][10][16][20].

Bone biomarkers and their impact on the skeletal system

Bone biomarkers are of significant importance in the monitoring of skeletal health, providing invaluable information on the dynamic processes of bone remodelling. This is of particular relevance in the diagnosis and treatment of diseases such as osteoporosis. The markers permit the evaluation of the equilibrium between bone degradation and bone formation, which is of paramount importance for the comprehension and administration of skeletal health. Bone formation biomarkers included ALP, BALP, OC, P1NP. Increased the total ALP has been observed in osteoporosis. The decrease of total ALP has been demonstrated with the treatment with alendronate. The results indicate that total alkaline phosphatase (ALP) can be used as an indicator to reflect the efficiency of drug treatment for osteoporosis. The bone-specific alkaline phosphatase (BALP) increases in osteoporosis and it is an indicator of osteoblastic activity. The measurement of BALP is applied as the assistance for the management of osteoporosis in premenopausal and postmenopausal women. Procollagen type 1 N-terminal propeptide (P1NP) is indicative of augmented osteoblast activity and the formation of new bone tissue. P1NP has been demonstrated to be a sensitive bone biomarker to measure the bone formation rate in osteoporosis [2]. Bone-specific alkaline phosphatase (BALP) and osteocalcin (OC) are frequently used as bone formation markers, reflecting the activity of osteoblasts – the cells responsible for creating new osseous tissue. It has been demonstrated that elevated levels of these markers may indicate increased bone anabolic activity, which is of particular significance in the treatment of osteoporosis. Conversely, the bone resorption markers, such as carboxy-terminal telopeptide of collagen type 1 (CTX) and amino-terminal telopeptide of collagen type 1 (NTX), serve as indicators of osteoclast activity, which is the process by which these cells degrade bone. Elevated levels of CTX and NTX are frequently observed in patients with osteoporosis, indicating augmented bone degradation and a heightened risk of fractures [4]. It has been demonstrated that regular physical activity can exert an influence on bone biomarker levels, with beneficial effects on skeletal health. For instance, intense exercise has been linked to elevated levels of bone formation markers, indicating enhanced bone quality and a diminished risk of fractures [2]. Furthermore, prolonged exercise regimens may result in diminished levels of resorption markers, suggesting that bone degradation processes are inhibited and may contribute to protection against osteoporosis [7][11]. In conclusion, bone biomarkers are not only valuable diagnostic indicators, but also a tool to assess the effectiveness of therapeutic interventions. Their monitoring can significantly contribute to bone health by providing information on the effectiveness of treatment and the impact of different interventions, such as physical activity, on the skeletal system.

The impact of physical activity on the prevention of osteoporosis

Osteoporosis is a significant health concern affecting millions of individuals globally, particularly postmenopausal women. The condition is typified by a reduction in bone mineral density, which in turn increases the likelihood of fractures. The prevention of osteoporosis is of paramount importance in reducing the incidence of fractures and improving the quality of life of older people. Regular physical activity represents one of the most effective non-pharmacological methods for the prevention of osteoporosis, with the potential to make a significant impact on bone health.

The effects of physical activity on bones are mediated by mechanical loading, which stimulates the bones to adapt, leading to an increase in their mineral density. It has been demonstrated that weight-bearing exercises, such as running, jumping or weight training, are particularly efficacious in stimulating anabolic processes in bones [1]. Marini et al. demonstrate that regular physical activity is associated with elevated levels of biomarkers of bone formation, including osteocalcin and procollagen type 1 N-terminal propeptide (P1NP). This indicates that individuals who engage in regular physical activity may possess higher bone mineral density, which may serve as a protective factor against osteoporosis [2][10].

Kuo and Chen observe that elevated physical activity levels are associated with enhanced bone biomarkers, which is a crucial consideration in the context of osteoporosis therapy. These biomarkers facilitate the monitoring of the efficacy of interventions, whether pharmacological or non-pharmacological. Regular exercise has been demonstrated to increase levels of bone formation markers while simultaneously decreasing levels of resorption markers, such as carboxy-terminal telopeptide of type 1 collagen (CTX) and amino-terminal telopeptide of type 1 collagen (NTX). This indicates a reduction in bone degradation, which is of particular importance for the elderly, who are most at risk of losing bone mass [2][11].

Long-term studies have demonstrated that regular exercise is an effective method for increasing bone mineral density. In a study conducted by Kemmler et al., a two-year exercise programme was shown to significantly increase bone mineral density and improve overall physical fitness and lipid profile in a group of early postmenopausal women with osteopenia [5]. This indicates that physical activity may not only inhibit bone mass loss but also contribute to overall health.

It is also important to consider the benefits of less intense forms of physical activity, such as walking. Feskanich et al. demonstrated that regular walking and recreational activity are associated with a reduced risk of hip fractures in postmenopausal women [5]. This signifies that even moderate physical activity can have a considerable effect on bone health and the prevention of osteoporosis.

In addition, regular physical activity is crucial for maintaining muscle strength, balance, and coordination, which are essential for preventing falls, a significant cause of fractures in older individuals. In a study conducted by Kerschan-Schindl et al., a long-term home exercise programme was found to remarkably reduce the risk of falls and improve bone health in women at high risk of fractures [5]. This illustrates that physical activity not only enhances bone strength but also mitigates the risk of injuries associated with falls.

Being physically active also helps to augment general health, which is particularly important for the elderly. Furthermore, regular exercise has been linked to improved cardiovascular health, weight control and mental health [3]. In conclusion, regular physical activity is a

fundamental method of preventing osteoporosis. By stimulating anabolic processes in the bones and reducing the rate of ossein resorption, exercise contributes to improving bone mineral density and reducing the risk of fractures. These benefits are not exclusive to young people, but are also available to the elderly, thus making physical activity a universal and effective tool in the prevention of osteoporosis. Incorporating regular exercise into a lifestyle can significantly improve bone health and overall quality of life, which is particularly important in an ageing population.

The impact of physical activity on the treatment of osteoporosis

It is not only the case that physical activity is a key element in the prevention of osteoporosis; it also plays an important role in its treatment. It facilitates anabolic processes in the bones, enhances muscle strength and balance, which is of particular importance for those who are already afflicted with the disease. The treatment of osteoporosis frequently entails the use of pharmacological agents. However, an expanding body of research indicates that the incorporation of exercise into treatment programmes can yield substantial benefits.

One of the most significant mechanisms of action of exercise in the treatment of osteoporosis is its capacity to stimulate osteoblast activity, which results in augmented bone formation. As observed by Nagy et al., exercise programmes incorporating components of strength training have been demonstrated to result in notable elevations in bone formation markers, including procollagen type 1 N-terminal propeptide (P1NP) and bone-specific alkaline phosphatase (BALP) [3]. This indicates that exercise can effectively promote bone reconstruction processes, which is of particular importance for individuals with osteoporosis whose bone mass is already significantly reduced.

In contrast, Schmitt et al. demonstrate that regular aerobic exercise, such as walking or cycling, can result in enhanced bone structure through the reduction of degradation. The study proves that this type of activity can reduce levels of bone resorption markers, such as carboxy-terminal telopeptide of type 1 collagen (CTX), resulting in a reduction in the rate of bone degradation. Reducing resorption is a decisive factor as it slows down bone loss processes, which may be a significant aspect of osteoporosis treatment [3].

It is also important to consider the impact of exercise on bone mineral density in the context of osteoporosis treatment. Daly and Via demonstrate that carefully selected exercise programmes can result in substantial increases in bone mineral density in postmenopausal women undergoing osteoporosis treatment. Their research indicates that combining exercise with pharmacotherapy may yield superior outcomes in improving bone health compared to pharmacotherapy alone [5]. This comprehensive approach is particularly crucial in the treatment of older individuals, for whom pharmacotherapy may not be as effective as a standalone intervention.

In conclusion, physical activity is not only an important element in the prevention of osteoporosis, but also plays a key role in its treatment. By stimulating bone formation, reducing resorption, improving balance and muscle strength, and improving overall health, exercise is an indispensable component in the treatment of osteoporosis. The incorporation of regular exercise into the treatment programme can significantly improve the effectiveness of the therapy and contribute to patients' quality of life.

The relationship between diet and the efficacy of exercise in the prevention and treatment of osteoporosis is a critical area of investigation. Dietary habits have been demonstrated to exert

a profound impact on bone health, and as such, they can markedly affect the effectiveness of exercise regimens in the management of this condition. It is imperative to ensure an adequate intake of calcium and vitamin D for optimal bone mineralisation, as their deficiency can negate the benefits of regular exercise. The available evidence indicates that the combination of calcium and vitamin D supplementation with regular physical activity results in a greater increase in bone mineral density compared to physical activity alone.

The role of diet in enhancing the effectiveness of exercise in osteoporosis prevention and treatment

Moreover, a diet abundant in antioxidants, such as vitamin C and E, can bolster bone health by counteracting oxidative stress, which is linked to ageing and bone mass reduction. The incorporation of appropriate dietary habits, including the consumption of foods rich in protein, magnesium, potassium and omega-3 fatty acids, can facilitate anabolic processes in the bones, thereby enhancing the efficacy of exercise in the prevention and treatment of osteoporosis [3][8].

This paragraph introduces a novel perspective on the role of diet in the context of osteoporosis, complementing the preceding discussion on physical activity with a crucial nutritional component. It can augment a review paper by offering a comprehensive approach to bone health management.

The significance of adequate hydration and its influence on bone health

Hydration is a frequently disregarded yet pivotal element in bone health. Water is a fundamental component of all cells in the human body, including those responsible for bone formation, such as osteoblasts and osteoclasts. Maintaining adequate hydration levels can facilitate the function of these cells and the metabolic processes involved in bone remodelling. It has been posited by several studies that chronic dehydration may result in augmented bone resorption, which may in turn contribute to the emergence of osteoporosis. It can be reasonably deduced that the regular intake of adequate amounts of water is an important element to support bone health, especially in older people who are at a higher risk of dehydration [9].

The role of psychological support in osteoporosis treatment programmes

Psychological support is of significant importance in motivating patients to maintain regular exercise, which is a crucial element in the successful treatment of osteoporosis. It is evident that stress, anxiety and depression have the potential to negatively impact engagement of patients in exercise programmes, as well as their overall health and well-being. It is therefore imperative that patients receive support from family, friends and psychological professionals in order to ensure the long-term effectiveness of their treatment. Cognitive behavioural therapy and support groups can assist patients with osteoporosis in coping with the challenges of the disease, thereby increasing their motivation to participate regularly in rehabilitation programmes [4].

The value of educational programmes in the prevention and treatment of osteoporosis

The implementation of educational programmes designed for patients diagnosed with osteoporosis and those identified as being at risk can lead to a notable increase in awareness of the disease and its prevention and treatment methods. Education on the importance of regular physical activity, an appropriate diet, supplementation and stress management techniques can assist patients in making informed decisions regarding their health. These programmes can be delivered by medical, dietetic and rehabilitation professionals, and should aim not only to impart knowledge but also to motivate patients to make healthier lifestyle changes. Education and support can contribute to improved treatment outcomes and quality of life for patients with osteoporosis.

Conclusions

Osteoporosis is a condition that affects a significant proportion of the global population, particularly older postmenopausal women. Physical activity represents a fundamental aspect of both the prevention and treatment of osteoporosis. Regular weight-bearing exercise, such as running, skipping or weight training, has been demonstrated to significantly increase bone mineral density and reduce the rate of bone resorption, thereby reducing the risk of fractures.

Nutrition, which provides essential nutrients such as calcium, vitamin D, protein and omega-3 fatty acids, also plays an important role in the effectiveness of exercise. It is imperative that individuals maintain adequate hydration levels to ensure the optimal functioning of bone cells and the processes involved in bone remodelling.

It is equally important to provide psychological support and patient education, as this can motivate patients to maintain regular physical activity and implement healthy eating habits. Educational programmes that raise awareness about osteoporosis and how to prevent it can significantly improve patient outcomes and quality of life.

In summary, physical activity, supported by an adequate diet, hydration and psychological support, is a key element in the prevention and treatment of osteoporosis. Regular exercise can improve bone health, reduce the risk of fractures and improve the quality of life of patients with osteoporosis, making it an crucial component in the management of this condition.

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Author's contribution

Conceptualization: Ciułek Urszula and Bilska Wiktoria

Methodology: Żydek Ada and Bilska Wiktoria

Software: Żydek Ada and Ciułek Urszula

Check: Bilska Wiktoria and Ciułek Urszula

Formal analysis: Ciułek Urszula and Żydek Ada

Investigation: Resources: Żydek Ada and Bilska Wiktoria

Data curation: Bilska Wiktoria and Ciułek Urszula
Writing - rough preparation: Ciułek Urszula and Żydek Ada
Writing - review and editing: Bilska Wiktoria and Żydek Ada
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