9

The Muscular System

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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

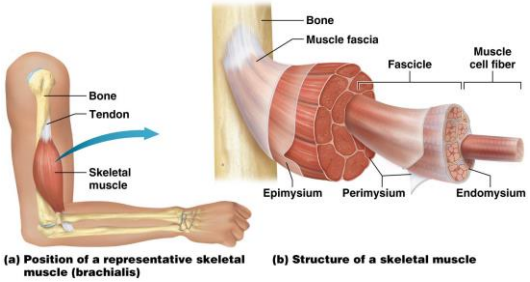


Figure 9.1 Position and structure of a skeletal muscle.

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

Figure 9.2a Fascicle pattern and muscle shape.

Structure of a Skeletal Muscle

Fascicles and Muscle Shapes (continued):

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

Figure 9.2b Fascicle pattern and muscle shape.

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

Figure 9.2c Fascicle pattern and muscle shape.

Structure of a Skeletal Muscle

Fascicles and Muscle Shapes (continued):

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

Figure 9.2c Fascicle pattern and muscle shape.

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

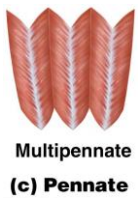


Figure 9.2c Fascicle pattern and muscle shape.

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**

Figure 9.2d Fascicle pattern and muscle shape.

Structure of a Skeletal Muscle

Fascicles and Muscle Shapes (continued):

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

Figure 9.2e Fascicle pattern and muscle shape.

Structure of a Skeletal Muscle

Fascicles and Muscle Shapes (continued):

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

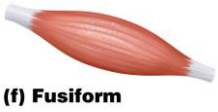


Figure 9.2f Fascicle pattern and muscle shape.

Structure of a Skeletal Muscle

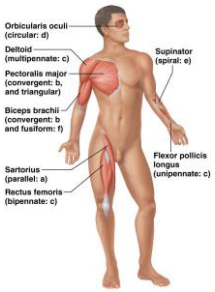


Figure 9.2 Fascicle pattern and muscle shape.

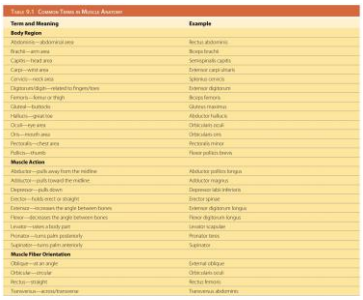
Structure of a Skeletal Muscle

- **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**

Structure of a Skeletal Muscle



Term and Meaning	Example
Body Region	
Abdomino—abdominal area	Rectus abdominis
Brachi—arm area	Biceps brachii
Capito—head area	Sternocleido capitis
Carpi—wrist area	Extensor carpi ulnaris
Cervico—neck area	Splenius cervicis
Digitorum/digiti—related to fingers/toes	Extensor digitorum
Femoro—femur or thigh	Biceps femoris
Gluteal—buttocks	Gluteus maximus
Hallucis—great toe	Abductor hallucis
Oculi—eye area	Orbicularis oculi
Oris—mouth area	Orbicularis oris
Pectoralis—chest area	Pectoralis minor
Pollicis—thumb	Flexor pollicis brevis
Muscle Action	
Abductor—pulls away from the midline	Abductor pollicis longus
Adductor—pulls toward the midline	Adductor magnus
Depressor—pulls down	Depressor labii inferioris
Erector—holds erect or straight	Erector spinae
Extensor—increases the angle between bones	Extensor digitorum longus
Flexor—decreases the angle between bones	Flexor digitorum longus
Levator—raises a body part	Levator scapulae
Pronator—turns palm posteriorly	Pronator teres
Supinator—turns palm anteriorly	Supinator
Muscle Fiber Orientation	
Oblique—at an angle	External oblique
Orbicularis—circular	Orbicularis oculi
Rectus—straight	Rectus femoris
Transversus—across/transverse	Transversus abdominis

Table 9.1 Common Terms in Muscle Anatomy.

Structure of a Skeletal Muscle

Term and Meaning	Example
Muscle Location	
Anterior—toward the front	Tibialis anterior
External—toward the outside	External intercostals
Infra—below	Infraspinatus
Intercostal—between the ribs	Internal intercostals
Internal—toward the inside	Internal oblique
Posterior—toward the back	Tibialis posterior
Profundus—deep	Flexor digitorum profundus
Superficialis—nearer the surface	Flexor digitorum superficialis
Supra—above	Supraspinatus
Muscle Heads of Origin	
Biceps—two heads	Biceps brachii
Quadriceps—four heads	Quadriceps femoris
Triceps—three heads	Triceps brachii
Muscle Size	
Brevis—short	Fibularis brevis
Longus—long	Adductor longus
Vastus—wide/large	Vastus lateralis
Muscle Shape	
Deltoid—triangular	Deltoid
Lateralis—wide or broad	Latissimus dorsi
Maximus—largest	Gluteus maximus
Minimus/Minoris—smallest	Gluteus minimus
Minor—small	Pectoralis minor
Quadratus—shaped like a rectangle	Pronator quadratus
Rhomboid—shaped like a rhombus (slanted parallelogram)	Rhomboid major
Serratus—serrated or jagged	Serratus anterior
Trapezius—shaped like a trapezoid	Trapezius

Table 9.1 Common Terms in Muscle Anatomy.

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 not *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 most force for a given muscle action
  - **Antagonists**, usually on opposite 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

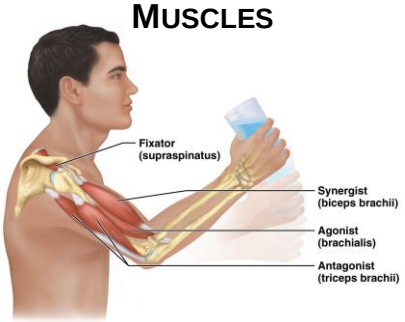


Figure 9.3 Functional groups of muscles.

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

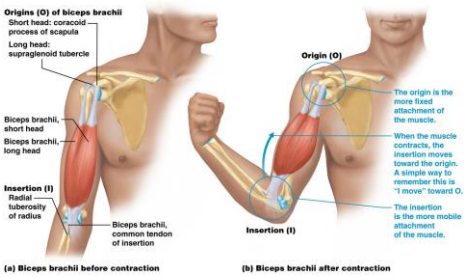


Figure 9.4 Muscle origin and insertion.

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

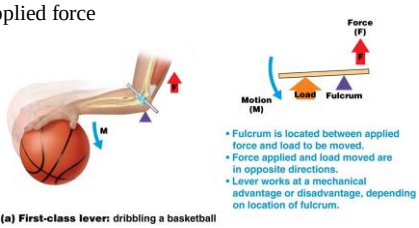


Figure 9.5a Lever systems.

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

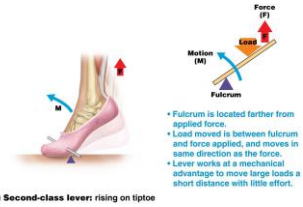


Figure 9.5b Lever systems.

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

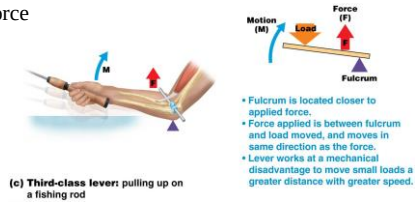


Figure 9.5c Lever systems.

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*

Concept Boost: Understanding Lever Systems and Mechanical Advantage