Chapter 39: Exercise prescription in those with osteoporosis

Epidemiology

- **Osteoporosis** is a skeletal disorder characterized by compromised bone strength that results in an increased susceptibility to fracture.

- 44 million afflicted in U.S. (200+ million worldwide)

- **Osteoporotic fractures** are low-trauma fractures that occur with forces generated by a fall from a standing height or lower and are most common at the spine, hip, and wrist.

- Costs $17 billion per year in U.S.

- Although women are more susceptible, men also can have osteoporosis and often go undiagnosed.

- A woman’s risk of an osteoporosis-related hip fracture is equal to her combined risk of breast, uterine, and ovarian cancers.
Bone Physiology

- Bone is a bisphasic material with crystals of hydroxyapatite (calcium-phosphate mineral) incorporated in a collagen matrix.
  - Cortical bone
  - Trabecular bone

- Modeling and remodeling: Affect the quantity, quality, and structure of the bone; regulated by hormonal and mechanical environments
  - Osteoblasts - forming cells
  - Osteoclasts - resorbing cells
Pathophysiology

- Skeletal fragility
  - Bone quantity: amount of material present
    - Rapid accumulation during adolescence
    - Peak in 2nd to 3rd decade of life
    - Decline over time with aging where resorption is greater than formation rate
  - Bone material quality: ability to withstand stressors
    - Able to absorb more energy in youth, which lowers fracture risk
    - Increased mean tissue mineralization and changes in collagen properties increase fracture risk with age.
    - Increased microdamage accumulation
  - Bone structure: distribution of bone material in bone space
    - Proper geometry can strengthen bone structure.
    - Increased porous bone results in loss of bone strength and increased fracture risk.
  - Falls
    - Falls significantly increase the risk of fracture, especially when skeletal fragility exists.
    - Hip fractures are a common occurrence due to falling.
**Diagnosis of Osteoporosis**

- Measurement of bone mineral density (BMD) by dual-energy x-ray absorptiometry (DEXA) is the primary method of diagnosis.

- World Health Organization (WHO) criteria:
  - **Osteopenia** (low bone mass): Site-specific bone density between 1.0 and 2.5 standard deviations below the mean for young white adult women
  - **Osteoporosis**: Bone density that is 2.5 standard deviations or more below the mean for young white adult women
### TABLE 39-1. RISK FACTORS FOR OSTEOPOROTIC FRACTURES

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor</th>
<th>Factor</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>Neuromuscular disorders</td>
<td>Excessive alcohol consumption</td>
</tr>
<tr>
<td>Previous fragility fracture</td>
<td>Cigarette smoking</td>
<td>Long-term immobilization</td>
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<tr>
<td>Glucocorticoid therapy</td>
<td>Low body weight</td>
<td>Low dietary calcium intake</td>
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<tr>
<td>High bone turnover</td>
<td>Premature menopause</td>
<td>Vitamin D deficiency</td>
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<tr>
<td>Family history of hip fracture</td>
<td>Primary or secondary amenorrhoea</td>
<td>Female sex</td>
</tr>
<tr>
<td>Poor visual acuity</td>
<td>Primary or secondary hypogonadism in men</td>
<td>Asian or white ethnic origin</td>
</tr>
</tbody>
</table>

Bold text indicates characteristics that capture aspects of fracture risk over and above that provided by bone mineral density. Adapted from Kanis, 2002 (14).
Clinical Management

- Pharmacologic therapy
  - Several categories are FDA approved.
    - Anti-remodeling agents act by suppressing resorption.
    - Regulation of calcium homeostasis-parathyroid hormone (PTH)
    - Hormone replacement therapy (HRT) increases BMD.
<table>
<thead>
<tr>
<th>DRUG CLASS</th>
<th>NAME OF DRUG</th>
<th>BRAND NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estrogens</td>
<td>Estrogen sulfate</td>
<td>Ogen</td>
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<tr>
<td></td>
<td>Conjugated estrogen</td>
<td>Premarin</td>
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<tr>
<td></td>
<td>Transdermal estrogen</td>
<td>Estraderm</td>
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<tr>
<td></td>
<td>Estropipate</td>
<td>Ortho-Est</td>
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<tr>
<td></td>
<td>Esterified estrogen</td>
<td>Estratab</td>
</tr>
<tr>
<td></td>
<td>Conjugated estrogen + medroxyprogesterone acetate</td>
<td>Premphase</td>
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<tr>
<td></td>
<td></td>
<td>PremPro</td>
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<tr>
<td></td>
<td></td>
<td>Activella</td>
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<tr>
<td></td>
<td></td>
<td>MiaCalcin</td>
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<tr>
<td></td>
<td></td>
<td>Calcimar</td>
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<td></td>
<td></td>
<td>Fosamax</td>
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<tr>
<td></td>
<td></td>
<td>Actonel</td>
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<td></td>
<td></td>
<td>Didroneal</td>
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<tr>
<td></td>
<td></td>
<td>Evista</td>
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<tr>
<td></td>
<td></td>
<td>Nolvadex</td>
</tr>
<tr>
<td>Calcitonin</td>
<td>Synthetic salmon calcitonin</td>
<td></td>
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<tr>
<td>Bisphosphonates</td>
<td>Alendronate(^d)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Risedronate(^d)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Etidronate(^e)</td>
<td></td>
</tr>
<tr>
<td>SERMs</td>
<td>Raloxifene(^f)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tamoxifene</td>
<td></td>
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<tr>
<td>Others</td>
<td>Isoflavones (natural flavonoids)</td>
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<tr>
<td></td>
<td>Tibolone or ipriflavone (synthetic flavonoids)</td>
<td></td>
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<tr>
<td></td>
<td>Calcitriol or other vitamin D metabolites</td>
<td></td>
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<tr>
<td></td>
<td>Teriparatide(^f) or other parathyroid hormones</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sodium fluoride(^g)</td>
<td></td>
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</tbody>
</table>

SERM, selective estrogen receptor modulator.

\(^a\)All estrogens have FDA approval for prevention of osteoporosis, but only Premarin is approved for treatment.

\(^b\)Premphase, PremPro, and Activella are estrogen and progesterone taken in combination. Premphase and PremPro are FDA approved for the treatment of osteoporosis; Activella is approved for prevention of osteoporosis.

\(^c\)Both calcitonins are approved for prevention, but only MiaCalcin is approved for treatment of osteoporosis.

\(^d\)Alendronate and risedronate have FDA approval for both prevention and treatment of osteoporosis. Alendronate is also approved for treatment of osteoporosis in men.

\(^e\)Etidronate has FDA approval but not with an osteoporosis indication in the United States.

\(^f\)FDA-approved treatment of osteoporosis.

\(^g\)Approval pending for an osteoporosis indication.
Clinical Management

- **Lifestyle modifications**
  - Adequate calcium (1000-1500 mg·d\(^{-1}\)) intake
  - Adequate vitamin D (400-800 IU·d\(^{-1}\)) intake
  - Regular exercise
  - Smoking cessation
  - Avoidance of excessive alcohol intake
  - Visual correction to decrease fall risk

- Exercise is the only lifestyle modification that can simultaneously ameliorate low BMD, augment muscle mass, promote strength gain, and improve dynamic balance, all of which are independent risk factors for fracture.
Exercise and Osteoporosis

- Physiologic response to exercise
  - Acute physiologic response
    - Exercise causes compression, tension, or torsion of bone tissue and ultimately deformation, which is the basis for chronic adaptations.
  - Chronic physiologic response
    - Changes via modeling/remodeling take several months
    - Requires continually acute exercise stress
• Osteogenic activities
  – Response is site specific.
  – Loading/stress should be designed to affect the location in which osteoporosis is identified (e.g., spine, hip, etc.).
  – Rest is important for proper bone adaptation or response.
• Physical Activity During Adolescence: Prevention of Osteoporosis
  – Exercise in youth is deemed very important for adult bone health.
  – Period of maximal velocity of height growth may be most important period of bone mineral accumulation.
  – If normal physical activity is performed, this should be adequate.
• Exercise Prescription for Optimizing Bone Development in Youth
  – ACSM Position Stand on Physical Activity and Bone Health: 10-20 minutes, 3 days per week, of impact activities such as plyometrics, jumping, moderate-intensity resistance training, and participation in sports that involve running and jumping (soccer, basketball)
  – 10 jumps, 3 times per day has also been shown to significantly increase bone mineral density in the proximal femur and intertrochanteric regions.
• Exercise and Bone Health in Adulthood
  – Goal of exercise in adulthood is to offset bone loss observed during this time in life.
  – Not as much research in men as women but appears men can also retard the BMD loss associated with aging

• Exercise Prescription to Preserve Bone Health During Adulthood
  – ACSM Position Stand on Physical Activity and Bone Health: 30-60 minutes per day of a combination of moderate- to high-intensity weight-bearing endurance activities (3-5 times per week), resistance exercise (2-3 times per week), and jumping activities
• Exercise in Elderly and Osteoporotic Individuals
  
  - Exercise testing in osteoporosis
    
    • Not contraindicated
    
    • Should get physician approval due to high incidence of coronary artery disease in the elderly
    
    • Use of cycle ergometry may be indicated in patients with severe vertebral osteoporosis if walking is painful.
    
    • Vertebral compression fractures compromise ventilatory capacity and may affect balance during treadmill walking.
    
    • May have increased false-negative test rate due to inability to exercise to significant level of stress
    
    • Strength testing may be contraindicated in those with severe osteoporosis due to risk of fracture.
Exercise Prescription in Individuals with Osteoporosis

- Pain management may be important.
- Minimal goal should be to avoid prolonged periods of immobilization.
- Contraindicated exercise for individuals with osteoporosis that may result in vertebral fracture
  - Twisting movements (e.g., golf swing)
  - Dynamic abdominal exercises (e.g., sit ups)
  - Excessive trunk flexion
- Flexibility training
  - Avoid any flexibility exercise that causes spinal flexion
  - Avoid all ballistic stretching
• Aerobic training for individuals with osteoporosis
  
  – Goals
    • Increase aerobic fitness
    • Decrease cardiovascular disease risk factors
    • Help maintain bone strength
    • Improve balance
  
  – Perform 3-5 days per week at an intensity of 40% to 70% of VO$_2$ reserve or heart rate reserve (HRR)
  
  – Initial goal of 20-30 minutes per session with slow increase to 30-60 minutes once tolerated
  
  – When possible, exercise mode should be weight bearing.
• Resistance training for individuals with osteoporosis
  
  – Goals
    • Improve bone health
    • Improve balance to lower risk of falling
  
  – Perform 2 to 3 days per week, 8-12 repetitions, at a moderate (60%-80%) or high (80%-90%) intensity of the 1 repetition maximum
  
  – Moderate intensity for those with established osteoporosis and high intensity for those attempting to lower their risk