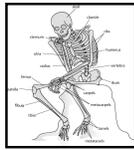


Biomechanics of Human Bone Growth and Development



Chapter 4

Stiffness & Compressive Strength

- **Stiffness**
 - Stress/strain in a loaded material
 - Stress divided by the relative change in shape
- **Compressive Strength**
 - Ability to resist compression

Calcium

- Calcium carbonate
- Calcium phosphate

Contribute to stiffness and compressive strength in bone

Collagen

- Contributes to flexibility and tensile strength in bone
- Collagen is progressively lost with age
- Loss of collagen causes bone brittleness

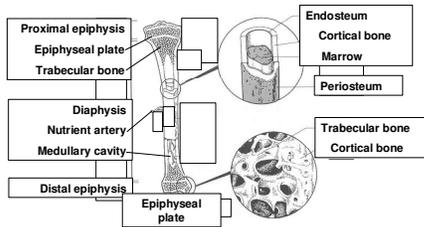
Other Factors Effecting Bone Strength

- Water Content
 - Usually comprises 25%-30% of bone weight
- Bone Porosity
 - Amount of bone volume filled with pores or cavities

Bone Categories: *based on porosity*

- Cortical Bone
 - Compact mineralized bone
 - Low porosity
 - Found in shafts of long bones
- Trabecular Bone
 - Aka cancellous or spongy bone
 - Less compact
 - High porosity
 - Found in the ends of long bone and vertebrae

Bone Structure: *typical long bone*

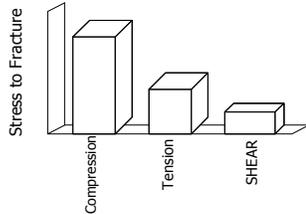


Effects of Bone Porosity

- Cortical bone can withstand more stress but less strain
 - Less porous
- Trabecular bone can undergo more strain before fracturing
 - More porous

Structure Effects Strength

- Bone is anisotropic
 - Bone has different strength and stiffness depending on direction of the load
- Bones are unique to each individual



Axial Skeleton

- Skull
- Vertebrae
- Sternum
- Ribs

Appendicular Skeleton

- Bones Composing the body appendages
 - Shoulder Girdle
 - Upper Extremities
 - Pelvic Girdle
 - Lower extremities

Bone Types

- Short Bones
- Flat Bones
- Irregular Bones
- Long Bones

Short Bones

- Approximately cubical
 - Carpals
 - Tarsals

Flat Bones

- Protect organs
- Provide surface for muscle attachments
 - Scapulae
 - Sternum
 - Ribs
 - Patellae
- Some bones of the skull

Irregular Bones

- Have different shapes to serve different functions
 - Vertebrae
 - Sacrum
 - Coccyx
 - Maxilla

Long Bones

- Framework of the appendicular skeleton
 - Humerus
 - Radius
 - Ulna
 - Femur
 - Tibia
 - Fibula

Epiphyseal Plates

- Growth Centers allowing bones to grow in length
- New bone cells are produced by osteoblasts until plate closure

Bone Growth in Circumference

- Inner layer of the periosteum builds concentric layers of new bone on top of existing bone
- Osteoblasts
 - Build new bone tissue
- Osteoclasts
 - Resorb old bone tissue

Training Bones???

- Bones respond to training....and or lack of training
- According to Wolff's Law
 - Densities
 - Sizes
 - ShapesAre determined by the magnitude and direction of forces

Wolff's Law

- Osteoblasts and osteoclasts are continually building and resorbing bone
- Increases and decreases in stress influence osteoblast/osteoclast activity

Increasing Bone Density



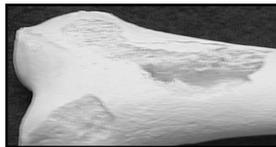
- Weight Bearing Exercise

Diminishing Bone Density



- Lack of weight bearing exercise
- Spending excessive time in water
 - Bed Rest
 - Space Travel

Osteoporosis



- Disorder involving decreased bone mass and strength
- Can result in:
 - Pain
 - FracturesDue to daily activities

Osteoporosis Effects

- Type I
 - Postmenopausal
 - Affects 40% of women after age 50
- Type II
 - Age-associated
 - Affects most men and women after age 70
- Female Athlete Triad
 - Disordered eating
 - Amenorrhea
 - osteoporosis

Prevention and Treatment of Osteoporosis

- Regular weight bearing exercise
- Postmenopausal women hormone replacement
- Adequate dietary calcium and vitamin D
- Avoid
 - Smoking
 - Excessive protein consumption
 - Caffeine
 - alcohol