Chapter 11

The Muscular System

An Introduction to the Muscular System

- The Muscular System
  - Consists only of skeletal muscles
- Muscle Organization and Function
  - Muscle organization affects power, range, and speed of muscle movement
  - *Fascicles*
    - Muscle cells (fibers) are organized in bundles (fascicles)

11-1 Fascicle Arrangement

- Classification of Skeletal Muscles
  - By the way fascicles are organized
  - By relationships of fascicles to tendons

11-1 Fascicle Arrangement

- Organization of Skeletal Muscle Fibers
  - Four patterns of fascicle organization
    1. **Parallel**
    2. **Convergent**
    3. **Pennate**
    4. **Circular**

11-1 Fascicle Arrangement

- Parallel Muscles
  - Fibers parallel to the long axis of muscle
  - For example, *biceps brachii*
  - Depends on total number of myofibrils
  - Directly relates to cross section of muscle
  - 1 $in.^2$ (6.45 cm^2) of cross section develops 50 lb (23 kg) of tension

11-1 Fascicle Arrangement

- **Convergent Muscles**
  - A broad area converges on attachment site (tendon, aponeurosis, or **raphe**)
  - Muscle fibers pull in different directions, depending on stimulation
  - For example, *pectoralis* muscles

11-1 Fascicle Arrangement

- **Pennate Muscles**
  - Form an angle with the tendon
  - Do not move as far as parallel muscles
  - Contain more myofibrils than parallel muscles
  - Develop more tension than parallel muscles

11-1 Fascicle Arrangement

- **Pennate Muscles**
  - *Unipennate*
    - Fibers on one side of tendon
    - For example, *extensor digitorum*
  - *Bipennate*
    - Fibers on both sides of tendon
    - For example, *rectus femoris*
  - *Multipennate*
    - Tendon branches within muscle
    - For example, *deltoid*

11-1 Fascicle Arrangement

- **Circular Muscles**
  - Also called **sphincters**
  - Open and close to guard entrances of body
  - For example, *orbicularis oris* muscle of the mouth

11-2 Levers

- Skeletal Motion
  - Skeletal muscles attach to skeleton, produce motion
  - Type of muscle attachment affects power, range, and speed of muscle movement

11-2 Levers

- Levers
  - Mechanically, each bone is a lever (a rigid, moving structure)
    - And each joint a fulcrum (a fixed point)
  - Muscles provide applied force (AF)
    - Required to overcome load (L)

11-2 Levers

- Function of a Lever
  - To change:
    - Direction of an AF

        - Distance and speed of movement produced by an AF
        - Effective strength of an AF

11-2 Levers

- The Three Classes of Levers
    - Depend on the relationship between applied force, fulcrum, and resistance
        1. **First-class lever**
        2. **Second-class lever**
        3. **Third-class lever**

11-2 Levers

- **First-Class Lever**
    - Seesaw or teeter-totter is an example
    - Center fulcrum between applied force and load
    - Force and load are balanced

11-2 Levers

- **Second-Class Lever**
    - Wheelbarrow is an example
    - Center resistance between applied force and fulcrum
    - A small force moves a large weight

11-2 Levers

- **Third-Class Lever**
    - Most common levers in the body
    - Center applied force between load and fulcrum
    - Greater force moves smaller load
    - Maximizes speed and distance traveled

11-3 Muscle Attachments to Other Tissues

- **Origins and Insertions**
    - Muscles have one fixed point of attachment (**origin**)
        - And one moving point of attachment (**insertion**)
    - Most muscles originate or insert on the skeleton
    - Origin is usually proximal to insertion

11-3 Muscle Attachments to Other Tissues

- **Actions**
    - Movements produced by muscle contraction
    - Body movements
        - For example, flexion, extension, adduction, etc.

- Described in terms of bone, joint, or region

11-3 Muscle Attachments to Other Tissues

- Muscle Interactions
  - Muscles work in groups to maximize efficiency
  - Smaller muscles reach maximum tension first, followed by larger, primary muscles
- Muscle Terminology Based on Function
  - **Agonist** (or **prime mover**)
  - **Antagonist**
  - **Synergist**

11-3 Muscle Attachments to Other Tissues

- **Agonist** (**Prime Mover**)
  - Produces a particular movement
- **Antagonist**
  - Opposes movement of a particular agonist
- **Synergist**
  - A smaller muscle that assists a larger agonist
  - Helps start motion or stabilize origin of agonist (**fixator**)

11-3 Muscle Attachments to Other Tissues

- Muscle Opposition
  - Agonists and antagonists work in pairs
    - When one contracts, the other stretches
    - Such as flexors–extensors, abductors–adductors, etc.

11-4 Naming Skeletal Muscles

- Names of Skeletal Muscles
  - Correct names of muscles include the term *muscle*
  - Exceptions:
    - *Platysma*
    - *Diaphragm*

11-4 Naming Skeletal Muscles

- Descriptive Names for Skeletal Muscles
  - Location in the body
  - Origin and insertion
  - **Fascicle organization**
  - Relative position
  - Structural characteristics
  - Action

11-4 Naming Skeletal Muscles

- Location in the Body
  - Identifies body regions
    - For example, *temporalis muscle*
    -
- Origin and Insertion
  - First part of name indicates origin
  - Second part of name indicates insertion
    - For example, *genioglossus muscle*

11-4 Naming Skeletal Muscles

- **Fascicle Organization**
  - Describes fascicle orientation within muscle
    - For example, **rectus** (straight), **transversus**, **oblique**

11-4 Naming Skeletal Muscles

- Position
  - **Externus** (**superficialis**)
    - Visible at body surface
  - **Internus** (**profundus**)
    - Deep muscles
  - **Extrinsic**
    - Muscles outside an organ
  - **Intrinsic**
    - Muscles inside an organ

11-4 Naming Skeletal Muscles

- Structural Characteristics
  - Number of tendons
    - *bi* = 2, *tri* = 3
  - Shape
    - *Trapezius, deltoid, rhomboid*
  - Size
    - Many terms refer to muscle size

11-4 Naming Skeletal Muscles

- Action
  - Movements
    - For example, *flexor*, *extensor*, *retractor*
  - Occupations or habits
    - For example, *risor* = laughter

11-4 Naming Skeletal Muscles

- Terms Indicating Specific Regions of the Body
  - Abdominal (abdomen)
  - Ancon (elbow)
  - Auricular (ear)
  - Brachial (arm)
  - Capitis (head)
  - Carpi (wrist)
  - Cervicis (neck)

11-4 Naming Skeletal Muscles

- Terms Indicating Specific Regions of the Body
  - Coccygeal (coccyx)
  - Costal (rib)
  - Cutaneous (skin)
  - Femoris (thigh)
  - Glossal (tongue)
  - Hallux (great toe)
  - Ilium (groin)
  - Inguinal (groin)

11-4 Naming Skeletal Muscles

- Terms Indicating Specific Regions of the Body
  - Lumbar (lumbar region)
  - Nasalis (nose)
  - Nuchal (back of neck)
  - Ocular (eye)
  - Oris (mouth)
  - Palpebra (eyelid)
  - Pollex (thumb)
  - Popliteal (posterior to knee)
  - Psoas (loin)

11-4 Naming Skeletal Muscles

- Terms Indicating Specific Regions of the Body
  - Radial (forearm)
  - Scapular (scapula)
  - Temporal (temple)
  - Thoracic (thorax)
  - Tibial (tibia; shin)
  - Ulnar (ulna)

11-4 Naming Skeletal Muscles

- Terms Indicating Position, Direction, or Fascicle Organization
  - Anterior (front)
  - External (on the outside)
  - Extrinsic (outside the structure)
  - Inferior (below)
  - Internal (away from the surface)
  - Intrinsic (within the structure)
  - Lateral (on the side)
  - Medial (middle)

11-4 Naming Skeletal Muscles

- Terms Indicating Position, Direction, or Fascicle Organization
  - Oblique (slanting)
  - Posterior (back)
  - Profundus (deep)
  - Rectus (straight)
  - Superficial (toward the surface)
  - Superior (toward the head)
  - Transverse (crosswise)

11-4 Naming Skeletal Muscles

- Terms Indicating Structural Characteristics of the Muscle
  - **Nature of Origin**
    - Biceps (two heads)
    - Triceps (three heads)
    - Quadriceps (four heads)

11-4 Naming Skeletal Muscles

- Terms Indicating Structural Characteristics of the Muscle
  - **Shape**
    - Deltoid (triangle)
    - Orbicularis (circle)
    - Pectinate (comblike)
    - Piriformis (pear-shaped)
    - Platy- (flat)
    - Pyramidal (pyramid)

11-4 Naming Skeletal Muscles

- Terms Indicating Structural Characteristics of the Muscle
  - **Shape**
    - Rhomboid (parallelogram)
    - Serratus (serrated)
    - Splenius (bandage)

        - Teres (round and long)
        - Trapezius (trapezoid)

11-4 Naming Skeletal Muscles

- Terms Indicating Structural Characteristics of the Muscle
    - **Other striking features**
        - Alba (white)
        - Brevis (short)
        - Gracilis (slender)
        - Lata (wide)
        - Latissimus (widest)
        - Longissimus (longest)
        - Longus (long)

11-4 Naming Skeletal Muscles

- Terms Indicating Structural Characteristics of the Muscle
    - **Other striking features**
        - Magnus (large)
        - Major (larger)
        - Maximus (largest)
        - Minimus (smallest)
        - Minor (smaller)
        - Vastus (great)

11-4 Naming Skeletal Muscles

- Terms Indicating Actions
    - **General**
        - Abductor (movement away)
        - Adductor (movement toward)
        - Depressor (lowering movement)
        - Extensor (straightening movement)
        - Flexor (bending movement)
        - Levator (raising movement)
        - Pronator (turning into prone position)
        - Supinator (turning into supine position)
        - Tensor (tensing movement)

11-4 Naming Skeletal Muscles

- Terms Indicating Actions
    - **Specific**
        - Buccinator (trumpeter)
        - Risorius (laugher)
        - Sartorius (like a tailor)

11-4 Naming Skeletal Muscles

- Divisions of the Muscular System
  1. **Axial muscles**
     - Position head and spinal column
     - Move rib cage
     - 60 percent of skeletal muscles
  2. **Appendicular muscles**
     - Support pectoral and pelvic girdles
     - Support limbs
     - 40 percent of skeletal muscles

11-5 Axial Musculature

- The **Axial Muscles**
  - Divisions based on location and function
    1. *Muscles of the head and neck*
    2. *Muscles of the vertebral column*
    3. *Oblique and rectus muscles*
    4. *Muscles of the pelvic floor*

11-5 Axial Musculature

- *Muscles of Facial Expression*
  - Originate on skull
- *Extrinsic Eye Muscles*
  - Originate on surface of orbit
  - Control position of eye
- *Muscles of Mastication*
  - Move the mandible
- *Muscles of the Tongue*
  - Names end in *glossus*

11-5 Axial Musculature

- *Muscles of the Pharynx*
  - Begin swallowing process
- *Anterior Muscles of the Neck*
  - Control position of larynx
  - Depress the mandible
  - Support tongue and pharynx

11-5 Axial Musculature

- *Muscles of Facial Expression*
  - **Orbicularis oris** constricts the mouth opening
  - **Buccinator** moves food around the cheeks
  - Muscles of the **epicranium** (scalp)

11-5 Axial Musculature

- Muscles of Facial Expression
  - Muscles of the **epicranium** (scalp)
    - **Temporoparietalis**
    - **Occipitofrontalis**
      - Frontal and occipital bellies
      - Separated by **epicranial aponeurosis**
    - **Platysma**
      - Covers anterior surface of neck

11-5 Axial Musculature

- *Six Extrinsic Eye Muscles* (*Oculomotor Muscles*)
  1. **Inferior rectus**
  2. **Medial rectus**
  3. **Superior rectus**
  4. **Lateral rectus**
  5. **Inferior oblique**
  6. **Superior oblique**

11-5 Axial Musculature

- *Muscles of Mastication*
  - **Masseter**
    - The strongest jaw muscle
  - **Temporalis**
    - Helps lift the mandible
  - **Pterygoid** muscles
    - Position mandible for chewing

11-5 Axial Musculature

- *Muscles of the Tongue*
  - All named for origin and insertion
    - **Palatoglossus**
    - **Styloglossus**
    - **Genioglossus**
    - **Hyoglossus**

11-5 Axial Musculature

- *Muscles of the Pharynx*
  - **Pharyngeal constrictor** muscles
    - Move food into esophagus
  - **Laryngeal elevator** muscles
    - Elevate the larynx
  - **Palatal muscles**

        - Lift the soft palate

11-5 Axial Musculature

- *Anterior Muscles of the Neck*
    - **Digastric**
        - From chin to hyoid
        - And hyoid to mastoid
    - **Mylohyoid**
        - Floor of the mouth
    - **Geniohyoid**
        - Between hyoid and chin

11-5 Axial Musculature

- Anterior Muscles of the Neck
    - **Stylohyoid**
        - Between hyoid and styloid
    - **Sternocleidomastoid**
        - From clavicle and sternum to mastoid
    - **Omohyoid**
        - Attaches scapula, clavicle, first rib, and hyoid

11-5 Axial Musculature

- Muscles of the Vertebral Column
    - Spinal extensors or **erector spinae** muscles (superficial and deep)
    - Spinal flexors (transversospinalis)

11-5 Axial Musculature

- Muscles of the Vertebral Column
    - Superficial Spinal Extensors
        - **Spinalis** group
        - **Longissimus** group
        - **Iliocostalis** group

11-5 Axial Musculature

- Muscles of the Vertebral Column
    - Deep Spinal Extensors
        - **Semispinalis** group
        - **Multifidus** muscle
        - **Interspinalis** muscles
        - **Intertransversarii** muscles
        - **Rotatores** muscles

11-5 Axial Musculature

- Muscles of the Vertebral Column
  - Spinal Flexors
    - Neck
      - **Longus capitis** and **longus colli**
      - Rotate and flex the neck
    - Lumbar
      - **Quadratus lumborum** muscles
      - Flex spine and depress ribs

11-5 Axial Musculature

- Oblique and Rectus Muscles
  - Lie within the body wall
  - Oblique muscles
    - Compress underlying structures
    - Rotate vertebral column
  - Rectus muscles
    - Flex vertebral column
    - Oppose erector spinae

11-5 Axial Musculature

- Oblique Muscles
  - Cervical region
    - **Scalene** muscles
    - Flex the neck
  - Thoracic region
    - **Intercostal** muscles (external and internal)
      - Respiratory movements of ribs
    - **Transversus thoracis**
      - Cross inner surface of ribs

11-5 Axial Musculature

- Oblique Muscles
  - Abdominopelvic region (same pattern as thoracic)
    - **External oblique** muscles
    - **Internal oblique** muscles
    - **Transversus abdominis**

11-5 Axial Musculature

- Rectus Muscles
  - **Rectus abdominis**
    - Between xiphoid process and pubic symphysis
    - Divided longitudinally by **linea alba**

        - Divided transversely by **tendinous inscriptions**

11-5 Axial Musculature

- Rectus Muscles
    - Diaphragmatic muscle or **diaphragm**
        - Divides thoracic and abdominal cavities
        - Performs respiration

11-5 Axial Musculature

- Muscles of the Pelvic Floor
    - Functions of pelvic floor muscles
        1. Support organs of pelvic cavity
        2. Flex sacrum and coccyx
        3. Control movement of materials through urethra and anus

11-5 Axial Musculature

- Muscles of the Pelvic Floor
    - **Perineum**
        - Muscular sheet forming the pelvic floor, divided into:
            1. Anterior **urogenital triangle**
            2. Posterior **anal triangle**

11-5 Axial Musculature

- Perineum
    - **Urogenital diaphragm**
        - Deep muscular layer between pubic bones
            - Supports the pelvic floor
            - And muscles of the urethra
        - Superficial muscles of the urogenital triangle
            - Support external genitalia

11-5 Axial Musculature

- Muscles of the Pelvic Floor
    - Perineum
        - **Pelvic diaphragm**
            - Deep muscular layer extending to pubis
                - Supports anal triangle

11-6 Appendicular Musculature

- Appendicular Muscles
    - Position and stabilize pectoral and pelvic girdles

- Move upper and lower limbs
- Two divisions of appendicular muscles
  1. Muscles of the shoulders and upper limbs
  2. Muscles of the pelvis and lower limbs

11-6 Appendicular Musculature

- Muscles of the Shoulders and Upper Limbs
  - Four groups
    1. *Muscles that position the pectoral girdle*
    2. *Muscles that move the arm*
    3. *Muscles that move the forearm and hand*
    4. *Muscles that move the hand and fingers*

11-6 Appendicular Musculature

- *Muscles That Position the Pectoral Girdle*
  - **Trapezius**
    - Superficial
    - Covers back and neck to base of skull
    - Inserts on clavicles and scapular spines

11-6 Appendicular Musculature

- Muscles That Position the Pectoral Girdle
  - **Rhomboid** and **levator scapulae**
    - Deep to trapezius
    - Attach to cervical and thoracic vertebrae
    - Insert on scapular border

11-6 Appendicular Musculature

- Muscles That Position the Pectoral Girdle
  - **Serratus anterior**
    - On the chest
    - Originates along ribs
    - Inserts on anterior scapular margin

11-6 Appendicular Musculature

- Muscles That Position the Pectoral Girdle
  - **Subclavius**
    - Originates on ribs
    - Inserts on clavicle
  - **Pectoralis minor**
    - Attaches to scapula

11-6 Appendicular Musculature

- *Muscles That Move the Arm*
  - **Deltoid**
    - The major abductor
  - **Supraspinatus**
    - Assists deltoid

11-6 Appendicular Musculature

- Muscles That Move the Arm
  - **Subscapularis** and **teres major**
    - Produce medial rotation at shoulder

11-6 Appendicular Musculature

- Muscles That Move the Arm
  - **Infraspinatus** and **teres minor**
    - Produce lateral rotation at shoulder
  - **Coracobrachialis**
    - Attaches to scapula
    - Produces flexion and adduction at shoulder

11-6 Appendicular Musculature

- Muscles That Move the Arm
  - **Pectoralis major**
    - Between anterior chest and greater tubercle of humerus
    - Produces flexion at shoulder joint
  - Latissimus dorsi
    - Between thoracic vertebrae and humerus
    - Produces extension at shoulder joint

11-6 Appendicular Musculature

- The **Rotator Cuff**
  - Muscles involved in shoulder rotation
    - Supraspinatus, subscapularis, infraspinatus, teres minor, and their tendons

11-6 Appendicular Musculature

- *Muscles That Move the Forearm and Hand*
  - Originate on humerus and insert on forearm
  - Exceptions:
    - The major flexor (**biceps brachii**)
    - The major extensor (**triceps brachii**)

11-6 Appendicular Musculature

- Muscles That Move the Forearm and Hand
  - Extensors
    - Mainly on posterior and lateral surfaces of arm
  - Flexors
    - Mainly on anterior and medial surfaces

11-6 Appendicular Musculature

- Flexors of the Elbow
  - **Biceps brachii**
    - Flexes elbow
    - Stabilizes shoulder joint
    - Originates on scapula
    - Inserts on radial tuberosity
  - **Brachialis** and **brachioradialis**

11-6 Appendicular Musculature

- Extensors of the Elbow
  - **Triceps brachii**
    - Extends elbow
    - Originates on scapula
    - Inserts on olecranon
  - **Anconeus**
    - Opposes brachialis

11-6 Appendicular Musculature

- Flexors of the Wrist
  - **Palmaris longus**
    - Superficial, flexes wrist
  - **Flexor carpi ulnaris**
    - Superficial, flexes wrist, adducts wrist
  - **Flexor carpi radialis**
    - Superficial, flexes wrist, abducts wrist

11-6 Appendicular Musculature

- Extensors of the Wrist
  - **Extensor carpi radialis**
    - Superficial, extends wrist, *ab*ducts wrist
  - **Extensor carpi ulnaris**
    - Superficial, extends wrist, *ad*ducts wrist

11-6 Appendicular Musculature

- Muscles That Move the Forearm and Hand
  - Pronation and supination
    - **Pronator teres** and **supinator**
      - Originate on humerus and ulna
      - Rotate radius
    - **Pronator quadratus**
      - Originates on ulna
      - Assists pronator teres

11-6 Appendicular Musculature

- *Muscles That Move the Hand and Fingers*
  - Also called *extrinsic muscles of the hand*
  - Lie entirely within forearm
  - Only tendons cross wrist (in synovial tendon sheaths)

11-6 Appendicular Musculature

- Tendon Sheaths
  - **Extensor retinaculum**
    - Wide band of connective tissue
    - Posterior surface of wrist
    - Stabilizes tendons of extensor muscles

11-6 Appendicular Musculature

- Tendon Sheaths
  - **Flexor retinaculum**
    - Anterior surface of wrist
    - Stabilizes tendons of flexor muscles

11-6 Appendicular Musculature

- The Intrinsic Muscles of the Hand
  - Muscles that move the metacarpals and phalanges
    - And originate and insert only on those bones

11-6 Appendicular Musculature

- Muscles of the Pelvis and Lower Limbs
  - Pelvic girdle is tightly bound to axial skeleton
    - Permits little movement
    - Has few muscles

11-6 Appendicular Musculature

- Muscles That Position the Lower Limbs

- Three Groups
  1. *Muscles that move the thigh*
  2. *Muscles that move the leg*
  3. *Muscles that move the foot and toes*

11-6 Appendicular Musculature

- *Muscles That Move the Thigh*
  - **Gluteal muscles**
  - **Lateral rotators**
  - **Adductors**
  - **Iliopsoas**

11-6 Appendicular Musculature

- **Gluteal Muscles**
  - **Gluteus maximus**
    - Largest, most posterior gluteal muscle
    - Produces extension and lateral rotation at hip
  - **Tensor fasciae latae**
    - Works with gluteus maximus
    - Stabilizes **iliotibial tract**
  - **Gluteus medius** and **gluteus minimus**
    - Originate anterior to gluteus maximus
    - Insert on trochanter

11-6 Appendicular Musculature

- **Lateral Rotators**
  - Group of six muscles, including the dominant:
    1. **Piriformis**
    2. **Obturator**

11-6 Appendicular Musculature

- Adductors
  - **Adductor magnus**
    - Produces adduction, extension, and flexion
  - **Adductor brevis**
    - Hip flexion and adduction
  - **Adductor longus**
    - Hip flexion and adduction

11-6 Appendicular Musculature

- Adductors
  - **Pectineus**

        - Hip flexion and adduction
    - **Gracilis**
        - Hip flexion and adduction

11-6 Appendicular Musculature

- **Iliopsoas**
    - Two hip flexors insert on the same tendon
        1. **Psoas major**
        2. **Iliacus**

11-6 Appendicular Musculature

- *Muscles That Move the Leg*
    - **Flexors of the knee**
        - Originate on the pelvic girdle
    - **Extensors of the knee**
        - Originate on the femoral surface
        - Insert on the patella

11-6 Appendicular Musculature

- Flexors of the Knee
    - **Hamstrings**
        - **Biceps femoris**
        - **Semimembranosus**
        - **Semitendinosus**
    - **Sartorius**
        - Originates superior to the acetabulum

11-6 Appendicular Musculature

- Extensors of the Knee
    - Four muscles of the **quadriceps femoris**
        - Three **vastus muscles**
        - **Rectus femoris muscle**

11-6 Appendicular Musculature

- *Muscles That Move the Foot and Toes*
    - Extrinsic muscles that move the foot and toes include:
        - Muscles that produce extension at the ankle
        - Muscles that produce flexion at the ankle
        - Muscles that produce extension at the toes
        - Muscles that produce flexion at the toes

11-6 Appendicular Musculature

- Four Muscles That Produce *Extension* (*Plantar Flexion*) at the Ankle
  1. **Gastrocnemius**
  2. **Soleus**
  3. Fibularis (group)
  4. Tibialis posterior

11-6 Appendicular Musculature

- Muscles That Move the Foot and Toes
  - The *Achilles Tendon*
    - The calcaneal tendon (*Achilles tendon*)
      - Shared by the gastrocnemius and soleus

11-6 Appendicular Musculature

- Muscles That Produce *Flexion* (Dorsiflexion) at the Ankle
  - **Tibialis anterior**
    - Opposes the gastrocnemius

11-6 Appendicular Musculature

- Muscles That Produce *Extension* at the Toes
  - **Extensor digitorum longus**
  - **Extensor hallucis longus**
    - Extensor retinacula fibrous sheaths
      - Hold tendons of toes as they cross the ankle

11-6 Appendicular Musculature

- Muscles That Produce *Flexion* at the Toes
  - Flexor digitorum longus
  - Flexor hallucis longus
    - Oppose the extensors

11-6 Appendicular Musculature

- The Intrinsic Muscles of the Foot
  - Muscles that move the tarsals, metatarsals, and phalanges and originate and insert only on those bones

11-7 Effects of Aging on the Muscular System

- Effects of Aging
  - *Skeletal muscle fibers become smaller in diameter*
  - *Skeletal muscles become less elastic*
    - Develop increasing amounts of fibrous tissue (fibrosis)

- *Decreased tolerance for exercise*
- *Decreased ability to recover from muscular injuries*

11-8 Muscular System Integration

- *Cardiovascular System*
  - Delivers oxygen and fuel
  - Removes carbon dioxide and wastes
- *Respiratory System*
  - Responds to oxygen demand of muscles
- *Integumentary System*
  - Disperses heat from muscle activity
- *Nervous and Endocrine Systems*
  - Direct responses of all systems