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Effects of Different Types of Physical Training on Bone Mineral Density in Men and Women

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Abstract

Now, Osteoporosis (OP) is considered one of health threatening diseases in men and women. Physical activity can act critical for bone development, bone health, and fracture risk reduction. It is an effective, low cost and sound way to inhibit the progression of OP if perform regularly and have a structured base. Progression of OP is often related to either little accumulation of peak bone mass before to obtain of skeletal maturity or to excessive rate of bone loss in aging process. Given the rapid aging of societies worldwide, and the fact that no cure exists for osteoporosis, without adequate preventive strategies, the burden of these fractures is likely to grow exponentially. The purpose of this review was to convey the effects of different types of physical training on bone mineral density (BMD) principally at the hip and spine in men and women.

Keywords: Osteoporosis; Endurance training; Resistance training; Bone mineral density

Abbreviations: OP: Osteoporosis; WHO: World Health Organization; BMD: Bone Mineral Density; RT: Resistance Training; AT: Aerobic Training; DEXA: Dual-Emission X-Ray Absorptiometry; ACSM: American College of Sports Medicine; PA: Physical Activity; GH: Growth Hormone

Osteoporosis

Osteoporosis (OP) is a serious skeletal disorder induced by bone mass reduction and micro-architectural deterioration of bone tissue that consequently lead to more fragility in bone and also frequent fractures [1]. This chronic disease causes 1.5 million fractures annually, 700,000 of which occur at the spine [2]. Base on the studies, it has been reported that 50% of women, and 20% of men with the age of 50 and over, will have fractures related to OP in their life time [3]. Osteoporotic fractures commonly occur at the hip, spine and wrist and of these hip fractures have the highest short-term mortality, morbidity and associated socio-economic impact [4,5]. After the age of 40, BMD declines progressively, 0.5% per year or more, especially in women. This decline approaches their mortality rate to 20% following hip fractures. Moreover, the other 2 sites are susceptible with fracture including the spine and the wrist [6]. Fractures lead to more mortality, morbidity, chronic pain, reduction in the quality of life, long-term attention, social and health care costs [7].

Typically, the diagnosis of OP is based on the BMD of the lumbar spine and hip measured by dual-emission X-ray absorptiometry (DEXA). In a pre or post-menopausal woman a T-score ≤ 2.5 (at least 2.5 standard deviations below the average BMD of a young woman) defines osteoporosis according to the World Health Organization (WHO). A T-score between -1 and -2.5 signifies osteopenia [6,8,9]. DXA is defined as the "gold standard" because experts identified it as high technique with high validation biologically [10].

Periods of growth are thought to be the best time to increase bone mineral content, bone area, and areal bone mineral density (aBMD) through increased loading owing to high rates of bone modeling and remodeling [11]. Bone stability links to a lot of interconnected factors, including the size and mass of bone tissue, the structural network of bone and the internal properties of the bone material (porosity, matrix mineralization, collagen traits and micro-damage) [12].

The skeletal performance is presented as two functions. First related with metabolism and second is related to body support. Individual fractures induced by bone mass reduction along with deterioration of its microarchitecture [13]. It is well known that the bone tissue is metabolically active; process of remodeling can be divided into five phases: activation, resorption, reversal, formation and quiescence.

The two cell types act related to bone metabolism: Osteoblasts engaged regarding formation modeling and osteoclasts are responsible for resorption modeling. Interactions between them determine the amount of the bone integrity [14]. A system known as RANK-RANKL-OPG controls the bone resorption and formation (coordination and synchronization) which provide a better concept of bone physiology and prepare the condition for the progression of new treatments [15]. Bone formation markers include serum bone-specific alkaline phosphatase, serum osteocalcin, serum type 1 procollagen. Bone resorption markers are tartrate-resistant acid phosphatase 5b, urinary deoxypyridinoline, urinary hydroxyproline, urinary collagen type 1 cross linked N-telopeptide, urinary or serum collagen type 1 cross-linked C-telopeptide, urinary pyridinoline bone sialoprotein [16].

The process of formation and resorption happen alternatively in the bone development during growth and aging. Formation is predominant until the age of 25 years, reach to stabilization until the age of 35 years, then declines gradually, demonstrating a higher decrease starting at the age of 70 years. Resorption often increases (at the age of 35 years starts) this process conduct quickly in women during the postmenopausal period (until the age of 70 years). OP can be categorized as primary or secondary [13] (Table 1).

Age
Early menopause
Estrogen deficiency
Excessive or too little exercise
Family history
Female gender
Health conditions
Late menarche
Low body weight
Pain
Poor health status
Poor nutrition
Obesity
Sarcopenia
Smoking
Steroid usage
White race

Table 1: Risk factors for osteoporosis.

Physical Training

Physical activity (PA) is one of the most effective tools to counter age-related health conditions. Regular PA has preventive effects on cardiovascular conditions, type 2 diabetes, and degenerative diseases such as osteoporosis and osteoarthritis [17]. Regular exercise is widely recommended as the most effective non-pharmacological method for improving and maintaining BMD and can also reduce the risk of falling [6,18].

American College of Sports Medicine (ACSM) declare that individuals with purpose of bone health should have an active life style, so that aerobic exercises and activities (weight-bearing exercises) with intensity of moderate-to-high are recommended to maintain or to ascend bone mass [18]. Exercise increases bone mineral density, bone mass, bone strength and bone mechanical properties. It seems to directly or indirectly act on almost all the bone cell types and affect many aspects of bone remodeling [19].

Mechanical stimuli influence bone strength, with internal muscular forces thought to be the greatest stressors of bone [20]. Exercise can cause a series of physiological responses that involve the hypothalamus-pituitary-adrenal and hypothalamus-pituitary-gonad axis. It promotes the release of growth hormone (GH), prostaglandin E2 (PGE2), parathyroid hormone (PTH) and thyroid hormones [21]. There is evidence that PGE2 increases bone formation and bone mass [22].

Those exercises have "lower impact" such as swimming, bicycling, have been considered to provide ground reaction forces varying from 0 to 2 times the body weight seems that not to be as effective at increasing bone. Other exercised with higher impact, such as jumping and gymnastics; forces imposed on bones can reach 6-8 times the body weight for jumping and 10-15 times body weight for gymnastics, respectively [18]. High-impact activities have been shown to be effective in increasing bone mass [23]. The ACSM currently recommends weight bearing endurance activities 3 to 5 days per week and resistance activities 2 to 3 days per week at moderate-to-high intensity for men and women to help maintain bone mass [18].

In addition, physical stress inhibits osteoclastogenesis and bone resorption via the OPG/RANKL pathway, which is secreted by MSCs, osteoblasts, and osteocytes, and the pro-inflammatory cytokines [19].

Endurance Training

Health experts and physicians primarily recommend endurance exercises and training such as walking and running. These weight bearing activities most widely used by the older men and women [13].

The data from Kohrt et al. [24] reported that an exercise programme including walking, jogging and stair climbing resulted in significant increases in BMD of the whole body, lumbar spine, femoral neck and Ward's triangle. However, high intensity exercises (ultra-marathon, running >64 km per week) is accompanied with a lot of osteoarticular damages and micro-injuries. In addition, the optimal level of physical activity promoting BMD benefits and modulating osteoprotectors is still unknown [13].

Some researchers reported increases in BMD among high-performance runners, primarily in the femoral neck [25]. There was a statistically significant effect of walking on femoral neck BMD but not lumbar spine, although the effect we observed at femoral neck is most likely too small to be of clinical significance in terms of fracture prevention. However, a prospective cohort study has found that walking for at least 4 h/week was associated with a 41% lower risk of hip fracture compared with walking for less than 1 h/wk. It has been reported that those do walking regularly, will experience less risk of fracture by promotion of balance [26,27] and reducing risk for falling, over changes observed in BMD among postmenopausal women [27]. However, Maud et al. designed the study of a long-distance runner older than 70 years who had training history more than 50 years. But, they did not find any alterations in musculoskeletal system [28] (Table 2).

Authors	Sample Size	Intervention	Results
Gerbaix et al. [29]	Sixty obesity male rats were divided into 4 groups of 15 rats	Training session: run on treadmill 5 d/wk for 8 weeks, first 10 days: rats were trained to the treadmill protocol by a progressive increase of time and velocity starting from 6 m/min for 15 min to 10 m/min for 50 min.	Training significantly improved tibia BMD and decreased CTX levels and trabecular osteoclast number

Pang et al. [30]	63 older individuals with history of chronic strokes were assigned to exercise (n=32) with fitness and exercise program and control (n=31) with a seated upper body program	Aerobic training	Training group without changes in the femoral neck BMD, while a meaningful decrease in BMD was reported in controls
Ilich and Brownbill [31]	97 women (post-menopausal period)	Walking rhythms (slow, quick, or brisk)	A meaningful higher femoral neck BMD/BMC at a brisk walking rhythms than A slow walking rhythms
Ilich-Ernst et al. [32]	77 older Caucasian females were studied for previous physical activity and past and present activity as walking	Physical activity as walking	Hip BMD increased in individuals walking at a brisk or fast rhythms
Engelke et al. [33]	46 postmenopausal women	3 year program of low volume high resistance strength training and high impact aerobics	BMD was maintained for 3 years at spine, hip, calcaneus, but not the forearm
Englund et al. [34]	48 women were assigned to exercise or control group	Isometric exercises, walking, and balance exercises	Intervention group showed significant increases in BMD of Ward's Triangle

Table 2: Summary of the effects of endurance training on bone strength.

Resistance Training

Research studies indicate that resistance training has been considered a key lifestyle factor ran optimum peak bone mass level [35]. Resistance training is one of the most commonly prescribed forms of exercise. The clear benefits of resistance training such as muscle hypertrophy, strength, and power [36] are only part of the advantages because it has also been reported to be influential in the prevention and treatment of OP [18].

Generally, resistance exercise training has been identified as the most effective type of exercise on bone health. It is clear that a diverse loads or resistances are imposed to the bone during resistance exercise training which induce stimuli and cause osteogenic response of the bone [37]. Really, it appears that mechanical loading forces have lower effect in emerging an osteogenic effect with aging. Based this, likely a progressive loss of bone sensitivity happen related to chemical and physical signals [38].

The osteoclastic activity regulation should be considered for understanding bone changes induced by physical stress (mechanical load). It appears that OPG and RANKL are important regulators of osteoclastogenesis, although few comprehensive endeavors have been made to characterize the effects of long-term physical training on serum expression of both cytokines. Overall, data from the present study have shown that RE increases the BMD at the trochanter and total hip, balance and strength and that these effects are more influential than after endurance training in elderly females [39].

A previous review as systematic has declared that performing resistance exercise training regularly during one year with frequency of 2-3 times per week has considerable effects to maintain or increase the BMD of spine and hip in postmenopausal females [40] (Table 3).

Authors	Sample Size	Intervention	Results
Hinton et al. [41]	58 healthy, physically active men (aged 25-60 years) trained the 12-month randomized	RT trained two time per week with a minimum of 48 h between sessions and Jump three times per week with at least 24 h between training, a 6 week cycle followed by a rest week, a total of 8 cycles were completed	WB and LS BMD significantly increased by0.6% and 1.3% after 6 months of RT or Jump and this increase was maintained at 12 month
Maddalozzo and Snow [42]	Men and women	1 year of training, squat and deadlift exercises	BMD in the P-A view of the spine of mature men and not women
Ryan et al. [43]	Males and females with the average age of 25 years	24 week resistance training	Created equal responses in BMD at the hip in males and females with the average age of 25 years
Wolfe et al. [44]	In adult and older adult women	Exercise programs	Prevented or reversed approximately 1% bone loss per year (femoral neck and lumbar spine)
Going and Laudermilk [45]	Premenopausal and postmenopausal women	Resistance training	Increased BMD between 1% and 3% (femoral neck and lumbar spine)
Kerr et al. [46]	Postmenopausal women	High load, low-repetition (6-8 repetitions) against low-load, high-repetition (20 repetitions) resistance training	High-load, low-repetition training was effective at increasing BMD, whereas low-load, high-repetition training was not effective

Table 3: Summary of the effects of resistance training on bone strength.

Conflict of Interests

The authors declare that they have no competing interests.

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