Exercise, Physical Activity and Osteoporosis
(Sigh) As much as I'd like to, I'd better pass.

SLIP'N'SLIDES AND OSTEOPOROSIS ARE HARDLY A MATCH MADE IN HEAVEN.
Food for thought...

How old would you be if you didn’t know how old you were?
DEFINITION: Osteoporosis

- Osteoporosis (OP) is a disease characterized by low bone mass & microarchitectural deterioration of bone tissue
  - leading to enhanced bone fragility & ↑ in risk fracture.

Consensus Development Conference, 1991
Osteoporosis

- 28 million Americans
  - 80-90% are women
- 18 million Americans have low bone mass & are at risk for developing Osteoporosis
- 50% of all women will develop osteoporosis
- Osteoporosis accounts for more than 1.5 million fractures
  - 700,000 – vertebral
  - 300,000 – hip
  - 250,000 – wrist
  - 300,000 – other sites
Bone Physiology

• Bone
  ■ a living tissue
  ■ Undergoes a continuous cycle of bone building by osteoblasts & bone resorption by osteoclasts.

• Remodeling Cycle:
  ■ Process of resorption & formation
  ■ One cycle completed - 4 months
Bone Remodeling Cycle

A. Quiescent Phase

B. Resorption Phase

C. Formation Phase

D. Quiescent Phase After Remodeling
Measures of bone integrity

1. Bone mass

2. Bone mineral content
   - Calcium
   - Phosphorous
   - Magnesium

3. Bone mineral density
   - Calcium or minerals/unit volume of bone
Screening for osteoporosis
Criteria for Assessing Disease Severity

- **Normal**
  - > -1.0 std

- **Osteopenia**
  - BMD -1.0 – 2.5 SD below the mean

- **Osteoporosis**
  - BMD ≤ - 2.5 SD below the mean

- **Severe Osteoporosis**
  - BMD ≤ - 2.5 SD below the mean with Fracture
Risk of hip fracture per 1000/year
INTACT
- Normal Loading
- Normal Ca++ Loading

Initial stages of Osteoporosis
- Normal loading
- Deficient Ca++ Loading

Osteoporosis
- Unloaded
- Deficient Ca++ Loading

(Lanyon & Rubin, 1986)
Bone Growth

- **Children**
  - Old bone is resorbed but because new bone is formed at a faster rate, total bone \(\uparrow\) linearly with 40-70\% \(\uparrow\) in bone mass during puberty.
  
  - Bone continues to \(\uparrow\) until peak bone mass is achieved around age 30 for both males & females.
Stages

- Bone Growth
  - Resorption < formation

- Between 25 & 35
  - Resorption = formation

- After 40
  - Resorption > formation
Bone Loss

- Women attain peak bone mass that is generally 10% less than males.

- Bone loss of approximately 0.7% - 1% a year occurs up until age of 50 for both genders.

- Bone loss for women to about 2%-3% / year beg. at menopause & continues for 5-10yrs.

- On average – women lose 1/3 -1/2 of the BMD during menopause.
BMD in Women

Bone Mineral Density Decreases at Menopause

- peak bone density
- puberty
- menopause
- osteopenia
- osteoporosis

Bone Mineral Density vs. Age
Demographics of Osteoporosis

- **Gender:** Women affected more than men
  - Lower peak bone mass
  - Rapid bone loss with declining estrogen levels
  - Longer lifespan

- **Race / Ethnicity (compared to Caucasians)**
  - African descent: higher bone mass
  - Asian: lower bone mass
  - Hispanic: same bone mass
Peak Bone Mineral Density (BMD)

- What factors would influence peak bone mass?
Extended bed rest is associated with increased Ca++ excretion
Factors Affecting Bone Mineral Density (BMD)

- **Lifestyle Factors:**
  - Dietary Ca$^+$
  - Vitamin D
  - Weight bearing PA levels
  - Smoking
  - Alcohol Consumption

- **Aging Factors:**
  - ↓Estrogen levels
    - [Menopause or amenorrhea]
  - Testosterone Levels in males
Post-Menopausal Women:

- Hormone replacement therapy will help maintain BMD in post-menopausal women. (RISKS ?)
Osteoporotic Fractures in Women, Compared With Other Diseases

1,200,000
513,000
228,000
184,300

Factors affecting BMD Cont.

- **Health-related Factors**
  - Long-term usage of corticosteroid
    - Oral Glucocorticosteroid (↓ bone formation & ↑ in bone resorption)

- **Genetics**
  - 70-80% of biologic potential is genetic
Oral Glucocorticosteroid Dose Strongly Correlates to Fracture Risk

Relative Risk

Daily Oral Glucocorticosteroid Dose

<2.5 mg/d  2.5–7.5 mg/d  >7.5 mg/d

Hip  Spine
Fractures

- 3 Common sites

- Wrist fracture
- Spinal fracture
- Fracture of the upper part of the femoral bone
Wrist & Vertebral Fractures

- **WRIST:**
  - Pain, reduced ROM
  - 50-70% recover within 6 months

- **VERTEBRAL:**
  - Deformity, postural abnormality
  - Pain
  - Functional impairment
HIP: BAD NEWS!

- 275,000 annually due to osteoporosis
- 20% die within 6 months of the fracture
- 20% require long term institutionalization
- 20% face permanent disability
OUTCOMES: Fractures

- Economic Consequences
  - Projected cost of $45.2 BILLION over the next 10 years

- Based on:
  - Current costs
  - 3 fracture sites
  - # of women over 45 yrs
Fracture Potential

- If applied load is > than structural capacity the fracture will occur.

- What determines the structural capacity?
  - Porosity
  - Mineral content
  - Bone matrix
Applied Load

- Magnitude and Direction of load falls.
  - Lateral – less than 2% of lateral falls result in hip fracture
  - Backwards – 40-60% of vertebral fractures due to backward falls.
ARE THERE CULTURAL DIFFERENCES?

Race
Ethnicity
Gender
Education
SES
Athletes:

- Cross country runners had 20% higher BMC in appendicular skeleton than non-exercisers.
  - Matched for age, height and weight (MALE).
Lumbar Density: Athletes

Drinkwater, 1994
BMC of women runners & untrained women who are amenorrheic (AM) & eumenorrheic (EU)
Power/Strength vs. Endurance
[Runners, Gymnasts & Controls]
Cross Sectional Data Summary:

- Weight bearing physical activity is beneficial & dependent upon body weight.

- Excessive physical activity may be detrimental, especially in association with amenorrhea.

- High impact physical activity appear to confer > BMD benefit.

- Muscle inactivity will result in both muscle & bone atrophy.
Post-menopausal Women:

- **Resistance training?**
  - Nursing home studies have reported BMD ↑ with weight-bearing exercise in VERY old women.
  - Generally will only slow the rate of loss, **NOT** reverse the process.
RESEARCH SUMMARY

- It appears that strenuous aerobic exercise & strength training may be beneficial for maintaining Bone Mineral Density.

- Mild general exercise such as walking may NOT be effective in preventing post-menopausal bone loss or enhancing bone mass in younger individuals.
RECOMMENDATIONS FOR OPTIMAL BONE HEALTH

- For developing peak bone mass (young)
  - Weight-bearing, bone-stressing physical activity
  - Diet adequate in Ca$^+$

- Pre-menopausal adults
  - Physical activity to maintain bone mass
  - Diet adequate in Ca$^+$

- Post-menopausal adults
  - Physical activity to slow bone loss
  - Diet adequate in Ca$^+$
Reduction of Fall Risk:

- Fractures often associated with falls.
  - ~90% of hip fractures
  - ~40-50% of vertebral fractures
  - 100% of radial fractures

- Fall risk due to:
  - Lower body weakness
  - Reduced power
  - Balance disturbances
  - Polypharmacy
Three target periods for intervention...

1. Enhance peak bone mass in developing years
2. Maintain peak bone mass in young adult years
3. Minimize loss of bone mass in postmenopausal years

Physical activity may positively affect bone health during each phase!
If that is the case…

EXERCISE PRESCRIPTION
Minimal Essential Strain (MES)

- Threshold stimulus that initiates new bone growth.
  - Forces that reaches or exceeds this threshold & is repeated will signal **osteoblasts** to migrate to the region to lay down matrix protein in the strength of the bone in that area.

- Osteoblast – Secrete collagen to build new bone.
Training Concepts for Stimulating New Bone Formation

- Specificity of loading
- Proper exercise selection
- Progressive overload
- Variation
Exercise Selection

- Multiple muscle groups
- Isolation of a single muscle group by stabilizing the rest of the body
  - Example: knee extension vs. back squat
Progressive Overload

- Progress @ a steady gradual increase.
- WANT TO AVOID INJURY & OVERTRAINING
Training Variation

- Forces on Different areas of the body
Exercises to Prevent Falls

- Increase lower body strength & power

- Challenge linear movement patterns
  - Stepping up and laterally
  - Incorporating Weights
  - Tai Chi-type movements
SUMMARY

- Movement is good!
- Bone responds most favorably to:
  - High forces
  - Young bodies (lifetime physical activity)
  - Optimal Ca\(^+\) intake
  - Adequate reproductive hormones
- Reducing fall risk is essential!
TINA'S EXTREMELY HIGH-IMPACT AEROBICS
References

