Muscular System

The Muscular System consists of about 700 muscle. The **muscular system** is an organ **system** consisting of skeletal, smooth and cardiac **muscles**. It permits movement of the body, maintains posture and circulates blood throughout the body. The muscular system is composed of specialized cells called muscle fibers. Their predominant function is contractibility. Muscles, attached to bones or internal organs and blood vessels, are responsible for movement. Nearly all movement in the body is the result of muscle contraction. Exceptions to this are the action of cilia, the flagellum on sperm cells, and amoeboid movement of some white blood cells.

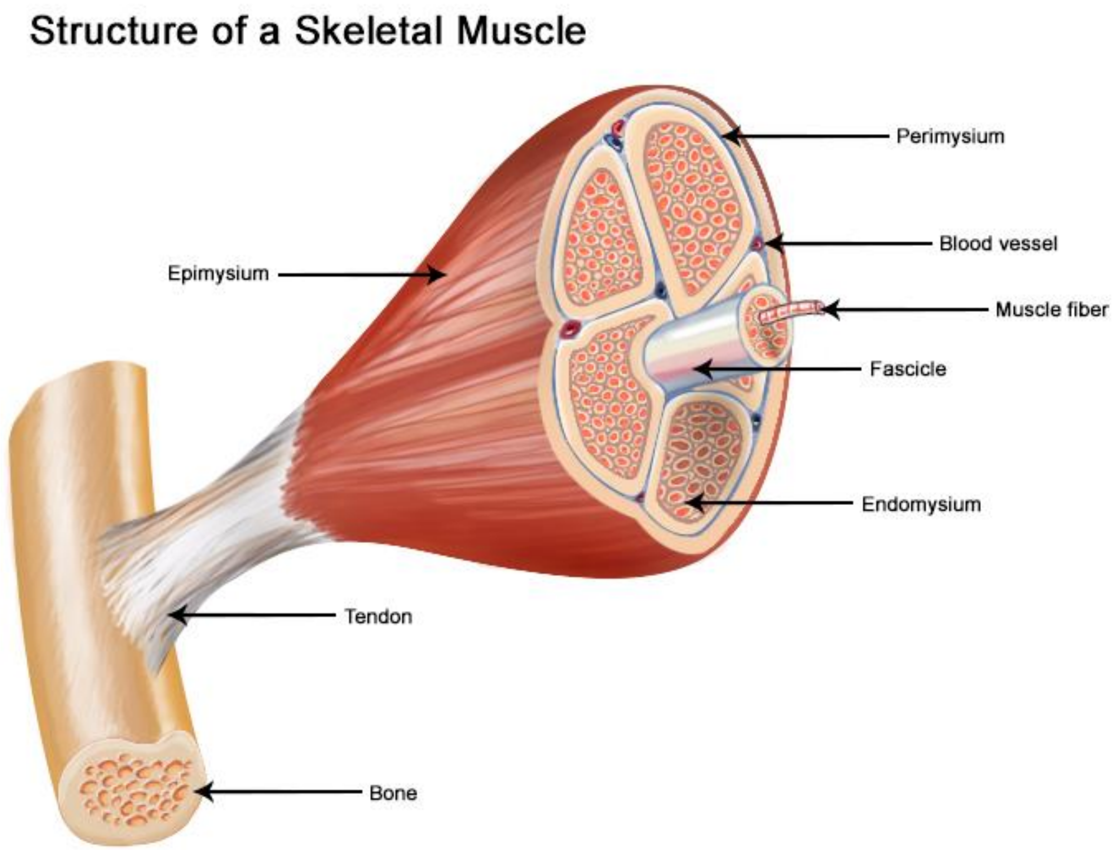
The integrated action of joints, bones, and skeletal muscles produces obvious movements such as walking and running. Skeletal muscles also produce more subtle movements that result in various facial expressions, eye movements, and respiration.

In addition to movement, muscle contraction also fulfills some other important functions in the body, such as posture, joint stability, and heat production. Posture, such as sitting and standing, is maintained as a result of muscle contraction. The skeletal muscles are continually making fine adjustments that hold the body in stationary positions

Structure of Skeletal Muscle

A whole skeletal muscle is considered an organ of the muscular system. Each organ or muscle consists of skeletal muscle tissue, connective tissue, nerve tissue, and blood or vascular tissue.

Skeletal muscles vary considerably in size, shape, and arrangement of fibers. They range from extremely tiny strands such as the stapedium muscle of the middle ear to large masses such as the muscles of the thigh. Some skeletal muscles are broad in shape and some narrow. In some muscles the fibers are parallel to the long axis of the muscle; in some they converge to a narrow attachment; and in some they are oblique.



Each skeletal muscle fiber is a single cylindrical muscle cell. An individual skeletal muscle may be made up of hundreds, or even thousands, of muscle fibers bundled together and wrapped in a connective tissue covering. Each muscle is surrounded by a connective tissue sheath called the epimysium. Fascia, connective tissue outside the epimysium, surrounds and separates the muscles. Portions of the epimysium project inward to divide the muscle into compartments. Each compartment contains a bundle of muscle fibers. Each bundle of muscle fiber is called a fasciculus and is surrounded by a layer of connective tissue called the perimysium. Within the fasciculus, each individual muscle cell, called a muscle fiber, is surrounded by connective tissue called the endomysium.

Skeletal muscle cells (fibers), like other body cells, are soft and fragile. The connective tissue covering furnish support and protection for the delicate cells and allow them to withstand the forces of contraction. The coverings also provide pathways for the passage of blood vessels and nerves.

Commonly, the epimysium, perimysium, and endomysium extend beyond the fleshy part of the muscle, the belly or gaster, to form a thick ropelike tendon or a broad, flat sheet-like aponeurosis. The tendon and aponeurosis form indirect attachments from muscles to the periosteum of bones or to the connective tissue of other muscles. Typically a muscle spans a joint and is attached to bones by tendons at both ends. One of the bones remains relatively fixed or stable while the other end moves as a result of muscle contraction.

Skeletal muscles have an abundant supply of blood vessels and nerves. This is directly related to the primary function of skeletal muscle, contraction. Before a skeletal muscle fiber can contract, it has to receive an impulse from a nerve cell. Generally, an artery and at least one vein accompany each nerve that penetrates the epimysium of a skeletal muscle. Branches of the nerve and blood vessels follow the connective tissue components of the muscle of a nerve cell and with one or more minute blood vessels called capillaries.

Muscle Types

In the body, there are three types of muscle: skeletal (striated), smooth, and cardiac.

Skeletal Muscle

Skeletal muscle, attached to bones, is responsible for skeletal movements. The peripheral portion of the central nervous system (CNS) controls the skeletal muscles. Thus, these muscles are under conscious, or voluntary, control. The basic unit is the muscle fiber with many nuclei. These muscle fibers are striated (having transverse streaks) and each acts independently of neighboring muscle fibers.

Smooth Muscle

Smooth muscle, found in the walls of the hollow internal organs such as blood vessels, the gastrointestinal tract, bladder, and uterus, is under control of the autonomic nervous system. Smooth muscle cannot be controlled consciously and thus acts involuntarily. The non-striated (smooth) muscle cell is spindle-shaped and has one central nucleus. Smooth muscle contracts slowly and rhythmically.

Cardiac Muscle

Cardiac muscle, found in the walls of the heart, is also under control of the autonomic nervous system. The cardiac muscle cell has one central nucleus, like smooth muscle, but it also is striated, like skeletal muscle. The cardiac muscle cell is rectangular in shape. The contraction of cardiac muscle is involuntary, strong, and rhythmical.

Muscle Groups

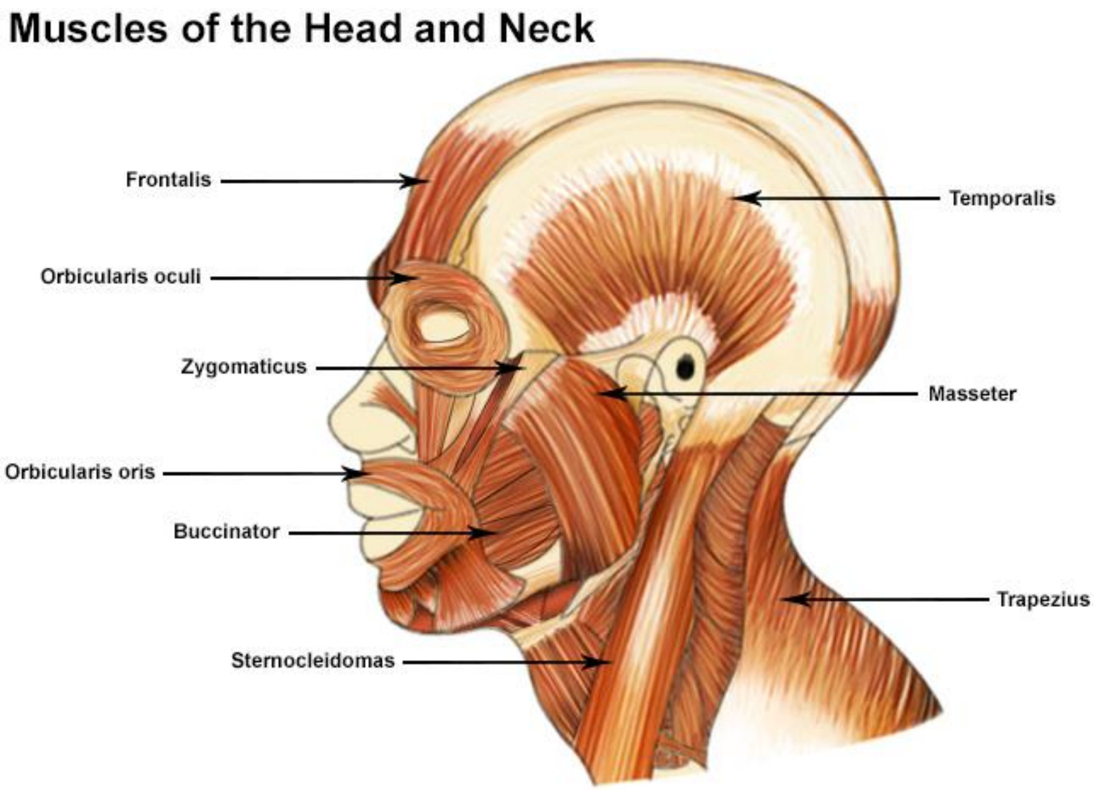
There are more than 600 muscles in the body, which together account for about 40 percent of a person's weight.

Most skeletal muscles have names that describe some feature of the muscle. Often several criteria are combined into one name. Associating the muscle's characteristics with its name will help you learn and remember them. The following are some terms relating to muscle features that are used in naming muscles.

- **Size:** vastus (huge); maximus (large); longus (long); minimus (small); brevis (short).
- **Shape:** deltoid (triangular); rhomboid (like a rhombus with equal and parallel sides); latissimus (wide); teres (round); trapezius (like a trapezoid, a four-sided figure with two sides parallel).
- **Direction of fibers:** rectus (straight); transverse (across); oblique (diagonally); orbicularis (circular).
- **Location:** pectoralis (chest); gluteus (buttock or rump); brachii (arm); supra- (above); infra- (below); sub- (under or beneath); lateralis (lateral).
- **Number of origins:** biceps (two heads); triceps (three heads); quadriceps (four heads).
- **Origin and insertion:** sternocleidomastoideus (origin on the sternum and clavicle, insertion on the mastoid process); brachioradialis (origin on the brachium or arm, insertion on the radius).
- **Action:** abductor (to abduct a structure); adductor (to adduct a structure); flexor (to flex a structure); extensor (to extend a structure

<u>Muscles of the Head and Neck</u>

Humans have well-developed muscles in the face that permit a large variety of facial expressions. Because the muscles are used to show surprise, disgust, anger, fear, and other emotions, they are an important means of nonverbal communication. Muscles of facial expression include frontalis, orbicularis oris, laris oculi, buccinator, and zygomaticus.These muscles of facial expressions are identified in the illustration below.

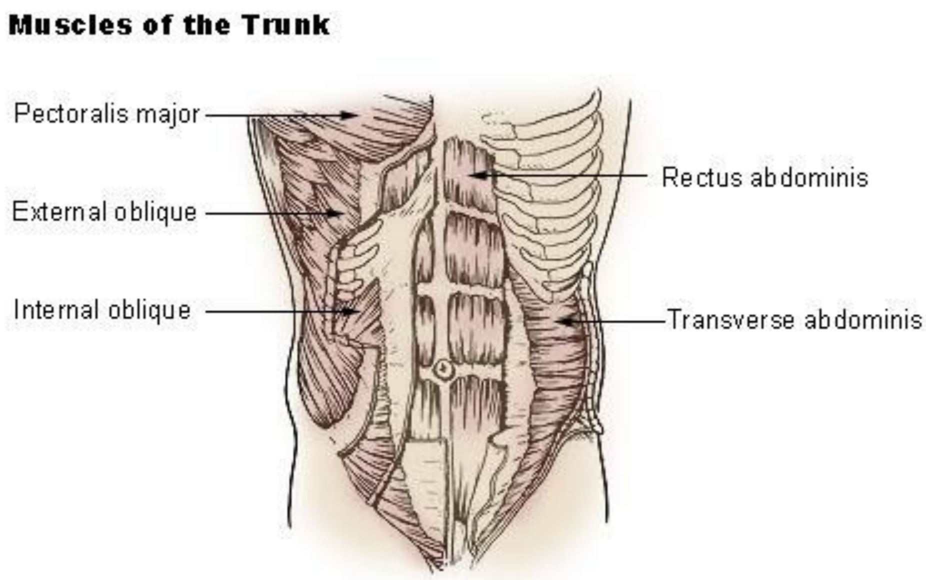


There are four pairs of muscles that are responsible for chewing movements or mastication. All of these muscles connect to the mandible and they are some of the strongest muscles in the body. Two of the muscles, temporalis and masseter, are identified in the illustration above.

There are numerous muscles associated with the throat, the hyoid bone and the vertebral column; only two of the more obvious and superficial neck muscles are identified in the illustration: sternocleidomastoid and trapezius.

Muscles of the Trunk

The muscles of the trunk include those that move the vertebral column, the muscles that form the thoracic and abdominal walls, and those that cover the pelvic outlet.

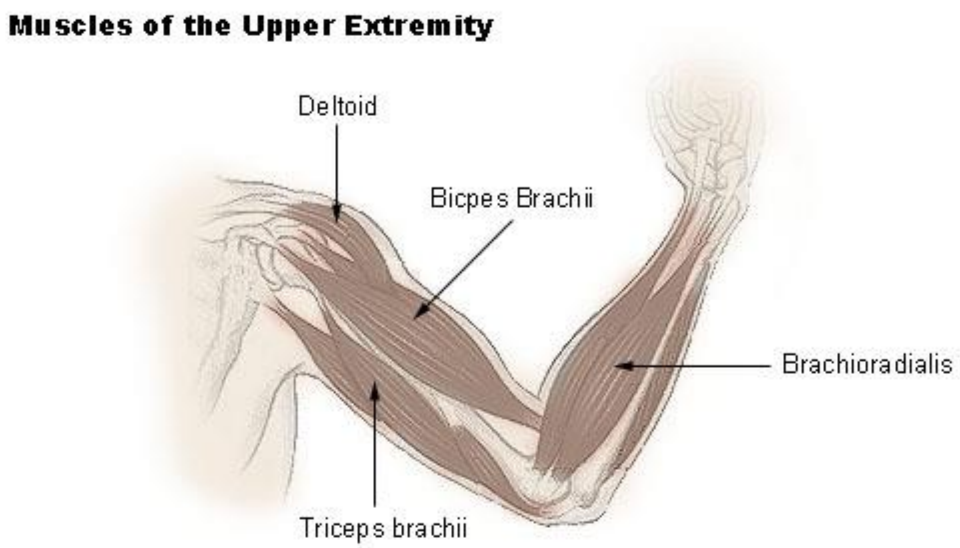


The erector spinae group of muscles on each side of the vertebral column is a large muscle mass that extends from the sacrum to the skull. These muscles are primarily responsible for extending the vertebral column to maintain erect posture. The deep back muscles occupy the space between the spinous and transverse processes of adjacent vertebrae.

The muscles of the thoracic wall are involved primarily in the process of breathing. The intercostal muscles are located in spaces between the ribs. They contract during forced expiration. External intercostal muscles contract to elevate the ribs during the inspiration phase of breathing.

Muscles of the Upper Extremity

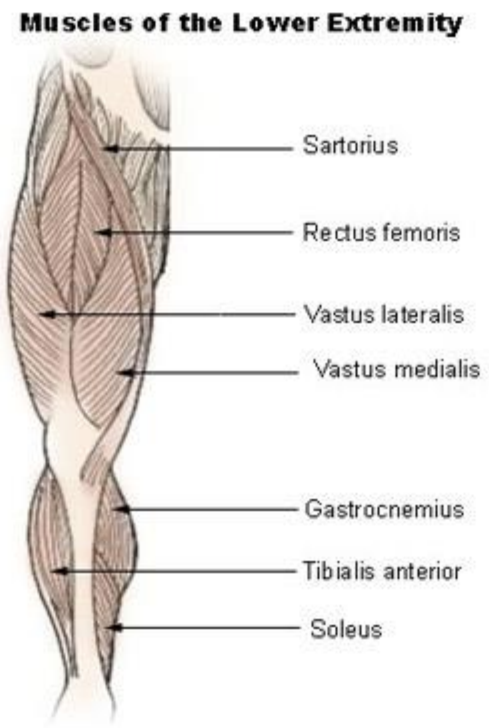
The muscles of the upper extremity include those that attach the scapula to the thorax and generally move the scapula, those that attach the humerus to the scapula and generally move the arm, and those that are located in the arm or forearm that move the forearm, wrist, and hand. The illustration below shows some of the muscles of the upper extremity.



Muscles that move the shoulder and arm include the trapezius and serratus anterior. The pectoralis major, latissimus dorsi, deltoid, and rotator cuff muscles connect to the humerus and move the arm.

The muscles that move the forearm are located along the humerus, which include the triceps brachii, biceps brachii, brachialis, and brachioradialis. The 20 or more muscles that cause most wrist, hand, and finger movements are located along the forearm.

Muscles of the Lower Extremity



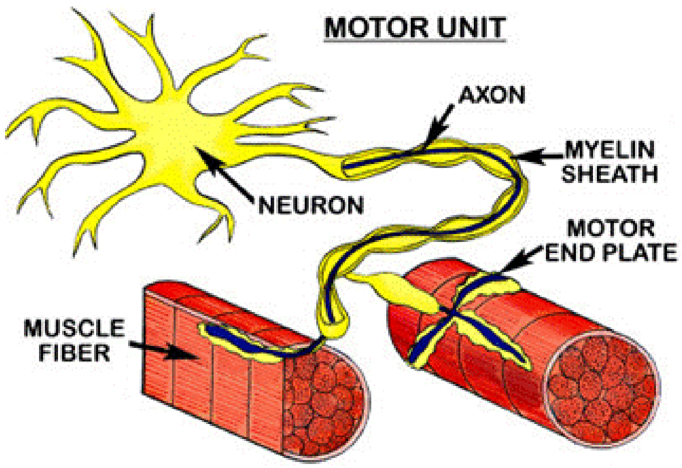
The muscles that move the thigh have their origins on some part of the pelvic girdle and their insertions on the femur. The largest muscle mass belongs to the posterior group, the gluteal muscles, which, as a group, adduct the thigh. The iliopsoas, an anterior muscle, flexes the thigh. The muscles in the medial compartment adduct the thigh. The illustration below shows some of the muscles of the lower extremity.

Muscles that move the leg are located in the thigh region. The quadriceps femoris muscle group straightens the leg at the knee. The hamstrings are antagonists to the quadriceps femoris muscle group, which are used to flex the leg at the knee.

The muscles located in the leg that move the ankle and foot are divided into anterior, posterior, and lateral compartments. The tibialis anterior, which dorsiflexes the foot, is antagonistic to the gastrocnemius and soleus muscles, which plantar flex the foot.

The Physiology of Skeletal Muscle Contraction

The Sliding Filament Theory
For a contraction to occur there must first be a stimulation of the muscle in the form of an impulse (action potential) from a motor neuron (nerve that connects to muscle).



Note that one motor neuron does not stimulate the entire muscle but only a number of muscle fibres within a muscle.

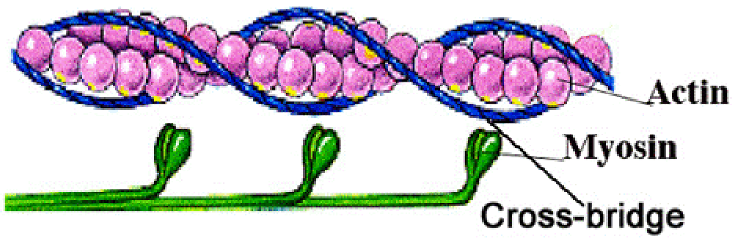
The individual motor neuron plus the muscle fibres it stimulates, is called a motor unit. The motor end plate (also known as the neuromuscular junction) is the junction of the motor neurons axon and the muscle fibres it stimulates.

When an impulse reaches the muscle fibres of a motor unit, it stimulates a reaction in each sarcomere between the actin and myosin filaments. This reaction results in the start of a contraction and the sliding filament theory.

The reaction, created from the arrival of an impulse stimulates the 'heads' on the myosin filament to reach forward, attach to the actin filament and pull actin towards the centre of the sarcomere. This process occurs simultaneously in all sarcomeres, the end process of which is the shortening of all sarcomeres.

Troponin is a complex of three proteins that are integral to muscle contraction. Troponin is attached to the protein tropomyosin within the actin filaments, as seen in the image below. When the muscle is relaxed tropomyosin blocks the attachment sites for the myosin cross bridges (heads), thus preventing contraction.

When the muscle is stimulated to contract by the nerve impulse, calcium channels open in the sarcoplasmic reticulum (which is effectively a storage house for calcium within the muscle) and release calcium into the sarcoplasm (fluid within the muscle cell). Some of this calcium attaches to troponin which causes a change in the muscle cell that moves tropomyosin out of the way so the cross bridges can attach and produce muscle contraction.



In summary the sliding filament theory of muscle contraction can be broken down into four distinct stages, these are;

1. **Muscle activation:** The motor nerve stimulates an action potential (impulse) to pass down a neuron to the neuromuscular junction. This stimulates the sarcoplasmic reticulum to release calcium into the muscle cell.

2. **Muscle contraction:** Calcium floods into the muscle cell binding with troponin allowing actin and myosin to bind. The actin and myosin cross bridges bind and contract using ATP as energy (ATP is an energy compound that all cells use to fuel their activity – this is discussed in greater detail in the energy system folder here at ptdirect).

3. **Recharging:** ATP is re-synthesised (re-manufactured) allowing actin and myosin to maintain their strong binding state

4. **Relaxation:** Relaxation occurs when stimulation of the nerve stops. Calcium is then pumped back into the sarcoplasmic reticulum breaking the link between actin and myosin. Actin and myosin return to their unbound state causing the muscle to relax. Alternatively relaxation (failure) will also occur when ATP is no longer available.

So, a few things can stop a contraction;

1. Energy system fatigue: There is no more ATP left in the muscle cell so it can't keep contracting.

2. Nervous system fatigue: The nervous system is not able to create impulses sufficiently or quickly enough to maintain the stimulus and cause calcium to release.

3. Voluntary nervous system control: The nerve that tells the muscle to contract stops sending that signal because the brain tells it to, so no more calcium ions will enter the muscle cell and the contraction stops.

4. Sensory nervous system information: For example, a sensory neuron (nerves that detect stimuli like pain or how heavy something is) provides feedback to the brain indicating that a muscle is injured while you are trying to lift a heavy weight and consequently the impulse to that muscle telling it to contract is stopped.

In the gym or during exercise virtually all muscular fatigue occurring is energy system fatigue. That is, the rate of work within the muscle can not be maintained because ATP (energy) can no longer be provided. Strength and hypertrophy (training to make muscles stronger or bigger) training are prime examples of the types of training that can cause muscle failure due to energy system fatigue.

Types of Muscular System Diseases

Muscle diseases are any disease that affects the human muscle system. A muscle disease will be either primary or secondary.

Primary Muscle Diseases

Common primary diseases of the muscular system include inflammatory myopathies, such as

- **Polymyositis-** PM): This a rare type of inflammatory myopathy (also called myosotis), a group of muscle diseases that cause inflammation of muscle and their associated tissues, including blood vessels. According to The Myositis Foundation, the condition is mostly seen in people over age 20, many of which are women.[3] PM is marked by muscle inflammation and weakness. A person with this condition may experience falls and problems getting up falls, chronic dry cough, and/or dysphagia (difficulty swallowing). PM has no known cause and there is no cure for the condition. Fortunately, the condition is treatable.

- **Dermatomyositis** (DM): DM is a rare inflammatory muscle disease affecting people of any age or sex, although it's more often seen in women.[4] Common symptoms of DM include a distinctive rash, muscle weakness, and inflamed and painful muscles. Much like other inflammatory myopathies, the cause unknown, and while there is no cure, the condition can be managed with medications and other therapies.
- **Muscular dystrophy** (MD): MD is a group of inherited muscle diseases. These conditions all cause muscle loss and weakness. Some appear in infancy or childhood, and others may not appear until middle age or even later.[5] Symptoms are specific to the type of MD and vary based on the muscle groups and people they affect. All forms grow worse with time, and most people lose their ability to walk. There is no cure for MD, but symptoms can be treated, and complications can be prevented. Treatments include medications, physical therapy, speech therapy, orthopedic devices, and surgery.