Chapter 8

The Muscular System
What do we want to learn in chapter 8?

• List, locate, and compare the structure and function of the three major types of muscle tissue

• Discuss the microscopic structure of a skeletal muscle sarcomere and motor unit

• Discuss how a muscle is stimulated and compare the major types of skeletal muscle contractions
What do we want to learn in chapter 8?

• Name, identify, and give the function of the major muscles of the body
• List and explain the most common types of movement produced by skeletal muscles
• Name and describe the major disorders of skeletal muscles
Introduction

• Muscular tissue enables the body and its parts to move
  – Movement caused by ability of muscle cells (called fibers) to shorten or contract
  – Muscle cells shorten by converting chemical energy (obtained from food) into mechanical energy, which causes movement
  – Three types of muscle tissue in body
Muscle Tissue

• Skeletal muscle—also called striated or voluntary muscle
  – Is 40% to 50% of body weight (“red meat” attached to bones)
  – Microscope reveals crosswise stripes or striations
  – Contractions can be voluntarily controlled
Muscle Tissue

- Cardiac muscle—comprises bulk of heart
  - Cardiac muscle cells branch frequently
  - Characterized by unique dark bands called *intercalated disks*
  - Interconnected nature of cardiac muscle cells allows heart to contract efficiently as a unit
Muscle Tissue

• Smooth muscle—also called nonstriated, involuntary, or visceral muscle
  – Lacks cross stripes or striations when seen under a microscope; appears smooth
  – Found in walls of hollow visceral structures such as digestive tract, blood vessels, and ureters
  – Contractions not under voluntary control; movement caused by contraction is involuntary
Muscle Tissue

• Function—all muscle cells specialize in contraction (shortening)
Structure of Skeletal Muscle

• Major structures
  – Each skeletal muscle is an organ composed mainly of skeletal muscle cells and connective tissue
  – Most skeletal muscles extend from one bone across a joint to another bone
Structure of Skeletal Muscle

• Structure
  – Parts of a skeletal muscle
    • Origin—attachment to the bone that remains relatively stationary or fixed when movement at the joint occurs
    • Insertion—point of attachment to the bone that moves when a muscle contracts
    • Body—main part of the muscle
Structure of Skeletal Muscle

• Structure
  – Muscles attach to bone by tendons—strong cords of fibrous connective tissue; tendons lubricated by synovial fluid
  – Bursae—small synovial-lined sacs containing a small amount of synovial fluid; located between some tendons and underlying bones
Structure of Skeletal Muscle

• Microscopic structure and function
  – Muscle fibers—grouped into bundles
  1. Fibers contain thick myofilaments (containing the protein myosin) and thin myofilaments (composed of actin)
  2. Together, the thick and thin myofilaments make a sarcomere
  3. Fiber→filaments→sarcomere
Sarcomere Function

- Basic functional (contractile) unit called a sarcomere
  - Sliding filament model explains mechanism of contraction
    - Thick and thin myofilaments slide past each other as a muscle contracts
    - Contraction requires calcium and energy-rich ATP molecules
1. A nerve impulse travels to a muscle fiber through a motor neuron, triggering an electrical impulse that travels along the muscle fiber membrane.

2. The impulse triggers the release of calcium ions (Ca^{++}) from the endoplasmic reticulum and into the cytoplasm.

3. The Ca^{++} ions bind to thin filaments and release actin to react with myosin. Myosin heads form ratcheting cross-bridges with actin, which pull the thin filaments toward the middle of the sarcomere—thus producing a contraction.
Functions of Skeletal Muscle

• Movement occurs at insertion
  – Muscles produce movement by pulling on bones as a muscle contracts
    • The insertion bone is pulled closer to the origin bone
    • Movement occurs at the joint between the origin and the insertion
Functions of Skeletal Muscle

• Movement

  – Groups of muscles usually contract to produce a single movement

  • Prime mover—muscle whose contraction is mainly responsible for producing a given movement

  • Synergist—muscle whose contractions help the prime mover produce a given movement

  • Antagonist—muscle whose actions oppose the action of a prime mover in any given movement
Functions of Skeletal Muscle

• Posture
  – A type of muscle contraction called tonic contraction enables us to maintain body position
    • In tonic contraction, only a few of a muscle’s fibers shorten at one time
    • Tonic contractions produce no movement of body parts
Functions of Skeletal Muscle

• Posture
  – Good posture (optimum body positioning) favors best body functioning
  – Skeletal muscle tone maintains posture by counteracting the pull of gravity
Functions of Skeletal Muscle

• Heat production
  – Survival depends on the body’s ability to maintain a constant body temperature
    • Fever—an elevated body temperature—often a sign of illness
    • Hypothermia—body temperature below normal
  – Contraction of muscle fibers produces most of the heat required to maintain normal body temperature
Fatigue

• Reduced strength of muscle contraction
• Caused by repeated muscle stimulation without adequate periods of rest
• Repeated muscular contraction depletes cellular ATP stores and outstrips the ability of the blood supply to replenish oxygen and nutrients
Fatigue

• Contraction in the absence of adequate oxygen produces lactic acid, which contributes to muscle burning

• *Oxygen debt*—the metabolic effort required to burn excess lactic acid that may accumulate during prolonged periods of exercise
  – Labored breathing after strenuous exercise is required to “pay the debt”
  – This increased metabolism helps restore energy and oxygen reserves to pre-exercise levels
Role of Other Body Systems in Movement

• Muscle functioning depends on the functioning of many other parts of the body
  – Most muscles cause movements by pulling on bones across movable joints
  – Respiratory, circulatory, nervous, muscular, and skeletal systems play essential roles in producing normal movements
Role of Other Body Systems in Movement

- Muscle functioning depends on the functioning of many other parts of the body
  - Multiple sclerosis, brain hemorrhage, and spinal cord injury are examples of how pathological conditions in other body organ systems can dramatically affect movement
Motor Unit

• Stimulation of a muscle by a nerve impulse is required before a muscle can shorten and produce movement

• A motor neuron is the nerve cell that transmits an impulse to a muscle, causing contraction
Motor Unit

• A neuromuscular junction is the point of contact between a nerve ending and the muscle fiber it innervates

• A motor unit is the combination of a motor neuron and the muscle cell or cells it innervates
Muscle Stimulus

- A muscle will contract only if an applied stimulus reaches a certain minimal level of intensity—called a threshold stimulus.
- Once stimulated by a threshold stimulus, a muscle fiber will contract completely, a response called *all or none*.
• Different muscle fibers in a muscle are controlled by different motor units having different threshold-stimulus levels
  – Although individual muscle fibers always respond all or none to a threshold stimulus, the muscle as a whole does not
  – Different motor units responding to different threshold stimuli permit a muscle as a whole to execute contractions of graded force
Types of Skeletal Muscle Contraction

• Twitch and tetanic contractions
  – Twitch contractions—quick, jerky responses to a stimulus—are laboratory phenomena and do not play a significant role in normal muscular activity
  – Tetanic contractions are sustained and steady muscular contractions caused by a series of stimuli bombarding a muscle in rapid succession
Types of Skeletal Muscle Contraction

- **Isotonic contractions**
  - Produce movement at a joint
  - During isotonic contractions, the muscle changes length, causing the insertion end of the muscle to move relative to the point of origin
  - Concentric contractions shorten muscles
  - Eccentric contractions allow muscles to increase in length
  - Most types of body movements such as walking and running are caused by isotonic contractions
Types of Skeletal Muscle Contraction

• Isometric contractions
  – Isometric contractions are muscle contractions that do not produce movement; the muscle as a whole does not shorten
  – Although no movement occurs during isometric contractions, tension within the muscle increases
  – Muscles grow larger
**ISOTONIC**
Same tension; changing length

- Muscle lengthens
- Eccentric contraction

**ISOMETRIC**
Same length; changing tension

- Relaxed
- Contracting

Effects of Exercise on Skeletal Muscles

• Exercise, if done regularly and practiced properly, improves muscle tone and posture, results in more efficient heart and lung functioning, and reduces fatigue

• Specific effects of exercise on skeletal muscles
  – Muscles undergo changes related to the amount of work they normally do
    • Prolonged inactivity causes disuse atrophy
    • Regular exercise increases muscle size, called *hypertrophy*
Effects of Exercise on Skeletal Muscles

• Effects of exercise on skeletal muscles
  – Strength training involves contraction of muscles against heavy resistance
    • Strength training increases the number of myofilaments in each muscle fiber, and as a result, the total mass of the muscle increases
    • Strength training does not increase the number of muscle fibers
Effects of Exercise on Skeletal Muscles

• Effects of exercise on skeletal muscles
  – Endurance training increases a muscle’s ability to sustain moderate exercise over a long period; sometimes called *aerobic training*
    • Endurance training allows more efficient delivery of oxygen and nutrients to a muscle via increased blood flow
    • Endurance training does not usually result in muscle hypertrophy
Types of Movements Produced by Skeletal Muscle Contractions

- **Flexion**—movement that decreases the angle between two bones at their joint: bending
- **Extension**—movement that increases the angle between two bones at their joint: straightening
Types of Movements Produced by Skeletal Muscle Contractions

- Abduction—movement of a part away from the midline of the body
- Adduction—movement of a part toward the midline of the body
- Rotation and circumduction—movement around a longitudinal axis
Types of Movements Produced by Skeletal Muscle Contractions

• Supination and pronation—hand positions that result from rotation of the forearm; supination results in a hand position with the palm turned to the anterior position; pronation occurs when the palm faces posteriorly.
Types of Movements Produced by Skeletal Muscle Contractions

• Dorsiflexion and plantar flexion—foot movements; dorsiflexion results in elevation of the dorsum or top of the foot; during plantar flexion, the bottom of the foot is directed downward
Major Muscular Disorders

- Myopathies—muscle disorders; can range from mild to life threatening

- Muscle injury
  - Strain— injury from overexertion or trauma; involves stretching or tearing of muscle fibers
    - Often accompanied by myalgia (muscle pain)
    - May result in inflammation of muscle (myositis) or of muscle and tendon (fibromyositis)
    - If injury is near a joint and involves ligament damage, it may be called a sprain
Muscle Strain
Major Muscular Disorders

• Muscle injury
  – Cramps are painful muscle spasms (involuntary twitches)
  – Crush injuries result from severe muscle trauma and may release cell contents that ultimately cause kidney failure
  – Stress-induced muscle tension can cause headaches and back pain
Treatment for Muscle Cramps
IT Band

Iliac crest

Gluteus medius m. covered by fascia

Tensor fascia latae m.

Gluteus maximus m.

Vastus lateralis m.

Iliotibial tract

Lateral condyle of the tibia

Patella

Lateral patellar retinaculum
Stress and Muscle Pain

Components of a Comfortable Workstation

- Document Holder
- Viewing Distance
- Monitor Angle
- Monitor Height
- Seat Back Angle
- Arm & Wrist Angle
- Keyboard Height
- Mouse
- Seat Height
Major Muscular Disorders

• Infections
  – Several bacteria, viruses, and parasites can infect muscles
  – Poliomyelitis is a viral infection of motor nerves that ranges from mild to life threatening
Poliomelitis
Major Muscular Disorders

• Muscular dystrophy
  – A group of genetic disorders characterized by muscle atrophy
  – Duchenne (pseudohypertrophic) muscular dystrophy is the most common type
    • Characterized by rapid progression of weakness and atrophy, resulting in death by age 21
    • X-linked inherited disease, affecting mostly boys
Major Muscular Disorders

• **Myasthenia gravis**—autoimmune muscle disease characterized by weakness and chronic fatigue