Skeletal System

Biol 105 - Lecture 8
Chapter 5

Outline

I. Overview of the skeletal system
II. Function of bones
III. Bone structure
IV. Bone cells
V. Cartilage
VI. Tendons and Ligaments
VII. Joints
VIII. Bone development
IX. Hormonal regulation of bone growth
X. Homeostasis
XI. Disorders of the skeletal system

Skeletal System

- The skeletal system is composed of different types of connective tissues:
  - Bones – rigid structure
  - Cartilage – soft, cushions the joints
  - Ligaments – attach bone to bone
  - Tendons – attach muscle to bone.

  - Tendons link the skeletal and the muscular systems

Functions of Bone

1. Supports and gives shape to the body.
2. Protects soft body parts.
3. Produce blood cells
4. Stores minerals (calcium and phosphate)
5. Stores fat.
6. Along with the muscles, permits flexible body movement.

Bone

- Bones have different types of tissue
  - Calcified tissue = osseous tissue
  - Blood vessels
  - Nerves
  - Contain collagen fibers that give flexibility

- This combination of calcified tissue and collagen fibers make the bone strong but flexible
Bone Structure

- All bones have two layers of bone:
  - Compact bone – dense mineralized outer layer
  - Spongy bone – inner layer with open network filled with marrow

Typical Bone Structure

- **Epiphysis** – rounded end of the typical long bone, composed mainly of red bone marrow where blood cells are made
- **Diaphysis** – shaft of the typical long bone, has a cavity filled with yellow marrow where fat is stored.

Periosteum

- **Periosteum** – fibrous outer covering of the bone, contains nerves, blood vessels, lymphatic vessels.
- Functions in bone repair and growth

Typical Long Bone Structure

- Spongy bone (spaces contain red bone marrow)
- Compact bone on surface
- Yellow bone marrow
- Blood vessel
- Periosteum

(e) A long bone, such as the femur of the leg, consists of a shaft and two heads, or enlarged ends. Compact bone is located on the outer surface of the bone. Spongy bone is found in the heads.

Bone Is Living Tissue

- Blood vessels and nerves in central canal
- (e) The internal struts of spongy bone support the bone from within.
Compact Bone Structure

- Osteon – structural unit of the compact bone

Osteon Structure

- **Central Canal** (Haversian) – contain blood vessels and nerves
- **Osteocytes** – Mature bone cells. Maintain bone structure and density and minerals
  - Found in cavities called lacunae
- **Canaliculi** are canals that connect the lacunae to the central canal

Figure 5.1c The structure of bone

(c) A light micrograph of compact bone showing an osteon.

Figure 5.1d The structure of bone

(d) Bone cells extend outward through tiny canals and touch one another. In this way, materials can be exchanged with the blood supply in the central canal.

Bone cells

- Osteoblasts
- Osteocytes
- Osteoclasts

Osteoblasts

- **Osteoblasts** = bone forming cells.
- Immature cells that secrete material called “bone ground substance” = non-cellular matrix that surrounds the cells.
- Osteoblasts mature into osteocytes after they have secreted enough material
Osteoclasts

- Osteoclasts – Bone absorbing cells.
- These are bone cells on the outer edge of bones.
- They release enzymes that eat away at the bone, releasing minerals.

Cartilage in bones

- Two regions of cartilage remain at each end of the long bone
- The cap that covers the surfaces that rub against other bones
- A plate of cartilage called the epiphyseal plate, or growth plate

Bone development and growth

- The skeleton begins to form at about 6 weeks.
- Most bones grow through adolescence but some bones continue to grow through about age 25.
- Ossification – formation of bones

Bone Growth

- Bone growth is stimulated by growth hormone during childhood
- Thyroid hormones ensure that the skeleton grows with the proper proportions
- At puberty, increasing levels of male or female sex hormones initially stimulate cartilage cells to divide, but eventually allow for the growth plates to fuse, and bone can no longer increase in length
**Hormonal Regulation of Bone Growth**

- **Growth hormone (GH)** - directly stimulates growth of the epiphyseal plate and bone growth in general.
- **Vitamin D** - converted to a hormone causing the intestines to absorb calcium.
- **Sex hormones** - adolescents experience a growth spurt due to an increased level of hormones.

**Hormonal regulation of Bone Calcium Levels**

- **Parathyroid hormone (PTH)** – produced by the parathyroid gland - accelerates bone recycling and increases blood calcium.
- **Calcitonin** – produced by the thyroid gland - a hormone that decreases blood calcium levels, deposits calcium into the bone.
- **Homeostasis** – maintaining a balance of calcium levels in blood and in bone.

**Healing broken bones**

- Broken bones and fractures are the same thing
- Bone fractures are healed by fibroblasts and osteoblasts.
- When a break occurs, there is bleeding followed by a clot.
- Fibroblasts secrete collagen fibers that form a *callus* linking the two parts of the bone. This is later replaced by bone.
Cartilage

- Cartilage - flexible connective tissue not as strong as bone tissue.
- Function: Cushion joints, flexibility
  - Found at the ends of long bones, nose, ends of ribs, larynx and trachea, disks between vertebrae and knee, ear flaps and epiglottis.
- Cartilage cells are chondrocytes
- Cartilage lacks blood vessels, so slow to heal

Tendons and Ligaments

- Ligaments – connective tissue that connects bone to bone
- Tendons – connective tissue that connects muscle to bone

Synovial Joints

- Freely movable joints held together by ligaments.
- Synovial membrane - produces synovial fluid, an excellent lubricant for the joints.
- Bursae – fluid filled sacs, reduce friction
- Menisci – cartilage between the bones, acts as a cushion
- Cartilage is also found at the ends of the bones
Osteoarthritis - deterioration of cartilage at joints.
Rheumatoid Arthritis – chronic inflammatory disorder of the joints.
Sprains – When ligaments are torn or stretched
Bursitis – inflammation of bursa
Tendonitis – inflammation of tendon sheath
Fracture – broken bone
  - simple = bone breaks but does not penetrate the skin
  - compound = bone breaks and protrudes through the skin

Osteoporosis
- When more bone is reabsorbed than is formed, this is when the homeostasis is not maintained and more calcium is taken out of the bones than is replaced.
- Estrogen and Testosterone help maintain the bone density.
- After menopause women produce less estrogen and this can lead to less bone density

Risk Factors
- Post menopausal
- Not enough exercise
- Poor diet, not enough calcium in the diet
- Smoking
- Low vitamin D levels
- Certain hormonal disorders

Treatment
- Exercise
- Increased Calcium in the diet, calcium supplements if needed, the type of calcium supplement is important
- Estrogen replacement therapy
- Prescription drugs

Recommended Calcium Intakes*

<table>
<thead>
<tr>
<th>Ages</th>
<th>Amount mg/day</th>
</tr>
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<tbody>
<tr>
<td>Birth - 6 months</td>
<td>210</td>
</tr>
<tr>
<td>6 months - 1 year</td>
<td>270</td>
</tr>
<tr>
<td>1-3</td>
<td>500</td>
</tr>
<tr>
<td>4-8</td>
<td>800</td>
</tr>
<tr>
<td>9-13</td>
<td>1300</td>
</tr>
<tr>
<td>14-18</td>
<td>1300</td>
</tr>
<tr>
<td>19-30</td>
<td>1000</td>
</tr>
<tr>
<td>31-50</td>
<td>1000</td>
</tr>
<tr>
<td>51-70</td>
<td>1200</td>
</tr>
<tr>
<td>70 or older</td>
<td>1200</td>
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</table>
### Food Calcium Table

<table>
<thead>
<tr>
<th>Food</th>
<th>Calcium (mg)</th>
<th>% DV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yogurt, plain, low fat, 8 oz.</td>
<td>415</td>
<td>42%</td>
</tr>
<tr>
<td>Yogurt, fruit, low fat, 8 oz.</td>
<td>245-384</td>
<td>25%-38%</td>
</tr>
<tr>
<td>Sardines, canned in oil, with bones, 3 oz.</td>
<td>324</td>
<td>32%</td>
</tr>
<tr>
<td>Cheddar cheese, 1 ½ oz shredded</td>
<td>306</td>
<td>31%</td>
</tr>
<tr>
<td>Milk, non-fat, 8 fl oz.</td>
<td>302</td>
<td>30%</td>
</tr>
<tr>
<td>Tofu, firm, ½ cup</td>
<td>204</td>
<td>20%</td>
</tr>
<tr>
<td>Mozzarella, part skm 1 ½ oz.</td>
<td>275</td>
<td>28%</td>
</tr>
<tr>
<td>Orange juice, calcium fortified, 6 fl oz.</td>
<td>200-260</td>
<td>20-26%</td>
</tr>
<tr>
<td>Turnip greens, boiled, ½ cup</td>
<td>99</td>
<td>10%</td>
</tr>
<tr>
<td>Kale, cooked, 1 cup</td>
<td>94</td>
<td>9%</td>
</tr>
<tr>
<td>Turnip greens, boiled, ½ cup</td>
<td>99</td>
<td>10%</td>
</tr>
<tr>
<td>Ready to eat cereal, calcium fortified, 1 cup</td>
<td>100-1000</td>
<td>10%-100%</td>
</tr>
<tr>
<td>Cottage cheese, 1% milk fat, 1 cup unpacked</td>
<td>138</td>
<td>14%</td>
</tr>
</tbody>
</table>

### Decreased Calcium Absorption
- Oxalic acid – potent inhibitor of calcium absorption, and is found in high concentrations in spinach and rhubarb and in somewhat lower concentrations in sweet potato and dried beans.
- Sodium – Increased sodium intake results in increased loss of calcium in the urine.
- Protein – As dietary protein intake increases, the urinary excretion of calcium also increases.
- Caffeine – Caffeine in large amounts increases urinary calcium content for a short time.

### Important Concepts
- Read Ch 7
- What are the four components of the skeletal system, and their functions
- What are the functions of bone
- What are the two layers of bone
- What is the periosteum and what is its function
- What is the structure of the osteon, what are the features found in the osteon
- What are the disorders of the skeletal system
- How do bones heal
- What is osteoporosis, what are the risk factors, what can you do to prevent it.
Definitions

- Compact bone, osteon, central canal (haversian canal), Spongy bone, Epiphysis, Diaphysis, Periosteum, lacunae, callus, fibroblasts, Osteoblasts, Osteocytes, Osteoclasts, Chondrocytes, growth hormone, Parathyroid hormone (PTH), Calcitonin, Vitamin D, epiphyseal plate, growth plate