CHAPTER 9: THE MUSCULAR SYSTEM

MODULE 9.1 OVERVIEW OF SKELETAL MUSCLES

STRUCTURE OF A SKELETAL MUSCLE

- Skeletal muscles are not made of muscle cells alone
- Skeletal muscle contains blood vessels that supply muscle cells with oxygen and glucose, and remove wastes, and nerves that coordinate muscle contraction
- Skeletal muscle also contains *connective tissue* (next slide)

STRUCTURE OF A SKELETAL MUSCLE

- Each individual muscle cell (fiber) is surrounded by thin connective tissue called endomysium (Figure 9.1)
- Several (between 10 and 100) muscle cells are *bundled together* into a **fascicle** by the connective tissue **perimysium**
- All fascicles that make up a muscle are, in turn, *enclosed* in an outer fibrous connective tissue wrapping (**epimysium**)

STRUCTURE OF A SKELETAL MUSCLE

- *Interconnected* connective tissues taper down and connect to tendons or other connective tissues; attach muscle to bone or other structure *to be moved*
- Example of **Structure-Function Core Principle**; makes sure muscle pulls *as a unit* even if some muscle cells are not pulling with *same strength* as others

STRUCTURE OF A SKELETAL MUSCLE

- **Motor unit** – describes motor neuron-muscle cell interaction; example of **Cell-Cell Communication Core Principle**
  - Consists of a single motor neuron and all muscle cells it connects to
  - Some motor units have only a few muscle cells, whereas others have many
  - Fewer muscle cells in a motor unit = more *precise movements* of that muscle when it contracts

STRUCTURE OF A SKELETAL MUSCLE

Shape, *size*, *placement*, and *arrangement* of fibers in a skeletal muscle contribute to function of that muscle; *form follows function* (**Figures 9.2**, **9.3**; **Table 9.1**)

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes

- **Fascicles** – bundles of muscle cells whose specific arrangement affects both *appearance* and *function* of whole skeletal muscle
- Following are *different arrangements* in which fascicles are found in human body (**Figure 9.2**)

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes (continued):

- **Parallel** – strap-like muscle with *evenly spaced fascicles*; muscle and tendon are same width

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes (continued):

- **Convergent** – broad *triangular-shaped* muscle that tapers down into a single tendon

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes (continued):

- **Pennate** – muscle where fascicles attach to tendon at an *angle*, giving it a feather-like appearance
- **Unipennate** – pennate variation; features fascicles that are only attached to one side of associated tendon

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes (continued):

- **Bipennate** – pennate variation; features fascicles that are attached to both sides of associated tendon

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes (continued):

- **Multipennate** – pennate variation; *several regions* of fascicles joined by connective tissue where each section contributes to form a single tendon

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes (continued):

- **Sphincters** – circular fascicle arrangements that *surround body openings*; provide voluntary control over defecation and urination; example of **Structure-Function Core Principle**

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes (continued):

- **Spiral** – in muscles that *wrap around* another structure such as a bone

STRUCTURE OF A SKELETAL MUSCLE

Fascicles and Muscle Shapes (continued):

- **Fusiform** – muscular shape where muscle midsection or belly is *thicker* than each *tapered end*

STRUCTURE OF A SKELETAL MUSCLE

- **Naming muscles**
  - Has been based on a specific muscle's *appearance*, *size*, or *position*
  - Some muscles have retained *historical names* that are unrelated to previous ways

of deriving a name

Structure of a Skeletal Muscle

- Muscles can be named based on (**Table 9.1**):
  - *Location* using directional terms in combination with Greek and Latin word roots
  - Anatomical structures where they are *attached*
  - *Actions* performed when contracted; includes **flexors**, **extensors**, **adductors**, **abductors**, and **levators**

Functions of Skeletal Muscles

- Muscle contractions are involved in more than just movement of bones at a joint; *other functions* of muscle contraction include:
  - Skeletal muscle contractions *generate heat* as a by-product; can be used as a homeostatic mechanism for maintaining *body temperature*
  - Contraction of **diaphragm** muscle is a vital function associated with respiratory system

Functions of Skeletal Muscles

- **Movement and Other Functions**
  - Skeletal muscles attached to facial skin allow for *facial expression*; muscles in throat assist with *swallowing*
  - Sphincters composed of skeletal muscle allow conscious control over *opening* and *closing* of body openings

Muscle Knots

- **Muscle knots** (**myofascial trigger points**) – groups of muscle fibers or fascicles (not entire muscle) that *contract painfully* and will <u>not</u> *relax*; pain and stress on joints and connective tissue can be severe
- **Causes** – not completely understood; microscopic tears from *repetitive, muscle-stressing exercises* (running), or sudden muscle use in those with poor posture or sedentary lifestyle; diet and ion imbalance may contribute

Muscle Knots

- *Palpation* is used to identify location of trigger point
- **Treatment** – relax muscle fibers in trigger points; *massage therapy, anti-inflammatory medications, and muscle relaxants* are helpful; regular, gentle stretching (yoga) also useful
- **Prevention** – moderate exercise and a healthy diet

Functions of Skeletal Muscles

- **Functional groups of muscles**: generally takes cooperation of several individual muscles working as a group to perform a movement or **action**; the following terms define role of different muscles in group (**Figure 9.3**):
  - **Agonists** (**prime movers**) provide <u>most</u> force for a given muscle action
  - **Antagonists**, usually on <u>opposite</u> side of bones and joint where they meet, have

opposite action of agonist; allows for modulation and control of agonist movement

FUNCTIONS OF SKELETAL MUSCLES

- **Functional groups of muscles** (continued):
  - **Synergists** aid agonists by supplying *supplemental force*, minimizing *unwanted movement*, and by helping to *stabilize joints*, all of which provide for more efficient movement
  - **Fixators** also provide *stabilizing force* that anchors a bone; provides movement efficiency and protection from injury due to unnecessary movements

FUNCTIONS OF SKELETAL MUSCLES

- **Muscle origin and insertion** – skeletal muscles begin and end at distinct anatomical locations (**Figure 9.4**)
  - **Origin** – *anchoring point* on a bone, where skeletal muscle "originates from"; typically not involved directly with movement of joint
  - **Insertion** – *moving end* of muscle whose tendon attaches to a bone or other structures, usually on far side of joint

FUNCTIONS OF SKELETAL MUSCLES

A **lever system** includes three components: **load** or resistance, applied **force** that moves load, and a pivot point or **fulcrum**; changing configuration of these variables leads to the following *lever classes* (**Figure 9.5**):

FUNCTIONS OF SKELETAL MUSCLES

- **First-class lever** – fulcrum sits between load and applied force; load is moved in opposite direction than applied force

FUNCTIONS OF SKELETAL MUSCLES

- **Second-class lever** – fulcrum is at *one end* of lever, applied force is near *other end*; load is somewhere in between; load is moved in same direction as applied force

FUNCTIONS OF SKELETAL MUSCLES

- **Third-class lever** – fulcrum and applied force are close to one another at same end of lever; load is near other end; load is moved in same direction as applied force

FUNCTIONS OF SKELETAL MUSCLES

- Lever system where fulcrum is located farther away from applied force works at a **mechanical advantage**; allows a *small force* to move a *large load* over a short distance
- Lever system where fulcrum is located close to applied force and load is further away works at a **mechanical disadvantage**; reduces the load it can move; however, load can be moved *faster* over a *greater distance*

CONCEPT BOOST: UNDERSTANDING LEVER SYSTEMS AND MECHANICAL ADVANTAGE

- Good **seesaws** are adjustable 3–4 notches so *position of fulcrum* can be moved off center, compensating for *weight differences* in partners
- Lighter person would move fulcrum position farther away to overcome the heavier weight that must be moved at the partner's end of seesaw; longer end of seesaw moves in a *greater arc distance* (and *faster*), but moves heavier partner (conferring a mechanical advantage) a *shorter distance*

CONCEPT BOOST: UNDERSTANDING LEVER SYSTEMS AND MECHANICAL ADVANTAGE

- Fulcrum placement in body's lever systems allows muscle contraction to be used for a variety of movements
- Placing fulcrum closer to or farther from applied force has a lot to do with whether lever system is built for *strength* or for *speed*