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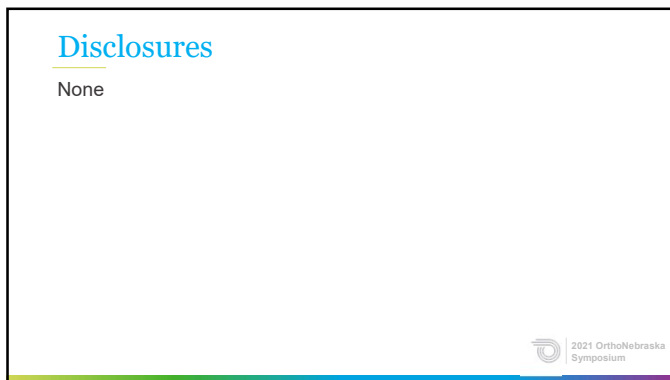
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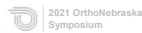
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## Learning Objectives

- Review bone structure and formation
- Discuss bone health risks
- Discuss nutrition and supplementation considerations for bone health
- Identify diseases and medication that may affect BMD
- Discuss exercise effects on bone health



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Let food and movement be your medicine. Unless you need medicine, then use all three. - me



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The acute concerns of bone health change as we age. However, what we do when we are younger can radically change our bone health when we are older.

- 0-30 years
  - "The foundational years"
  - Stress fractures
  - Menstrual dysfunctions
  - Bad vs good habit formation (e.g. nutrition)
- 30-60 years
  - "The wear and tear years"
  - Early degenerative changes
- 60+ years
  - "The maintenance or replacement years"
  - Osteoarthritis
  - Osteoporosis
  - Fall related injuries



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## Risky Business



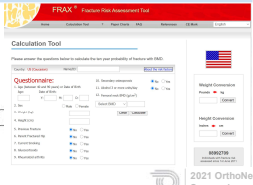
Risks we can't change:	Risks we can change:
Age/Height	Nutrition
Gender	Weight/BMI
Ethnicity	Muscle weakness
Genetics/Medications/Previous injuries	Tobacco/Alcohol/Medications
Injury	Injury

**Local mechanical factors that facilitate progression:**  
Malalignment  
Muscle weakness  
Structural integrity of the joint (mechanical damage or bone marrow lesions)

**Joint loading:**  
Obesity  
Joint injury

**Vulnerable joint:**  
Age  
Female gender  
Nutritional factors  
Genetic predisposition  
Lifestyle

**Knee osteoarthritis (1)**



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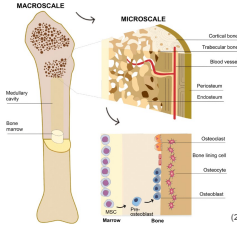
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## Understanding Bone Structure

- Layers
  - Periosteum
    - appositional bone growth in children
    - partial blood supply to bone
    - bone fracture repair
  - Osseous Tissue
    - Trabecular
      - scaffold with quicker healing
    - Cortical
      - mechanical strength with slower healing
  - Endosteum
    - similar to periosteum, maintains structure of bone weight, growth, and healing
  - Bone marrow
    - Blood organ with highest level of hematopoietic and mesenchymal stem cells



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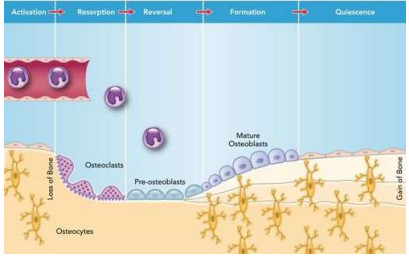
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## Understanding Bone Formation

- Main components:
  - Living cells
  - Collagen
  - Hydroxyapatite
    - Calcium
    - Phosphate
  - Various proteins



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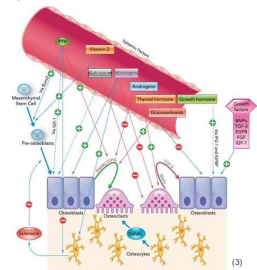
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## Understanding Bone Formation

- Main hormonal pathways:

- Calcitonin
- PTH
- Estrogen
- TSH



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## Nutrition: Supplements

- Vitamin D3

- 400-1000IU daily, for healthy. 800IU is a good recommendation.
- Sunlight, UVB rays
  - Can't pass through windows or sunscreen
  - Highly variable time depending on geographic location, skin color and Fitzpatrick skin type (I-V)
    - 6min-2hours
  - Probably not recommended by your friendly neighborhood dermatologist
  - May consider supplement during winter months only
- Foods:
  - Natural: Oily fish. Salmon, mackerel,
  - Supplemented: Milk,
- Caution: Vit D3 can be a marketing tactic, so make sure patients are looking at how much they are taking if they are taking multiple supplements. Too much VitD can lead to hypercalcemia.

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## Supplements

- Calcium (Ca)

- Ca Carbonate highest amount of elemental Ca (40%)
- Supplement split into BID to aid in absorption and avoid constipation
- Take with food
- Anecdotal practice:
  - 2000mg/day (not necessarily the elemental Ca) for fractures

Milk (whole, 2%, 1%, skim, chocolate) → ~300mg (~100mg Fortified) → 1 cup (8oz)  
 Soy milk (fortified) → ~300-450mg (organic Ca content lower) → 1 cup (8oz)  
 Almond milk (fortified) → ~300-450mg (organic as low as ~100mg) → 1 cup (8oz)  
 Coconut milk (fortified) → ~450mg (organic as low as ~100mg) → 1 cup (8oz)  
 Yogurt (plain, low fat) → ~400mg → 1 cup (8oz)  
 Orange juice (fortified) → ~350mg → 1 cup (8oz)  
 Almonds, dry roasted → ~300mg → 1 cup  
 Cheese, cheddar shredded → ~400 → 1/2 cup  
 Cheese, mozzarella stick → ~200mg → 1 stick  
 Cheese, sliced american (fortified) → ~350mg → 1 slice

Other foods: Beans, broccoli, oranges, figs, raisins, breads, tuna, sardines

Life Stage Group	Calcium (mg/d)
Infants	
0-6 mo	210 <sup>2</sup>
7-12 mo	270 <sup>2</sup>
Children	
1-3 y	500 <sup>2</sup>
4-8 y	800 <sup>2</sup>
Adults	
9-13 y	1,300 <sup>2</sup>
14-18 y	1,300 <sup>2</sup>
19-30 y	1,000 <sup>2</sup>
31-50 y	1,000 <sup>2</sup>
51-70 y	1,200 <sup>2</sup>
> 70 y	1,200 <sup>2</sup>
Older Adults	
9-13 y	1,300
14-18 y	1,300 <sup>2</sup>
19-30 y	1,000 <sup>2</sup>
31-50 y	1,000 <sup>2</sup>
51-70 y	1,200 <sup>2</sup>
> 70 y	1,200 <sup>2</sup> (5)

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## Supplements

- Magnesium
  - 200-300mg
  - Foods
    - ~30% to 40% consumed is absorbed
    - Water: varies by type, 1mg/L- 120mg/L
    - Foods with fiber typically have Mg
    - Processed foods typically remove Mg

Chia seeds → ~110mg → 1 oz  
 Almonds → ~80mg → 1 oz  
 Peanut butter, smooth → ~50mg → 2 Tbs  
 Soy milk (fortified) → ~60mg → 1 cup (8oz)  
 Rice, brown, cooked → ~40mg → 0.5 cup  
 Banana → ~30mg → 1 medium

Other foods: Salmon, halibut, breakfast cereals, oatmeal, green leafy vegetables, ground beef.

(4)

Life Stage Group	Magnesium (mg/d)
Infants	
0-6 mo	36 <sup>2</sup>
7-12 mo	75 <sup>2</sup>
Children	
1-3 y	80
4-8 y	130
Males	
9-13 y	240
14-18 y	410
19-30 y	400
31-50 y	420
51-70 y	420
> 70 y	420
Females	
9-13 y	240
14-18 y	360
19-30 y	310
31-50 y	320
51-70 y	320
> 70 y	320 (5)

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## Supplements

- Collagen
  - Human studies do show decreases in bone turnover markers and 1 study did show increase in spinal and femur BMD with collagen supplements. However, unregulated product and the collagen supplements used were very specific and not OTC. (6)
- Probiotics
  - Live, non-pathogenic microorganisms
  - Foods: Yogurt, Kefir, fermented foods, fortified
  - Studies, mostly animal

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## Proper Nutrition

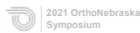
- Relative Energy Deficiency Syndrome (RED-S)
  - a.k.a. Female Athlete Triad
  - Relative energy deficiency
    - Intake is less than expenditure with little to no reserve
  - Causes disruption of many hormonal pathways
  - Decreased osteoblastic activity, decreased building blocks for bone
    - Decreased bone density
    - Increase risk of stress fractures
  - Important to look for risk factors with multiple stress fractures
    - LMP - one of the best diagnostic factors of fertile period females and osteoporotic risk if early menopausal
    - Energy intake – consider lab work and early referral to RD

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## Proper Nutrition

- Energy Excess/Obesity
  - Reverse epidemiology
  - Some people who are "obese" have a higher BMD secondary to increased load on bones thus increasing bone formation
- Healthy Obese vs. Obesity with Co-morbid conditions
  - BMI is not the best assessment of "healthy habits"
    - If building blocks are there, bone density may not suffer
    - Co-morbid conditions detrimental to BMD
      - Sedentary activity level
      - Hyperlipidemia
      - Diabetes
      - Cardiorenal disruptions
      - Some negative androgenic effects of excess white fat



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## Nutrition: Things to avoid

- Carbonated beverages
  - No good studies to prove the acid-balance or excess phosphorus intake theories of decreasing BMD is true
  - However, 'colas' often contain other ingredients that may affect BMD negatively (e.g. excess sodium, sugar, HFCS)
- Alcoholism
  - Decreased intake nutrients, intervenes with Vit D3 production, negative effects on hormones, fall risks
- Salt (NaCl)
  - Kidneys use Ca to eliminate excess Cl, may even tap into Ca stores to eliminate



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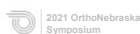
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## Medications to Consider:

- Glucocorticoids
  - Increase resorption, decrease remodeling
- PPI's – Maybe not
  - Recent studies show this does not appear to be true (7)
- Anti-epileptic drugs
  - Offer supplementation of Vit D3
- Medroxyprogesterone ("Depo" shot) contraceptive
  - Noted in first 2 years of use
  - Takes ~2 years after cessation to reach non-Depo user BMD
  - Monitor Ca and Vit D, routine DEXA not indicated
- Aromatase Inhibitors



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## Medications

- OCP's for prevention?
  - Good for contraception
  - Not a preventative medication
  - The menstrual cycle can be a useful indicator of health status
  - Not recommended for women who have irregular cycles due to caloric deficiency (Female Athlete Triad)

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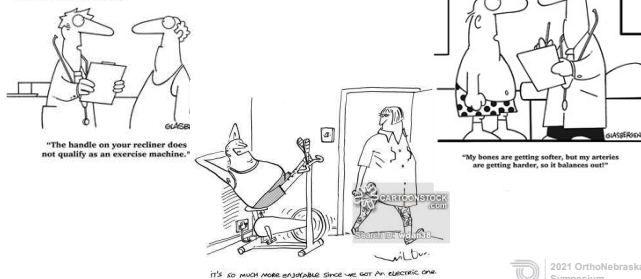
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## Exercise

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## Exercise

- Increased bone remodeling throughout the lifetime
  - 0-30yo: Important to build a strong foundation
  - 30-60yo: Maintain a good structure, make repairs as needed and get ready for retirement
  - +60yo: Continue to make repairs and keep the house clean
- Loading on the bones via the musculotendinous junctions and mechanical loading stimulate bone remodeling that strengthens the bone by increasing bone density <sup>(1)</sup>
- Not found to worsen osteoarthritis in setting of non-injury, in fact can be beneficial to maintain ROM and improve strength

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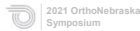
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## Exercise

- Long distance runners have lower BMD
- Swimming, cycling, rowing have lower BMD than those who perform regular weight-bearing activities <sup>(8)</sup>
- BMD increases in exercise <sup>(8)</sup>
  - High load, low reps had greatest effect <sup>(9)</sup>
  - Progressive resistance strength training (greater effect on femoral neck BMD)
  - Multicomponent training (greater effect on spine BMD)
  - Most changes from exercise were seen after 6mo-24mo and >3 times a week, for 30-60minutes
- BMD maintenance with exercise
  - Walking seems to help maintain but not increase



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## Exercise

- High-Intensity Resistance and Impact Training Improves Bone Mineral Density and Physical Function in Postmenopausal Women With Osteopenia and Osteoporosis: The LIFTMOR Randomized Controlled Trial. <sup>(10)</sup>
  - Watson et al. Journal of Bone and Mineral Research. 2019 Mar;34(3):572.
- Single-blind, randomized controlled trial
  - 101 participants (406 consented to participate), zt-score <-1.0 at hip and/or spine
  - Intervention (49): 8-month, twice weekly, 30-minute, supervised HIRIT program (5s/5r, 80-85%1)
  - Control (52): 8-month, twice weekly, 30-minute, home Li program
- Results
  - HIRIT superior to Control
    - Lumbar spine BMD 2.9±2.8% vs -1.2±2.8%, p<0.001
    - Femoral neck BMD 0.3±2.6% vs -1.9±2.8%, p<0.004



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## Exercise

- 0-30 years
  - "The foundational years"
  - Bone mass peaks in the second decade of life
    - ~90% obtained: by 18yo in females and 20yo in males
  - Burst exercises of running, jumping, dancing and vigorous activity help to lay down strong frameworks of cortical bone
  - Sports, encouraged play, and weightlifting
  - Avoid sports specialization
    - Adequate rest, decrease injury by allowing healing
      - At least 4 months (non-consecutive) off each year from main sport
    - Multi-dimensional athletes have greater all-over strength



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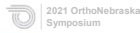
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## Exercise

- 30-60 years
  - "The wear and tear years"
  - Continue weight-bearing activities
  - Start learning or consistently incorporate strength training and core strength
  - Core strength
    - Abdominal muscles
    - Gluteus medius/minimus (hip abductors)
    - Iliopsoas (hip flexors)



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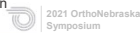
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## Exercise

Motion is lotion. – Andrew Porter, DO, CAQSM

- 60+ years
  - "The maintenance or replacement years"
  - Consider decreasing frequency and duration of high impact activities such as repetitive jumping, running long distances
  - Fracture reduction
    - JUST MOVE
    - Movement also stimulates gains in strength of the muscles as well as decreases the proprioception losses associated with aging
    - Better balance leads to less falls
    - Physical Therapy to learn home exercises that can be done based on individual limitations
    - Tai Chi, pool exercise
    - Modified yoga, chair yoga
    - Modified weightlifting, e.g. seated and avoid axial compression



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## Interesting

- Bone stimulators:
  - Stimulates osteoblasts, capillary proliferation, etc.
  - Basically, gives exercise to bone without actually moving
  - Often used with delayed union fractures or high-risk fractures
    - eg. navicular, base of the 5<sup>th</sup> metatarsal, anterior tibia
    - Unfortunately, insurance generally requires malunion diagnosis and >3months of closed fracture care. Cash price can be thousands of dollars.
- OR
  - Cat's purr produces: 25-150 Hertz
  - Human bone healing: 50-80Hertz



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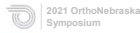
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The acute concerns of bone health change as we age. However, what we do when we are younger can radically change our bone health when we are older.

- 0-30 years
  - "The foundational years"
  - Stress fractures
  - Menstrual dysfunctions
  - Bad vs good habit formation (e.g. nutrition)
- 30-60 years
  - "The wear and tear years"
  - Early degenerative changes
- 60+ years
  - "The maintenance or replacement years"
  - Osteoarthritis
  - Osteoporosis
  - Fall related injuries



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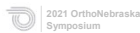
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The acute concerns of bone health change as we age. However, what we do when we are younger can radically change our bone health when we are older.

- 0-30 years
  - "The foundational years"
  - Stress fractures
    - Improper nutrition
    - Energy deficiency
    - Poor mechanics
  - Menstrual dysfunctions
    - Red-S
  - Bad vs good habit formation (e.g. nutrition)
    - Learning and incorporating proper nutrition
    - Exercise as part of routine
    - Adequate rest to decrease injury



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The acute concerns of bone health change as we age. However, what we do when we are younger can radically change our bone health when we are older.

- 30-60 years
  - "The wear and tear years"
  - Early degenerative changes
    - Changes from early life now may become noticeable in daily life
    - Lifestyle changes will have less positive effects but positive lifestyle changes may greatly attenuate negative effects on bone health
    - Wear and tear injuries related to tendon are more common but begin to affect the underlying bone health



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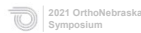
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The acute concerns of bone health change as we age. However, what we do when we are younger can radically change our bone health when we are older.

- 60+ years
  - "The maintenance or replacement years"
  - Osteoarthritis
    - Pain is largely dependent on severity but more on activity level
    - Management is mostly about improving quality of life with replacements
  - Osteoporosis
    - Still possible to make positive changes to BMD but focus is more on maintaining BMD and decrease rate of loss
  - Fall related injuries
    - Muscle recruitment, core stability, and mobility issues more compounded
    - Hip fracture and mortality<sup>(11)</sup>
      - 33% mortality rate at 12 months
      - Mortality rate increasing and greatly affected by co-morbid diseases



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## Helpful Resources

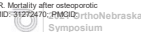
- NIH - Osteoporosis and Related Bone Diseases National Resource Center
  - <https://www.bones.nih.gov/>
- Osteoporosis Canada
  - <https://osteoporosis.ca/>
  - Exercises for Healthy Bones
    - [Too Fit to Fall or Fracture Exercises](#)
    - [How to Safely Do Everyday Activities](#)



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Let food and movement be your medicine. Unless you need medicine, then use all three. – me

QUESTIONS?



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