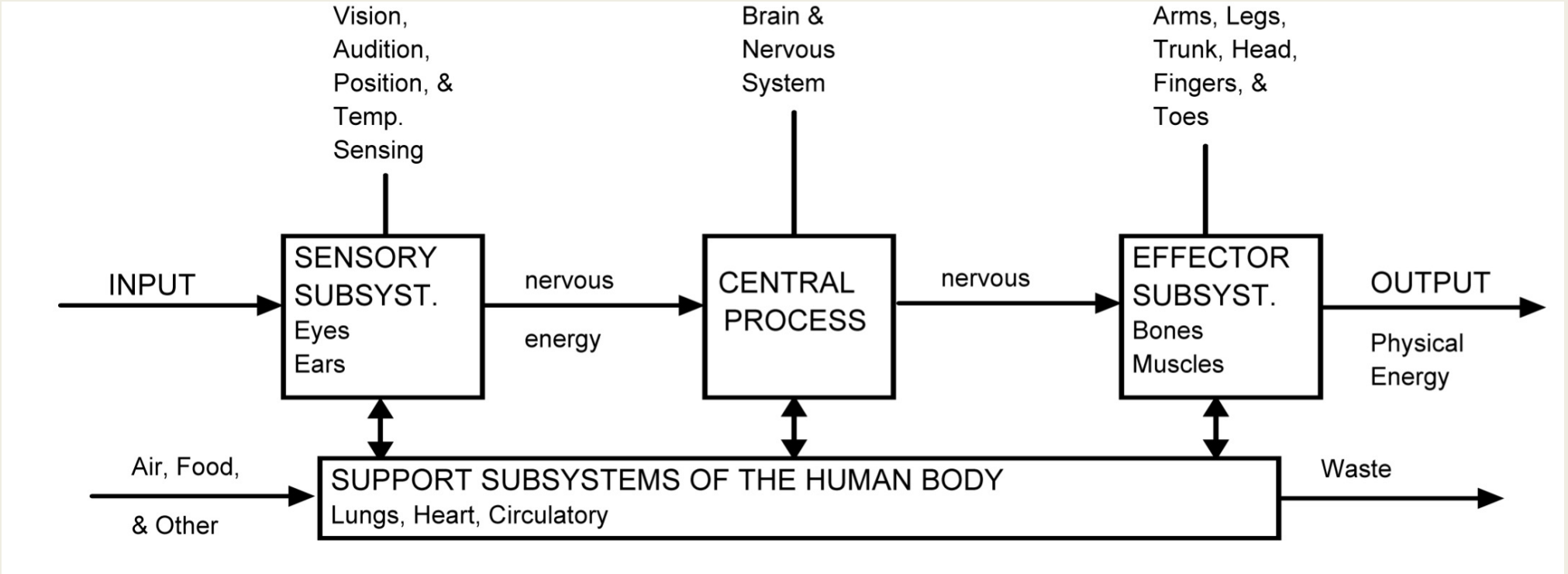
THE HUMAN SYSTEM

Spring 2024

Human systems

- Ergonomists must deal with the fact that people come in different sizes and shapes, and vary greatly in their strength, endurance, and work capacity. A basic understanding of human anatomy, physiology, and psychology can help ergonomists find solutions that deal with these issues and help prevent problems that can cause injury to workers.
- Human body has four component systems:
    1. *The sensory systems (vision, hearing, position, touch, taste, and smell) are stimulated by energy sources (e.g., light, sound, or heat) or materials (e.g., air- borne chemicals, acid on skin, salt on tongue) in the outside environment.*
    2. *The central information processor (brain and nervous system) processes information acquired from the sensory systems.*
    3. *The effector systems (arms, hands, eyes, legs, etc.) are consciously controlled to modify the environment and acquire information.*
    4. *The support systems (circulatory, digestive, metabolic, heat-regulatory, etc.) act in various ways to keep the other systems functioning.*

Human systems



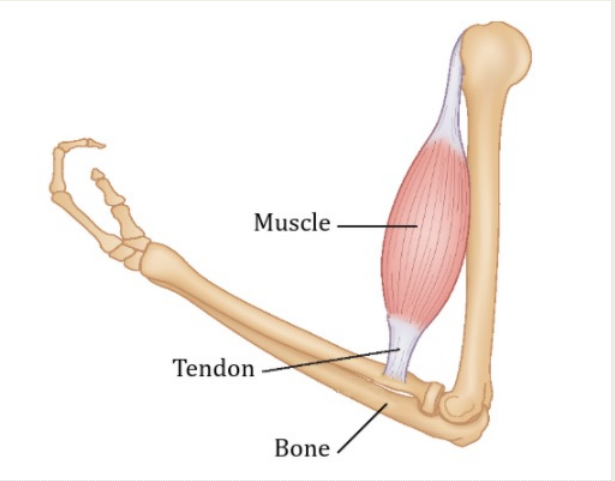
Human systems

- Each of these systems contains a sometimes overlapping set of subsystems. For example, people can use their fingers to read Braille (as sensors) and type (as effectors).
- The components of systems and subsystems are intricately interfaced throughout the body. For example, the skeletal and muscular subsystems contain nerves and sensors, as well as muscles and bone, and are controlled by the central processor.
- The circulatory system, an important component of the body's support system, similarly connects with the effector system through veins and arteries that supply the muscles with nutriments..

THE SKELETAL SUBSYSTEM

- The human skeleton consists of two principal systems of levers, the arms and legs, which are flexibly connected to the central body structure consisting of the skull, spine, rib cage, and pelvis.
- Joints between these bones allow for body movements, and the shape of these joints constrain those movements. The human skeleton contains over 200 bones and a corresponding set of joints.

THE EXTREMITIES



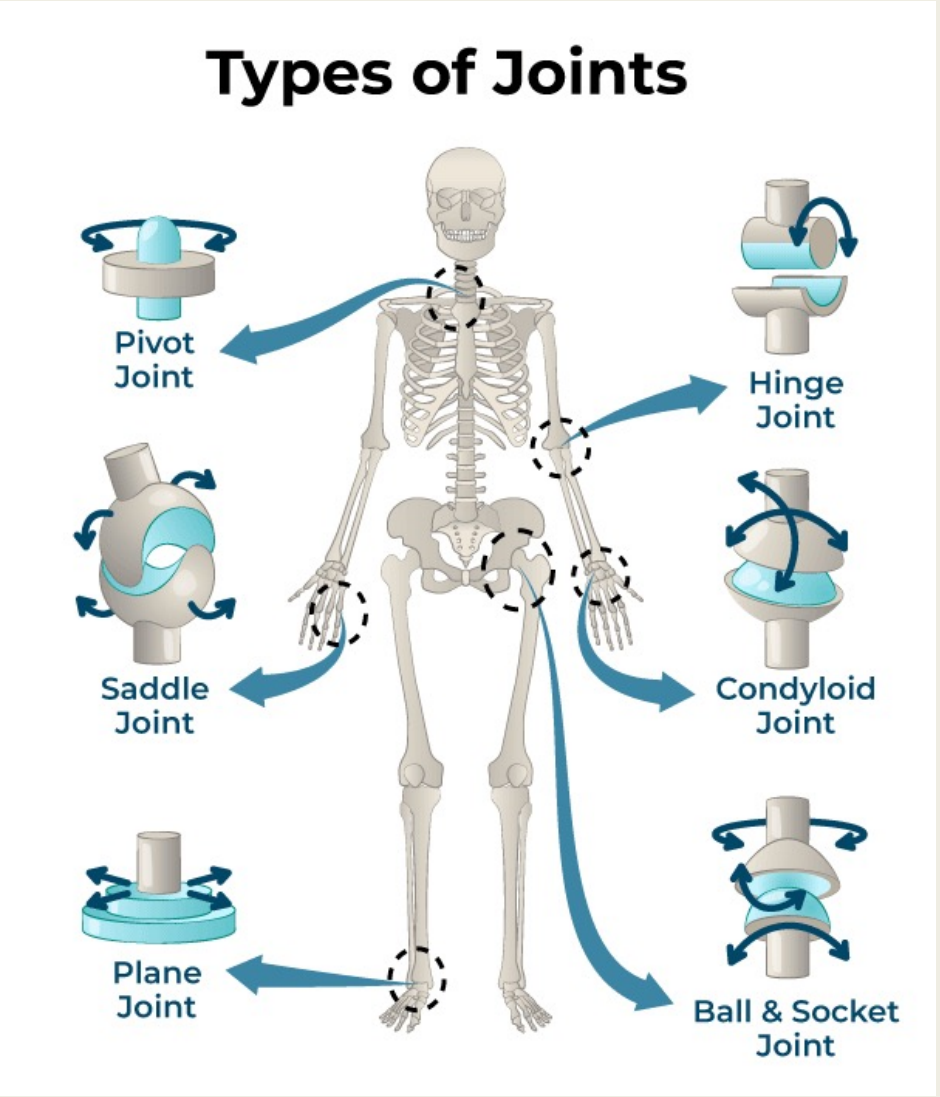
- Bones in the extremities are structured like pipes, with closed ends near the joints. Muscles are attached to the bones by tendons. A bone depression or protrusion is normally present at the spot where the tendon attaches. The surface layers of a bone are hard and dense and tend to be smooth except for roughened areas where ligaments and tendons are attached. Several small holes allow arteries, veins, and nerves to pass into the soft and spongy interior of the bone.
- Joints occur at the locations where bones come together. Joints tend to be complex structures, made from many different materials besides bone. Within a joint, ligaments and muscles hold the bones together. Most ligaments and tendons are made from inelastic *collagen fibers*. Some joints, especially in the spine, are held together by stretchable ligaments made from elastic fibers.
- The contact surfaces of bones in a joint are normally covered with a thin, smooth, and very slippery layer of collagen fibers, referred to as *cartilage*. This cartilage layer acts as a shock absorber and also helps minimize friction forces.

THE EXTREMITIES

- Joint Types:
  - *Joints at the ends of the fingers, knee joints, and elbow joints are known as hinge joints. Hinge joints have inelastic ligaments stretching down each side that prevent sideways movements. Other joints are less restrictive.*
  - *Gliding joints allow two-dimensional movement at articulations in the wrists and ankles.*
  - *The saddle joint found at the base of the thumb also allows two-dimensional movement.*
  - *The hip and shoulder joints are examples of spherical joints (or ball and socket joints) .Since the hip joint is a large ball and socket joint that is deep within the pelvis, it can carry heavy loads over a small range of movement.*
  - *The shoulder joint is smaller and not nearly as deep within the shoulder bone, so it cannot take as great a load, although it has a greater range of movement than the hip joint.*

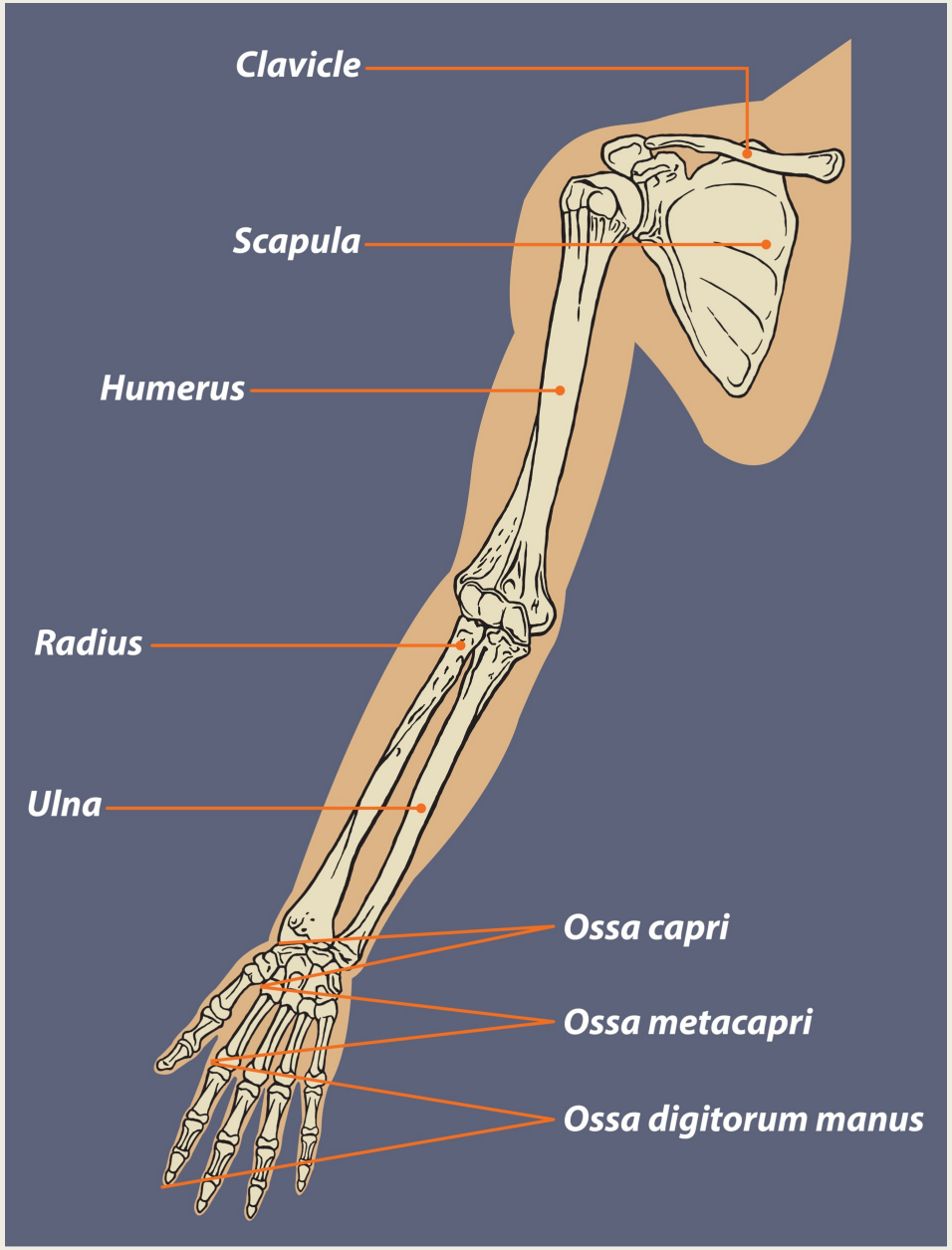
THE EXTREMITIES

- *Pivot* joints are joints where a protrusion from one bone fits into a recess of another. For example, at the upper end of the lower arm near the elbow, a protrusion of the radius bone fits into a recess in the ulna bone. Pivot joints restrict movements in some directions.
- The range of movement allowed by a joint is influenced by many factors including:
  1. *The shape of the articulation surfaces.*
  2. *The distribution of the muscles and ligaments.*
  3. *Muscle bulk.*



THE UPPER EXTRIMITY

- The single *humerus* bone of the upper arm connects to the *scapula* in the shoulder. The forearm has two bones, the *radius* and *ulna*, which connect the elbow to the *carpal* bones of the wrist. Note that the bone on the outside of the wrist is the ulna.
- The radius is interior to the ulna. The lower part shows bones of the wrist and hand. *Gliding joints* are found where the carpal bones articulate with each other and with the radius.
- The joint at the base of the thumb where the carpal bones articulate with the metacarpal bones within the hand is called a *saddle joint*. The *phalange* bones form the fingers.



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JOINT-RELATED DISORDERS

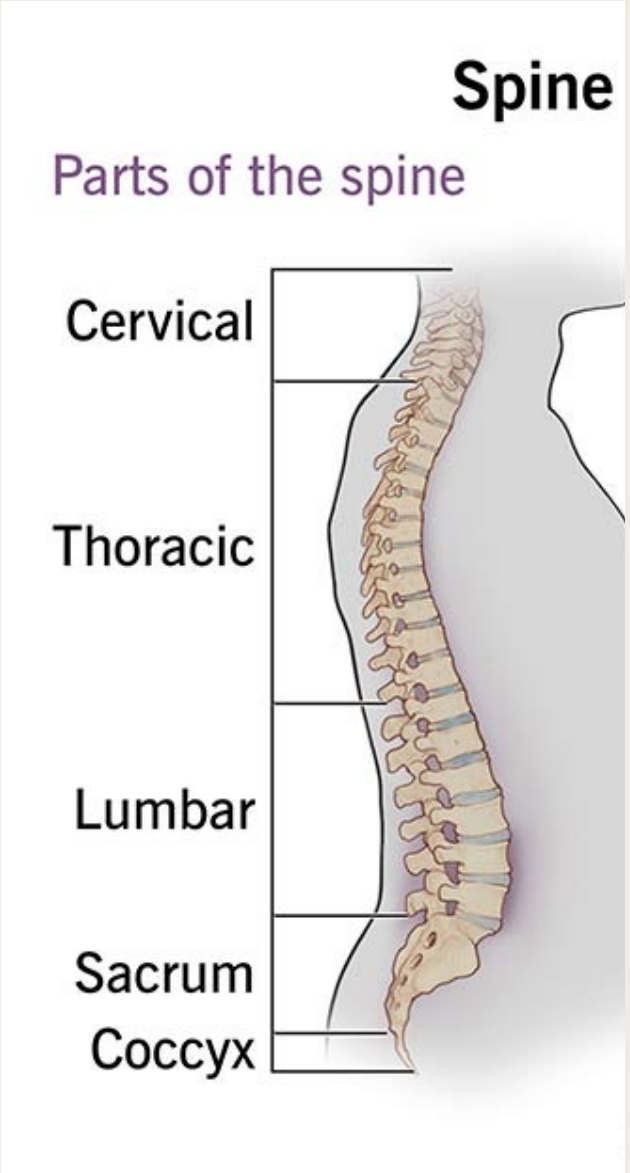
- Sudden forces may cause a ***sprain*** **or** ***dislocation*** of the joint, two types of injury that are common in sports medicine and which occur occasionally in industrial operations.
- ***Tearing*** of the protective joint capsule is another common injury. This tearing allows the synovial fluid to leak out of the joint capsule, resulting in disorders such as water on the knee.
- Continued misuse of joints over time can cause several types of ***cumulative trauma disorders*** (or CTDs, also called overuse or repetitive-use disorders).
- ***Ulnar deviation*** is a case in point. This disorder occurs when ligaments are stretched to the point that they no longer hold the lower part of the ulna bone in place, resulting in permanent disability.
- ***Trigger finger*** is a related disorder due to overuse of the finger used in shooting guns, first observed among soldiers who fired rifles on the rifle range for many hours of the day.
- ***carpal tunnel syndrome*** involves both the hand and the wrist. Joints of the finger are operated by muscles in the forearm which attach to tendons encased in sheathes. These sheathes pass over the bones of the wrist in what is known as the *carpal tunnel*.

THE SPINE

- Bones of the spine progressively increase in size from the top to the bottom of the spine, corresponding to an increase in carrying capacity for the lower bones.
- The individual bones of the spine are called *vertebrae* and are divided into four different categories, depending on their location:. there are 7 *cervical* vertebrae, counting from the top of the spinal column downwards; 12 *thoracic* vertebrae in the middle region; 5 *lumbar* vertebrae below the thoracic vertebrae, in the next lower region; and a fused group of *sacral* vertebrae, just above the coccyx, or tailbone.
- The specific vertebrae are numbered in terms of their location (i.e., C1–C7, T1–T12, and L1–L5).

THE SPINE

- Most back problems related to the spine involve the vertebrae of the lumbar region.
- The vertebrae are separated by discs, these discs serve as shock absorbers between the bony vertebrae in the spine. Over the course of a day of standing, these discs are under compression, causing the spine to shrink about 1.25 cm. Those discs also begin to degenerate after middle age.
- Since the discs occupy about 25% of the spinal length, and discs compress as the person ages, older people tend to grow shorter.



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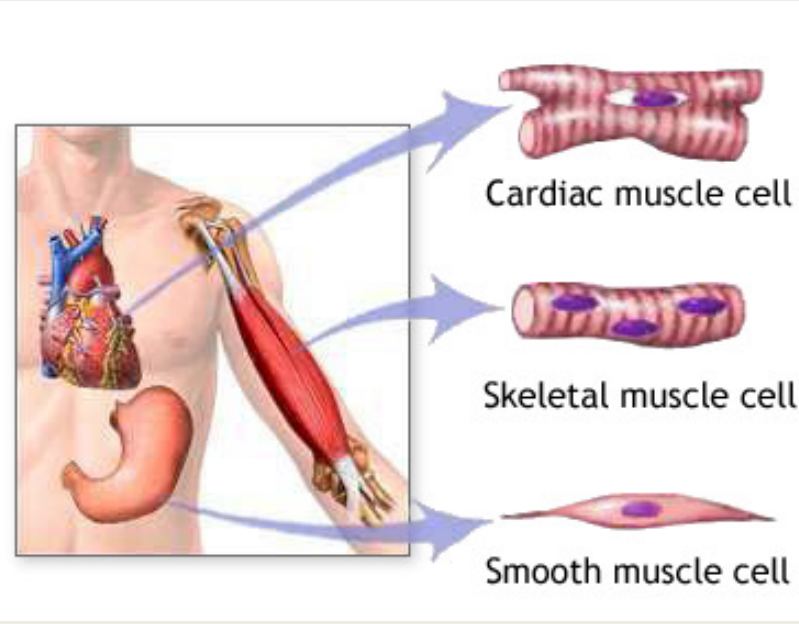
THE MUSCLES

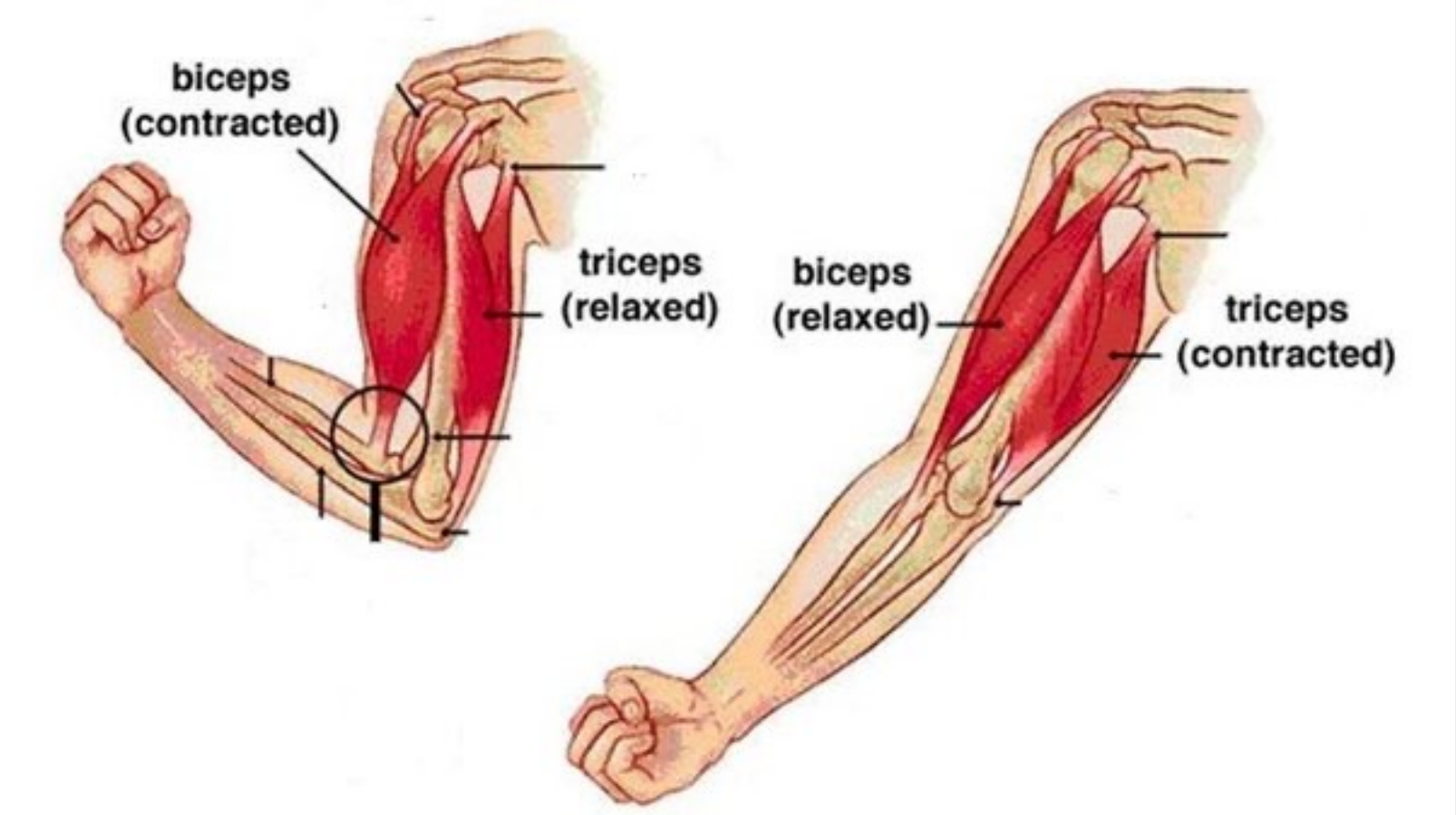


- Muscles are made up of body cells that have the ability to contract along a single direction. Microelements of a muscle include the tiny filaments called *actin* and *myosin*, which slide along each other during contractions and extensions.
- Muscles are classified into three different categories:
  - *Striped muscles connect to bones in the body and are used to make voluntary movements and maintain posture.*
  - *Smooth muscles are used within the organs to perform functions, such as constricting blood vessels.*
  - *Cardiac muscles in the heart pump blood.*
- Striped muscles are the most important for an ergonomic perspective.

MUSCLE CONTRACTIONS AND CAPABILITIES

- Muscles are positioned in opposing pairs so that contraction of one muscle causes movement around a joint in one direction, and contraction of the other muscle causes movement in the opposite direction.
- When fully contracted, the length of a muscle fiber is roughly half that of the relaxed length.
- Each fiber contraction creates a muscle force, with greater numbers of contracted fibers resulting in greater forces. Bigger muscles usually have greater maximum force capabilities or force endurance capabilities than smaller muscles.
- Severe muscle bulk, however, limits contraction.

Muscles work in opposing pairs



THE ROLE OF OXYGEN IN MUSCLE ACTIONS

- Muscle fibers are activated by nerve impulses within the muscle bundles. Those impulses trigger a complex series of enzyme and chemical reactions that result in muscle fiber contraction. Oxygen is needed in this process and is brought from the lungs to the muscle by its blood supply.
- When oxygen is not in sufficient supply, lactic acid builds up in the muscle bundle until more oxygen is available. Typically, in sudden start-ups of an activity, the resident oxygen supply is used up and the current blood supply has not delivered enough oxygen, so some lactic acid builds up in the muscles
- With increases in the blood flow, oxygen is delivered fast enough to reduce the level of lactic acid in the bundle. The increased blood supply typically continues after the physical effort has stopped in order to remove all of the lactic acid.

THE ROLE OF OXYGEN IN MUSCLE ACTIONS

- If working muscles are contracted too much or for too long, they cannot get an adequate supply of blood and oxygen. Lactic acid accumulates in the affected muscles, and they may become painful.
- W*ork designs that call for the application of excessive forces over long time periods must therefore be avoided.*
- Another issue is that rigid, unnatural postures can cause muscles in the back, neck, and elsewhere to become painful. For this reason, postural freedom is an important principle of workplace design. It also follows that when extensive physical exertion is necessary, rest periods are required to balance the muscular effort.
- Redesigning the work method so that the loads are spread over more muscle groups by allowing the operator to change posture between cycles of the task or by rotating personnel. After people are hurt, another challenging problem must be dealt with—that is, ergonomic specialists are often responsible for developing ways to accommodate people with temporary or permanent disability due to job-related injuries.

MUSCLE INJURIES AND DISORDERS

- In some cases, whole muscle bundles may go into contraction simultaneously and cause a muscle ***cramp*** or ***spasm***. Once a cramp occurs, the person usually tries to use unaffected muscles, which may overburden these other muscles and result in further pain or cramps. A common case of cramp or spasm is a *charley horse*. Spasms or cramps are a natural body defense against overexertion.
- What triggers charley horses?
- Things that can trigger a charley horse include:
  - *Poor blood flow.*
  - *Working your muscles too much.*
  - *Not stretching enough.*
  - *Being active in high temperatures.*
  - *Dehydration.*
  - *A problem such as a spinal cord injury or a pinched nerve in your neck or back.*

MUSCLE INJURIES AND DISORDERS

- Another issue is that sudden, unexpected, force exertions often cause muscle injuries. For example, a worker might make a quick violent movement to secure a slipping load.
- **Muscle strains** occur when muscles or tendons are stretched too far. In minor cases, this results in stiffness and soreness. In more severe cases, the muscle may **tear** or the tendon may tear loose from the bone. This results in intense pain and requires a long time for recovery.

EFFECTS OF GENDER AND MUSCULAR STRENGTH

- In general, women are not as strong as men of the same age, weight, and physical condition. The size of this difference depends on the task performed.
- Studies have shown that women's ability to lift objects from the floor ranges from 50% to 65% of men's ability
- The classic rule of thumb is that women of the same age, weight, and physical condition are on average *about two thirds as strong as men.*
- Muscular strength is an important issue because weaker people may need to exert forces close to their maximum capability when they perform strenuous tasks. This increases fatigue and the potential for injury.

EXERCISE AS A MEANS OF CTD PREVENTION

- Exercise is beneficial because it builds up endurance and strength.
- Many people advocate warming up before starting a task and doing stretching exercises during regular work breaks.
- For athletes, these exercises provide a physical transition from the static to the dynamic state.
- Persons whose jobs tend to be very static are urged to do some stretching exercises during breaks. The use of exercise is to condition the specific muscle bundles used heavily on the job.