

Chapter 6- The Muscular System

- I. The muscular system
 - A. Muscles are responsible for all types of body movement
 - B. Three basic muscle types are found in the body
 1. Skeletal muscle
 2. Cardiac muscle
 3. Smooth muscle
- II. Characteristics of muscles
 - A. Skeletal and smooth muscle cells are elongated (muscle cell = muscle fiber)
 - B. Contraction of muscles is due to the movement of microfilaments
 - C. All muscles share some terminology
 1. Prefixes myo and mys refer to "muscle"
 2. Prefix sarco refers to "flesh"
- III. Comparison of skeletal, cardiac and smooth muscles
 - A. Skeletal muscle characteristics
 1. Most are attached by tendons to bones
 2. Cells are multinucleate
 3. Striated- have visible banding
 4. Voluntary- subject to conscious control
 5. Connective tissue wrappings of skeletal muscle
 - a. Cells are surrounded and bundled by connective tissue
 - 1) Endomysium- encloses a single muscle fiber
 - 2) Perimysium- wraps around a fascicle (bundle) of muscle fibers
 - 3) Epimysium- covers the entire skeletal muscle
 - 4) Fascia- on the outside of the epimysium
 6. Skeletal muscle attachments
 - a. Epimysium blends into a connective tissue attachment
 - 1) Tendons- cord-like structures
 - a) Mostly collagen fibers
 - b) Often cross a joint due to toughness and small size
 - 2) Aponeuroses- sheet-like structures
 - a) Attach muscles indirectly to bones, cartilages, or connective tissue coverings
 - b. Sites of muscle attachment
 - 1) Bones
 - 2) Cartilages
 - 3) Connective tissue coverings
 - B. Smooth muscle characteristics
 1. Lacks striations
 2. Spindle-shaped cells
 3. Single nucleus
 4. Involuntary- no conscious control
 5. Found mainly in the walls of hollow organs
 - C. Cardiac muscle characteristics
 1. Striations Usually has a single nucleus
 2. Branching cells
 3. Joined to another muscle cell at an intercalated disc

- 4. Involuntary
- 5. Found only in the heart
- D. Skeletal muscle functions
 - 1. Produce movement
 - 2. Maintain posture
 - 3. Stabilize joints
 - 4. Generate heat
- IV. Microscopic anatomy of skeletal muscle
 - A. Sarcolemma- specialized plasma membrane
 - B. Myofibrils- long organelles inside muscle cell
 - C. Sarcoplasmic reticulum- specialized smooth endoplasmic reticulum
 - D. Myofibrils are aligned to give distinct bands
 - 1. I band = light band
 - a. Contains only thin filaments
 - 2. A band = dark band
 - a. Contains the entire length of the thick filaments
 - 3. At rest, there is a bare zone that lacks actin filaments called the H zone
 - E. Sarcomere- contractile unit of a muscle fiber
 - F. Organization of the sarcomere
 - G. Myofilaments
 - 1. Thick filaments = myosin filaments
 - a. Composed of the protein myosin
 - b. Has ATPase enzymes
 - c. Myosin filaments have heads (extensions, or cross bridges)
 - d. Myosin and actin overlap somewhat
 - 2. Thin filaments = actin filaments
 - a. Composed of the protein actin
 - b. Anchored to the Z disc
 - H. Sarcoplasmic reticulum (SR)
 - 1. Stores and releases calcium
 - 2. Surrounds the myofibril
 - I. Stimulation and contraction of single skeletal muscle cells
 - 1. Excitability (also called responsiveness or irritability) ability to receive and respond to a stimulus
 - 2. Contractility- ability to shorten when an adequate stimulus is received
 - 3. Extensibility- ability of muscle cells to be stretched
 - 4. Elasticity- ability to recoil and resume resting length after stretching
 - 5. The nerve stimulus action potential
 - a. Skeletal muscles must be stimulated by a motor neuron (nerve cell) to contract
 - b. Motor unit- one motor neuron and all the skeletal muscle cells stimulated by that neuron
 - c. Neuromuscular junction
 - 1) Association site of axon terminal of the motor neuron and muscle
 - 2) Synaptic cleft
 - a) Gap between nerve and muscle
 - b) Nerve and muscle do not make contact

- c) Area between nerve and muscle is filled with interstitial fluid
 - d. Transmission of nerve impulse to muscle
 - 1) Neurotransmitter- chemical released by nerve upon arrival of nerve impulse
 - a) The neurotransmitter for skeletal muscle is acetylcholine (ACh)
 - 2) Acetylcholine attaches to receptors on the sarcolemma
 - 3) Sarcolemma becomes permeable to sodium (Na⁺)
 - 4) Sodium rushes into the cell generating an action potential
 - 5) Once started, muscle contraction cannot be stopped
- J. The sliding filament theory of muscle contraction
 - 1. Activation by nerve causes myosin heads (cross bridges) to attach to binding sites on the thin filament
 - 2. Myosin heads then bind to the next site of the thin filament and pull them toward the center of the sarcomere
 - 3. This continued action causes a sliding of the myosin along the actin
 - 4. The result is that the muscle is shortened (contracted)
 - 5. Contraction of the skeletal muscle
 - a. Muscle fiber contraction is "all or none"
 - b. Within a skeletal muscle, not all fibers may be stimulated during the same interval
 - c. Different combinations of muscle fiber contractions may give differing responses
 - d. Graded responses- different degrees of skeletal muscle shortening
 - e. Graded responses can be produced by changing:
 - 1) The frequency of muscle stimulation
 - 2) The number of muscle cells being stimulated at one time
 - 3) Types of graded responses
 - a) Twitch
 - b) Single, brief contraction
 - c) Not a normal muscle function
 - d) Tetanus (summing of contractions)
 - i. One contraction is immediately followed by another
 - ii. The muscle does not completely return to a resting state
 - iii. The effects are added
 - iv. Unfused (incomplete) tetanus- some relaxation occurs between contractions, the results are summed
 - v. Fused (complete) tetanus- no evidence of relaxation before the following contractions, the result is a sustained muscle contraction
- K. Muscle response to strong stimuli
 - 1. Muscle force depends upon the number of fibers stimulated
 - 2. More fibers contracting results in greater muscle tension
 - 3. Muscles can continue to contract unless they run out of energy

- L. Energy for muscle contraction
 - 1. Initially, muscles use stored ATP for energy
 - a. ATP bonds are broken to release energy
 - b. Only 4-6 seconds worth of ATP is stored in muscles
 - 2. After this initial time, other pathways must be utilized to produce ATP
 - 3. Direct phosphorylation of ADP by creatine phosphate (CP)
 - a. Muscle cells store CP
 - 1) CP is a high-energy molecule
 - b. After ATP is depleted, ADP is left
 - c. CP transfers energy to ADP, to regenerate ATP
 - d. CP supplies are exhausted in less than 15 seconds
 - 4. Aerobic respiration
 - a. Glucose is broken down to carbon dioxide and water, releasing energy (ATP)
 - b. This is a slower reaction that requires continuous oxygen
 - c. A series of metabolic pathways occur in the mitochondria
 - 5. Anaerobic glycolysis and lactic acid formation
 - a. Reaction that breaks down glucose without oxygen
 - b. Glucose is broken down to pyruvic acid to produce some TP
 - c. Pyruvic acid is converted to lactic acid
 - d. This reaction is not as efficient, but it is fast
 - 1) Huge amounts of glucose are needed
 - 2) Lactic acid produces muscle fatigue
- M. Muscle fatigue and oxygen deficit
 - 1. When a muscle is fatigued, it is unable to contract even with a stimulus
 - 2. Common cause for muscle fatigue is oxygen debt
 - a. Oxygen must be "repaid" to tissue to remove oxygen deficit
 - b. Oxygen is required to get rid of accumulated lactic acid
 - 3. Increasing acidity (from lactic acid) and lack of ATP causes the muscle to contract less
- V. Types of muscle contractions
 - A. Isotonic contractions
 - 1. Myofilaments are able to slide past each other during contractions
 - 2. The muscle shortens and movement occurs
 - B. Isometric contractions
 - 1. Tension in the muscles increases
 - 2. The muscle is unable to shorten or produce movement
- VI. Muscle tone
 - A. Some fibers are contracted even in a relaxed muscle
 - B. Different fibers contract at different times to provide muscle tone
 - C. The process of stimulating various fibers is under involuntary control
- VII. Effect of exercise on muscles
 - A. Exercise increases muscle size, strength, and endurance
 - 1. Aerobic (endurance) exercise (biking, jogging) results in stronger, more flexible muscles with greater resistance to fatigue
 - a. Makes body metabolism more efficient
 - b. Improves digestion, coordination

2. Resistance (isometric) exercise (weight lifting) increases muscle size and strength

VIII. Muscles and body movement

- A. Movement is attained due to a muscle moving an attached bone
- B. Muscles are attached to at least two points
 1. Insertion
 - a. Attachment to a moveable bone
 2. Origin
 - a. Attachment to an immovable bone
- C. Types of ordinary body movements
 1. Flexion
 - a. Decreases the angle of joint
 - b. Brings two bones closer together
 - c. Typical of hinge joints like knee or elbow
 2. Extension
 - a. Opposite of flexion
 - b. Increases angle between two bones
 3. Rotation
 - a. Movement of a bone around its longitudinal axis
 - b. Common in ball-and-socket joints
 - c. Example is when you move atlas around the dens of axis (shake your head "no")
 4. Abduction
 - a. Movement of a limb away from the midline
 5. Adduction
 - a. Opposite of abduction
 - b. Movement of a limb toward the midline
 6. Circumduction
 - a. Combination of flexion, extension, abduction, and adduction
 - b. Common in ball-and-socket joints
 7. Special movements
 - a. Dorsiflexion- lifting foot so that the superior surface approaches the shin
 - b. Plantar flexion- depressing the foot (pointing toes)
 - c. Inversion- turn sole of foot medially
 - d. Eversion- turn sole of foot laterally
 - e. Supination- forearm rotates laterally so palm faces anteriorly
 - f. Pronation- forearm rotates medially so palm faces posteriorly
 - g. Opposition- move thumb to touch the tips of other fingers on the same hand

IX. Types of muscles

- A. Prime mover- muscle with the major responsibility for a certain movement
- B. Antagonist- muscle that opposes or reverses a prime mover
- C. Synergist- muscle that aids a prime mover in a movement that helps prevent rotation
- D. Fixator- stabilizes the origin of a prime mover

X. Naming skeletal muscles

- A. By direction of muscle fibers
 1. Example: Rectus (straight)

- B. By relative size of muscle
 - 1. Example: Maximus (largest)
 - C. By location of the muscle
 - 1. Example: temporalis (temporal bone)
 - D. By number of origins
 - 1. Example: triceps (three heads)
 - E. By location of the muscle's origin and insertion
 - 1. Example Sterno (on the sternum)
 - F. By shape of the muscle
 - 1. Example: deltoid (triangular)
 - G. By action of the muscle
 - 1. Example: Flexor and extensor (flexes or extends a bone)
- XI. Head and neck muscles
- A. Facial muscles
 - 1. Frontalis- raises eyebrows
 - 2. Orbicularis oculi- closes eyes, squints, blinks, winks
 - 3. Orbicularis oris- closes mouth and protrudes the lips
 - 4. Buccinator- flattens the cheek, chews
 - 5. Zygomaticus- raises corners of mouth
 - 6. Chewing muscles
 - a. Masseter- closes the jaw and elevates mandible
 - b. Temporalis- synergist of the masseter, closes jaw
 - 7. Neck muscles
 - a. Platysma- pulls the corners of the mouth inferiorly
 - b. Sternocleidomastoid- flexes the neck, rotates the head
 - B. Muscles of trunk, shoulder, arm
 - 1. Anterior muscles
 - a. Pectoralis major- adducts and flexes the humerus
 - b. Intercostal muscles
 - 1) External intercostals- raise rib cage during inhalation
 - 2) Internal intercostals- depress the rib cage to move air out of the lungs when you exhale forcibly
 - c. Muscles of the abdominal girdle
 - 1) Rectus abdominis- flexes vertebral column and compresses abdominal contents (defecation, childbirth, forced breathing)
 - 2) External and internal obliques- flex vertebral column; rotate trunk and bend it laterally
 - 3) Transversus abdominis- compresses abdominal contents
 - 2. Posterior muscles
 - a. Trapezius- elevates depresses, adducts, and stabilizes the scapula
 - b. Latissimus dorsi- extends and adducts the humerus
 - c. Erector spinae- back extension
 - d. Quadratus lumborum- flexes the spine laterally
 - e. Deltoid- arm abduction
 - 3. Muscles of the upper limb
 - a. Biceps brachii- supinates the forearm, flexes elbow
 - b. Brachialis- elbow flexion
 - c. Brachioradialis- weak muscle

- d. Triceps brachii- elbow extension (antagonist to biceps brachii)
- C. Muscles of posterior neck, trunk, arm
 - 1. Muscles of the lower limb
 - a. Gluteus maximus- hip extension
 - b. Gluteus medius- hip abduction, steadies pelvis when walking
 - c. Iliopsoas- hip flexion, keeps the upper body from falling backward when standing erect
 - d. Adductor muscles- adduct the thighs
 - 2. Muscles of the pelvis, hip, thigh
 - a. Muscles causing movement at the knee joint
 - 1) Hamstring group- thigh extension and knee flexion
 - a) Biceps femoris
 - b) Semimembranosus
 - c) Semitendinosus
 - 2) Quadriceps group- extends the knee
 - a) Vastus muscles (three)
 - b) Rectus femoris
 - 3) Sartorius- flexes the thigh
 - 3. Muscles causing movement at ankle and foot
 - a. Tibialis anterior- dorsiflexion and foot inversion
 - b. Extensor digitorum longus- toe extension and dorsiflexion of the foot
 - c. Fibularis muscles- plantar flexion, everts the foot
 - d. Soleus- plantar flexion
- D. Intramuscular injection sites