Changes in Skeletal Systems over the Lifespan

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Disclosures

Boards/Scientific Advisory Committees –
  ILSI
  Showalter
  Pharmavite

Grants –
  NIH
  Dairy Research Institute
  Nestle
  Tate and Lyle
  Fonterra
  Kraft
  Dairy Australia
  Pharmavite
Strategies to prevent fracture are to build peak bone mass early in life and to reduce bone loss later in life.
Why is peak bone mass important?

- 30 to 50% of children have at least one fracture by the end of teenage years
- 50% of women and 20% of men over 50y will experience an osteoporotic fracture
- Estimated annual costs exceed $18 billion
Bone Mass Across the Lifespan

In childhood, 89%↑ in fracture risk per 1SD below age & sex specific median BMD

a 5–10% difference in PBM may result in a 25–50% difference in hip fracture rate later in life (Weaver et al. Osteopor Int 2016)

How Bones Grow

1. **Spine**
   - Increased size and trabecular thickness

2. **Long bones**
   - Increased length and diameter

- Inner bone expands as bone redistributes from endocortical to periosteal surface.
- Birth weight triples in the first year of life.
- Outer bone expands as bone redistributes from endocortical to periosteal surface. BMD decreases but bone strength increases.
• Increases in sex-steroid hormones triggers growth hormone and IGF-1 production to initiate the growth spurt
• IGF-1 predicts skeletal calcium accretion
• When estrogen levels rise in late puberty, epiphases close and linear growth ceases
• Testosterone stimulates periosteal expansion at cortical sites → large bone size in males
• Estrogen limits periosteal expansion in females
Interventions may be more effective when Bone Turnover is Rapid.
NOF Position Statement on Peak Bone Mass Development and Lifestyle Factors

Writing Team

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Structural Strength Across the Life Span
Annual Incidence of Common Diseases

- Osteoporotic Fracture*: 2,000,000
- Stroke*: 800,000
- Heart Attack**: 600,000
- Breast Cancer*: 232,340

*National Osteoporosis Foundation (2013)
†http://www.cdc.gov/stroke/ (2013)
What is Osteoporosis?

Normal Bone  Osteoporotic Bone

Consequences of Osteoporosis

Women may lose 15% of bone mass in first 5 years after menopause (Hansen et al. 1991), with osteoporosis affecting 1 in 3 postmenopausal women.

Proportion of population > 80 years is increasing rapidly and is projected to triple between now and the year 2050.

Overall prevalence of osteoporosis and related fractures will likewise increase.
Osteoporosis

- Costs
  - $22 billion in 2008
    (National Osteoporosis Foundation)
  - 2 Million fractures/yr

- Risk factors
  - Modifiable: low physical activity, low calcium intake, vitamin D deficiency
  - Non-modifiable: genetics, female, advanced age, Caucasian

- Incidence
  - 15.8% white female, 3.9% white male
  - 7.7% African American female, 1.3% African American male
  - 20.4% Mexican American female, 5.9% Mexican American male
  - ½ hip fracture patients → long term care, 20% die within 1 yr
Prevalence of Osteoporosis and Low Bone Mass (spine and femoral neck) in US NHANES 2005-2010

Overall:

10.3% prevalence of osteoporosis
10.2 M have osteoporosis
43.9% prevalence low bone mass
43.4 M have low bone mass
Total 53.6 M

Wright et al. JBMR 29:2520-6, 2014
Predictors of BMD

- Genetics
- Diet
- Exercise
- Hormones
Clinical Risk Factors for Osteoporosis Independent of BMD

- Age > 65
- Low body weight
- Family history of fracture
- History of postmenopausal fracture (including vertebral fracture)
- Genetic factors
10 yr probability of hip fracture in women ≥65 y with prior fracture and DXA T-score ≤-2.5 SD at femoral neck by country

Female aged 65 years, prior fragility fracture, T-score -2.5 SD
Current Treatment Options

• Hormone replacement therapy increased risk of coronary heart disease, stroke, breast cancer (Rossouw et al., JAMA. 2002)

• Bisphosphonates
  • Linked to atypical fractures (Russell et al., Osteoporos. 2008)
  • Osteonecrosis of the jaw (Arrain et al., Dent Update. 2008)

• Lifestyle choices – Ca, vitamin D, weight bearing exercise

• Increased interest in botanicals
Bone Building Nutrient – Calcium

- Constant uptake and release = bone turnover
- Only 10 – 30% of calcium is actually absorbed
- Absorption is best in <500 mg doses

NEW – Estimated Average Requirement

- 4-8 year olds – 800 mg/day
- 9-18 year olds – 1100 mg/day
- Adults <51 – 800 mg/day
- Males 51-70 – 800 mg/day
- Females 51-70 – 1,000 mg/day
- All adults >70 – 1,000 mg/day

Sources

- Dairy products
- Fortified foods
- Broccoli, kale

Institute of Medicine, National Academies, 2010
Bone Building Nutrient – Vitamin D

- Cholecalciferol (D3) & ergocalciferol (D2) are both bioactive
- Enhances absorption of calcium and phosphorous
- Found naturally in very few foods
  - Fortified foods provide ~70% of Vit D in the diet

**NEW – Estimated Average Requirement**

- All ages – 400 IU/day

**Sources**

- Fortified dairy products
- Fortified cereal and juice
- Fatty fish

J Nutr 2005; 135:2478 & Institute of Medicine, National Academies, 2010
There is much confusion in the literature about calcium, dairy and bone

• Poor compliance and baseline status in RCTs

• Methods for assessing intake weak

• Life stage, sex, genetic dependent
What is the relationship between calcium and vitamin D and hip fracture?

Women’s Health Initiative RCT of CaD (n=68,719 postmenopausal women)

- All subjects including those taking own supplements
  
  No relationship

- >5 Year CaD Intervention-related Health Outcomes in Subjects Adherent & Not Taking Baseline Supplements
  
  Large benefit

*Prentice et al., Osteopor Int 24:567, 2013*
Meta analysis shows Calcium plus vitamin D reduces risk of hip fractures by 30%
Figure 1. Composition by weight of bone and dietary sources

- Water (45-50%)
- Ash (30-35%)
- Protein (10-15%)
- Fat (5-10%)

Calcium (36%) from dairy products
Phosphorus (17%) from dairy, meats, processed foods
Magnesium (0.8%) from green leafy vegetables, nuts, whole grains, dairy
Milk Provides Essential Nutrients

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Percentages for vit D and calcium based on EAR, percentages for all others based on RDA.
Conclusion

The source matters but intake matters more!
Prudent Recommendations

- 3 cups of low-fat dairy product equivalents/day

- 300mg calcium supplement for each serving missed
Overall Conclusions

• Building peak bone mass and reducing bone loss later in life are two strategies to reduce osteoporosis

• Increasing peak bone mass by 5-10% can reduce fracture risk substantially

• Lifestyle choices can modify both peak bone mass and bone loss

• Several of the essential nutrients important to bone are shortfall nutrients as identified by the Dietary Guidelines for Americans, i.e., calcium, vitamin D, magnesium
Bone healthy diet:
Calcium rich foods, dairy
Fruits/Vegetables
Whole grains

Benefits of Diet:
Maximize peak bone mass
Minimize bone loss
Promote overall health