

# UNIT 5 - MUSCULAR SYSTEM

## LECTURE NOTES

### 5.01 MUSCLE TISSUE – FUNCTIONS

- A. Motion by moving the skeletal levers of the body
- B. Posture - stabilizing body positions
- C. Regulation of organ volume
- D. Thermogenesis - heat production
- E. Protection of internal organs

### 5.02 CHARACTERISTICS OF MUSCLE TISSUE

- A. Elasticity  
The ability of muscle tissue to return to its normal resting length after it has been stretched or contracted.
- B. Excitability (Irritability)  
The ability of muscle tissue to receive and respond to a stimulus such as a nerve impulse.
- C. Extensibility  
The ability of muscle tissue to be elongated or stretched.
- D. Contractility  
The ability of muscle tissue to become short and thick while producing movement.

### 5.03 CHARACTERISTICS OF THE THREE MUSCLE TISSUE TYPES

- A. Skeletal Muscle
  - 1. Functions
    - a. Movement
    - b. Thermogenesis
    - c. Posture
    - d. Protection of internal organs
  - 2. General Location  
Attached to bones by tendons
  - 3. Microscopic Appearance
    - a. Striated  
Striped appearance created by alternating light (actin) and dark (myosin) protein bands.
    - b. Multinucleated  
Have more than one nucleus per cell

4. Control  
Voluntary control by conscious nervous system.
- B. Smooth Muscle
1. General Location  
Located in the walls of hollow internal organs such as the blood vessels, stomach, intestines, urinary bladder, and the ureters.
  2. Microscopic Appearance
    - a. Non-striated appearance
    - b. Individual fibers (cells) taper (narrow) at the ends
    - c. One nucleus per cell
  3. Control  
Involuntary
  4. Functions
    - a. Controls the diameter of blood vessels
    - b. Peristalsis (wave-like contractions) to propel food and wastes through the digestive system and to move urine from the kidneys to the urinary bladder.
    - c. Muscular contractions to push urine out the urinary bladder.
- C. Cardiac muscle
1. General Location  
Forms the myocardium (middle, muscular layer) of the heart.
  2. Microscopic Appearance
    - a. Striated muscle
    - b. Fibers branch to form networks throughout the tissue
    - c. Has a single, large, centrally located nucleus
    - d. Muscle fibers are held together by junctions known as intercalated disks
  3. Control  
Typically involuntary control
  4. Functions  
Contractions of the heart

#### 5.04 THICK AND THIN MYOFILAMENTS

- A. Actin
1. Thin, light-colored myofilaments
  2. Actin myofilaments are anchored to the Z lines or boundaries of the sarcomeres (the functional units of muscle contraction)
  3. Composed of two single-stranded, intertwined protein molecules
  4. Contain two regulatory proteins arranged along the actin
    - a. Tropomyosin
      - (1). Thread-like, intertwined protein molecules
      - (2). When the muscle fiber's sarcomere is relaxed, tropomyosin blocks actin's active sites preventing cross-bridge formation with myosin.

b. Troponin

- (1). Globular proteins composed of three subunits
- (2). One subunit binds to actin, another binds to tropomyosin, and the last subunit binds to  $\text{Ca}^+$ .

B. Myosin

1. Thick, dark-colored myofilaments
2. Found in the center of the sarcomere
3. Alternate with the actin myofilaments to form striations
4. Shaped like a golf club
  - a. Long, thick protein molecule (tail)
  - b. Globular head at one end
5. Forms cross-bridges with actin molecules during muscle contraction.

## 5.05 THE SLIDING FILAMENT THEORY OF MUSCULAR CONTRACTION

A. Summary

During muscle contraction, the globular heads of the myosin attach to the active sites of the actin myofilament and “ratchet” or swivel pulling the actin towards the center of the sarcomere (unit of contraction). This causes the actin myofilaments to slide past one another resulting in a shortening of a sarcomere. The sarcomere shortens and the muscle contracts.

B. Events Leading To Muscular Contraction

1. An action potential (nerve impulse) travels from the brain transmitted by a motor nerve. When it arrives at the motor end plate, the membrane of the nerve at the synaptic cleft is depolarized, thereby increasing the  $\text{Ca}^{++}$  permeability of the membrane.
2.  $\text{Ca}^{++}$  diffuses from the area of greater concentration (outside the cell) to the area of lesser concentration (inside the cell).
3. The influx of  $\text{Ca}^{++}$  into the nerve causes synaptic vesicles to be pushed to the nerve membrane where they fuse and release the neurotransmitter acetylcholine (Ach).
4. Ach is secreted into the synaptic cleft, diffuses across the cleft and depolarizes the muscle membrane. This increases the permeability of  $\text{Na}^+$  through the membrane.  $\text{Na}^+$  rushes into the cell (down a concentration gradient), thereby depolarizing the membrane further and initiating an action potential. Ach is quickly broken down in the cleft by an enzyme, Ach-ase, so that each action potential arriving from the nerve initiates only one action potential within the muscle fiber.
5. The action potential spreads across the muscle membrane and down the T-tubules (which are actually extensions of the membrane which go deep into the muscle cell).
6. The action potential within the T-tubules depolarizes the membrane of the nearby sarcoplasmic reticulum, which releases  $\text{Ca}^{++}$  into the sarcoplasm ( $\text{Ca}^+$  is removed very quickly by the sarcoplasmic reticulum, so the effects of one action potential are very short-lived and produce a very small

contraction. Many action potentials are necessary to produce strong or prolonged contractions).

7. The  $\text{Ca}^{+}$  is bound to troponin, and troponin changes shape.
8. When troponin changes shape, it physically moves tropomyosin out of the way, thereby exposing the active sites on the actin.
9. Since the myosin heads have a very high attraction for the active sites on actin, they make contact immediately after the active sites are exposed forming a cross-bridge. Attached to each globular head is an ATP molecule.
10. The actin-myosin complex contains the enzyme ATPase, and ATP is split into ADP+P and energy is released.
11. The energy from the ATP is used to produce power-strokes or movement of the myosin heads which slide the actin filaments past each other and the muscle fiber contracts.
12. The myosin cross-bridge has low affinity for ADP, but very high affinity for ATP. It therefore discards the ADP and becomes recharged with a new ATP molecule. The myosin head releases its hold on actin, and returns back to its original position, ready to act again.
13. The steps are repeated until the H zone disappears and the sarcomere is contracted

## 5.06 THE NEUROMUSCULAR JUNCTION

### I. Definitions

#### A. Motor Neuron

A nerve carrying impulses from the brain and stimulates muscles to contract.

#### B. Neuromuscular Junction

The end of the axon terminal where it attaches to the muscle fiber.

#### C. Motor End Plate

The location on the muscle fiber at the end of the axon terminal.

#### D. Acetylcholine (Ach)

The neurotransmitter released from the synaptic vesicles which initiates an action potential in the muscle fiber.

### II. What Occurs At the Neuromuscular Junction

A. Muscle fibers are stimulated to contract by motor neurons.

B. When the impulse is transmitted to the end of the motor nerve (the synaptic knob), acetylcholine is released from small sacs called synaptic vesicles.

C. The acetylcholine fills in the small gap between the motor neuron and the muscle fiber membrane, known as the neuromuscular junction.

D. The muscle fiber membrane then depolarizes and the muscle starts to contract.

E. The acetylcholine is destroyed by an enzyme known as cholinesterase.

## 5.07 ORIGIN AND INSERTION

When muscles shorten and produce movement of the musculoskeletal lever system, one body segment usually remains stable while the other body segment produces angular motion. The body segment to which the muscle is attached, that remains stable or stationary, is called the ORIGIN while the body segment to which the muscle is attached that moves is called the INSERTION.

### A. Origin

1. Body segment with the most mass
2. Usually more proximally located
3. Usually has a larger surface area of attachment
4. Typically the immovable end of the muscle

### B. Insertion

1. Attached to body segment with least mass
2. Usually more distally located
3. Usually has smaller surface area of attachment
4. Typically the moveable end of the muscle

## 5.08 ROLES OF SKELETAL MUSCLES

The roles of skeletal muscles are not fixed, meaning they change depending upon the particular movement that is being executed.

### A. Agonist (Prime Mover)

The muscle that is responsible for the majority of force when a movement is executed.

### B. Antagonist

The muscle which performs the opposite movement of the agonist.

### C. Synergist

A muscle that assists the agonist by providing additional force or directing the force of the agonist so the movement can be most effectively executed.

### D. Fixator (Stabilizer)

A muscle that functions to stabilize a point or body position.

## 5.09 MUSCLE IDENTIFICATION

A. Identify the following muscles or muscle groups on a diagram:

- |                        |                     |
|------------------------|---------------------|
| 1. biceps brachii      | 7. pectoralis major |
| 2. triceps brachii     | 8. latissimus dorsi |
| 3. sternocleidomastoid | 9. gastrocnemius    |
| 4. trapezius           | 10. hamstrings      |
| 5. deltoid             | 11. quadriceps      |
| 6. diaphragm           | 12. gluteus maximus |

B. Identify the location and function of selected muscles.

**SELECTED SKELETAL MUSCLES**

<b>MUSCLE</b>	<b>LOCATION</b>	<b>FUNCTION</b>
1. Biceps Brachii	anterior aspect of the upper arm	flexes the forearm
2. Triceps Brachii	posterior aspect of the upper arm	extends the forearm
3. Sternocleidomastoid	anterior aspect of the neck	flexes the head and neck
4. Trapezius	posterior aspect of the neck	extends or hyperextends the head and neck
5. Deltoid	covers the shoulder	abducts the arm
6. Pectoralis Major	chest	adducts the arm
7. Latissimus Dorsi	superficial muscle of the thoracic and lumbar region of the back	extends a flexed arm or hyperextends the arm from the anatomical position
8. Diaphragm	internal muscle that separates the thoracic and abdominal cavities	deflects the diaphragm inferiorly increasing volume of the thoracic cavity
9. Gastrocnemius	posterior aspect of the lower leg	plantar flexes the foot
10. Hamstring muscle group	posterior aspect of the thigh	flexes the lower leg
11. Quadriceps muscle group	anterior aspect of the thigh	extends the lower leg
12. Gluteus Maximus	buttocks region	extends a flexed thigh or hyperextends the thigh from the anatomical position

## 5.10 Diseases and Disorders of the Muscular System

### A. **Fibromyalgia**

A widespread musculoskeletal pain and fatigue disorder for which the cause is still unknown. Fibromyalgia means pain in the muscles, ligaments, and tendons. Most patients with fibromyalgia say that they ache all over. Their muscles may feel like they have been pulled or overworked. Sometimes the muscles twitch and at other times they burn.

### B. **Muscular Dystrophy**

A group of genetic diseases characterized by the atrophy of skeletal muscle tissue. The most common form of muscular dystrophy is Duchenne's Muscular Dystrophy in which the skeletal muscle is replaced by fat and fibrous tissue. Death occurs as the respiratory or cardiac muscle weakens usually in the early twenties. DMD typically occurs in men and is linked to the X-chromosome.

### C. **Shin Splints**

Shin splints involve soreness and pain of the front lower leg due to excessive straining of the flexor digitorum longus. It is often a result of walking up and down hills or overbuilding the gastrocnemius. Tapping of the foot will help to increase the strength of the front of the lower leg and the symptoms of pain should disappear.

### D. **Muscle Strain**

Muscle strain is characterized by muscle pain and involves the overstretching or tearing of muscle fibers. Although muscle fibers and their associated connective tissues are flexible, they can be torn if overstretched. The seriousness of the injury depends on the degree of damage sustained by the tissues. In a mild condition, only a few muscle fibers are injured and the fascia remains intact. In a severe condition, many muscle fibers as well as the fascia are torn, and muscle function may be lost completely. Symptoms include pain, bruising, and swelling. In severe cases, surgery may be required to repair the damage.