Exercise and osteoporosis

A wealth of data supports the relationship between physical activity and bone health at all ages. Mechanical loading of the skeleton (lifting weights or weight-bearing exercise) leads to increases in bone density and strength, whereas unloading (in the form of bedrest, immobilization, casting, denervation, space travel) produces rapid and dramatic resorption of bone and increased susceptibility to fracture. Comparative studies of athletes and non-athletic populations demonstrate significantly higher bone density in the active groups, ranging from 5-25% higher, depending upon the type, intensity, and duration of exercise training undertaken. Less dramatic, but similar differences are observed between habitually active and sedentary non-athletic individuals. Consistent with these findings, hip fracture incidence is approximately 50% lower in older adults with a history of high levels of physical activity in daily life, compared to age-matched sedentary adults.

Thus, it is important for clinicians and adults of all ages to understand the rationale and recommendations for the use of exercise in the prevention and treatment of osteoporosis and osteoporotic fracture. The optimal use of exercise is dependent upon the prescription of a sustained, adequate dose of the correct type of exercise to the target age group while minimizing the risk of side effects. A "blanket" exercise prescription is not possible as the relative importance of skeletal and non-skeletal contributants to osteoporotic fracture shift over the course of the lifespan.

Prevention of Osteoporosis in Childhood and Young Adulthood

Many studies suggest that exercise effects on peak bone mass are particularly potent when activity is begun before the onset of puberty and sustained throughout the young adult years. The goal of physical activity in youth is to maximize peak bone mass which is attained by age 20-30. The kinds of activities which are most robust in their effect on the skeleton are those which include:

- High impact loading
  (jumping, running, gymnastics, volleyball)
- A variety of loading angles
  (basketball, gymnastics)
- Weight-bearing, high forces
  (dancing, weight lifting, not swimming, cycling).

Local mechanical factors predominate, so that dominant arms used in sports such as tennis have greater bone density than non-dominant arms, for example. Balancing the load imposed on right and left extremities is important therefore.

Beginning in childhood, all individuals should be encouraged to engage in regular weight-bearing exercise, via a combination of lifestyle choices (such as walking to school or errands), structured sports, and unstructured games (outdoor play). Participation in competitive sports, although associated with positive effects on bone, may be hindered by many barri-

ers, including skill level, self-efficacy, gender bias, financial burden, lack of parental encouragement,, time commitments, and travel requirements, and is not attractive to all children. Therefore, emphasizing the replacement of sedentary activities (TV, video games) with active outdoor play, physical education in school, and less reliance on mechanical modes of transportation (cars, elevators, escalators) is likely to have a far greater impact on public health and sustained behavioral patterns in adult life than simply encouraging more competitive team sports. If sports are chosen, those involving jumping from different angles, running, and lifting appear to have the greatest effect on bone. It is important for growing children and adolescents to maintain adequate energy, protein and calcium intake, as bone health is compromised in the presence of eating disorders, excess phosphate from carbonated drinks, and hormonal disturbances associated with very low levels of body fat sometimes seen in very active young women.

Prevention of Osteoporosis in Middle Age

After the age of 30, the physical activity prescription for the maintenance of bone health becomes more comprehensive. Peak levels of muscle and bone have already been attained, and may start to decline even 10 years before menopause in women. Chronic health conditions that may influence one density or temper the exercise prescription may have started to emerge. Recreational and occupational physical activity levels have simultaneously started to decline in most adults. Although both weight-bearing aerobic exercise and resistance training (weight lifting) have been shown to maintain or augment bone density in this stage of life, resistance training has the added benefit of increasing muscle mass and strength, as well as balance. Aerobic exercise does not increase muscle mass and strength, and does not improve balance, and is therefore less comprehensive in its effects on the multiple risk factors for osteoporotic fracture in the future. Although high impact exercise (such as jumping with a weighted vest) has been shown to have very robust effects on bone in middle-aged and older women, degenerative changes in joints at midlife and beyond may preclude this form of training in some individuals.

The physiological response in bone and muscle is proportional to the load imposed, and therefore moderate to high intensity progressive resistance training is recommended as the primary mode of planned exercise in this age group. Rest periods between sets of weight lifting exercise may be used to complete 10-20 jumps or heel drops (depending on the presence or absence of osteoarthritis of the knees and hips). Such a routine incorporates resistance training and high impact loading in one session without extending the time required, an economical prescription for busy adults juggling work and family care responsibilities. Two or three days per week of such regimens have been shown to augment bone density by 1-4% per year compared to sedentary controls.

Treatment of Osteopenia and Osteoporosis after Age 50

At this stage in the lifecycle, a combination of decreased hormones (estrogen, testosterone, growth hormone), the emergence of musculoskeletal and other diseases, retirement, and reduced recreational activities have a major negative impact on bone as well as muscle tissue. The majority of studies demonstrating the efficacy of aerobic or resistive exercise on bone density have been conducted in women between 50 and 70 years of age. Both types of exercise have approximately equivalent effects on bone health. Systematic reviews indicate a difference of about 1 to 1.5% per year

between exercisers and non-exercisers in well-designed trials.

However, no exercise studies have yet been carried out long enough to determine whether such protective effects on the skeleton will result in fewer osteoporotic fractures. Choosing between exercise modalities should be based on a consideration of "non-bone" factors, since bone effects are similar. Such factors include:

- Need for muscle mass and strength
- Gait and balance impairments
- Patient preference/access to facilities or trainers
- Musculoskeletal limitations/pain with certain activities.

In general, the older the individual, the more favorable resistance training appears, due to its broader benefits on muscle, bone, balance, and fall risk, relative to aerobic training.

In addition to the above considerations, activity recommendations for this age group should include avoidance of forward flexion of the spine, particularly while carrying an object (bowling, bending over to pick up something from the floor, sit ups with straight legs, etc.). Such actions increase the risk of anterior compression fractures of thoracic vertebrae in the presence of osteopenia. Similarly high-risk activities or hazardous environments which may lead to falls in those with poor balance are best avoided.

In older men and women who have already sustained an osteoporotic fracture, exercise is still extremely important to assist in recovery of function as well as prevent recurrent injurious falls. Progressive resistance training has been shown to be superior to standard physical therapy during the recovery from hip fracture in elderly patients. A combination of resistance training and balance training offers the best approach to rehabilitation in this setting, as it optimally targets the remediable physiological risk factors for falls, fractures, and disability in this cohort. In addition, resistance training has been shown to be a potent treatment for depression in the elderly, and may thus be able to substitute for antidepressant medications, which are known to increase the risk of hip fracture.

Conclusion

At all ages, an exercise prescription is important for the prevention and treatment of osteoporosis. A combination of lifestyle choices, organized sports, unstructured play, and household and occupational tasks can all contribute to a desirable exposure to physical activity that will be lifelong and robust enough to counteract age and disease-related losses of bone. An initial emphasis on weight-bearing aerobic and high-impact activities in youth, shifting towards resistive loading and balance-enhancing exercises in old age appears to optimally address the needs and capacities of the musculoskeletal system throughout the lifespan.

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