

Osteoporosis and Exercise Interventions

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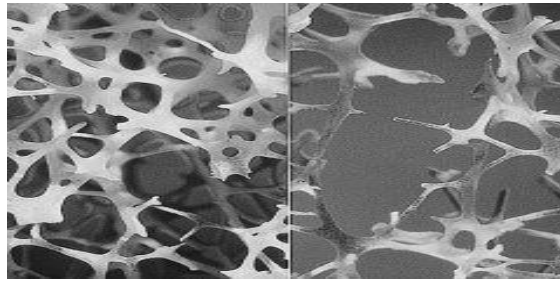
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Abstract: Calcium is the most abundant mineral in the body. Calcium combines with phosphorus to form the bones and teeth. It also activates several enzymes, is part of calcitriol, the active form of vitamin D. Inadequate calcium intake, the body draws upon its calcium “reserve” in bone to restore the deficit. If this imbalance is prolonged, the condition of osteoporosis develops progressively as bone loses its mineral mass and progressively becomes porous and brittle, bone may eventually break under the stresses of normal living. A literature search over the past twenty years and helpful documents are selected. There are several instruments and methods to measure BMD and DEXA scan is more common. A BMD test is essential for Everybody after the age forty to avoid a fracture due to osteoporosis without trauma. Female are more prone to osteoporosis after menopause. Glucocorticoids therapy, Primary/secondary Hypogonadism in men is major causes to develop osteoporosis. Regular high impact exercise from childhood is essential to prevent osteoporosis in later life and regular weight bearing exercises are more helpful in maintaining required BMD and BMI as well as preventing fall in old age. Life style risk factors should be minimized by taking precautions for early bone loss. Calcium and vitamin-D play a vital role for bone integrity. Calcium and vitamin-D intake should be adequate for proper bone growth. Exercise should generally be part of the treatment plan in patients with osteoporosis. Exercise plays a significant part of a life style prescription for reducing fracture in later life.

Key Words: *Calcium, phosphorus, Vitamin-D, Osteoporosis, BMD and BMI.*

Introduction:

Osteoporosis is the main chronic bone disorder is determined by the progressive disruption of the micro-architecture of bone tissue. It is considered one of the most common skeletal disorders in elderly. The bone loss process can occur with no symptoms and the individual feels fine until a fracture occurs, therefore the attribute “silent” given to the disease.



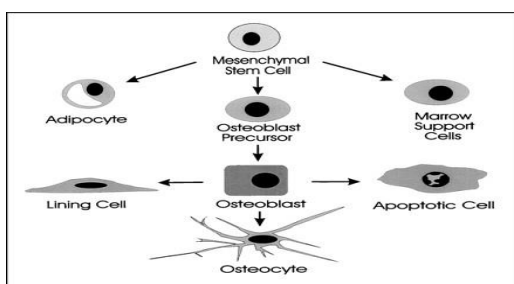
Physiology of Bone Homeostasis:

Bone Formation: In embryos, the skeleton is primarily hyaline cartilage. During growth & Development much of this cartilage is replaced by bone i.e. intracartilaginous ossification. There are two processes –1. Increase in length of the bone by addition of cartilage on outside. 2. Replacement of cartilage by bone at epiphyseal disc.

Bone growth: Epiphyseal plates allow for growth of long bone during childhood. New cartilage is continuously formed and older cartilage becomes ossified. Cartilage is broken down and bone replaces cartilage. Bone are remodeled and lengthened until growth stops.

Types of cells: Osteocytes – Mature bone cells.
Osteoblasts – Bone forming cells.
Osteoclasts – Bone destroying cells.

Remodeling: After bone formation, osteoclasts and osteoblasts continue to remodel the bone. Resorption and deposition are hormonally regulated to keep bone mass constant. The hormone controlling bone resorption is PTH or parathyroid hormone. The hormone of bone synthesis is calcitonin.



Interaction of hematopoietic and stromal cells:

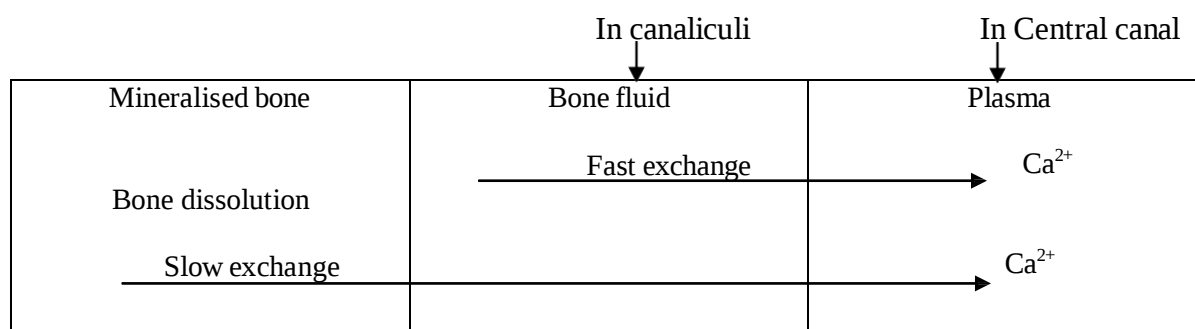
The cells of the osteoblast lineage can interact with hematopoietic cells to initiate osteoclast formation. These same cells can also differentiate to become matrix-synthesizing osteoblasts. The latter pathway may be stimulated by substances released from the osteoclast or from the bone matrix during resorption.

Origin and fate of osteoblasts: The fates of the osteoblast are terminal; reactivation of lining cells and possibly osteocytes back to active osteoblasts has been postulated.

Bone and Calcium regulation: - 99% of body's calcium is in bone. Stable calcium ion concentrates in interstitial fluid vital for membrane function. Calcium-ion concentration maintained by balance of osteogenic and osteoclastic activity.

There are two Ca^{2+} compartments:

1. Mineralised bone – stable pool of Ca^{2+} .
2. Bone fluid: labile pool of Ca^{2+} .



Hormonal regulation of bone:

Bone growth	Bone loss
• Vitamin-D: Promote differentiation of Osteoblast • Growth Hormone: • Increase osteoblast function • Decreased breakdown: oestrogen – inhibits osteoclasts • Calcitonin - inhibits osteoclasts function	• Increased breakdown of parathyroid hormone (PTH) : Stimulates osteoclasts. • Thyroid: Stimulates osteoclasts. • Decreased growth cortisol : Osteoblast death (apoptosis)

Osteoporosis Risk Factors: Doctors and researchers have compiled vast amounts of information on osteoporosis risk factors. Many of those that cannot be reduced through life style changes can be lessened by taking measures to increase bone health.

Modifiable risks	Fixed risks
• Alcohol • Smoking • Low BMI • Poor Nutrition • Eating disorders • Insufficient exercise • Low Ca^{2+} intake • Vitamin- D deficiency • Frequent falls	• Age • Female gender • Family history • Previous fracture • Race/ethnicity • Menopause • Long term glucocorticoid therapy • Primary/secondary hypogonadism in men

Who Criteria for Diagnosis Osteoporosis:

World Health Organization Definitions of Osteoporosis Based on Bone Density		
T-Scores		BMD Category
Examples	Range	
1.0 0.5 0 -0.5 -1.0	-1 and above	Normal BMD
-1.5 -2.0	Between -1 and -2.5	Low BMD (Osteopenia)
-2.5 -3.0 -3.5 -4.0	-2.5 and below	Osteoporosis

Diagnosis Osteoporosis:

What is a BMD test?

Traditional X-rays can't measure bone density, but they can identify spine fractures. Bone mineral density (BMD) has to be measured by more specialised techniques. A number of different types of BMD tests are available, but the most commonly used is DXA (dual-energy X-ray absorptiometry). DXA is a low radiation X-ray capable of detecting quite small percentages of bone loss. It is used to measure spine and hip bone density, and can also measure bone density of the whole skeleton. There are a number of different types of test options

- DXA (peripheral DXA) measures bone mass at the forearm, finger and heel
- SXA (single-energy X-ray absorptiometry) measures the heel or wrist
- DPA (dual photon absorptiometry) measures the spine, hip or total body
- SPA (single photon absorptiometry) measures the wrist
- QCT (Quantitative Computed Tomography) measures the spine or hip PQCT (peripheral QCT) measures the forearm
- QUS (Quantitative Ultrasound) uses sound waves to measure the heel or finger

A DXA scan, which is used to measure spine and hip bone density, is the most common technique for assessing the risk of osteoporosis.

Preventing Osteoporosis:

1. Childhood to adolescence

Children and adolescents should:

- Ensure a nutritious diet with adequate calcium intake
- Avoid protein malnutrition and under-nutrition
- Maintain an adequate supply of vitamin D
- Participate in regular physical activity
- Avoid the effects of second-hand smoking

2. Adulthood

Bone mass acquired during youth is an important determinant of the risk of osteoporotic fracture during later life. The higher the peak bone mass, the lower the risk of osteoporosis.

Adults should:

- Ensure a nutritious diet and adequate calcium intake
- Avoid under-nutrition, particularly the effects of severe weight-loss diets and eating disorders
- Maintain an adequate supply of vitamin D
- Participate in regular weight-bearing activity
- Avoid smoking and second-hand smoking
- Avoid heavy drinking

Exercise Recommendations:

Bone loading exercise recommendations for prevention and treatment of osteoporosis
Recommendations for children and adolescents

This section focuses on children from eight years old through to adolescence and young adulthood. Data drawn from different studies with children in these age groups have been used to develop the following recommendations [6]:

- Make a lifelong commitment to physical activity and exercise.
- In terms of bone health, weight-bearing activities such as basketball, volleyball and gymnastics are more effective than weight-supported activities such as swimming and cycling.
- Intense daily activity is more effective than prolonged activity carried out infrequently.

- Perform activities that will increase muscle strength, such as running, hopping, or skipping games.
- Select activities that work all muscle groups like gymnastics.
- Avoid immobilization and perform short weight-bearing movements if confined to bed.
- Eat a well-balanced diet that is rich in calcium (milk instead of soft drinks) and protein to promote normal growth and puberty as well as regular menses for girls.

The following exercise program from Melbourne, Australia, demonstrated significant increases in BMD in 9- to 10-year old children at both the lumbar spine and the proximal femur. In addition to regular physical education at school, this program incorporated extra classes for the children which resulted in an additional increase in BMD of 4% at the spine and 2% at the proximal femur.

Frequency: Three times per week

Intensity: High impact

Time: 30 minutes of physical activity after school

Type: 1. Aerobic workouts:
Aerobics, soccer, step aerobics, skipping, ball games, modern dance and weight training
2. Circuit training:
20-minute weight-bearing, strength-building circuit consisting of 10 exercises designed to load the biceps, triceps, pectoralis major, latissimus dorsi, trunk, deltoids, rectus abdominis, quadriceps femoris, hamstrings, gastrocnemius, and soleus

Approximately 1 minute per station

One set of 10 repetitions progressing to 3 sets of 10 over time

These recommendations are based on strong scientific evidence suggesting that weight-bearing physical activity plays a key role during the normal growth and development of a healthy skeleton. High-intensity exercise of short duration appears to elicit the greatest bone

density increase in the growing skeleton. This information is especially important to parents, teachers and health authorities that are responsible for school curricula. A sedentary lifestyle, rather than an excessively active one, is more likely to be the risk faced by most children today.

Recommendations for young adults and pre-menopausal women After puberty, bone mineral density (BMD) is not easily augmented. The main role of exercise in young adults and pre-menopausal women, therefore, is to maintain BMD rather than to increase it. Nevertheless, high-intensity exercise can lead to modest bone accrual in targeted areas. Even small increases in bone mineral may significantly reduce the risk of fracture in later life.

The following exercise plan designed by Heinonen and colleagues in Tampere, Finland, has been shown to increase lumbar spine and femoral neck BMD in 35- to 45-year old Finnish women by approximately 2%:

Activity	Duration
Warm-up	15 minutes
High-impact jumps*	20 minutes
Stretching and non-impact activities	15 minutes
Cool-down	10 minutes

*High-impact jump training consisted of an aerobic jump program alternated weekly with a step program. Sessions were performed three times per week over an 18-month period and the height of the jumps increased progressively from 10 to 25 cm, while the number of jumps per session decreased from 200 to 100.

Friedlander and colleagues described a resistance-training protocol that used three different classes per week over two years to augment BMD at the lumbar spine (approximately 5%) and femoral neck (approximately 3%).

Conclusion:

Although no amount of physical activity can stop the biological aging process, there is evidence that regular exercise can minimize the physiological effects of an otherwise sedentary lifestyle and increase active life expectancy by limiting the development of chronic disease.

References:

1. Bailey DA, Faulkner RA, McKay HA. Growth, physical activity and bone mineral acquisition. In: Holloszy JO et al. Ed. Exercise and Sport Sciences Reviews. Baltimore: Williams & Wilkins, 1996; 24:233-266
2. Bradney M, Pearce C, Naughton G et al. Moderate exercise during growth in prepubertal boys: changes in bone mass, size, volumetric density and bone strength. A controlled study. J Bone Miner Res 1998;13:1814-1821
3. Friedlander AL, Genant HK, Sadowsky S et al. A two-year program of aerobics and weight training enhances bone mineral density of young women. J Bone Miner Res 1995; 10:574-585.
4. Gortmaker SL, Must A, Sobol AM et al. Television viewing as a cause of increasing obesity among children in the United States 1986-1990. Arch Pediatr Adolesc Med 1996;150:356-362.
5. Heinonen A, Kannus P, Sievänen H et al. Randomised controlled trial of effect of high-impact exercise on selected risk factors for osteoporosis. Lancet 1996; 348:1343-1347
6. Kannus P, Sievanen H, Vuori I. Physical loading and bone. Bone 1996;18:1-3.
7. Khan K, McKay H, Kannus P, Bailey D, Wark J, Bennell K. Physical activity and bone health. Human Kinetics. IL, 2001:103
8. McArdle William D, Katch Frank I, Katch Victor L. Exercise Physiology, 4th ed. Baltimore USA, Williams & Wilkins. 1996.
9. Morris FL, Naughton GA, Gibbs JL et al. Prospective 10-month exercise intervention in premenarcheal girls: positive effects on bone and lean mass. J Bone Miner Res 1997;12:1453-1462
10. Pfeifer M, Sinaki M, Geusens P, Boonen S, Preisinger E, Minne HW. Musculoskeletal rehabilitation in osteoporosis: a review. J Bone Miner Res 2004; 19:1208-1214
11. Reid C, Dyck L, McKay H et al. The benefits of physical activity for women and girls: a multidisciplinary perspective. Vancouver: British Columbia Centers of Excellence in Women`s Health 1999:249
12. Sallis JF, Owen N. Physical activity and behavioural medicine. Thousand Oaks. Ca: Sage, 1998:210