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Review Article

EFFECTS OF PHYSICAL ACTIVITY ON BONE HEALTH: INVESTIGATE HOW DIFFERENT TYPES OF EXERCISE INFLUENCE BONE DENSITY AND STRENGTH

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Abstract: *This review study investigated the impact of various types of exercise on bone density and strength among individuals at LRH Peshawar between January 2023 and June 2023. Physical activity is a cost-effective and readily available modifiable factor significantly contributing to bone health. Given that nearly half of an adult's bone mass is accrued during adolescence, exercise is incredibly beneficial. This paper reviews the most recent research to determine the optimal exercise components for enhancing bone strength and density. While walking alone may not increase bone mass, it can attenuate bone loss. Weight-bearing exercises must achieve the requisite mechanical intensity to generate a significant ground reaction force to be effective. This review examines the impact of exercise on bone density and strength.*

Keywords: Physical Activity, Exercise, Bone Density

Introduction

The human is composed mainly of the musculoskeletal system (Gomarasca et al., 2020). It provides shape, support, and movement of the body. Additionally, the mechanical stress that muscle contractions place on bone significantly impacts bone density, size,and strength (Hart et al., 2017). When muscles are not utilized or paralyzed, both muscles and bones atrophy from disuse, and when function is restored, both bones and muscles are rebuilt. This illustrates the strong relationship between the functions of both muscles and bones (Isaacson and Brotto, 2014; Tagliaferri et al., 2015). Exercise is the most crucial component for bone health compared to physiological, genetic, and lifestyle factors, whichdepend on good bone health. Regular activity is crucial in many ways to preserve ideal bone health. In addition to promoting bone growth and strength, exercise-induced stress on the bones also increases calcium deposition, making bones stronger and denser. Regular exercise affects bone density, size, and shape, significantly increasing mechanicalstrength. In contrast, a lack of exercise causes a lossin bone mass (Isaacson and Brotto, 2014). It's worth highlighting that bone modeling is influenced by mechanical forces, emphasizing the significance of engaging in physical activities throughout one's lifetime. Not every exercise benefits bonemineral density (BMD) similarly. While research indicates that exercise can enhance bone mass in younger individuals, its impact on adults and the elderly remains a subject of ongoing debate. The study suggests that physical activity may improve cortical bone thickness and resistance in older individuals at load-bearing skeletal locations (Nikander et al., 2010). Exercise-inducedimprovements in bone strength in older persons appear to be more likely to result from adecreased loss of endocortical bone and an increase in tissue density than the gain in bone sizethat young participants normally experience (periosteal apposition).

Several strategies have been proposed for how mechanical strain might be converted into biochemical cues that promote bone growth. Uncertainty exists over the elements required to reach optimal bone mineral content (BMC) and bone mineral density (BMD). All four factors, genetics, exercise, hormonal status, and nutrition, play essential roles. The peak bone massobtained or maintained can be altered by exercise, hormones, and nutrition, while genetics seems to have the most impact. The present study investigated how differenttypes of exercise influence bone density and strength.

Effect of exercise on Bone health:

In many ways, maintaining ideal bone health requires regular exercise. Exercise-induced bone stress benefits bones by encouraging calcium deposition, resulting in denser, stronger bones and bone growth and strength in both muscles and bones. On the other hand, bone mass decreases due to physical inactivity (Kim et al., 2019). The responsiveness of bone modeling to mechanical loading is notably impressive, emphasizing the significance of physical activity and the enduring nature of this phenomenon throughout one's lifetime (Santos et al., 2017). During childhood and adolescence, rapid bone growth, bone density development, and bone strength building are common. Exercise at this time speeds up these processes and builds bone mass tothe greatest extent; this increase in bone mass endures into later years. Bones

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grow, develop, and expand due to a continualprocess of bone deposition and resorption. This process of bone modeling begins considerably earlier, throughout foetal life, and lasts until epiphyseal fusion, which occurs near the end of the second decade of life. After epiphyseal fusion, thebone's density, mineral content, and structural strength are significantly influenced by the bone's thickness and dimensions.

Weaver et al. (Santos et al., 2017) observed a consensus in the scientific community regarding the pivotal role of lifestyle in promoting optimal bone health across the lifespan. Their findings highlighted that physical activity and calcium intake emerge as primary determinants for achieving peak bone mass during late childhood and adolescence, a critical period for bone development that can contribute to preventing osteoporosis later in life. Exercise and calcium might not work independently despite each having independent pathways affecting bone.

The specific biochemical process of exercise affecting bone mass has been extensively studied. For over two decades, research has consistently shown that any elevation in mechanical pressure applied to bone results in strains affecting the entire bone structure. These strains cause specialized osteocytes embedded in the bone to become activated. These cells function as mechanosensitivecells and possess the unique capacity for mechanotransduction, enabling them to detect andrespond to mechanical tension. Osteocytes control bone production and resorption by activating osteoblasts and osteoclasts in turn and through a series of molecular signals (through the differentiation of both the osteoblasts and osteoclasts). Due to physical activity and the subsequent muscle contractions exerted on the bone, the bone undergoes adaptation by initiating an osteogenic response. Notably, this response to strain naturally occurs at the site of strain and deformation, aligning with the primary loading direction of the contracting muscle. More sources comprehensively cover this subject (Santos et al., 2017).

The above-discussed bone adaptation responses to exercise fulfill a crucial physiological purpose by enhancing bone mineral density (BMD), bone structure, and strength, thereby contributing to the prevention of bone injuries. High-impact sports like tennis benefit significantly from this effect. It's interesting to note that children who engage in physical exercise have more bone mineral content as adults than their non-exercising, sedentary peers, especially in the femoral neck andhip (Meyer et al., 2013). It has been noted that former football players had a lower risk of fracture for up to 30 years after they leave because they often have highBMD and larger bone size (Tveit et al., 2015). It is widely acknowledged that exercise plays a crucial role in averting or postponing age-related bone deterioration and susceptibility to osteoporosis.

Consequently, this aspect holds practical benefits in addressing these concerns. The area that experiences the most loading determines where the bone adapts to physical activity. For instance, baseball players' dominant humerus has much higher structural and bone strength indices than their non-dominant humerus.

Moreover, sports involving high-impact and multidirectional loading on the lower limbs, such as hockey, football, and volleyball, demonstrate significantly higher hip bone mineral density (BMD) and section modulus when compared to individuals leading a sedentary lifestyle or engaging in low-impact activities. (Bellver et al., 2019)

Effect of exercise on women's bone health:

Over 1.7 million persons were admitted to hospitalsin 2011 due to fragility fractures, and the direct expenditures of treating osteoporosis in the United States exceeded 70 billion dollars (Hernlund et al., 2013). A woman just over 50 years old had a 3.4%, 5.3%, and 6.8% chance of experiencing a fragility fracture (Brown, 2019). The inability to achieve and sustain optimal peak bone mass during adulthood significantly elevates the likelihood of experiencing fragile fractures in later life.

Physical activity is a variable, easily attainable, and inexpensive aspect of bone health. Osteocytes can detect mechanical signals like bone strain produced when the skeleton is understress from exercise. In healthy biological systems, signals associated with the intensity and rate of mechanical strain initiate a cascade of metabolic processes that promote localized and systemic bone turnover, ultimately leading to a net increase in bone formation. Because of this, weight-bearingactivities are advised by the National Osteoporosis Foundation, International OsteoporosisFoundation, and other organizations (Bassey and Ramsdale, 1995). When assessing the impact of weight-bearing exercise, specifically vertical leaping, on these two groups of women, a notable increase in femoral bone mineral density (BMD) was observed among pre-menopausal women, whereas postmenopausal women did not experience any discernible improvement. (27) The mechanism behind this variation was linked to boththe drop in circulating estrogen levels and the disappearance of oestrogen receptors on bone cells.Since estrogen is crucial for bone homeostasis and skeletal growth in postmenopausal women, this reduces osteoblast proliferation.On the other hand, males between the ages of 60 and 85 were asked to perform a unilateral 12-monthleg hopping exercise while the other leg was left atrest as a control. After completing the exercise phase, a significant increase in femoral bone mineral density (BMD) was evident, with a more pronounced effect observed in the leg that underwent exercise compared to the resting leg. This can be primarily attributed to the mitigation or postponement of anticipated age-related changes in bone, highlighting one of the advantages of exercise for maintaining bone health. Physical activity provides additional advantages for boosting overall body fitness and health, slowing down aging, and maintaining bone health.

The fact that physically active women frequently do not experience the benefits of exercise on bone health that one might anticipate, given the BMD seen in female athletes, is one of the issues with theassociation between sports participation and bone density. Physically active women's exercise-related gains in BMD are typically only 2-6% larger than non-exercising women's (Noirrit-Esclassan et al., 2021). Most likely, the difference in training duration andintensity, as well as the fact that most athletes start training at a young age when exercise may have a higher impact on BMD, are to blame for the variance.

Type of exercise best for bone health:

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All forms of exercise benefit bones since any muscle contraction works against bone or stresses bone to some degree. However, weight resistance and weight-bearing activities are the most effective for boosting bone mass, maintainingbone density, and reducing bone loss over the longterm. Walking, running, jogging, and tennis are a few examples of these weight-bearing workouts (Brown). These are the best exercises for constructing bone because they put the bone under stress from both muscle contraction and gravity. Stair climbing, gymnastics, and dance are more comparable exercises. As expected, the advantage increases with increasing stress and bone impact.

Additionally, holding weights in your hands whileyou walk can improve the effects of your exercise. Weightlifting, elastic tubing, and other varied machines are examples of resistance exercises used in physical treatment clinics and health clubs. Major muscular groups in the arms, torso, and legs should be the exercise's focal point. Swimming and cycling do not include weight-bearing, but they still cause muscles to contract, which may help bones in some ways. Anyone whowants to stay healthy must routinely engage in whatever exercise they love. Regular exercise also offers the additional benefit of boosting cardiorespiratory fitness, which improves muscle strength, body balance, and reaction time and, as a result, reduces the risk of falls and fractures.

Fast bowling in cricket has an uneven movementpattern characterized by solid ground response pressures and multi-planar trunk motions (Ruegsegger and Booth, 2018), which may be a factor in the high estimatedloading on the lumbar spine (Keylock et al., 2022). These elements and the high match volume requirements of elite cricket may help explain why male fast bowlers have considerably higher L1-L4 BMDthan other cricket players or inactive controls (Orchard et al., 2015). According to Always et al. (2019)(Orchard et al., 2015), there is themost bone growth on the side of L3 and L4 opposite the bowling arm, where BMD is up to14.6% higher than on the ipsilateral side.

Compared to male fast bowlers, femalesbowl faster and with a different style.

Felton, Lister, Worthington, and King (2019) (Alway et al., 2023) discovered that when comparing female fastbowlers to male fast bowlers, female fast bowlers had a slower run-up velocity, lower ground response forces, and higher contralateral pelvic and trunk rotation contributions. The typical femaleCounty Cricket Club is scheduled to compete on 15days every season (first class = 4 days, list A and twenty over = 1 d), compared with 93 match days for the male counterpart, according to statistical analysis of publicly available scorecards. This is because women bowl significantly less often than men during matches. Also, lumbar lordosis is higher in females than males and lumbar vertebrae are more minor in females.

Weight-bearing activities are advised by the National Osteoporosis Foundation, International Osteoporosis Foundation (NIAMS), and other organizations for preventing osteoporosis. Jumping, aerobics, and running are examples of high-impact workouts while walking and weight training are examples of low-impact exercises. The evidence is vital for high-impact exercises, while weight training may also benefit pre-menopausal women. For instance, it has been shown that weightlifting and plyometric exercise (bounding, jumping, or hopping) are suitable for bones of all ages (Troy et al., 2018). Recent findings from a brief clinical study on high-intensity resistance and impact training have indicated substantial improvements in proximal femur and lumbar spine density and geometry among postmenopausal women. In addition to its role in averting age-related bone loss, a varied exercise regimen that includes a blend of high-impact, weight-bearing, and aerobic activities may also enhance bone mineral density (BMD) in the hip and spine (Zhao et al., 2017). Walking only slightly or not at all affects bone in the aging population.

Cycling, yoga, and swimming are examples of lower-impact sports frequently suggested as lifetime fitness pursuits for ageing populations and are typically not considered osteogenic. Forinstance, throughout a 12-month study period, professional female cyclists' BMD at the hip and lumbar spine changed by 1.4% and 1.1%, respectively (44). BMC and BMD in the lower limbs are typically similar or slightly lower while swimming (Gomez-Bruton et al., 2013).

When choosing a suitable exercise program, additional factors are needed, even if vigorous, high-impact activity is ideal for building BMD. Mechanical loading duringexercise generally has no detrimental effects on joint health and is advised to relieve osteoarthritis (OA) symptoms. Nevertheless, high-impact loading can exacerbate joint degeneration in individuals with osteoarthritis (OA) who are dealing with obesity or have experienced abnormal joint biomechanics due to previous severe injuries or surgeries.

Running, in particular, has been associated with an elevated risk of joint injury but can also offer benefits for bone, muscle, and cardiovascular well-being. A recent meta-analysis comprising 17 studies with over 100,000 individuals revealed that only 3.5% of individuals who engaged in leisure running developed osteoarthritis (OA), compared to 10.2% of sedentary individuals and 13.3% of competitive runners (Alentorn-Geli et al., 2017). Therefore, even if high-impact exercise at a leisure level is not associated with an increased risk of OA over a person's lifetime, beginning a high-impact exercise programme after joint degradation has already occurred may negatively impact the disease's progression.

.Discussion

The present study was conducted to investigate how different exercise types influence bone density and strength. Physical activity has several positive effects on bone health (Kohrt et al., 2004; Proia et al., 2021). Regular physical activity can help build and maintain strong and healthy bones throughout a person's life. Weight-bearing and resistance exercises, such as walking, running, weightlifting, and dancing, stimulate the bones to become denserand more potent. This is especially important for children and adolescents as they are still developing bone mass, but it continues to be beneficial for adults to maintain bone density as they age. Bone is a dynamic tissue that constantly undergoes remodeling, and physical activity influences this process in several ways. Maintaining a healthy weight through physical activity can positively impact bone health. Excess body weight can stress bones andincrease the risk of conditions like osteoarthritis while being underweight can lead to lower bone density. Regular physical activity, particularly weight-bearing and

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resistance exercises, can significantly impact bone health by increasing bone density, strength, and mineralization, reducing bone loss, and improving overall well-being. To maximize these benefits, adopting a balanced and sustainable approach to physical activity throughout one's life is essential.Exercise can have a significant and positive effect on bone density. Bone density refers to the amount of mineral matter (mainly calcium and phosphorus) in bone tissue, determining bone strength. Maintaining or increasing bone density is essential for overall bone health and reducing the risk of osteoporosis. Research studies have consistently shown the positive effects of exercise on bone density.

A study conducted in 2010 by HG Bone et al. (Bone et al., 2010) examined the impact of high-impact and resistance training on bone density in postmenopausal women. The results indicated that high-impact activities (like jumping exercises) and resistance training (with weights) significantly increased bone mineral density at the hip and spine in the study participants. It was concluded that combining these types of exercises effectively improves bone health in postmenopausal women. Another study by P Zhang et al. (Zhang et al., 2020) investigated the association between physical activity and bone density in older adults. It was found that older adults who engaged in regular physical activity, such as walking or strength training, had higher bone density measurements compared to sedentary individuals. The study emphasized the importance of maintaining physical activity throughout the aging process to reduce the risk of osteoporosis. AH Alghadir et al. (Alghadir et al., 2016) stated that a combination of exercises that target different muscle groups and bones could effectively enhance bone density. A research study explored the impact of long-term swimming on bone density in elite swimmers. It was stated that despite the low-impact nature of swimming, elite swimmers had similar or even higher bone mineral density levels than the general population.This research study suggested that the high training volume and intensity of elite swimming might contribute to these positive bone density outcomes.These studies collectively demonstrate that various types of exercise, including high-impact activities,resistance training, and aerobic exercises, can benefit bone density in individuals of different ages and health conditions.

The specific exercise regimen and duration can vary, but the common theme is that regular and appropriately designed physical activity positively influences bone health by increasing bone mineral density and strength. Various types of exercise, including resistance training, weight-bearing exercises, and high-impact activities, can positively influence bone strength by increasing bone density and mineralization. A well-rounded fitness routine that includes a variety of exercises can contribute to overall bone health and reduce the risk of fractures and bone-related conditions like osteoporosis. (Melton, 2023) Individual factors, such as age, fitness level, and specific health concerns, should be considered when designing an exercise program to improve bone strength (Pfeifer et al., 2004)..

Conclusion

Adequate bone health depends on physical activity. The above investigation concluded that different types of exercise influence bone density and strength. Exercise promotes osteoblastic bone-building activity.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
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The authors declared absence of conflict of interest.

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